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DESIGN ACROSS BORDERS UNITED IN CREATIVITY

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DESIGN ACROSS BORDERS
UNITED IN CREATIVITY

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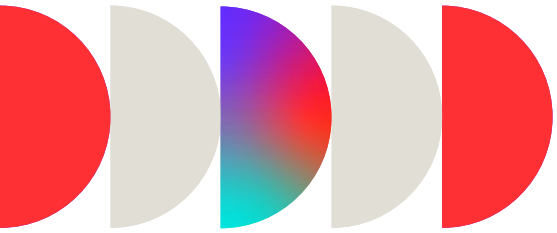


Preface

In a world shaped by constant transformation and global interconnectedness, design emerges as a bridge between people, places, and ideas. Cumulus Monterrey 2024: Design Across Borders – United in Creativity invited the international design community to reflect on the profound potential of design to transcend cultural, geographic, and disciplinary boundaries, uniting us in the shared pursuit of innovation, inclusion, and positive change.

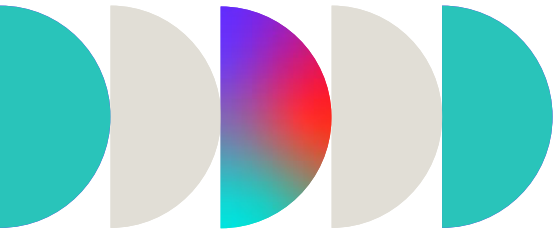
This edition of the Cumulus Proceedings gathers contributions that respond to urgent questions: How can design foster empathy and intercultural understanding? In what ways does it become a catalyst for social transformation in a complex, globalized world? Can design truly become a universal language—and what are the challenges in achieving that ideal?

The richness of perspectives represented in these proceedings speaks to the global nature of the Cumulus network. Authors, researchers, educators, and practitioners from across continents have come together to share insights, experiences, and provocations within four thematic tracks:

- Design for Change explores design's role in social innovation, sustainability, equity, and the circular economy—highlighting projects that place co-creation and inclusion at their core.
- Speculative Futures ventures into emerging territories shaped by technology, artificial intelligence, and immersive experiences, imagining the future of creative practice.
- Education in Art and Design focuses on pedagogical innovation, interdisciplinarity, and the challenges and opportunities of digital transformation in global learning environments.
- Translocality brings critical attention to issues of migration, decolonization, and the Global South, recognizing the importance of diverse voices and perspectives in shaping a more equitable world through design.

Together, these contributions reflect a collective commitment to harnessing creativity as a force that transcends barriers—linguistic, political, cultural—and brings people together around shared values and visions.

We are proud to present this volume as a testament to the power of design to imagine, inspire, and unite. May it serve not only as a record of this important moment in time but also as a spark for continued dialogue, collaboration, and transformation in the global design community.



Design Across Borders: United in Creativity

Lorenzo Imbesi
Full Professor, Sapienza University of Rome
President, Cumulus Association

The Cumulus Monterrey 2024 Conference marked a timely and vital moment in the global conversation about the role of design in shaping a better world. Hosted at the prestigious design institutions of Tecnológico de Monterrey and Universidad de Monterrey (UDEM), the international gathering has been further enhanced by the unique Monterrey's rich heritage and cultural identity, contributing to a thriving ecosystem of creative exchange for scholars, researchers, and practitioners across various design disciplines.

The central theme of the conference, "Design Across Borders: United in Creativity," provided an inspiring gateway for exploring how design holds the possibility to transcend geographical, cultural, and disciplinary boundaries. In particular, the conference was framed by four imperative trajectories: "Design for Change," investigating how design practices can drive social innovation and sustainable development; "Design Futures," exploring the interplay between technology and creativity, immersive experiences, virtual realities, and the implications of artificial intelligence; "Education in Art and Design," investigating pedagogical approaches in the field; and "Translocality," addressing complex issues of migration, decolonisation, and North-South dynamics. Themes highlight the broad scope of contemporary artistic and design pursuits.

At the heart of the conference was a shared recognition that design can be a dynamic force for empathetic understanding and intercultural dialogue. Through a rich program of keynote lectures, panel discussions, workshops, exhibitions, and informal exchanges, the international community demonstrated determination to work collaboratively across geographical and cultural divides, confirming the foundational premises of the conference: that creativity knows no boundaries, and through design, we can forge connections that transcend the limitations of space, time, and cultural difference. In an era of unprecedented global challenges, from climate change to technological acceleration, from cultural conflicts to social inequities, designing without boundaries means identifying areas of commonality, intersection, and convergence, highlighting them in ways that resonate with and reflect the spirit of our transborder region. As traditional confines between nations, disciplines, and cultural contexts become increasingly permeable, the design community must find itself uniquely equipped to harness this fluidity. Rather than resisting uncertainty, design must embrace it, transforming constraints into opportunities for innovative problem-solving and cross-cultural exchange.

The proceedings collected in this edition offer an extensive variety of perspectives on the ideas and projects discussed at the event. They include case studies, speculative work, educational reflections, and practical strategies, all pointing to the evolving role of design to shape societal interactions, encouraging intercultural dialogue, and building a more harmonious and interconnected world. However, these proceedings capture only a portion of the energy and insight shared during the conference, with the remaining impact continuing to reverberate through ongoing collaborations and dialogues within our global community.

As we move forward, the conversations from Cumulus Monterrey 2024 remind us that creativity thrives not in isolation, but in community. And in a time marked by division and uncertainty, design, when practiced with care and intention, can truly serve as a bridge. One that brings us together to learn, to act, and to imagine a positive change.

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PAPERS

FROM DYSTOPIA TO MICRO-UTOPIA: SOCIETAL CHANGE THROUGH DIGITAL DESIGN INNOVATION.

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ABSTRACT | This research paper combines socio-cultural sustainability with digital product design through a co-design and user experience (UX) approach. It draws attention to the unsustainable relationship between design and technology and proposes a problem-focused approach instead of a solution-focused one. The study showcases the Digital Experience Theatre (DXT), a creative tool influenced by Augusto Boal's Theatre of the Oppressed, customised for digital design. DXT combines speculative co-design and text-to-image AI to urge participants to imagine dystopian situations to recognise and address current societal problems. This approach has been implemented in educational environments, particularly in the Zambujal 360 initiative – the focus of this paper – where students developed digital solutions to tackle issues specific to their community in the neighbourhood of Zambujal in the Lisbon metropolitan area, Portugal. The paper contends that shifting from a dystopian to a micro-utopian mindset can facilitate substantial societal changes by encouraging critical consciousness and cooperative resolution of problems. By fostering a participatory design process that emphasises critical awareness and creative problem-solving, the DXT method has the potential to inspire innovative solutions that address complex social challenges. Ultimately, the paper argues that digital design innovation, when coupled with socio-cultural sustainability principles, can play a pivotal role in driving positive societal transformation and nurturing a more equitable and sustainable future.

KEYWORDS | SOCIO-TECHNOLOGICAL DESIGN, USER EXPERIENCE, IDEATION TOOL FOR CHANGE, SPECULATIVE CO-DESIGN, TEXT-TO-IMAGE AI GENERATION

1. Image theatre for social change

This study stems from the pattern of unsustainability in the design-technology relationship. Sustainability is a concept first defined in the Brundtland Report on the environment in 1987 as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs", integrating environmental goals with economic ones. The use of the term has spread widely in the past four decades, and it can be found alongside most various adjectives, which contributes to its ambiguity (Garcia et al., 2018, p. 242). When digital processes and products are preoccupied with sustainability, they tend to associate social responsibility and environmental standards with economic and business sustainability. Despite their growing role in facilitating human activities within a global-local context, there is a common problem of digital products frequently failing to convey ecological and socio-cultural insights. We argue that the integration of technology in digital devices should be guided not simply by economic sustainability but also by environmental, social, and cultural sustainability.

To do so, our contribution stems from the development of a co-design UX method, using a problem-focused approach. Contrary to solution-focused approaches, which are intimately linked with creative thinking and the pursuit of answers to the "how?", "problem-oriented thinking is closely linked to critical thinking, and questions like why? and what? help with the formulation of the problem" (Pusca & Northwood, 2018, p. 48). Our ideation tool can be metaphorically described as shifting from dystopian to micro-utopian thinking to drive innovation in socio-technological design. Richard Howells (2014) argues that the very act of design is a Utopian process. And Dystopia is inevitably bound with Utopia. In this sense, design processes and practices that use tools that envisage crisis scenarios for the future can help identify present problems and, ultimately, ways to deal with them. Instead of picturing ideal and hopeful futures, the depiction of desperate and catastrophic alternatives may be more useful as a methodology. Lucy Sargisson suggests that dystopias can stimulate thought and debate and can eventually trigger behavioural change (Sargisson, 2013).

Nonetheless, we drift from the dystopian-centered perspective and try to pay attention to the referred micro-utopias. Instead of focusing on the ideal, unreal, and non-accomplishable prospects of utopias (or their dystopian shadow), micro-utopias, or "utopias of proximity", as the art critic Nicolas Bourriaud called them, are located in the micro-realm of "the concrete, the material and the everyday", or a "space of concrétude" (Blanes et al., 2016, p.9). In that way, they can be not simply thought-provoking but actually useful for application in society.

With his concept of "everyday micro-utopias", Bourriaud wanted to approximate art practices to the processes of ordinary life, with its particular social contexts and human relations. Criticising the objectification of social interactions and the dissociation of the artist from their audience led to his conceptualisation of a type of art practice that should be more flexible, relational, and collective. The artists – in our case, the designers – should not distance themselves from the public if they aim at a more useful and democratic practice. Micro-utopias appear as statements that result from the collective ability to imagine and create in the local and concrete sphere of social life.

This is what Mark Featherstone talks about when he begins his Planet Utopia by recalling psychoanalyst D. W. Winnicott, for whom the creativity we learn through childhood play is what will model cultural development in our future. The experience that occurs in a safe family environment that allows the child to imagine an infinite number of possible worlds is the one that we transpose into adult life. For Featherstone, "imagination, creativity, and the invention of the new are absolutely reliant on psychological security defined and provided by others and community" and derive from "experiences that are enabled by groups that create secure spaces to allow them to happen" (Featherstone, 2017, p.2). This idea of community and collective as a driver of new ideas is central to our project.

Within this scope, the research's main goal is to develop a teaching method and ideation tool titled Digital Experience Theatre (DXT) that embodies an approach to integrating social and cultural sustainability into digital product design through the conceptualisation of microutopias. The DXT leitmotif stems from the Theatre of the Oppressed (TO), crafted by Augusto Boal (2019), viewing users of digital products as oppressed individuals navigating through a multitude of ineffective solutions whose main focus is related to commercial interests instead of being more useful for society, generating fruitful interactions with human and non-human communities. This paper specifically examines the application of the DXT method in the classroom, focusing on its use in the Digital Interfaces course within the Master's program in Design and Visual Culture at IADE, Universidade Europeia (Lisbon, Portugal).

Augusto Boal's Theatre of the Oppressed was influenced by Paulo Freire's Pedagogy of the Oppressed (2014), which involves critical awareness of social reality, enabling

intervention and emancipation from oppressive relations. Paulo Freire's (1921-1997) educational concept can be condensed as a journey of conscientisation toward social realities, enabling individuals to actively intervene and liberate themselves from oppressive structures. Formulated during the 1960s and 1970s amidst Brazil's literacy initiatives, Freire's theory emphasised the necessity of a dialogical relationship between educator and learner for effective literacy programs. True literacy should encompass not only technical skills but also critical thinking capabilities to review different contexts and issues. According to Freire, this process of problematisation is pivotal for achieving liberation (Freire, 1970).

Augusto Boal (1931-2009) had always been a social advocate and consistently viewed art and theatre as inherently intertwined with social and political contexts, essential for fostering participation and activism. Affiliated with Freire's principles, he conceived the Theatre of the Oppressed methodology while in political exile during the 1970s and 1980s. This methodology has theatre as its central piece, functioning as a tool accessible to all as a means to escape oppressive relationships. The DXT ideation tool adapts one of the introspective techniques from Boal's book Rainbow of Desire, specifically The Image of the Rainbow of Desire (Boal, 1994).

2. Speculative co-design method

The study undertaken for the DXT teaching method and the related ideation tool is exploratory, serving as both a process of probe and a way to generate more insights (Cross, 2007). DXT's research through design has been moving forward through several design workshops involving undergraduate and graduate design courses in Portugal and abroad. Design students participate in the process of reflection in action (Schön, 1983) by actively experimenting with the ideation tool for exploring design problems and tackling specific issues, as well as enabling them to explore and generate new ideas for the teaching method and tool. From the start of the research to the final version of the tool presented in this paper, the DXT evolved significantly with contributions from the students who tested it, particularly following observations of their interactions with the process and insights gained through unstructured interviews. At the heart of the research approach is the comparison of several versions of DXT, aiming to enhance the understanding of various theoretical and practical aspects (Gaver, 2012). This is achieved through iterative cycles of design, prototyping, testing, literature review, reflection, and dissemination, spanning from its development in 2021 to the present.

The DXT employs a co-design method where groups of students collaborate to create speculative dystopian scenarios using text-to-image AI generation. In this process,

participants collectively identify a problem and agree on a speculative framework within which they can assume either active or passive roles. Co-design and participatory design are characterised by collaborative discussions among individuals (Manzini, 2015). In this dialogic approach, where listening is as crucial as speaking, the development of the dystopian co-design process hinges on effective dialogue. While critical thinking and creativity are key in the DXT, enhancing participants' dialogical skills is essential for optimising the co-design process. This dialogical approach should facilitate and enrich the co-design process rather than control it (Fuad-Luke, 2009). Although co-design and participatory design are often seen as methods for achieving consensus among participants with divergent perspectives, they can evolve into agonistic design processes, where conflicting viewpoints lead to productive analyses (DiSalvo, 2012). The final phase of the DXT ideation tool and method involves a critical analysis of the created dystopia and a thorough evaluation of potential solutions.

Integrating text-to-image AI models with The Image of the Rainbow of Desire (Boal, 1994) approach facilitates the collaborative generation of visual representations. This AI method of generating visual representations of speculative dystopian scenarios enables participants using the DXT to experiment with unexpected situations and further explore the design problem they aim to address. Following Boal's sequential approach, the DXT entails a similar systematic procedure whereby participants are separated into conductor-designers and antagonistdesigners, both essential for the effective functioning of the ideation tool. The conductordesigners take charge of the process and initiate an image-based conversation with the antagonist-designers. The antagonist-designers, in response, challenge the dystopian speculation put out by the conductor-designer, thereby altering an identical image or idea. The DXT process engages participants in both roles in the sequential co-design of dystopian imagery, utilising an adapted version of The Rainbow of Desire method (table 1). The end result is that following an iterative cycle of dystopian images related to a problem's worst-case scenario, the group acquires a more profound comprehension of a specific matter and is presumably prepared to put its energy into designing solutions that address the very problem that triggered the conversation.

Table 1. Comparison table showcasing differences between the *Rainbow of Desire* (RoD) and the Digital Experience Theatre (DXT) methods, highlighting RoD omissions and DXT additions.

RoD Rainbow of Desire	**DXT** Digital Experience Theatre
[extra step added to the DXT column]	**Step 1** The group selects the problem to tackle according to threats to the earth's ecology or to societal needs, and the selected community.
Rainbow The protagonist creates the images and presents them, which are subsequently reproduced by the participating characters who play the role of antagonists. The antagonist characters can create new images (from the protagonist's perspective).	**Step 2** A pair of conductor-designers create and present to the antagonist-designers a dystopian image based on the tackled problem (an AI image based on text-to-image generation).
[extra step added to the DXT column]	**Step 3** The antagonist-designers manipulate the created image, deepening the dystopia. Each antagonist-designer creates a new version of the AI image or a different one, but from the perspective of the conductor-designers (thinking the same way they did).
Confidential monologue The images are presented together. The protagonist delivers a brief 'confidential monologue' for each image, emphasizing their thoughts and feelings for each situation. All antagonist characters watch the confidential monologues, analyzing the protagonist's desires.	**Step 4** The AI images are displayed together in a grid. The pair of conductor-designers interfere in each image created by the antagonist-designers with keywords that function as 'a confidential monologue', identifying critical problems and possible solutions.
The part takes over the whole The images created by each antagonist character are presented to the other antagonist characters, following an order devised by the protagonist. The antagonist observing the images reproduced by other antagonists must react to each one as if they represent different characters.	**Step 5** The antagonist-designers incorporate the ideas of the conductor-designers into their images by creating new versions.
The protagonist arranges all the images on the plateau, considering the antagonist's perspective, to emphasize certain characteristics more or less highlighted in each image.	All the images are presented to the antagonist-designers through a specific sequence (GIF animation) thought up by the conductor-designers.
The protagonist takes the place of the antagonist After organizing the images, the protagonist adopts the perspective of the antagonist, becoming aware of how they are perceived.	[no correspondence with the RoD column]
Will against desire The protagonist confronts each of their desires (images), emphasizing those approved by their will and confronting those disapproved by their will.	[no correspondence with the RoD column]
Agora of desires The antagonist characters and their respective images discuss their views of the protagonist in pairs. The meetings repeat until all antagonists have met with their counterparts. The protagonist observes the antagonists in dialogue.	**Step 7** Each antagonist-designer writes a comment for each of the other antagonist-designers' images.

Such as the DXT steps, the text-to-image exercise is a repetitive procedure that relies on combining visual components across consecutive prompts. Chance and the creative's willingness to embrace unforeseen pathways both play important roles in this process of interacting with AI and experimenting with dystopian situations. Within this cyclical text-toimage creative technique, the AI images do not appear instantly in their ultimate form. Instead, they are formed gradually, allowing one to observe the progress of the images as they develop visually. In such a method, it is important to not only create images but also curate them, as the images are made in groups, and creatives choose to delete or further develop some until the most representative one is created.

During the DXT process, participants are made aware that text-to-image AI generation worsens societal stereotypes and contributes to environmental concerns, particularly impacting the climate and humanity. The collective reflection promoted within the DXT teaching method emphasises the social and ecological challenges associated with AI technology and underscores the need for continuous improvement in AI effectiveness to address these challenges and mitigate its negative impacts. It is highlighted that gender, racial, and age expanded prompts may not fully mitigate bias in image generation, leading to incorrect or unusual responses and maybe introducing new biases (Naik & Nushi, 2023). Regarding the effect of AI on climate change, the training and operation of AI systems demand significant computational resources and electricity, leading to the release of carbon dioxide emissions. Furthermore, AI's environmental impact extends beyond carbon emissions to encompass other ecological concerns, such as driving increased consumerism. Therefore, participants in the DXT debate are encouraged not only to reflect on the environmental impact of AI but also to research how AI can be used to address sustainability, climate change, and other environmental issues on both local and global levels.

Prompt expansion strategies effectively broaden or refine the scope of a prompt to elicit a wider range of relevant or varied responses from an AI model. These strategies may differ depending on the circumstances, but their main objective is to promote more detailed and informative responses from AI systems. Thus, the participants of DXT are advised to employ efficient semantics and prompt expansion tactics to attain the best possible results in image generation. The procedures encompass offering comprehensive and elaborate explanations to enhance the interpretation of the intended image, employing specific keywords to depict desired visual aspects more accurately, and integrating textual descriptions with visual references, which clarify demands. Additionally, participants should refine prompts based on initial results and iterate to enhance image quality. This involves balancing specific details with allowing AI model creativity to foster innovative outcomes, among other strategies for understanding model responses and improving image generation.

3. Interaction designs for the Zambujal 360

The Zambujal 360 is in the Zambujal neighbourhood, with a population of approximately 4000 inhabitants. It is located in the Alfragide parish, Amadora municipality, Lisbon metropolitan area. It is an initiative from the NGO Ad Gentes, and the CAZAmbujal association focused on creating an urban art gallery inspired by the 17 Sustainable Development Goals (SDGs) and acting as a social change agent to promote sustainability. Each SDG is supported by a sponsoring organisation that is tasked with conducting global citizenship activities, such as guided tours to the urban art gallery dedicated to the SDGs, providing training for schools and companies, promoting the adoption of sustainable business models, and offering educational programs focused on development (Ad Gentes, n.d.; UNRIC, n.d.). IADE, Universidade Europeia, was involved in this fertile coalition between citizens and entities, mainly through the curricular unit of Digital Interfaces within the Master of Design and Visual Culture from the same institution.

A group of 17 artists, each with a unique background, sources of inspiration, and artistic methods, have been collaborating to finish the construction of the urban art gallery before the end of 2024 (figure 1) (UNRIC, n.d.). The Zambujal 360 aims to establish a paradigmatic SDG route to attract visitors, tourists, and students to the neighbourhood, which was precisely what happened with the group of IADE students and professors that engaged with this local initiative to develop innovative smartphone concepts for applications that contribute not only to boosting local commerce and education through health and art but also to encouraging community empowerment and holistic growth while valuing interrelationships and multiculturalism.

Figure 1. Mural paintings from the Zambujal 360 project. On the left is a painting illustrating SDG 5, Gender Equality, by Mariana Duarte Santos. On the right is a painting by the artist Lígia Fernandes on SDG 2, Eradicate Hunger. Photos by M. Linhares (2023).

The Zambujal 360 is founded on three main principles: (1) supporting local businesses - establishing a network of merchants, promoting their businesses, and fostering sustainable economic practices; (2) promoting health education - addressing the physical, mental, and emotional impacts of the COVID-19 pandemic through physical activity as a means to enhance well-being; and (3) improving art education - establishing an urban art gallery centred around the 17 SDGs, serving as a catalyst for social change, promoting sustainability, strengthening local identity, and challenging external barriers and stereotypes. The initiative aims to comprehensively transform the area by creating value via youth training, establishing a network of merchants, improving urban spaces, and promoting artistic, social, and cultural activities (Ad Gentes, n.d.).

The briefing delivered to students targeted the creation of a smartphone app associated with the brand and visual identity of the Zambujal 360 project – a digital product for mobile devices that considers contemporary visual culture and all the aspects that determine effective communication with the users to be considered, such as the neighbourhood residents, tourists, and other visitors (table 2). Students were asked to select an existing service or propose a new one and develop a touchpoint, the point of contact whose function is to boost a user's service experience. In this case, the touchpoint would need to be an integral part of a smartphone app that users would activate during their experience. Students followed the UX/UI methodology to develop the information architecture plan, the sitemap, and the creation of low-fidelity wireframes, followed by the design system, from the fundamentals to the UI components and patterns. Finally, high-fidelity prototyping, heuristic evaluation, usability testing, and iterative refinement were performed.

Table 2. Annotated portfolio showing three projects from the same DXT workshop related to the Zambujal 360 briefing.

Group	Selected problem	Image technique	Dystopian images	Solution definition
Group 1	Scarcity of shops offering fresh daily food pushes residents to resort to buying cheaper processed food and fast food.	AI images based on text-to-image generation.		An app that lets users find nearby grocery stores selling fresh produce on a map and view video recipes. It also allows shops to advertise unsold items at reduced prices at the end of the day.
Group 2	Children's mental health issues stemming from bullying or other emotional trauma that occur within their social bubble.	AI images based on text-to-image generation.		An app that uses augmented reality (AR) technology to let children explore mural paintings and the culture of the Zambujal community. It features a virtual exploration game where users collect characters and visual references inspired by the paintings.
Group 3	Loneliness and physical vulnerability among low-income older adults place them in difficult situations.	AI images based on text-to-image generation.		App that connects seniors and volunteers residing in a low-income housing community, enabling seniors to request assistance and volunteers to offer their help.

Students were asked to use the DXT approach and take a speculative design tactic as a starting point to represent a vision of the world that focuses not only on the user (user-centred) or on the human being (human-centred) but on humanity as a whole (humanity-centred). However, before using the DXT ideation tool in the Zambujal 360 context, students engaged in the environment described in the design briefing to begin exploring ideas for their mobile apps. They specifically focused on socio-technological sustainability, community empowerment, and holistic development. From this perspective, understanding the design problem and the eventual users started with design ethnography as an early stage to investigate and analyse users' cultural and social contexts to inform and inspire the design process. In our case, design ethnography entailed the systematic observation of social circumstances, analysis, and conceptualisation. Table 2 presents the challenges students addressed using the DXT

ideation tool and its speculative approach to respond to the Zambujal 360 brief, along with the solutions developed by the end of the workshop.

The digital product prototype created by group two, titled Zambujal 360 Hero: An Educational Game App, is an innovative application that uses augmented reality (AR) technology to actively involve young people in the neighbourhood mural paintings and multicultural heritage of Zambujal (figure 2). The app transforms traditional sightseeing by providing an immersive experience, which allows users to explore the original artworks and gain knowledge of the local history and culture through compelling augmented reality features.

A key feature of the application is a virtual adventure game that seeks to captivate users by including elements inspired by Pokémon GO. Children can gather different characters and visual references from the artworks as they engage with the murals through a gamified interaction. Each character and reference is complemented with educational content, including informative details and narratives about the local culture and the paintings' significance.

The app aims to enhance understanding and appreciation for art and culture while providing interactive activities to improve education. This educational experience combines augmented reality technology with a gamified approach to exploration. It aims to address mental health issues resulting from bullying or emotional trauma by providing a fun and informative adventure. Additionally, it strengthens social connections and allows easy access to the history and culture of Zambujal for future generations.

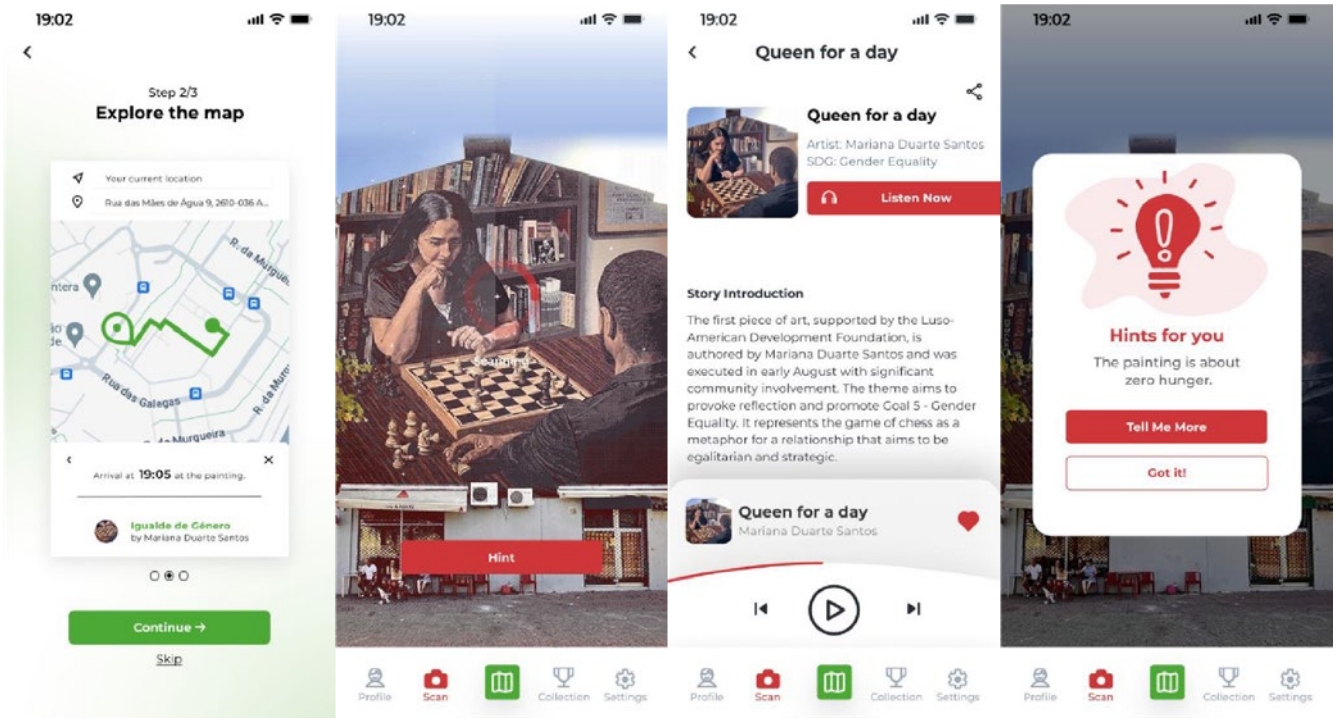

Figure 2. Screenshots from the app prototype titled Zambujal 360 Hero: An Educational Game App, by Jiaai Cao & Alexa Fislage, that uses gamification and AR technology to involve users in the mural paintings' interpretation.

4. Assessing DXT's educational and societal outcomes

The present research focuses on the intersection of UX design and societal transformation, emphasising the transformative power of co-design methods and the Theatre of the Oppressed methodology to boost sustainability and social innovation. The DXT proposes an uncommon strategy to tackle current socio-technological problems by shifting from dystopian to microutopian scenarios. In this context, it is essential to scrutinise the consequences and results of using DXT, considering its effectiveness in the educational setting and broader societal influence.

Regarding the co-design approach and the practice of creating micro-utopias, the DXT ideation tool and teaching method targets the collaborative recognition and solution discovery of design problems. Such a collaborative approach is consistent with Augusto Boal's The Image of the Rainbow of Desire method, which emphasises the significance of critical consciousness and engaged participation in dismantling oppressive systems. DXT involves creatives actively participating in speculative co-design by employing text-to-image AI generation to create and continuously improve dystopian scenarios. This technique stimulates creativity and critical thinking and improves participants' ability to engage in dialogue, facilitating effective communication and collaboration.

The practical applications and societal impact of DXT were exemplified by several student projects, including those undertaken as part of the Zambujal 360 initiative. These projects demonstrate how speculative design can confront real-world issues across different areas, such as food scarcity, mental health difficulties, and social isolation among older adults. Using DXT, students created innovative digital solutions, including a mobile application designed to pinpoint places of local fresh food vendors and an augmented reality game that fosters a connection between users and their local culture. These solutions not only tackle the current needs of the Zambujal community but also contribute to larger objectives of sustainability and cohesiveness.

In the near future, the DXT ideation tool and teaching method have significant potential for broader application in various human and non-human scenarios, where a speculative approach can drive the development of digital solutions with non-anthropocentric objectives. By nurturing a culture that promotes critical awareness and collaborative problem-solving, DXT has the potential to bring about significant societal transformation, turning dystopian realities into small-scale utopian opportunities.

5. Conclusion

The research featured in From Dystopia to Micro-Utopia: Societal Change Through Digital Design Innovation highlights the potential of UX and interaction design to face socio-technological concerns by employing a specific co-design method. The study presents the Digital Experience Theatre (DXT) as a research approach, teaching method, and tool for generating ideas, inspired by Augusto Boal's Theatre of the Oppressed. Its purpose is to promote collaborative problemsolving and critical thinking among participants. The DXT aspires to bring innovative and sustainable solutions for local-global everyday problems by employing text-to-image AI generation to create speculative dystopian scenarios. The effectiveness of this approach has been demonstrated in educational settings, particularly in the case study highlighted in this paper – the Zambujal 360 project – where students developed digital solutions to address challenges specific to the Zambujal community. The research stresses the significance of incorporating social and cultural sustainability into digital design, favouring a transition from a dystopian to a micro-utopian mindset to facilitate substantial societal change. The possible uses of the DXT extend beyond human situations, indicating a broader influence on many socioeconomic and environmental concerns.

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CRAFTING IMMIGRANT NARRATIVES OF BELONGING: ART AND DESIGN FOR SOCIAL INNOVATION WITH THE LATINO, LATINA, AND LATINX COMMUNITY OF IOWA CITY.

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ABSTRACT |

This paper is based on the fourth iteration of Shifting Ground (SG), an art and design initiative that engages immigrant communities. Established in 2019, the project has hosted workshops in the US and Portugal, using clay as a foundational material to connect with immigrant memories. SG engages in participatory ceramic sculpture workshops that articulate memories and aspirations tied to cultural heritage and unique immigrant skills, fostering dialogue and belonging within a new context. It aims to give local immigrants visibility and voice, valuing their contributions to the community. In 2023, the Ceramics Department at the University of Iowa hosted the SG's fourth iteration workshop on Latino, Latina, and Latinx immigrants, focusing on the evolving concepts of home and identity. The research explores cocreation methodologies, emphasising the relational concept's role as a network of relationships and interactions in engaging participants, ceramic sculptures, and communication for social and cultural integration. Relational thinking challenges the dualistic perspective and advocates for interconnected policies. It emphasises the constant relationships of interdependence between human and non-human. The paper discusses the US immigration process, SG's concept, objectives, and the relational concept. It analyses the project through opinions collected from participants via a survey. Positive feedback validates the initiative's role in supporting immigrants. The authors argue that embracing the commons and relational dynamics is crucial for a socially equitable and sustainable society, urging local organisations to adopt this approach systematically.

KEYWORDS | SOCIAL INNOVATION, SERVICE DESIGN, DESIGNING RELATIONALLY, PARTICIPATION, IMMIGRATION

1. Key factors on immigration and community art practice

At the core of the present paper is the project Shifting Ground, which we developed in 2019 and 2023 in collaboration with the American artist Jane Gilmor. The last iteration, in 2023, which is highlighted later in the text, was supported by local institutions in Iowa City (US), including the Ceramics Department of the School of Art and Art History at the University of Iowa, Public Space One, and involved the active participation of Hispanic immigrants.

In 2023, the period in which the fourth iteration of Shifting Ground was carried out in the United States, Joe Biden had already (since 2021) assumed the presidency with a mandate to reform the US immigration system in order to end, among other policies, the ban on mostly Muslim immigrants. Despite the presentation of more inclusive immigration policies, such as allowing citizenship to more than 11 million undocumented immigrants, their implementation has been complex (Boundless, 2024).

In 2019, when the Shifting Ground project was launched in the United States, the admission processes for refugees and immigrants faced severe threats. The legislative measures adopted were aimed at significantly reducing family-based immigration (Krogstad & Gonzalez-Barrera, 2022). While the US diversity visa programme, created in 1995 to diversify the immigrant population, has been a benefit, Donald Trump has sought to end this programme, along with the Temporary Protected Status (Krogstad and Gonzalez-Barrera, 2022). Authorisations granted to refugees in the US were also significantly reduced during this period, especially in 2019. This decline in refugee resettlement coincided with the highest number of refugees globally since World War II (Krogstad, 2019).

2. Shifting Ground

Shifting Ground is a social innovation art and design service that was launched in 2019 in Cedar Rapids, Iowa (US). It has since had two iterations in Lisbon (Portugal), and another one in Iowa City (US). The project took place in Lisbon between the years 2021

and 2022 and in Iowa City again in 2023. In 2019, Shifting Ground received funding from the Iowa Arts Council and the Centre for Art History and Artistic Research at the University of Évora (CHAIA). Additionally, it has garnered support from several institutions, including the Iowa Ceramic Center and Glass Studio, St. Paul's United Methodist Church, and the Immaculate Conception Church. From 2021 to 2022, the project was funded by the Aga Khan Foundation Portugal, the Museum of Contemporary Art, Lisbon, and CHAIA. The fourth and last edition of Shifting Ground, held in 2023, received support from CHAIA and was hosted by the Ceramics Department of the School of Art and Art History at the University of Iowa. This edition of Shifting Ground specifically addressed the topic of Latino, Latina, and Latinx immigrants (figure 1).

The project's primary impetus stems from contemporary issues of intolerance and social injustice related to immigration policies. These issues are likely to escalate due to the ongoing human and environmental crises, including climate change and war, which compel individuals to migrate in search of a new home with equitable living conditions and prospects for a brighter future. Faced with this situation, a collective of artists and designers, ourselves together with Jane Gilmor, have been exploring a community service aimed at immigrants and new arrivals by holding ceramics workshops, using sculpture as a means of social and cultural integration in their new home. By articulating experiences and goals linked to cultural heritage and distinctive immigrant talents, these participatory ceramic sculpture workshops promote dialogue and a sense of community (Gilmor et al. 2019).

In addition to promoting the emancipation of the participants through creative thinking, the project aims to cultivate a greater understanding among the general public about the power of social art and design, specifically, and culture in a broader context, as crucial tools for embracing diversity. Over its various editions, the Shifting Ground community service has engaged immigrants from Mexico, Colombia, Honduras, Indonesia, Angola, Mozambique, and Sao Tome and Principe. It has also included migrants and refugees from Burundi and the Democratic Republic of Congo.

Figure 1. Shifting Ground workshop in 2023 at the Ceramics Department of the School of Art and Art History at the University of Iowa. On the left side, Amaris Hurtado (foreground) and Patricia Rodriguez (background); on the right side, Nahid Rivera and Javier Espinosa.

The project incorporates a game named MOT, which stands for memory, object, and talent, with the aim of fostering empathy and facilitating a flexible, customised approach to participant engagement. This game encourages spontaneous participation and supports selfrepresentation by cultivating a creative dialogue between new arrivals and the host community. Throughout the Shifting Ground iterations, the MOT game has evolved. During the initial workshops, we asked participants to share a personal narrative, a significant object, and a key skill, ensuring that these elements are interconnected. In the final Lisbon Shifting Ground, participants' life stories centred on food-related memories and knowledge, acknowledging that food experiences, whether positive or negative, elicit strong feelings and emotions, which they further explored through ceramic sculptures. In the last Iowa City Shifting Ground, the workshop explored how concepts of home and identity shift with repeated moves. To this end, a game – MEMO – was played with the participants, which was made up of the relationship between memories related to food and each person's home. Through MEMO, the personal experiences that each participant explored served as inspiration for the creation of clay sculptures (figure 2).

Figure 2. Alejandra Alvarez's MEMO on the left side, and the sculptures developed from it during Shifting Ground's 2023 workshop.

To play the game, each participant was given a sheet with four ordered topics: a memory related to their food culture, a place associated with that memory, a sound that recalled the place and, finally, a significant object linked to the memory and the place. We inquired about the sound because the final ceramic sculptures would be displayed with mixed sounds. For this, they began writing about their own concepts, which they presented to one another. The process involved dialogue about each participant's MEMO, allowing them to share their individual experiences. This established a unified method across all iterations of the service that is based on an empathic methodology of dialogue with the participants. By engaging in collaborative art practices, their know-how transforms elements typically seen as discriminatory and culturally different into opportunities for integration. This process turns differences into a celebration of diversity.

Furthermore, we used photography and video to record the immigrant artists' engagement with the project activities and establish an image repository for the project, in addition to the ceramic sculptures created using the MEMO ludic method. This functions as a fundamental platform in our approach, enabling organised communication with diverse audiences. In addition, the use of installations and happenings creates a substantial and significant space for community self-expression and public involvement. Participants, their friends, and project supporters came together to celebrate the occasion and promote greater inclusiveness and democratic engagement (figure 3).

Figure 3. Shifting Ground's show at Public Space One, Iowa City, 2023. On the left site, Nahid Rivera's sculptures (foreground), and the sculptures of Isaac López Torres, Miriam Alarcón Avila, and Amaris Hurtado (background). On the right side, Janet Marcelino's sculpture.

3. Relational services and the commons

The desired outcome of an art and design service for social innovation like Shifting Ground is to generate and build settings that occur as situations for social innovation. These services can effectively adapt to a specific context in which they are provided by establishing strong connections with all social actors in the community and incorporating local culture and experience (Joly & Cipolla, 2013). It is a social activity that revolves around human-centric, relational, and societal components (Penin, 2018).

Interactions with services tend to be cyclical and difficult to predict as they evolve over time, influenced by numerous variables, random factors, inherent uncertainty, and spontaneity, which make accurate planning challenging. A common denominator of service interaction occurs whenever a user engages with a touchpoint, which functions as a tangible instance of a service and includes the components that provide the interactions. Touchpoints are crucial in improving the efficiency, effectiveness, and significance of

interactions. They are concrete connections or support associated with a particular object. Like other services, a service for social innovation can be delivered through face-to-face contacts, various types of relationships, digital interfaces, or a combination of multiple methods (Penin, 2018). Shifting Ground's MOT and MEMO games serve as crucial touchpoints, encouraging participants to reflect on their sociocultural backgrounds, which ultimately influences the creative process of their ceramic sculptures.

The sphere of art and design services for social innovation is driven by the concept of the commons, offering a profound societal framework for understanding humanity's shared experiences and representing a fundamental sociopolitical perspective. It recognises important connections and offers an alternative method of operating. The commons concept envisions humans as proactive members of larger social groups, participating in diverse collective structures such as local associations, virtual communities, and community services. These relationship patterns do not nullify the unique characteristics of individuals but rather shape how their opinions, beliefs, and actions eventually determine their personal and collective identities (Bollier & Helfrich, 2012).

Humans initiate the construction of a culture centred on the principles of care and shared accountability for their collective resources while protecting their means of existence. In this context, the understanding of the commons enhances the capacity of humans to identify, evoke, and improve these behaviours. The objective is to encourage people to consider the world from a more flexible, integrated, and long-range viewpoint based on the mutual principle that personal development is interconnected with the development of others and that these relationships are an essential part of a broader, interconnected social structure (Bollier & Helfrich, 2012).

Therefore, the most effective way to use shared assets is to establish platforms like Shifting Ground, among other social innovation services, for substantial communication and collaboration. This kind of service, focused on commoning, has the capacity to establish social practices and routines that enable individuals to engage in exploring, creating, and discussing alternative generative strategies, working as a medium for bottom-up activities to thrive and have an impact on the existing condition of citizenship and governance.

The collaborative platforms where social innovation occurs usually involve designers, artists, and other social innovation actors and stakeholders. It combines two approaches: working together to implement ideas that address societal needs and showcasing the commitment and ability to take action through various collaborative efforts. Hence, many civil associations, communities, families, and other social groups play crucial roles as valuable collaborators who may actively engage with professionals to test and organise diverse approaches. Establishing the rationale

for societal achievement and common ground is essential since most government policies are insufficient in resolving recurring issues (Manzini, 2015).

Within a social innovation art and design approach that prioritises the creation of subjectivity, creatives serve as catalysts for local communities, while creative sectors collaborate in open networks to provide services. They foster a common understanding of using art and design skills to develop innovative products, services, or communication artefacts, exploring several opportunities to shape cultural attitudes and behaviours.

The relational dimension is equally vital in service design for the purpose of social innovation. Considering service users as relational beings instead of simply customers must be a primary objective. The relational approach depends on being open to others and facilitating interpersonal interaction, which serves as the foundation for potential service opportunities. The effectiveness of people's engagement with the service is significantly determined by the interpersonal dynamics developed between them. Relational services differ from other types of services that rely on pre-established interactions between users and service providers. On the contrary, they are characterised by a connection between participants and service hosts, who facilitate a caring and flexible relationship that encourages an active part of everyone involved in the social innovation service (Cipolla, 2023).

Shifting Ground inevitably relies on the ideas of the commons and the significance of relational dynamics. This kind of service encourages substantial societal change by developing collaborative and flexible services that integrate local culture and actively involve the community. The emphasis on interpersonal aspects and the flexible nature of touchpoints guarantee that these services stay useful and efficient in tackling complex issues in society. By prioritising the establishment of inclusive environments for dialogue and collaborative exploration, individuals are empowered to actively participate in and benefit from the generation of innovative solutions. This, in turn, enhances the social structure and fosters a more cohesive and supportive community.

4. Designing relationally: Shifting Ground's relationships, interactions, and ceramic sculptures

In the context of the Shifting Ground project, it is crucial to consider the concept of relationality as defined by Escobar, Osterweil and Sharma (2014). In their book Relationality: An Emergent Politics of Life Beyond the Human, the authors scrutinise the concept of relationality as a strategy to combat inequality, climate change and ecological degradation. The authors challenge the prevailing dualistic perspective and argue for a policy that is based on interconnectedness and interdependence. People exist in constant relationships with each other and between them and the rest of the

environment (Escobar, 2014). It explores its epistemological and political implications and provides practical strategies for implementing relationality in various life aspects.

In the authors' opinion, building sustainable societies is based on recognising the diversity of knowledge and the interdependent relationship of all existing phenomena. According to this concept of relationality (Escobar et al., 2024), reality is interconnected, so human beings are no exception and cannot exist autonomously, disconnected from their non-human environment (Escobar 2014, p. 59). In contrast to the dominant modernist worldview, which is characterised by a single universal way of understanding and interacting with the world, this concept explores the idea of designing in a relational manner to promote pluriversal transitions, advocating for the recognition and valuing of a multiplicity of knowledge and ways of being (Escobar et al., 2024). According to the concept of pluriversal transitions, the Shifting Ground workshops, conducted through various interrelationships with immigrants from diverse backgrounds and cultures, highlighted the recognition of various epistemologies and practices from different cultures and communities.

Rational thinking aims to counter the egocentric view of human beings based on the idea that they were the creators of the Universe and existed in isolation and independently of other nonhuman beings. The concept of relationality, on the other hand, considers that everything exists in interrelationship and interdependence so that individuals influence but are also influenced by the world. The self is not an isolated, self-centred entity but a conscious being that comes into existence through the act of creation. We mutually mould each other's realities since our personal perceptions and feelings do not arise in isolation. Empowering yourself and reducing the feeling of being at the mercy of an indifferent cosmos provides a greater sense of security. Relationality is a mode of understanding, existence, and action, forming a unique combination of knowledge and ontology, referred to as a new narrative of life (Escobar et al., 2024). The postcartesian notion of the interconnectedness of all life is central to ecology insofar as the relational and interdependent being replaces the autonomous and isolated being (Escobar, 2020; Gablik, 1992).

In the Shifting Ground project, we adopted the term designing (Escobar et al., 2024) as a continuous action, methodical process, and creative mindset aimed at improving life and expressing concern. It acknowledges our interconnectedness with one another, the planet, and nonhuman entities. Individuals are complex webs of relationships that involve minds, bodies, feelings, social structures, and information systems. We are interrelated beings with a link to both the future and the present and the stories we create about them. Designing relationally promoted a sense of possibilities in the Shifting Ground workshops by emphasising the connectivity and co-creation of life. Designers may enhance their problem-solving abilities by embracing

relationality and pluriversal viewpoints, enabling them to create solutions that are both inclusive and effective in tackling the intricate difficulties of our time.

The sharing of the participants' life stories generated the expectation that each immigrant could develop their individual freedom and make decisions in the creation of their sculptures, thus promoting inclusion and democratic involvement. Using a collaborative artistic approach, relational design contributes to participants' ambitions of knowledge production and cultural understanding.

The Shifting Ground shares the logic of the politics of relationality (Escobar et al., 2024) since it is based on the specific and constantly changing local context. The project evolves organically by adapting practices to the different cultures of the various immigrants, fostering new forms of knowledge based on mutual respect. The collective nature of relational politics is echoed in the collaborative practice of the workshops through which participants have a plural experience.

Contrary to categorisation, Shifting Ground promotes the coexistence and complementarity of its participants' diverse perspectives as productive knowledge. In this regard, the transformative potential of Shifting Ground is developed through the sharing of each immigrant's personal experiences, which promotes personal enrichment, resilience, and the production of knowledge.

The interactions among participants during the workshop also reflected the holistic perspective of quantum physicist David Bohm (1992), whose aim was to enhance well-being through the appreciation of interpersonal relationships and connections with the environment. Electrons' behaviour plays a crucial role in Bohm's understanding of the interconnected and interdependent nature of the entire cosmos, where everything is in a constant dynamic relationship and cannot be separated from its surrounding context. Bohm (1992) emphasises the importance of dialogue, comparing it to a methodology that can be used to enhance and foster connections between individuals and their surroundings. This approach aims to solve societal problems. In the case of the Shifting Ground ceramic workshops, dialogue among participants served as a strategy to promote active listening, strengthen relationships between people, and help address issues such as the social and cultural integration of the immigrants involved in the project.

According to Escobar (2020), relationally designed systems study the interconnection of all things and the ways in which these connections may be used for creative endeavours. Establishing links between individuals with different backgrounds and expertise to create a cohesive whole, the objects they make, and underlying structures like social formations, political systems, and personal subjectivities with the aim of developing creativity is one of the main benefits of the Shifting Ground ecosystem. Workshops, exhibitions, and dialogue

served as strategies to assist immigrants in integrating into the new culture. Designing relationally has enabled the project to transcend its material condition, establishing itself as a network of interactions and connections that continually transform and adapt to its environment.

5. Volunteers and participants' view

The Shifting Ground conducted a series of interviews with participants in its last iteration, gathering feedback from volunteers involved in the workshops. They acknowledged the project's quality, noting it as a learning experience that showcased alternative approaches to engaging migrant communities.

Everyone enjoyed the PS1 as the local of the exhibition. Alejandra Alvarez highlighted this space as an excellent venue for the Shifting Ground exhibition and celebration, as it allowed the Iowa community to learn about the real visions and stories of immigrants. She believed that promoting the project through other "guerrilla" methods was necessary because many immigrants arrive in different ways. She also pointed out that if the exhibition had lasted longer, its impact would have been greater.

Regarding the participants' experience in the project, overall, it was valued a lot. Miriam Alarcón Avila, a Mexican immigrant, activist artist, founder of the collective Immigrant Luchadores, and mentor to the other participants, highlighted the importance of projects involving the Latin immigrant community in artistic activities that enhance integration. From her viewpoint, the Shifting Ground project accomplished this by unveiling the individual attributes of every member. The way the workshop combined writing, voice, and touch to explore memories and turn those experiences into a sculpture captivated Alejandra Alvarez. She highly appreciated her involvement in the initiative, deeming it important on both an individual and collective level. Pamela Quintero Rodriguez (Pammie) highlighted the significance of engaging in the ceramics workshop, as it provided her with the opportunity to convey her thoughts and feelings through manual expression, utilising the medium of art. Jose Marentes (Seso), a Mexican immigrant, activist artist, who belongs to the Collective Immigrant Luchadores, was exhilarated by the chance to listen to others' motivations and rationale for their creations. From his perspective, it is not the art itself that adds value to the pieces, but rather the narratives we have shared. Javier Espinosa Momox, a master's student in ceramics, volunteered for the Shifting Ground project and helped to facilitate the workshop for other participants. His interest in bringing ceramics to those who would not normally have access to these methods was what inspired him to take part. Nahid Rivera's engagement with the initiative started with the facilitators' explicit request. The explicit invitation served as a catalyst for their engagement in the project.

Regarding how art, such as ceramics and

sculpture, can serve as a means to express both personal experiences and those of other immigrants, and how they contribute to valuing immigrants' memories, skills, and cultures, participants provided positive feedback. Nahid Rivera, admited that ceramics do indeed contribute to the value of memories. Patricia Rodriguez, Pammie's mother, regarded her experience of participating in the collaborative workshop as profoundly enriching. Particularly during the initial phase of dialogue and sharing the participants' life stories, she sensed a strong and beautiful emotional connection among all the participants and the clay. Miriam Alarcón Avila expressed great joy about the use of clay as the primary material in the workshops, noting that it is an ancestral, malleable, inspiring, and effective medium for communicating and valuing immigrants' diverse life experiences. Specifically, it allows the creation of sculptures with significant meaning. Alejandra Alvarez mentioned that initially, she faced some difficulties as she had never worked with clay, but she realised that accepting the material's "life" and her inability to fully control it helped her let the artistic and emotional process flow. For Pammie, the experience of working with clay was highly relaxing. According to Seso, ceramics is the perfect medium for expressing feelings. He articulated a powerful desire to physically seize something when feeling anxious, and perceived clay as the ideal substance to satisfy this requirement. Particularly for Javier Espinosa Momox, ceramics offer a means through which people can engage with the earth's inherent qualities and our shared humanity. Furthermore, ceramics have cultural characteristics unique to certain societies, which contributes to an appreciation of immigrant experiences, talents, and cultures.

Everyone agrees that games should be used as a tool to find their own ideas for creating sculptures. Miriam Alarcón Avila praised the use of the MEMO game to stimulate the sharing of life stories, generate ideas for creating sculptures, and foster bonds among participants. She found this both beneficial and moving. The MEMO game was vital to Alejandra Alvarez because it was lively and generated a powerful, distinct bond. The game's lightheartedness facilitated individuals in expressing and embracing aspects that could otherwise be challenging to disclose or acknowledge. In her opinion, using the game as a strategy for creating a sculpture made the transformation process even more engaging. Pammie regarded the MEMO game as an excellent strategy to help individuals think about what they want to create. For Patricia Rodriguez, using the game MEMO proved to be a highly effective method of eliciting personal memories from each participant and facilitating their sharing. For her, it was a remarkable and beautiful experience, as all participants were pleased to recall their loved ones and other memories, allowing them to momentarily escape their daily concerns. She found it deeply moving to physically engage with the clay and to realise that, together with her daughter, she was creating a sculpture that symbolised the unity among all the members of her family. For her, it was

an extraordinary experience. Seso believes that games are ideal for alleviating our anxieties, thereby enabling our willingness to participate in conversation. Nahid Rivera considers that the use of games is crucial for challenging preconceived notions of what qualifies as "artistic" creations. According to her, games help to remove rigid notions and facilitate a more open approach to generating ideas for sculptures.

Every participant acknowledged the important role that art plays in deepening our understanding of people and their cultures. Miriam Alarcón Avila thinks that one of the noblest ways to foster creativity, share, and shape ideas that are frequently hard to articulate is via art. Additionally, it encourages individuals in discovering their synchronicities and emotions within a community. Alejandra Alvarez highlighted the power of participatory art by promptly enabling all participants to collaboratively establish a communal environment, even without prior acquaintance. She has the belief that art amplifies awareness and facilitates the cultivation of empathy towards others. She holds the belief that art serves as a medium for expressing the thoughts or feelings of something or someone. In the context of Shifting Ground, it allows us to immerse ourselves in the viewpoints and realities of others. Although she believes that individuals frequently reject what they cannot comprehend, art delves into uncharted territories that have the potential to be embraced in the future. According to Nahid Rivera, art is vital for comprehending and relating to other individuals and their cultures. Through her participation in the project, Pammie came to the awareness that art functions as a medium for comprehending and acknowledging the multiplicity of individuals and societies. In this sense, the workshops facilitated an appreciation of immigrant culture. According to Patricia Rodriguez perspective, art serves as the finest method of avoiding stress and daily worries. Working on art completely shifts one's attention towards creation, disregarding everything else. She establishes a clear and strong connection with the other participants in the project. She considers that throughout the process, all the participants had the opportunity to develop their creativity and design their own unique creations. Seso considers that art transcends linguistic barriers, becoming a universal medium of communication. Introduced as a method of expression, art transforms language into a universal tool for conveying meaning. Seso believes that although the participants came from different backgrounds, the art exhibition gave them a chance to momentarily connect and find common ground. Javier Espinosa Momox thinks that art can facilitate comprehension of individuals and their cultures by virtue of the sentiments and emotions conveyed therein.

The concluding event was an exceptional moment, emphasised by the participating immigrants in the Shifting Ground project and acknowledged by all those in attendance. Almost everyone emphasised that the exhibition served as a distinct celebration

of immigrant culture and the unity among various communities. They noted that the event showcased the most creative aspects of the involved communities, along with the participation of family and friends. For them, the celebration of immigrant culture was enriched by the fact that participants prepared regional dishes and drinks, featured a curated playlist of Mexican music, and decorated the exhibition space predominantly with Mexican cultural ornaments, all of which were considered exhilarating by everyone. Alexandra highlighted that PS1, the space of the exhibition, was an excellent venue for the Shifting Ground exhibition and celebration, as it allowed the Iowa community to learn about the real visions and stories of immigrants.

The positive feedback we received from participants in the Shifting Ground project demonstrates the importance of community-based efforts in fostering a welcoming environment for immigrants. It also signifies that the methodology employed is suitable and beneficial. We assert that collaboration and cooperation among individuals and groups with special interests are crucial determinants for the societal shift towards more fairness and long-term viability in the social and cultural domain. This process should be supported and systematically overseen by local organisations.

6. Conclusions

The Shifting Ground, through its iterations in Cedar Rapids, Lisbon, and Iowa City, showed considerable promise as a social innovation art and design service. The initiative demonstrates how effective it is at fostering social and cultural assimilation through the use of art, as evidenced by the success in bringing together immigrants who identify as Latino, Latina, or Latinx, as well as those from multiple international backgrounds. Through ceramic workshops, Shifting Ground has created an atmosphere where immigrants can express their abilities, cultural heritage, and personal narratives by utilising the social dynamics inherent in community-based artistic activities. The MEMO game, a crucial element of the campaign, has fostered a sense of community among participants through the promotion of empathetic conversation and artistic self-expression.

Relational services and the commons concept have played a major role in shaping the project's framework. By emphasising human-centred, relational, and societal components, Shifting Ground has created environments that are conducive to social innovation. These services integrate local culture and expertise and build strong relationships with community members to tailor their approach to specific problems. The initiative is based on the concept of the commons, which offers a comprehensive social framework for understanding humanity's collective experiences and expressing a fundamental

socio-political perspective. This strategy prioritises the importance of collaboration, adopting established protocols, and taking responsibility for shared resources in order to foster a more supportive and unified community.

The project's focus on creating in a relational manner and prioritising the commons underscores the need for collaborative methods in tackling current social problems. The project's influence in fostering comprehension and inclusiveness is evidenced by the positive responses garnered from participants and the wider community. Shifting Ground reflects how art and design can promote social transformation, generating a unified and nurturing society through the celebration of diversity and the promotion of active engagement in cultural dialogue. This initiative highlights the significance of collaborating with local organisations with the aim of attaining enduring social and cultural sustainability.

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ARTISTIC RESISTANCE IN THE POST-PRIVACY ERA: REFLECTION, IMAGINATION, AND RECONSTRUCTION UNDER LIQUID MODERNITY

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ABSTRACT | In an era marked by rapid digital transformation, contemporary artists adeptly utilize digital media to interrogate and redefine the essence of human connections. This research paper delves into the dynamic interplay between art, technology, and society, exploring how digital art forms critique surveillance, dismantle digital control systems and forge new pathways for communal interactions and shared experiences. By examining the works of Aram Bartholl, Trevor Paglen, and Jonas Lund, the study highlights artistic practices reflecting the erosion of traditional notions of privacy, public space, and personal autonomy within the fluid and ever-evolving frameworks of "liquid modernity." Employing theoretical insights from scholars of Zygmunt Bauman, Jürgen Habermas, and Michel Foucault, this research navigates the complexities of the "post-privacy era," investigating how artists reimagine public space, cultivate communicative rationality, and open avenues for personal and communal liberation. These artistic endeavors are positioned as crucial interventions that foster social cohesion and collective empowerment amidst fragmentation and uncertainty. This research contributes to broader discussions on the transformative potential of art in challenging entrenched power structures and envisioning more connected futures. It underscores the vital role of artistic engagement in maintaining and enhancing the social, cultural, and political connections essential for thriving in our interconnected world.

KEYWORDS | SURVEILLANCE CRITIQUE, POST-PRIVACY ERA, LIQUID MODERNITY, ARTISTIC RESISTANCE

1. Introduction

In an era where digital surveillance has permeated every facet of society, the notion of privacy is being relentlessly redefined. This phenomenon, often referred to as the "post-privacy era," marks a significant shift in the way personal information is accessed, used, and controlled. As rapid technological advancements blur the boundaries between the public and private spheres, individuals grapple with an unprecedented erosion of privacy. Concurrently, the societal framework described by Zygmunt Bauman (2001) as "liquid modernity" underscores these transformations, characterizing modern life by its fluidity, where traditional structures dissolve, and new forms of social instability emerge. Multiple phenomena parallel and contribute to each other while complicating the question of privacy and the public for many.

The intersection of these phenomena creates a fertile ground for artistic exploration and resistance. Contemporary artists utilize digital media as both a tool and a subject, expressing critically while navigating these shifts. They not only reflect on the gradual erosion of privacy and the pervasive influence of surveillance but also actively participate in the reconstruction of public spaces and reimagine personal and collective identities. This paper seeks to explore how artistic practices encapsulate and resist the challenges posed by liquid modernity and the postprivacy era. This study aims to unravel the complex dynamics between art, technology, and societal change through a detailed analysis of the works of artists such as Aram Bartholl, Trevor Paglen, and Jonas Lund.

In a nutshell, we argue that contemporary artists employ digital media to critique and resist the erosion of privacy and the expansion of surveillance; art attempts to reconstruct public spaces and foster new forms of communicative rationality and social engagement; art has the potential to imagine new possibilities for personal and collective liberation in the face of ongoing societal transformations. By addressing these issues, this paper aims to contribute to the broader discourse on the role of art in confronting contemporary challenges and envisioning

alternative futures against a critical backdrop of technological advancements and uncertainties. Through the lens of artistic resistance, we strive to understand not just the impact of digital media on privacy and identity but also the potential of art to instigate meaningful societal reflections and transformations.

2. Theoretical Framework

The theoretical underpinnings of this paper rest on two main pillars: Zygmunt Bauman's concept of "liquid modernity" and the socio-cultural implications of the "post-privacy era." It supports an exploration of how contemporary art deals with the fluid social structures and pervasive surveillance that characterize modern life. This article builds on these two pillars and supplements these theories by providing an artistic solution to a dystopian vision.

2.1 Liquid Modernity and Artistic Expression

Zygmunt Bauman's concept of liquid modernity provides a critical lens through which to view the transient, precarious nature of social forms and personal identities in contemporary society. In liquid modernity, change is the only permanence, and uncertainty is the only certainty. This fluidity infiltrates the artistic world, influencing contemporary artworks' form and content. Through their works, artists often reflect on the disintegration of longstanding social structures and the impact of these changes on individual autonomy and identity. In the context of art, liquid modernity challenges artists to navigate and respond to these transient conditions, often pushing them towards innovative, ephemeral forms of expression that mirror the instability of the era.

Liquid modernity seems to be associated with modernism, and then conceptualism, and then global contemporary art, by suggesting and expressing the unstable nature of truth and knowledge, which slip, assemble, and reconstruct new meanings and, thus, new forms. For example, both Cubism and Surrealism highlight the fluidity of vision and symbolism which according to Foucault (1978), were two major foundations of Western modernity by a structural order of knowledge. However, the alienation and problems brought by modernity throw them into question, and turns art no longer representation of truth and knowledge, but of their fluid nature and boundaries. Following this vein, another two strands of theories related most to liquid modernity and its relevant art forms are deconstruction and poststructuralism, which produce enlightenment and emancipation by "focusing on the ambiguities between knowledge and belief" (Harcourt, 2007, p.21). By contrast, deconstruction spearheaded by scholars like Derrida never attempts to offer an explanation, a social theoretic, while poststructuralism tries to provide an explanation of how the distribution of power leads to the construction of knowledge and develops a "social theoretic, historical, or genealogical account of how we come to take that central leap of faith" (Harcourt, 2007, p.23).

Harcourt (2007) considers poststructuralism as the penultimate stage of modernity, while deconstruction as the ultimate, linking back to Bauman's idea of liquid modernity as the most recent and new phenomenon. However, what Bauman fails to mention as what comes after the liquidation, just like Derrida, is what Harcourt (2007) recognizes as the "turn to randomization" (Harcourt, 2007, p.23). Going back to the original problematic of privacy erosion, many have identified this phenomenon as an erosion on power, liberty, humanity, and equality predominantly, but what artists have adopted can be seen as mostly a poststructuralist approach, which chooses to resist this erosion by either providing, or gesturing to provide a critical genealogical account of what we believe as privacy and public, or fighting this erosion with a performative type of "artistic erosion," that is randomization of process and symbol, all the defining bedrocks of algorithm, and sometimes both (ironically, Cubism and Surrealism were termed "erosion" at the time of their nascence).

Moreover, the term "Post-Privacy" can be also understood as profoundly poststructuralist. It is a term firstly and coherently put forth by Kosinski (2018) as he previously claimed, "There is going to be no privacy," and that "we are already living in the post-privacy" world through his previous study (2013) which finds that algorithm may be more effective and accurate than humans in predicting one's behaviors. This statement provocatively questions the superior position of autonomy and individuality in dealing with private matters (Kosinski, 2013). In addition, "privacy," or the rational boundary between the public and private sphere, as put by Arendt (1958), is now being eroded, but not for the automatic reactivation of the public sphere, which leads to the collective action of group liberation (Arendt, 1958). The liquidation of modernity can be seen as a deepening of Arendt's (1958) conception of modernity as the rise of the social over the previous distinction between the public and private sphere-and it is no longer an institutionalization of alienation and violence, but a transformation of such by digitization into ubiquity, invisibility, and benignity (Arendt, 1958).

Therefore, it is crucial to place liquid modernity, and its relevant forms of art into this critical context of deconstruction and poststructuralism, which calls for new and creative solutions to more complex problems of modernity represented by surveillance culture.

2.2 Surveillance and Artistic Expression

In the digital age, surveillance has become a ubiquitous element of everyday life, with technologies tracking and archiving endless streams of personal data. This pervasive monitoring raises profound questions about privacy, freedom, and control - increasingly prominent themes in digital and contemporary art. Theoretical perspectives such as Michel Foucault's panopticism and Gilles Deleuze's societies of control are pertinent here, as they describe mechanisms through which power is exercised in modern societies. New theories include Zuboff's (2022) idea of surveillance capitalism, which points out the collection, utilization, and

commodification of personal data without individual permission based on algorithmic surveillance, an all-time monitoring of digital activities (Zuboff, 2022). Most critically, Zuboff (2022) indicates that it ruptures the organic integrity of collective and individual behavior, jeopardizes personal autonomy, and imposes new power over human life (Zuboff, 2022).

However, these theories have fallen short of providing a timely explanation to what artists and netizens are experiencing at an unprecedented pace. Art, by contrast, tends to respond to these problems in a more premonitory and tangible way. Specifically, artists respond to these dynamics by critiquing surveillance practices and reappropriating surveillance technologies to explore and expose their implications. This dual approach highlights the invasive nature of these technologies and reclaims them as tools for artistic and political resistance. Essentially, this approach also corresponds to the diagnostic of fluid modernity by, on the one hand, showing a genealogical account, reverse engineering, repurposing, revelation, and imitation of the "rational" logic behind the surveillance idea and practice, and on the other hand, using this idea and practice in a randomized way to perform and inspire enlightenment, hence, echoing the theoretical kernels of deconstruction and poststructuralism.

2.3 Resistance Theories in Art

Artistic resistance in the context of liquid modernity and the post-privacy era can also be framed through various resistance theories that explore how culture and art can oppose dominant power structures. Theories of hegemony by Antonio Gramsci, for instance, suggest that cultural production is a battlefield where societal norms and ideologies are both established and contested. Artistic resistance, therefore, can be seen as a form of 'counterhegemonic' practice that challenges prevailing power dynamics and opens up spaces for alternative narratives and forms of social engagement. Additionally, as discussed by Judith Butler, the concept of "subversive repetition" in art points to the potential of repeating norms in altered contexts to undermine their authority.

In addition, it is important to highlight other theories. For instance, Wendy Chun's (2008) critique of the Internet as a bifurcating duality of total freedom or control deserves our attention. She attributes this misconception to reducing the political problem to a technological one, while reminding us that the relationship between control and freedom in of the Internet is experienced and negotiated through sexuality and race. Therefore, to use the Internet as a liberating tool lies in not the illusory promises of individual empowerment as promoted by tech media and corporations, but in the multitude of unexpected ways the Internet can expose us to other humans and machines. Again, this theory calls for a

randomization of the Internet technology. Moreover, not reducing the political problem of the Internet to a technological one, and reintroducing the problem of race, sexuality, and other social factors are where artists can make most effective interventions and have been witnessed to have done so for decades.

2.4 Art as a Tool for Societal Reflection and Reconstruction

Art serves not only as a mirror reflecting societal issues but also as a hammer with which to shape them, as famously noted by Bertolt Brecht. In the digital and post-privacy context, artists leverage their platforms to question and reconstruct societal norms and spaces. The role of art in fostering communicative rationality, as theorized by Jürgen Habermas, emphasizes the potential of art to facilitate democratic discourse and rational-critical debate, essential for the functioning of a vibrant public sphere. Art, in this framework, becomes a crucial player in the dialogue about privacy, surveillance, and identity, providing a space to resist, reimagine, and reconstruct the narratives and structures of liquid modernity.

Using art as a tool for societal reconstruction is inextricably related to the idea of public sphere. According to Habermas (1990), it is a domain of social life where public opinions can emerge and circulate (Habermas, 1990). However, the Habermasian conception of the public domain lies in an idealization, which assumes the relative equality and similarity of the citizens to whom the domain is accessible, neglecting the existence and importance of different and personal interests in such a space. Similarly, artists care about the public sphere because art has long been incorporated as a critical tool for reflecting on and reconstructing public opinion and discourse rather than staying as the background as in premodern or early modern epochs. However, they engage the issue differently because heterogeneity often inspires more art than their obverse. Habermas (2022) also updates his own theory by considering the multifaceted aspects of digital technology. He argues that it provides an incomparable opportunity for interactive and deliberative exchanges but it also increases the power of centrifugal forces in the public sphere, so he calls for a political re-regulation of the digital public sphere (Habermas, 2022, in Thiel, 2023).

Nevertheless, artists often take a more microscopic perspective to tackle macroscopic problems because the issues of privacy, surveillance, and identity not only impacts how society as a whole consume media and how corporations and governments use media but also shapes our daily life in a subtle and personal way. A more relevant explanation can be found in Manovich's (2002) idea of "transcoding" which argues that the convergence of the machine and human layers in the age of new media, meaning that "the interpretation of the human 'cultural layer' in computer ontology and the 'computer layer' in human cultural terms" (Manovich,

2002). This background calls for artists to consider an integrated dimension of cultural and computer layers when engaging the issues of a digitizing society. For example, artist resistance should be directed not only to machines and data, but also the integrated layers of digital economy and governance. Specifically, they appropriate and empower the various ways individuals engage with digital networks and seek to express and reconfigure the personal differences as power and liberation against a popular imagination of the digital world as dialectical, homogeneous, or dystopian. They proffer us an alternative imagination of the public sphere in the post-privacy era-liquidation can also be liberation.

3. Case Studies of Artistic Resistance

In this section, we will explore the artworks of Aram Bartholl, Trevor Paglen, and Jonas Lund, focusing on how each artist engages with contemporary digital cultures and surveillance with distinct methodologies and thematic concerns.

3.1 Aram Bartholl

Aram Bartholl (1972) is a Berlin-based conceptual artist renowned for his profound explorations of the interplay between the digital and physical worlds. His innovative art pieces often delve into the complex themes of anonymity and privacy, reflecting on how digital age dynamics reshape human interaction and societal norms.

From "Dead Drops" to "Forgot Your Password?"

Aram Bartholl's works explore the intersection of digital culture, surveillance, and public space. Through provocative installations and interventions, Bartholl seeks to make visible the hidden infrastructures of digital surveillance and challenge the normalization of data collection and monitoring in everyday life.

One of Bartholl's most well-known projects is "Dead Drops (2010 - ongoing)[1]", a series of USB flash drives embedded into walls, buildings, and curbs in public spaces worldwide (see Figure 1). By creating an anonymous, offline file-sharing network, "Dead Drops" encourages audiences to engage in a form of digital exchange that is free from the surveillance and tracking of online platforms. As Bartholl explains, "In the Internet age, city walls have become the last remaining spaces for free and anonymous communication." By appropriating these physical spaces for digital communication, "Dead Drops" challenges the assumption that online interaction entails a loss of privacy and autonomy.

[1] Dead Drops: https://arambartholl.com/dead-drops/

Figure 1. Dead Drops, 2010 - ongoing. ©Credit by Aram Bartholl.

In "Forgot Your Password? (2013)[2]", Bartholl takes a more confrontational approach, displaying the vulnerability of our data (see Figure 2). This installation consists of large-scale, publicly displayed passwords collected from various online databases and leaks. He seeks to reveal the vulnerability and insecurity of personal data in the age of surveillance capitalism by making these passwords visible in public space. Bartholl explains, "The work is a reminder of how easily our privacy can be compromised and how little control we have over our data." The scale of the installation, with its overwhelming array of exposed passwords, speaks to the sheer magnitude of this violation and the difficulty of resisting or opting out of a system that has become so deeply embedded in our daily lives.

Figure 2. Forgot Your Password?, 2013. ©Credit by Aram Bartholl.

Both his works are characterized by a sense of raw materiality and exposure. In "Dead Drops," the USB drives are embedded into the walls and sidewalks of the city, becoming a physical manifestation of the hidden surveillance and control networks surrounding us. While in "Forgot Your Password?", the passwords are displayed in a stark and unadorned manner, stripped of any context or explanation, creating a sense of vulnerability and exposure that is both unsettling and revealing.

[2] Forgot Your Password?: https://arambartholl.com/forgot-your-password/

Bartholl's works build on the past artists who have used their practice to critique and subvert the power structure. In the 1960s and 70s, artists Hans Haacke ("MoMA Poll" and "Manhattan Real Estate Holdings, a Real-Time Social System) (Haacke, 2007b) and Martha Rosler ("Semiotics of the Kitchen[3]") used their work to expose the hidden connections between art, politics, and corporate power (Griffin, 2004). Bartholl's installations continue this tradition, using the tools and techniques of art to reveal the hidden infrastructures of surveillance and control that shape our contemporary moment.

However, what sets Bartholl's work apart is its engagement with the specific technologies and platforms of the digital age, which rely on the active engagement and collaboration of the viewer and make his works highly participatory. In "Dead Drops," Bartholl appropriates the devices and networks typically used for surveillance and data collection and repurposes them as anonymous communication and exchange tools. He subverts the traditional power dynamics of online communication by creating a physical network of USB drives embedded in public spaces. Bartholl creates a space for resistance and autonomy within the very fabric of the city. The work becomes fully realized when individuals connect their devices to the USB drives and share their data and files. This creates a sense of intimacy, collaboration between the artist and the audience, and shared vulnerability and trust. And in "Forgot Your Password?", Bartholl creates a visceral and confrontational experience that forces us to see how easily our data can be compromised and exploited. The viewer is confronted with the unsettling reality of their digital exposure, as the passwords on display could easily be their own. This creates a powerful emotional response that is personal and political, forcing the viewer to reflect on their relationship to privacy and security in the digital age.

Bartholl's works are a powerful and provocative exploration of how our lives are being shaped and compromised by the technologies of surveillance and control. By making visible the hidden infrastructures of power within the digital realm, Bartholl challenges us to confront the reality of our complicity and vulnerability. His works critique the present moment, make a call to action, and show a vision of a more just and equitable future.

[3] Semiotics of the Kitchen, by Martha Rosler: https://www.moma.org/collection/works/88937

3.2 Trevor Paglen

Trevor Paglen (1974) is an American artist, geographer, and author who has been pivotal in exposing and critiquing the pervasive surveillance systems that define our contemporary society.

From "Autonomy Cube" to "ImageNet Roulette"

The growing awareness of digital surveillance has spurred new forms of resistance and critique. Civil society groups and privacy advocates are advocating for greater transparency and accountability in the use of surveillance technologies. Simultaneously, artists and media activists are employing their work to expose the covert infrastructures of digital control and envision alternative futures. As we confront the implications of digital surveillance, it's crucial to recognize that this issue transcends technology, touching deeply on social and political fields.

Paglen explores art's capability to critique and reflect on a surveillance-dominated society, one of his most significant works, "Autonomy Cube (2014)[4]", a collaboration with digital rights activist Jason Applebaum, is a sculpture that doubles as a functional Tor router encased in a transparent cube (see Figure 3). This allows users to connect to the internet anonymously. Paglen and Applebaum counter the notion that surveillance is an abstract or intangible phenomenon by materializing the principles of privacy and autonomy in a physical object. They make the tools of resistance tangible and accessible, empowering individuals to take control of their digital lives. Simultaneously, this work also highlights the critical relationship between transparency and autonomy and suggests a possible solution to fighting surveillance domination as making the power relation more transparent and tangible so that we have no choice but to recognize and negotiate its existence.

Figure 3. Autonomy Cube, 2014. ©Credit by Trevor Paglen.

[4] Autonomy Cube: https://paglen.studio/2020/04/09/autonomy-cube/

"ImageNet Roulette (2020)[5]" sharply critiques the biases inherent in artificial intelligence systems, serving as a provocative tool to demonstrate how AI's visual recognition capabilities can perpetuate racism, misogyny, and other harmful biases (see Figure 4). As a vital and timely intervention in the discourse on artificial intelligence and digital ethics, it uses digital installation as a medium to engage, challenge, and educate its audience about the deep-seated biases within AI technologies.

Figure 4. ImageNet Roulette, 2020. ©Credit by Trevor Paglen.

The project utilizes the "person" categories from ImageNet, allowing the AI to categorize users' uploaded images in disturbing and enlightening ways. This direct interaction lets audiences witness firsthand the potential errors and stereotypes AI can propagate, making AI's abstract and often hidden biases tangible and immediate. It demystifies the illusory promise of AI as infallible and neutral, calling for more human intervention by paying attention to the ethical issues of AI. In addition, it also throws into question the sourcing and processing of digital data as purely mechanical, so removed from culture and identity, bringing out again the inseparable relationship between human intent and computer algorithm.

Although physically limited in accessibility, its impact on discussions about digital ethics and the future of AI is far-reaching.

His works remind us to think back to the 1980s, highlighting a long-term artwork of video installations called "Watch (1995-2008)[6]" by David Rokeby. For years, he has been constructing artificial perception systems — electronic systems that are able to see. Deeply rooted in the discourse around surveillance, a prevalent concern in contemporary society, "Watch" extends beyond mere artistic exploration. By manipulating how people are seen or unseen, Rokeby comments on the power dynamics inherent in surveillance technologies and the potential for these

[5] ImageNet Roulette: https://paglen.studio/2020/04/29/imagenet-roulette/

[6] Video installations: Watch: http://www.davidrokeby.com/watch.html

systems to distort reality and influence behavior. There is no doubt that artists have a long history and a predictable awareness of social surveillance. Another example is "Always There – Surveillance Bed (2020)[7]" by Julia Scher, surrounded by four cameras and video monitors; the cameras record the events pictured on the bed. In correlation to her comment, "Power and its abuse is my most important subject matter; how power is misused to harm people," she has been focusing on questions of personal identity within the context of power, such as surveillance and control.

But Trevor Paglen's works are far more than them, he underscores the pervasive nature of surveillance but pushes the conversation into new territories—exploring not only how surveillance operates but also how it's integrated into the broader visual and cultural landscape. His works serve as a critical reflection on the state of privacy, freedom, and human agency in a world where surveillance has become normalized, challenging us to question who watches the watchers and at what cost.

3.3 Jonas Lund

Jonas Lund (1984) is a Swedish contemporary artist known for his critical and often playful approach to systems of art, technology, and information. His works frequently explore themes such as control, transparency, and the dynamics of the art market, utilizing data and algorithms to both critique and rethink modern digital and networked systems.

From "The Fear of Missing Out" to "The Red Telephone"

"The Fear of Missing Out (2013)[8]", an early work by Lund, leverages algorithms designed to forecast emerging trends in the art world, enabling the creation of artworks that resonate with the anticipated preferences of contemporary art experts (see Figure 5). This project underscores the art market's vulnerability to controlled narratives and decision-making driven by data. Through a detailed analysis and classification of a broad spectrum of works by leading contemporary artists, Lund developed a comprehensive set of instructions detailing how to produce the most successful art pieces.

Figure 5. The Fear of Missing Out, 2013. ©Credit by Jonas Lund.

[7] Always There – Surveillance Bed:
https://www.estherschipper.com/exhibitions/642-always-there-surveillance-bed-julia-scher/

[8] The Fear of Missing Out: https://jonaslund.com/works/the-fear-of-missing-out/

Following these guidelines, the artist executed the works accordingly. "The Fear of Missing Out" challenges critical concepts within the art community, including authenticity, artistry, talent, and creativity. Moreover, the title alludes to the desire to engage with a transparent, digitally interconnected information society. It also sheds light on the overlooked impact of digital technology by its capacity of connection and prediction through collection and calculation on contemporary artists, especially on its influence on market positioning in terms of what constitutes and defines artist success and on its repercussion on the autonomy of artist in terms of who to decide what to make and how to make an artwork. As a result, it inspires artists to take a more active and critical approach when using digital technology in their artmaking on the one hand, because it shows a surprising ability to impose a new form of normative pressure either from the market to reshape the community or from the individual desire to stay relevant and successful. On the other hand, it also shows the other side of contemporary art by repurposing a manipulative power structure to look back on itself and propose an alternative way of engagement.

The underlying idea of "The Red Telephone (2020)[9]" is innovative and audacious, a recent work by Lund (see Figure 6). The artwork breaks down traditional barriers between the creator and the audience by allowing viewers to directly call the artist and subsequently record these interactions. This direct line to the artist literalizes the concept of accessibility while also playing with the notion of privacy in the digital age. The work questions the limits of artist accessibility and challenges the viewer to reconsider the roles of observer and participant. The physical aspect of the piece - a standard telephone - serves as a powerful symbol of communication and an almost nostalgic callback to the old analog times before digital communication took precedence. The color (red) choice is striking, evoking urgency and importance, which complements the serious implications of the interaction it facilitates. The auto-dialing feature adds an element of unpredictability and spontaneity, enhancing the interactive experience.

Figure 6. The Red Telephone, 2020. ©Credit by Jonas Lund.

[9] The Red Telephone: https://jonaslund.com/works/call-me-maybe-red-telephone/

However, the functionality of automatic dialing and recording calls with the artist without clear, ongoing consent each time could be seen as invasive. Additionally, it challenges the viewer to think about the implications of instant connectivity and the erosion of personal boundaries in the age of digital communication. Furthermore, the gesture of recording conversations and their exclusive availability to token holders introduce a layer of exclusivity and commodification of personal interactions, mirroring concerns present in the broader digital economy. This artwork utilizes a pre-digital symbol to imitate the process of digital connection as an anachronistic gesture to underscore the problematic power relation underlying our times.

Compared to a telephone, digital communication seems to take a more abstract form. The comparison is also strikingly critical: the sacrosanct practice of how to call someone properly and what deems as privacy to be respected during the pre-digital times is now stripped bare under contemporary gaze, and the caller-receiver relationship has been replaced by an artistaudience, or observer-participant relationship, which remains dynamic and unstable during the communication. Consequently, this work performs this relationship to highlight an irony embedded in the technological advancement from analog to digital, and from telephone to computer.

4. Privacy, Surveillance, and Modernity

In summary, three artists have adopted both poststructural and deconstruction approaches to analyzing and reconfiguring a post-privacy reality. Specifically, they conduct artist resistance to a pervasive practice of surveillance culture and privacy erosion from two aspects: imitating the power structure through its technological and administrative structure to arrive at a revelation that our knowledge about digital networks is an unstable belief that requires reflection and expansion; repurposing the structure through performance and randomization to arrive at an enlightenment and empowerment of the same technologies and agents, no longer the passive victims of power relations, but participating subjects to embrace the unpredictable connections opened up by the technologies and direct them toward more collective, political, and reflexive courses to counteract the problems.

Respectively, the exemplified artists have their emphases. For instance, Aram Bartholl engages privacy anxieties and transforms this anxiety by revealing its nature while using the technology to make more meaningful and intimate connections with the city and its residents. Trevor Paglen criticizes and reflects on the surveillance society but he does not stop there and proposed for more transparency and tangibility in our

connections. Finally, Jonas Lund reveals the worrying degree of information control on the artist community, and its clutch on all technology users alike. He provokes us to pay more attention to the issues of accessibility, consent, and commodification underlying our daily exchanges of information, masquerading as equal interactions.

5. Approach to Liquid Modernity

The ability of individuals to navigate, understand, and resist the pervasive and often opaque forces of control in liquid modernity is significantly enhanced by the critical interventions of contemporary artists. Their work provides a vital critique and a counter-narrative to the dominant discourse on surveillance and control, offering new perspectives and empowering public discourse.

Bartholl, Paglen, and Lund each tackle the contemporary issues of digital surveillance and privacy through their unique artistic approaches. Their creations stimulate a critical dialogue at the intersection of technology, privacy, and societal control, encouraging public engagement and resistance to omnipresent digital structures. Bartholl's works, characterized by their tangible rawness, initiate conversations about digital privacy and carve out niches of resistance within the surveillance landscape. Trevor Paglen's projects lay bare and challenge the infrastructures of surveillance that shape our modern society. He critiques these systems and prompts the public to consider emerging technologies' broader ethical and political ramifications. Meanwhile, Lund's art playfully yet incisively interacts with the mechanisms of control and transparency that define the digital era, prompting viewers to contemplate their own engagements with these pervasive systems.

In liquid modernity, the paramount importance of reflexive engagement cannot be overstated. Art's role in resistance is transformative—it does not merely represent or reflect reality; it also challenges and redefines it. Through their creative expressions, artists critique existing systems and propose innovative ways of seeing and interacting with the world. In addition, the ethical and political implications of technologies and their surveillance capacities are brought to the forefront through these artistic endeavors. Artists demand accountability and transparency from those who wield control over digital and surveillance technologies, challenging the status quo. From this aspect, liquidation calls for more responsible, reflexive, and creative users of technology which do not reduce themselves to the passive objects submitting to the ferocious flows of the dissolving forces of digital economy and culture, but as acting citizens of a new public sphere which entails the efforts to uphold difference, flexibility, transparency, audacity to learn, and a critical porosity to recycle increasingly complex data and technologies toward public opinions. This realization also ties back to the Habermasian theory of the public sphere, but a more realistic and porous one.

6. Conclusion

In summary, each artist brings a unique perspective to themes of privacy, surveillance, and modernity, using digital media to represent and actively question and resist these forces. Their works foster a critical dialogue that encourages viewers to reconsider their roles and rights within the digital age. Through their distinct artistic strategies, these artists contribute significantly to the discourse on digital rights and the pervasive reach of technology in contemporary life. Against the contemporary backdrop of our post-privacy era and liquid modernity, this article answers the question of how digital art can resist and respond to the issues of privacy, surveillance, and information and power control by examining the case studies of three artists through textual and visual analysis, and critical theory interpretation, especially poststructuralism and deconstruction. By discovering that artists can make effective interventions through the revelation and repurposing of biased technologies and problematic conceptions of how they are used and should be used, the article brings light to the significance of transparency, flexibility, and criticality in our engagement with digital technology. Furthermore, it reaches beyond the field of art and expands the study of ethics, sociology, economics, and computer science by providing an artistic perspective into the stolid landscape of digitization. It also calls more understanding and collaboration between artists and technologists in this direction.

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EMPATHY ENGINE: USING GAME DESIGN AND REAL-TIME TECHNOLOGY TO CULTIVATE SOCIAL CONNECTION

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ABSTRACT |

This study examines the game "Takeaway Rider" to demonstrate the integration of cognitive psychology and game design theory for fostering empathy. By analyzing related works, we designed a game. We investigated how this real-time interactive game, driven by a sophisticated user interface, enables players to navigate the challenges of delivery work, facilitating emotional engagement and bias reduction. In this role-playing, parkour-style game, players adopt the perspectives of takeaway riders, engaging with the narrative and a system of rewards and punishments to develop perceptual empathy. We conducted semi-structured interviews during gameplay, which confirmed the effectiveness of this game genre in enhancing player empathy. This finding opens new paths for future research focused on empathy development among diverse groups through games. We also discuss potential developments using Unity to create a more immersive interactive model. The goal is to strengthen the connection between players and the game, thereby personalizing the gaming experience and optimizing educational impacts. Our study underscores the value of an interdisciplinary approach that combines cognitive psychology and design, enhancing the problem-solving capacity of educational games aimed at social issues. This approach provides valuable experiential insights for academics, game developers, and educators working to improve group empathy skills.

KEYWORDS | SERIOUS GAMES, EMPATHY, GAME DESIGN, REAL-TIME INTERACTION, TAKEAWAY RIDERS

Introduction

In the contemporary gig economy of China, takeaway riders represent a significant segment of labor engaged through digital platforms (Jinyang, 2022). The onset of the COVID-19 pandemic has exacerbated existing tensions between these riders and consumers, leading to increased visibility of their disputes in digital and social media spaces. Notable incidents such as "takeaway rider injures customers[1][2]" (; Guangming.com, 2021) and "takeaway rider threatens door-to-door with a stick[3]" have surfaced prominently, highlighting this intensifying conflict. Through the interviews of twelve consumers (C=12) and six takeaway riders (R=6) before the project, we uncovered that the principal catalyst for these altercations is the stringent delivery timelines imposed on riders. These workers are required to navigate complex and frequently changing urban traffic conditions, which can unpredictably extend delivery times, thus exacerbating the situation. Such demanding job requirements' logistical and psychological burdens are substantial[4].

These findings elucidate a significant discrepancy in consumer understanding and empathy toward takeaway riders' challenges. There exists a pronounced disjunction between the expectations set by the rigid operational protocols of digital platforms and the actual human capabilities of the riders. This disparity often culminates in unrealistic expectations from consumers, who remain largely unaware of the intricacies involved in fulfilling their orders under such constrained

1 上海独居女子点外卖给差评，第二天遭外卖员砸门辱骂：我弄死你！(Woman living alone gets "death threats" in retaliation for giving a bad review). https://new.qq.com/rain/a/20210201A07DGJ00

2 因超时近30分钟起冲突，深圳一外卖员砍伤订餐者！饿了么致歉 (A takeaway worker in shenzhen slashed an orderer after a conflict over a nearly 30-minute overrun!). https://m.gmw.cn/baijia/2021-08/29/1302520079.html

3 外卖骑手，困在系统里 (Takeaway rider, stuck in the system). https://baijiahao.baidu.com/s?id=1677231323622016633&wfr=spider&for=pc

4 女子称给外卖员差评后 外卖员持棍上门威胁要投毒 (Takeaway man was threatened with a stick after giving him a bad

circumstances. So consumers' lack of empathy and understanding often leads to friction and misunderstandings. To address this, we integrated an educational add-on game into existing takeaway applications, using a digital approach that offers scalability, interactivity, real-time feedback, and widespread accessibility to eliminate the gap between takeaway riders and customers as much as possible.

Our "Takeaway Rider" project is a real-time parkour game in a 2.5D visual style, integrated into delivery software to synchronize with customers' experiences after ordering. The 2.5D visual design balances the detailed environment of 3D with the simplicity of 2D graphics, thereby reducing production costs and complexity. It enhances user immersion and realism while ensuring compatibility with existing takeout software such as Meituan and Ele.me. This game is designed to simulate the challenges takeaway riders encounter, providing players with a deeper insight into the riders' daily hurdles. By enhancing consumer awareness of these workers' conditions and pressures, we aim to reduce tensions and create a more empathetic and supportive environment for gig workers. This method improves relationships between consumers and service providers and uses digital technology to foster a greater understanding of the gig economy. This paper's most original and outstanding contribution is the application of real-time interaction techniques to game design to enhance empathy toward delivery riders. It incorporates Experiential Learning Theory (ELT) to provide a structured framework for cognitive and affective empathy and evaluates the feasibility of this design model through rigorous quantitative testing.

2. Related Theories and Projects

Developing empathy is crucial for the survival of our species and increases the likelihood of maintaining social groups. It is a unique social personality trait for humans (Archer et al., 1981) and is essential to promote harmonious co-existence, mutual understanding, and cooperation between individuals (Bošnjaković & Radionov, 2018; Gonzalez-Liencres et al., 2013; Oliveira-Silva & Gonçalves, 2011). However, the rapid proliferation of mobile social networks has inadvertently reduced the richness of natural emotional cues in face-to-face interactions (Terry & Cain, 2016). This evolution in communication, coupled with contemporary societal conflicts and technological advances, underscores the urgency to reinvigorate empathy within human interactions. In this context, games emerge as a powerful tool for educational efforts, offering immersive experiences and role-playing games that can effectively promote empathy skills (Belman & Flanagan, 2010). Their interactive nature can simulate real-life scenarios, allowing individuals to practice and deepen their empathy. This paper uses the conflict between a takeaway rider and a customer as a case study to explore a novel approach to cultivating cognitive empathy through gameplay and promoting the development of emotional empathy in the process.

2. 1 Empathy: Concept, Types, and Importance

Empathy is the ability to place oneself in another' s shoes (Rolbin & Della Chiesa, 2010) and understand their situation (Decety et al., 2007). Empathy is often categorized into emotional and cognitive empathy. Emotional empathy involves experiencing and sharing the emotions of others, emphasizing emotional alignment. In contrast, cognitive empathy requires setting aside one' s perspective to understand and speculate on the mental states and behaviors of others, focusing on understanding their thoughts and feelings. It is important to note that emotional and cognitive empathy are intertwined developmental processes that should not be examined in isolation. The affective component is the essence of empathy, while the cognitive component is the process through which this essence is formed (Hollan, 2012).

Advances in neuroscience and psychology have also significantly enhanced our understanding of empathy. Current research indicates that there is no universal neural model for empathy, but the discovery of "somatosensory neurons" (Gallese et al., 1996) provides a physiological basis for linking self- and other-emotion perception and action (Decety, 2011). Decety and Jackson identify three main components of empathy: emotional reactions to others, adopting others' perspectives, and regulating emotions to distinguish self from others (Decety & Jackson, 2004; Decety et al., 2007).

Carl R. Rogers' cyclical model of empathy includes three stages: empathic resonance, expressing empathy, and receiving empathy (Rogers, 1975). Although descriptions of the empathy generation process vary due to differences in context and methodology, most scholars agree that fostering awareness of others and their environments is central to empathic training. The differentiation of intersubjectivity between self and others is crucial (Singer & Lamm, 2009; Walter, 2012; Watt, 2007) for effective empathy training design and assessment.

2.2 Cognitive Learning Theories Underpinning Empathy Research

Cognitive learning is essential for empathy training as it helps subjects better understand others. This type of learning involves acquiring and processing information through mental processes such as thinking, memorization, and problem solving (Kolomitro & Lam, 2011). It emphasizes understanding and knowledge construction rather than just behavior change (Richmond et al., 1987). Unlike behavioristic learning, cognitive learning focuses on internal mental processes and the formation of knowledge structures. Complex tasks and situational simulations provide players with rich cognitive learning opportunities in games. For example, players must analyze customer needs, plan optimal routes, and solve unexpected problems. These activities demand a high level of cognitive engagement and reflection.

Experiential Learning Theory can be a theoretical framework to support research on empathic play, promoting cognitive transformation and thereby reducing prejudice through enhanced empathy. ELT, proposed by psychologist David A. Kolb, offers a solid theoretical foundation and practical guidance for enhancing empathy through game design. It outlines a four-stage learning cycle: Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation (Kolb et al., 2014).

Immediate or concrete experience serves as the basis for observation and reflection. These reflections are assimilated and refined into critical concepts, leading to new insights for action. These insights can then be actively tested and used to create new experiences. This theory supports the validity of enhancing empathy through game design, providing valuable empirical insights and practical guidance for future research focused on developing empathy among diverse groups through play.

(a) "PeaceMaker "by ImpactGames (b) "Nevermind"by Lobel, et al. (c) "A Breathtaking Journey",by kors, et al. (d) "AS IF",by Tong, et al.

Figure 1. The Related Works of Horizon of Khufu, Notre-Dame de Paris and China Grand Canal Museum.

2. 3 Review of Empathic Games

Empathic play is a cognitive education tool with great potential. It enables players to inhabit the roles and perspectives of other individuals or groups in an immersive way, improving empathy through innovative interactions and narratives (Hudnall & Kopecky, 2020). One notable example is "PeaceMaker", a real-time strategy game addressing the Israeli-Palestinian conflict (see Figure 1a). Players assume the role of a side' s president, navigating complex decisions and stakeholder considerations. The game incorporates real-life news visuals, fostering emotional and cognitive empathy (Belman & Flanagan, 2010). Lobel et al. designed the horror game "Nevermind" to explore adjusting the difficulty of the game by monitoring the player' s heart rate and improving immersion through biofeedback (2016) (see Figure 1b). Kors et al. focused on narrative persuasion and developed "A Breathtaking Journey," a mixed reality game that simulates the experiences of refugees (2016) (see Figure 1c). Another motion sensing game, "AS IF" by Tong et al., allows players to inhabit the virtual body of a patient with cerebral palsy, offering insight into chronic pain experiences (2017) (see Figure 1d). These diverse approaches contribute to the evolving landscape of empathic game design, exploring varied strategies to evoke empathy in players. These games are not isolated experiments but

represent a collective endeavor to harness the immersive potential of gaming to deepen our understanding of others' lives. They challenge the player to confront complex social issues and internal emotional landscapes, proving that games can be both mirrors reflecting our humanity and windows into the lives of others. The above efforts pioneer a path towards a more empathetic form of interactive entertainment that resonates with the deepest aspects of our social being, urging us to connect, understand, and ultimately care more deeply for one another.

However, researchers frequently confuse games offering empathic experiences with empathic games that aim to enhance empathy. Moreover, the absence of theoretical models that address empathy in existing games introduces uncertainty about the validity of research findings that provoke empathic responses (Schrier & Farber, 2021). Thus, we employ the "Takeaway Rider" game as an example to demonstrate how interactive real-time game design can resonate with consumers. We designed the game mechanism based on Kolb' s ELT. Additionally, we investigated the efficacy of achieving emotional resonance across different groups through the transformation of real-time game data (Belman & Flanagan, 2010). In the end, we evaluate the impact of the primary 2.5D game on players' empathic abilities using IRI scores and then enhance it to a VR-based game to acquire a deeper immersive environment for players.

3. Design Process

In our project, we have implemented a 2.5D visual style in our mobile gaming application to enhance user immersion and realism while ensuring compatibility with existing mobile platforms like Meituan and Eleme. This design balances the detailed environments of 3D and the simplicity of 2D graphics, resulting in lower production costs and reduced complexity.

This game demonstrates the potential of interactive, real-time design to engage and influence consumer perceptions. This game reflects the potential of interactive, real-time design to engage and influence consumer perceptions. It fosters empathy for the situation of the takeaway rider by immersing the customer in the delivery context. Its main objectives were to enhance the connection between the target audience and the game, create a personalized game experience, and enhance the interactive model' s primary goal, which is to deepen the player' s emotional connection (see Figure 2).

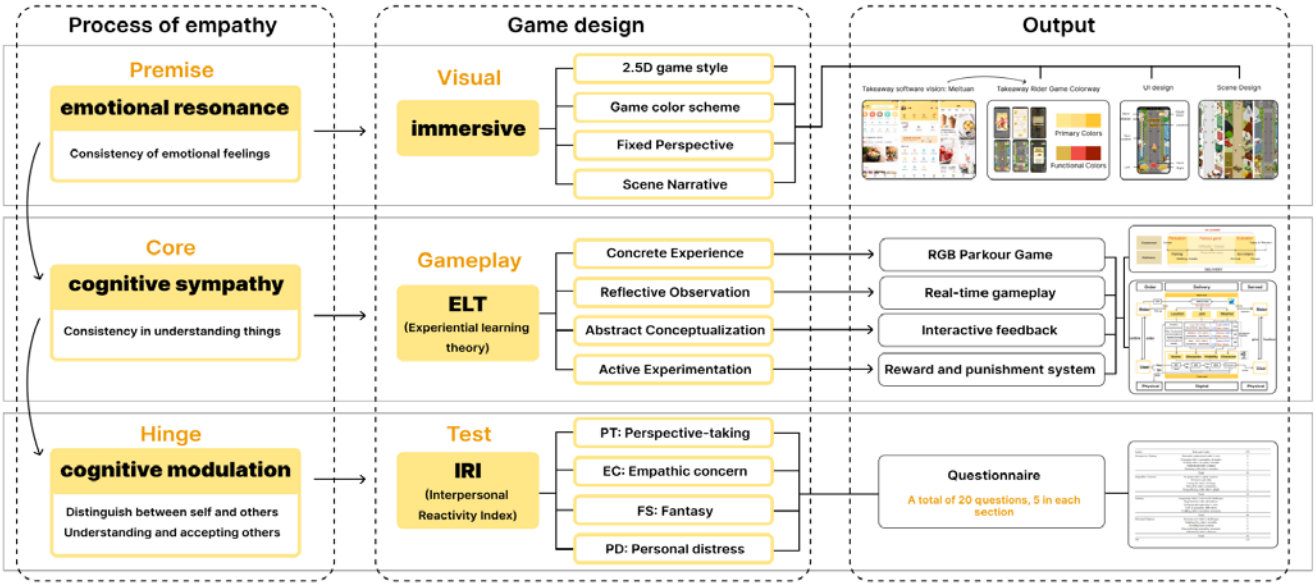

Figure 2. The Theoretical Framework for Empathy in Game Design.

3.1 Design Concept

Based on the four-stage model of ELT (Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation), we designed and built the framework for the game "Takeaway Rider." This framework provides players with opportunities for authentic experiences, self-reflection, and practical application to enhance their empathic abilities.

Firstly, the authenticity of concrete experience is crucial for effective engagement (Yardley et al., 2012). "Takeaway Rider" is positioned as a real-time role-playing game (RPG) to simulate concrete experiences within the game. Parkour games, which involve players controlling characters to perform running, jumping, rolling, and climbing actions to overcome obstacles, align well with the daily work of delivery riders (Gilchrist & Osborn, 2017). Players can immerse themselves in these workers' daily challenges by role-playing as delivery riders in a real-time, synchronized parkour game. The game is designed as a mobile mini-game integrated into takeout software, allowing customers to experience it during delivery. This stage provides rich sensory and emotional inputs that enhance the player's sense of realism regarding the character's situation.

Secondly, the game's mechanics are designed to assist players in reflectively observing their behavior and decision-making. The interactive plot encourages a focused, empathic stance, prompting reflection on choices and behaviors, such as responding to customer requests and handling transportation issues and time pressures. A key mechanism is the real-time synchronization of game difficulty

with actual conditions like weather and road conditions, creating a sense of unpredictability and anxiety. Reflecting on their actions and feedback, players gain a deeper understanding of the work and emotional experiences of the riders.

Furthermore, the game helps players differentiate between self and role self-consciousness (Watt, 2007), transforming their concrete experiences and reflections into broader cognitive understandings. This abstract conceptualization process enables players to recognize commonalities between new and previous experiences and understand the reasons behind differences (Yardley et al., 2012). This includes recognizing professional bias and social injustice faced by delivery drivers. Post-game visuals and narratives can remind players to return to reality, and questionnaires can facilitate feedback and organization of their in-game experiences.

Finally, the game encourages continuous experimentation through rewards. An achievement system and convertible virtual currency motivate players to try new strategies and methods, optimizing their performance. This phase helps players consolidate their learning and apply it to various contexts.

3.2 Prototype

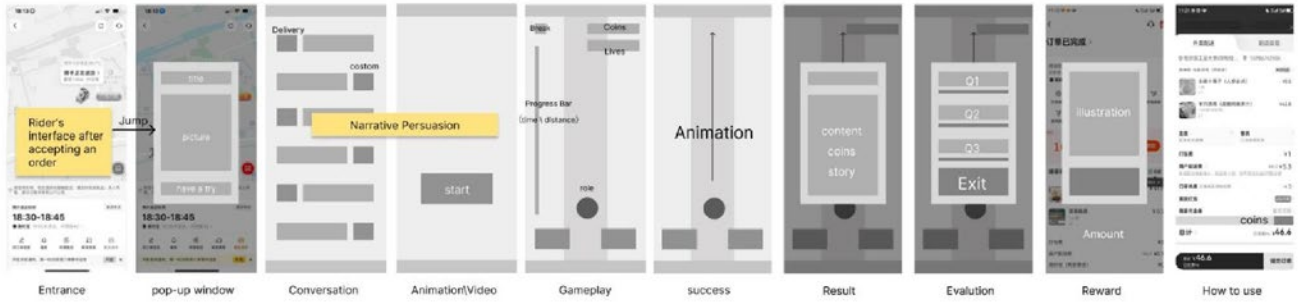

Figure 3. Real-time interactive game "Takeaway Rider" interaction prototype design.

We prototyped the game based on the real takeaway process from the previous interviews. The prototype of the delivery rider game was designed to test the effectiveness of the parkour mechanism and the empathy plot, ensuring that players could genuinely experience the daily work and emotional challenges of a delivery rider. We established the game's interaction flow and functional design through several discussions and iterations from start to settlement and evaluation (see Figure 3).

Players enter the game from the takeaway order window, transitioning into the role through narrative persuasion. During the game, players control the character's movement with left

and right buttons, and the screen displays a progress bar, life value, and the number of gold coins. Collisions with obstacles incur penalties; for example, hitting a car may stun the player for 10 seconds, affecting delivery efficiency, while stepping on a banana peel may cause slipping, making control more difficult. Upon successful delivery, an animation shows the rider entering the neighborhood. The settlement session informs the player of their game performance (game level score, number of gold coins gained). It provides context about real events or statistics, such as takeaway riders being penalized for late deliveries or damaged meals. The final evaluation session assesses the player's awareness and reflection on the takeaway rider's experience and the empathic effect of the game through a question-and-answer format.

The interaction prototype enhances situational realism, promotes player reflection and cognitive deepening, and motivates players to keep trying new strategies and consolidate their learning through the reward mechanism. The preparation of narrative persuasion, obstacle design, and evaluation sessions in the early stages was crucial to ensure the game's educational effect.

3.3 Visual Design

Emotional resonance is a prerequisite for players' willingness to empathize. The game enhances players' immersion through its visual design, scene, and interface to help them better connect with the object of empathy. The game adopts the 2.5D visual style, balancing real environments' detail and three-dimensional effects with reduced complexity and production costs. This style increases realism and immersion while maintaining accessibility and real-time information transfer speeds, especially in a 5G environment (Shen & Gopalan, 2022).

The yellow palette conveys a bright, positive, and friendly atmosphere, attracting players and maintaining an enjoyable gaming experience. This palette allows for smooth integration with the Meituan Takeaway mobile application. The red buttons of action contrast strongly against the yellow background, emphasizing their importance and helping players quickly identify and tap the buttons, thus improving operational efficiency. The interface and scene design maintain color consistency, enhancing the overall visual style. The contrast of different colors and layered design increases the sense of hierarchy and clarity of information.

The game uses a fixed perspective, allowing players to control the character's left and right movements with one thumb, creating a forward motion as the scenes on both sides of the road move backward (see Figure 4a-a). Maintaining a stable speed helps players earn rewards and reduce shipping costs. Additionally, the game includes scenes and obstacles based on the visual elements of the actual delivery areas. Urban areas feature cafes, skyscrapers, and schools, with obstacles like garbage, pedestrians, and cars. Rural areas include pastures, forests, and wooden

houses, with animals posing challenges for delivery. The game is regularly updated with visual elements corresponding to festivals, honoring local cultures and enticing players to explore and continue engaging with the dynamic game environment, such as the themed map designed for Christmas (see Figure 4a-b).

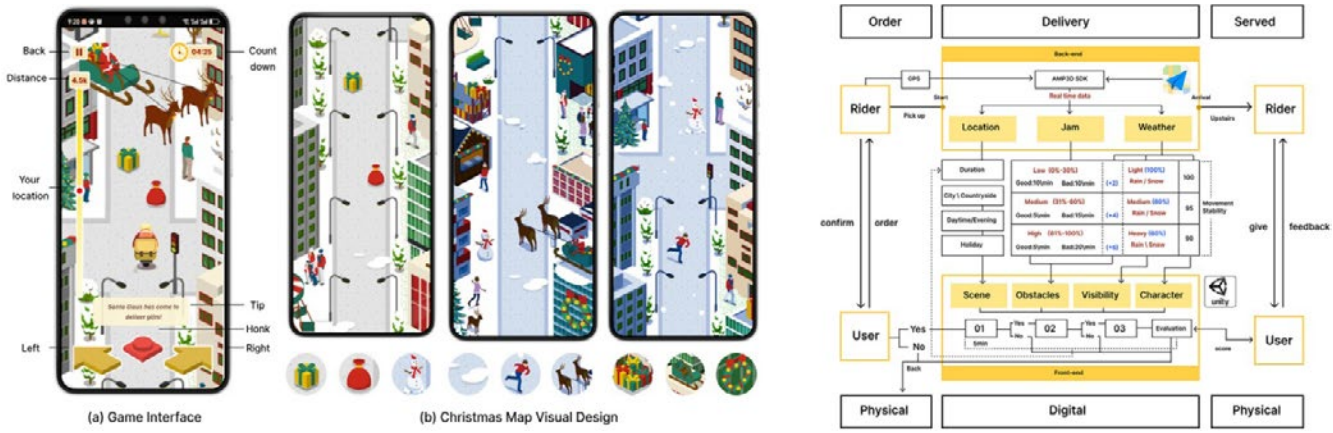

Figure 4. (a) Visual Design of Christmas in "Takeaway Rider"; (b) The Workflow of "Takeaway Rider".

4. Technical Implementation

The mobile vertical screen game "Delivery Rider" is developed using Unity version 2022.3.16f1. The game's development encompasses several key modules, including player control, obstacle and coin generation algorithms, collision detection, UI design, sound effects, and animation processing. This game's technical challenge and innovation lie in transforming real-time data from actual delivery riders into obstacle and coin generation algorithms. This is the core mechanism that supports the game's empathy, as it integrates real-world elements into the gaming experience.

4.1 Framework And Mechanism

In the game, the narrative guidance and game mechanics enhance realism and tension, and optimizing reward systems heightens empathic engagement, impacting individuals' attitudes and behaviours. To prevent leisure gameplay from prevailing, the game emphasized the goal of the game at the beginning. It provided details of the deliveryman's job to help players engage consciously and empathetically (see Figure 5b, c). Also, the game uses a wireless map mode in a parkour environment where the player needs to constantly analyse the effects of terrain, weather, and obstacles. Passing through intersections requires quick decision-making, obeying traffic signals, and adapting to adverse weather conditions to ensure the mission is completed within the allotted time. If a car accident occurs, the delivery

time will be delayed, affecting the final delivery score and rewards (see Figure 5h, j). It includes gold collection on the road, challenge completion, and end-of delivery rewards, fostering player enthusiasm through ingame currency exchangeable for delivery software coupons (see Figure 5g, i).

Figure 5. The Game of "Takeaway Rider" 1.0 by Unity, Allows Consumers to Empathize with the Delivery Riders' Difficulties.

And in-game interactions trigger guidance prompts, sharing takeaway riders' psychological experiences. For example, suppose a special static obstacle, such as snow, is encountered in bad weather. In that case, the system prompts players to hit the honk button quickly within ten seconds to ensure they don't think the road is slippery and roll over while stepping on a normal obstacle. If a dynamic obstacle is encountered, the system will prompt the player to honk their horn to signal them to get out of the way, but a person or animal may pass quickly because players warn them. This is randomized and simultaneously simulates real traffic (see Figure 6a).

Figure 6. (a) Interaction Mechanism for Players Encountering Static/Dynamic Obstacles; (b) The Design of Scenarios and Obstacles for Different Regions and Time Periods.

4.2 Interactive Method

This game establishes rules by translating real-time weather and traffic data into the game using the AMAP30 SDK development interface (see Figure 4b). It integrates AMAP map data, extracting information to determine key game parameters like location, obstacle density, and weather visibility. The system maps real-world data to game metrics, confirming content based on delivery rider order details. It confirms map size for rider delivery time, determining timeslots, environment, and architectural style for a visually consistent representation (see Figure 6b). Game difficulty processing logic correlates congestion level with delivery speed

impact, influencing obstacle frequency, such as congestion levels (low: 0-30, moderate: 31-60, high: 61-100) define obstacle density (low: 10, moderate: 15, high: 20), while rain or lighter snow adds penalty obstacles like puddles or snowdrifts. The game classifies obstacles by severity. For example, low blockages are small obstacles, and high blockages introduce movement obstacles. Obstacle placement rules consider spacing, randomness, and road alignment. Weather conditions affect visibility; for instance, moderate rainfall reduces visibility to 80. The game uses a data structure to represent defined parameters, updating obstacles every two minutes for a 30-second smooth transition between configurations. Visual and audio feedback, including HUD elements and color changes, informs players of congestion level changes and obstacle difficulty.

Table 1. Main Themes and Relevant Codes, and Number of Code Occurrences(OC).

Scales	Relevant Codes	CO
Perspective Taking	Naturally understood rider' s view	8
	Grasping rider' s gameplay struggles	7
	Feeling rider' s in-game triumph	6
	Understood rider' s stance	7
	Thinking with rider' s mindset	7
	Total	35
Empathic Concern	In-game rider' s safety matters	6
	Driven to aid rider	4
	Caring for rider' s feelings	5
	Moved by rider' s emotions	5
	Sympathizing with rider' s plight	4
	Total	24
Fantasy	Imagining riders' real-world challenges	7
	Engrossed in rider adventures	7
	Escaping through rider' s view	6
	Lost in gameplay difficulties	5
	Crafting rider' s narrative scenarios	5
Personal Distress	Anxious over rider' s challenges	6
	Saddened by rider' s troubles	5
	Avoiding hard content	6
	Discomforting gameplay moments	4
	Affected by rider' s distress	5
	Total	26
All		115

5. User Feedback And Improvement

Building upon the Interpersonal Reactivity Index (IRI) principles (Davis et al., 1996b), this study implemented an empathic ability assessment after the gameplay. The IRI is the most widely and frequently used measure of empathy (Hall & Schwartz, 2019). At the same time, it is considered to be the most comprehensive measure of self-reported empathic tendencies. Moreover, the scale is relatively small and thus easy to collect and administer (De Corte et al., 2007). It encompassed four scales: perspective-taking (PT), empathic concern (EC), fantasy (FS), and personal distress (PD) (Bošnjaković & Radionov, 2018), to measure the broad spectrum of empathic responses with five targeted questions per scale (20 questions in total). Participants were required to respond to each item using a 5-point Likert scale, where a score of 1 signified "it does not describe me well," and a score of 5 represented "it describes me well." Higher average scores for each subscale indicate a stronger self-reported inclination toward the corresponding empathic trait.

Our study consisted of a pre-and post-game survey of 12 participants (see Appendix Table 1). They were college students between the ages of 18-25 (M=5, F=7), of which six participants rarely played games (once or twice a month), three participants played games regularly (two to three times a week), and three participants were heavy gamers (played almost everyday). Results showed that the PT and FS scales were significantly enhanced after gaming for the majority of participants, indicating significant increases in cognitive empathy and imaginative engagement. Eight participants reported an increase in their understanding of character dilemmas, especially the male participants. The six participants who rarely played the game and the one participant who played the game regularly affirmed that their ability to imagine similar dilemmas in real life had improved.

Conversely, the EC and PD scales did not demonstrate statistically significant shifts, implying stable affective empathic responses and consistent levels of personal distress in empathic situations. The scores for EC and PD remained relatively unchanged, suggesting that the gameplay did not significantly alter the participants' affective responses or levels of discomfort when confronted with others' distress. This was further exemplified by the fact that half of the participants could not grasp the full extent of the safety concerns faced by the characters, indicating a potential gap in the game' s ability to convey the emotional gravity of such situations. This indicates that while the players understood and could imagine the challenges faced by the characters, the game did not sufficiently personalize the characters' experiences to evoke a deeper emotional connection.

This led us to reflect on the importance of neglecting emotional empathy in the game design framework. Emotional empathy can

activate players' emotions and beliefs to motivate them to participate in the game narrative (Belman & Flanagan, 2010). So as a next step towards improvement, we will consider enhancing immersive experiences in virtual reality environments.

To investigate the enhancement of players' empathy in alleviating tensions between takeaway riders and consumers, we will develop the VR game "Takeaway Riders" 2.0. While 2.5D games exhibit high user acceptance and accessibility, their limitation lies in a lack of truly immersive experiences, hindering the target group' s deep emotional connections and empathy. Immersive virtual environments lead to more pronounced behavioral changes than mere observation (Yee & Bailenson, 2009). Recent advancements in immersive VR technology have created affordable 3D environments for enhanced role-playing exercises. Participants will be reinvited to participate in the VR game demo. We believe that the VR game will offer insights into the emotional experiences of actual delivery riders, significantly elevating participants' empathic caring (EC). This approach includes additional interactive devices to heighten their real-time perception of couriers' emotions in the physical world by engaging their other senses.

6. VR Application As Future Development

Technological advancements are pivotal in expanding the capabilities of VR, significantly enhancing its ability to cultivate empathy; this provides us with a new direction for enhancing our game. Better Hardware brings advancements in VR headsets, offering higher resolutions, improved field of view, reduced latency, and lighter designs. These improvements enhance user comfort and realism, making prolonged VR engagements more feasible and enjoyable.

Advanced Software capabilities provided by platforms like Unity and Unreal Engine continuously evolve to support more realistic physics and complex interactions. This evolution allows for the creation of more nuanced and emotionally engaging narratives. Haptic Feedback technologies provide tactile feedback that mimics real-world sensations, adding a layer of realism that enriches the immersive experience. Users can feel the texture of objects or the impact of their actions, deepening their connection to the virtual environment. AI Integration enhances the responsiveness of characters within VR, enabling them to react more naturally to user inputs. This improvement is crucial for fostering believable social interactions and enhancing empathetic connections. Increased Accessibility and Affordability of VR technology, as it becomes more widespread, reduces costs and expands access to a broader audience. This democratization of technology enhances the reach and impact of empathy-driven VR experiences, making them a powerful tool in fields that benefit from enhanced empathetic understanding.

Thus, the future development of our VR game "Takeaway Rider 2.0" aims for an advanced

immersive experience. We will employ the Meta Quest VR headset as the platform for our game by Unity. This version will provide us with a framework to test an immersive environment. When designing the control mechanics, we will utilize the XR Interaction Toolkit, a suite of tools available in Unity that simplifies the development of user interactions within VR environments.
This toolkit will allow us to create intuitive and responsive controls that players can easily adapt to, enhancing the overall user experience. Additionally, we will focus on the aesthetic and functional aspects of the game' s environment by using Spline to smooth curves and complex shapes. With Spline, we will design the game' s assets, including the architecture of the virtual cityscape and the characters that players encounter within the game levels. This will enable us to construct a detailed and visually appealing world that supports the narrative and gameplay.

The following prototype of our VR game illustrates four challenging scenarios encountered by a takeaway rider, each crafted to enhance player empathy and engagement:

- **Driving to pick up points** Imagine the rider, helmet streaked with raindrops, as they navigate slippery streets to reach a pickup point. The sound of rain patters against the backdrop, and the visuals of blurred lights and wet asphalt immerse the player in the struggle against inclement weather.

- **Find an order** In a frantic rush against time, the rider must sift through a confusing flurry of orders. The table fills with multiple orders, each ticking down its timer. The player must quickly identify and select the correct order, feeling the pressure of potential penalties looming with each passing second.

- **Delivering orders** As the rider speeds through the city, they encounter a number of obstacles-each dodge and swerve is a test of the player' s reflexes and decision-making, simulating the real-life perils of urban delivery.

- **Making a call** Upon arrival at a customer' s house, the rider faces the unexpected challenge of an angry dog barking fiercely by the doorstep. The player must navigate this tense situation, figuring out how to calm the dog or safely alert the customer, adding a layer of unpredictability and urgency to the delivery experience.

Each prototype is designed to challenge the player and plunge them into the everyday realities of a takeaway rider, fostering a deep sense of empathy and understanding through vivid, immersive gameplay.

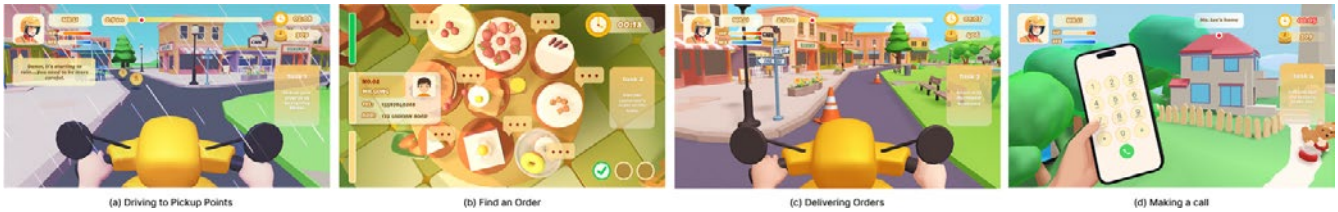

Figure 7. The VR Game of "Takeaway Rider 2.0", Four Main Sections of the Game Process.

7. Discussion And Limitation

This study examines "Takeaway Rider," a real-time interactive game that fosters team cohesion, accountability, and improved empathy. Plans include the development of interactive devices to enhance sensory experiences and real-time player-group interactions. Building on Alotaibi et al.' s electrotactile stimulation (2022) and Lu et al.' s chemotactile device (2021), multi-sensory tools will be employed for a richer empathic experience. Additionally, insights from Nacke et al. (2011) will guide the incorporation of biofeedback design to enhance real-time inter- actions between players and takeaway riders in the physical world, utilizing Arduino-based biosensors for heart rate and data synchronization in VR games. This approach aims to increase players' ability to interact with empathic groups during gameplay.

However, the study faces certain limitations that could affect the integrity and applicability of its findings. The primary concern is the limited sample size, which might introduce a bias based on individual subjectivity, potentially skewing the experimental outcomes. Moreover, the sustainability of the induced empathy effect remains unassessed, posing a question about the long-term impact of the game' s empathetic engagements. Addressing these issues, future efforts will focus on expanding the sample size to include a more diverse group of participants. This expansion will provide a more robust dataset for analysis, helping to mitigate individual biases. Additionally, continuous monitoring and follow-up studies will be implemented to assess the durability of the effects of empathy. By taking these steps, the project aims to ensure that "Takeaway Rider" fosters immediate empathetic responses and contributes to lasting empathetic development among its players, making it a valuable tool in enhancing social cohesion and interpersonal understanding in gaming communities and beyond.

8. Conclusion

Enhancing empathy within the "Takeaway Rider" game plays an important role in achieving the game's overarching goals, including fostering team cohesion, improving accountability, and enriching the player's overall immersive experience. Empathy will allow players to step into the shoes of others-specifically, the daily challenges faced by a takeaway rider-providing a profound understanding and connection to the characters and scenarios depicted in the game. Players who connect emotionally with the game's narrative and characters are likely to find the game more compelling and engaging, which can lead to increased player retention and satisfaction. The emotional depth added by empathy makes the narrative more immersive and transformative, turning a simple gameplay experience into a powerful, resonant story that mirrors complex real-life emotions and situations. Beyond entertainment, "Takeaway Rider" is an educational tool that fosters essential life skills such as emotional intelligence and perspective-taking. These skills are beneficial beyond the game, improving real-life personal and professional relationships. Moreover, by exposing players to the life of a takeaway rider, the game enhances awareness about different lifestyles and the challenges within them, promoting greater social sensitivity and inclusivity.

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DIGITAL DROPLETS: SHAPING THE APPRECIATION EXPERIENCE OF "SPRING WATER" AT JINAN QUAN-SHUI CULTURAL HALL

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ABSTRACT | The rich tapestry of spring water culture in Jinan, with its roots deeply embedded in the local history, offers a unique cultural heritage that has been celebrated since the Tang and Song dynasties. Despite its profound historical significance, contemporary engagement with this heritage has often been superficial, lacking the depth and interactivity that modern audiences crave. This study introduces an innovative approach to cultural immersion through the Quan Shui Cultural Experience Hall, a pioneering initiative in Lixia District, Jinan. By integrating advanced technologies such as Augmented Reality (AR) and Virtual Reality (VR), this initiative aims to bridge the gap between traditional cultural appreciation and the expectations of a digitally attuned audience. This paper outlines the theoretical foundations of immersive cultural experiences, reviews current methodologies in cultural engagement, and proposes a new model that leverages technology to enhance visitor interaction and educational outcomes. Through a study of the Quan Shui Cultural Experience Hall, this research assesses the potential impacts of these technologies on visitor engagement, knowledge retention, and cultural preservation. Preliminary findings suggest that this approach increases visitors' interest and understanding and facilitates a deeper connection with the cultural essence of Jinan's spring waters. This study enhances the extensive scholarly dialogue concerning the preservation of cultural heritage, providing perspectives and theoretical models that may apply to analogous cultural contexts worldwide.

KEYWORDS | Cultural Experience, Mixed Reality Technology in Museums, AR and VR in Cultural Tourism, Cultural Experience Center Design, Digital Empowerment in Cultural Spaces

1. Introduction

Jinan, the capital city of Shandong Province, often referred to as "Spring City," is distinguished by its seventy-two artesian springs, which have been the lifeblood of the city throughout its history (Hu, 2020). These springs, including famous ones like Baotu Spring and Black Tiger Spring, are natural wonders and pivotal cultural symbols (Luo et al., 2020). Historically, they have been gathering places for the community, sources for daily water use, and inspirations for poets and artists. The well-known writer Lao She used to use "Baotuquan" as a setting in his writings to depict the serene and culturally rich life in Jinan (Laoshe, 2000). The culture surrounding these springs encompasses folklore, traditional practices, and a deep-rooted reverence for nature, which has been integral to Jinan's identity and development, such as the Lotus Art Festival, which provides new urban nighttime experiences. This unique cultural heritage, woven around the natural springs, positions Jinan distinctively on both historical and cultural tourism maps.

However, the current cultural engagement with Jinan's spring water predominantly relies on conventional methods, such as static museum exhibits and guided tours. These traditional formats are increasingly inadequate for capturing the attention of a generation accustomed to digital interactivity and immersive experiences. Further compounded by rapid urban development and technological progress (Chen et al., 2008), Jinan's springs' physical and cultural visibility has diminished, leading to a growing disconnect among younger residents and visitors. Therefore, there is need to adopt more dynamic and engaging methods that resonate with contemporary audiences. Innovatively integrating technology to revitalize and preserve this rich cultural heritage while also educating, engaging, and entertaining effectively is crucial. Such an approach is critical to re-establishing a connection with the historical and ecological importance of the springs, ensuring the continuation and prosperity of Jinan's cultural legacy within a contemporary framework.

This study aims to develop a new framework for cultural engagement that harnesses modern technology to provide immersive and interactive experiences centered around Jinan's spring water culture (Lin et al., 2020).

- Enhance educational value by integrating interactive technologies that provide users with hands-on learning experiences about the ecological and historical significance of the springs in the physical museum space (Jakobsson & Davidsson, 2012).
- Revitalize interest in spring water culture by offering augmented reality (AR) tours, virtual reality (VR) experiences (Kamel & Elshiwy, 2022), and interactive digital exhibits that allow deeper exploration of historical and cultural narratives.

2. Related Works

This section provides a comprehensive overview of the methodologies and technological advancements implemented globally in cultural heritage preservation and engagement. It explores how modern technology is being harnessed to enhance and revitalize these experiences and emphasizes the role of water as a central theme in cultural expressions across various regions.

2.1 Global Perspective

We initiate our design from a global perspective, focusing on how cultural projects around the world have successfully integrated novel technologies to enhance visitor engagement and understanding (see Fgure 1). This approach allows us to draw upon a rich array of international examples and best practices, ensuring that our installations are locally relevant and globally competitive (see Table 1).

Figure 1. The Related Works of Horizon of Khufu, Notre-Dame de Paris and China Grand Canal Museum.

1 Horizon of khufu: https://immersive-expeditions.io/en/horizon-of-khufu/

Horizon of Khufu

The "Horizon of Khufu[1] (2024)" initiative by Excurio Productions epitomizes the convergence of technology and cultural heritage. Utilizing Virtual Reality (VR), this project revolutionizes the appreciation experiences of participants by transporting them to the era of ancient Egypt, facilitating an immersive exploration of the Giza Plateau. This technological approach allows for a vivid educational experience transcending traditional learning methods, making inaccessible historical sites reachable and engaging for a global audience. This project allows participants to explore areas of the Giza Necropolis that are typically inaccessible to the public. The journey begins at sunrise over the Giza Plateau. It sets a dramatic backdrop with the three Great Pyramids and their surrounding mastabas, which are tombs of the monarchs' families and inner circles. Transformed into virtual avatars, participants navigate this ancient landscape, eventually reaching the majestic Sphinx and proceeding to a unique nighttime exploration of the Pyramid of Giza.

Despite its benefits, the project also highlights limitations, such as the potential for technological disparities that could restrict access to such experiences for underprivileged populations or regions with less technological infrastructure. Additionally, the need for continuous updates and maintenance of digital content to reflect the latest archaeological findings can pose challenges. Nevertheless, this initiative inspires future projects by demonstrating how technology can preserve and animate cultural heritage in captivating and accessible ways, potentially transforming education and increasing cultural appreciation worldwide.

Augmented Exhibitions of Notre-Dame de Paris

The use of AR in exhibitions like "Notre-Dame de Paris: The Augmented Exhibition[2]" represents a transformative approach to cultural preservation and visitor engagement (Allal-Chérif, 2022). By integrating AR devices such as the Histopad, historical sites, and their stories are vividly brought to life through immersive reconstructions and interactive displays, allowing visitors to deeply engage with historical events and architectural nuances. For instance, visitors at the Shanghai exhibition could scan "Time Portals" to witness events like the spire's collapse and the cathedral's subsequent structural damage. This technique not only showcased the capabilities of the Histopad but also emphasized the fire's emotional and cultural impact on Parisians and the global community. The exhibition also detailed the restoration process, including using 2,000 solid oak trees for the new frame, underscoring a harmonious blend of historical preservation and modern engineering.

2 Experience Notre-Dame de Paris in a visual way : https://www.shine.cn/feature/art-culture/2212083791/
3The China Grand Canel Museum: https://canalmuseum.net/English.html

However, this technology-driven approach has its drawbacks, primarily its dependency on digital devices, which may lessen the authenticity of directly experiencing a heritage site. Despite these limitations, the successful fusion of AR and heritage preservation serves as a compelling inspiration, demonstrating how modern technology can enrich our understanding and appreciation of cultural landmarks, stimulate broader public interest, and ensure that the stories and significance of historic sites are conveyed to future generations in innovative and impactful ways.

The China Grand Canal Museum

The China Grand Canal Museum[3], led by Academician Zhang Jinqiu from the Chinese Academy of Engineering, showcases the fusion of technology and cultural heritage through its innovative design and implementation. The Nanjing Museum oversees planning and operations, while the Xenario Company manages the integrated construction. The project employs immersive techniques such as 360° projections, real-time rendering, and interactive AR to vividly bring the historical narrative of the Grand Canal to life in a contemporary and engaging format.

The museum employs omnidirectional projections and real-time rendering to create an immersive interactive theater experience, enveloping visitors in the history and culture of the Grand Canal from all angles. This experience is augmented by live-action games and interactive puzzle-solving elements that enhance visitor engagement and make learning both educational and entertaining. Additionally, AR displays animate scenes of boats on the canal, offering insights into the structural design of ancient vessels and highlighting the craftsmanship of ancient Chinese shipbuilding. The environment within the museum is designed to make visitors feel as though they are aboard a traditional boat, surrounded by scenes of ancient life and traditional performances, with interactive features that further draw visitors into the content.

Using VR, AR, and other immersive technologies in cultural heritage exhibitions represents a promising frontier that can transform educational experiences and increase accessibility (Buonincontri & Marasco, 2017). These projects highlight both the potential and the challenges of integrating modern technology into the preservation and appreciation of cultural heritage, providing us valuable insights for project development.

Table 1. The Comparison of Technological Integration in Cultural Heritage Exhibition Spaces.

Project	Horizon of Khufu	Augmented Exhibition of Notre-Dame de Paris	China Grand Canal Museum
Technology Used	Virtual Reality (VR)	Augmented Reality (AR) using Histopad	360° projections, real-time rendering, Interactive AR
Educational Value	Offers an immersive exploration of the Giza Plateau, enhancing learning about ancient Egyptian structures.	Uses interactive AR to allow users to experience historical events and the restoration of Notre-Dame de Paris.	Provides an engaging way to learn about the history and culture of the Grand Canal through immersive and interactive experiences.
Accessibility	Makes inaccessible historical sites reachable globally.	Requires digital devices which may limit access for some visitors.	High-tech installations that can be both physically and geographically accessible depending on the availability of the necessary technology.
Pros	Dynamic learning tool Global accessibility	Enhances user engagement with interactive elements Detailed insights into restoration processes	Multisensory engagement Immersive cultural experience
Cons	Requires advanced technology Needs continuous updates	Potentially less authentic experience Dependent on specific digital devices	Requires ongoing maintenance and updates Resource-intensive
Impact on Cultural Appreciation	Enhances appreciation through vivid educational experiences.	Stimulates interest and educates about historical preservation and modern engineering.	Increases understanding and appreciation of historical contexts and cultural impacts.

2.2 Water Related Projects

We also explored water-related projects as water is important for human beings (Everard & Moggridge, 2012), particularly within domestic museums (see Figure 2); we have observed a diverse application of traditional and modern methods to spread awareness and knowledge about water-related topics. This dual approach ensures that our exhibition educates and connects with visitors on multiple levels, bridging historical contexts with contemporary issues.

Figure 2. The Related Works of The Yellow River Museum, The National Water Museum, and The Chongqing Baiheliang Underwater Museum.

The Yellow River Museum

The Yellow River Museum[4] in Zhengzhou, China, established in 1955, is the first river-themed museum in the country, focusing on the natural evolution, socio-cultural development, and management of the Yellow River. It serves as a modern museum that collects and preserves cultural relics and educates and enlightens the public. The museum adopts traditional exhibition methods, including pictorial and text introductions and historical artifacts, to help visitors understand the Yellow River. Additionally, it collects and exhibits Yellow River-themed calligraphy and traditional Chinese paintings. A distinctive interactive element of the museum is the provision of Yellow River clay, enabling participants to engage directly in the design and creation of pottery. This hands-on approach offers a profound experiential insight into the Yellow River culture, facilitating a deeper understanding and appreciation through active participation.

The National Water Museum

The National Water Museum of China[5] guided by the Ministry of Water Resources and managed jointly with the Zhejiang Provincial Government, is a unique national museum in Hangzhou. Unlike traditional museum structures, the main building is designed in the shape of a pagoda, which not only serves the purpose of storing artifacts but also symbolizes the historical challenges of water management through its form. This design integrates ancient architectural styles with modern materials and advanced technology. The museum features extensive immersive environments and displays related to ancient hydraulic architecture and tools, effectively merging space, history, and knowledge. It also houses a specialized Zhejiang Water Management exhibit, utilizing advanced multimedia and remote connectivity to innovate its displays, directly linking to a water management database to access relevant regional data, transcending traditional exhibition limitations, and pioneering integrating water culture exhibits with modern technology. Despite some areas retaining conventional exhibition methods, such as introductory text and image presentations, the museum's innovative approach serves as a valuable reference for the development of cultural exhibits focused on water themes.

4 The Yellow River Museum: https://www.watermuseums.net/network/yellow-river-museum
5 National Water Museum of China: https://www.watermuseums.net/network/national-water-museum-of-china
6 The Chongqing Baiheliang Underwater Museum: https://www.watermuseums.net/network/chongqing-baiheliang-underwatermuseum

The Chongqing Baiheliang Underwater Museum

The Chongqing Baiheliang Underwater Museum[6], recognized as the world's first museum of its kind, embodies a unique architectural and conservation approach through its underwater structure and the use of a non-pressure container. The museum's design features an innovative non-pressure container that isolates the relics from the Yangtze River using a reinforced concrete cover. This cover is filled with filtered river water to maintain hydrostatic balance and prevent long-term erosion of the relics by the river. Inside the cover, a visitor corridor constructed with pressure-resistant metal and 23 glass observation windows allow close-up views of the Baiheliang inscriptions. The museum also includes an advanced air monitoring system with sensors for temperature, humidity, and CO2 levels, enhancing the air quality for both the displays on the surface and the underwater visiting area. This pioneering museum protects significant historical inscriptions and serves as an inspiring model for integrating cultural heritage with modern technology in water-related projects.

We identified these common paradigms and limitations by comparatively analyzing existing cultural experience centers across China (see Table 2). These projects and museums advocate for a departure from traditional museum formats, which rely heavily on static displays and textual information, towards a more dynamic and interactive approach. The research inspired us to develop our project further.

Table 2. The Comparison of Water-themed Museums in China.

Criterion	Yellow River Museum	National Water Museum of China	Chongqing Baiheliang Underwater Museum
Architectural Design	Traditional building design	Pagoda-style building symbolizing water management challenges	Innovative underwater structure using non-pressure container
Exhibition Methods	Traditional methods (pictorial, text, artifacts), interactive clay pottery workshop	Immersive environments, multimedia displays, connection to water management database, traditional methods in some areas	Underwater viewing corridor with glass observation windows, advanced air monitoring system
Technological Integration	Low; mainly hands-on pottery experience	High; multimedia and remote database connectivity	High; uses technology to create a controlled environment for underwater relics
Focus of Exhibits	Natural evolution, socio-cultural development, and management of the Yellow River	Ancient and modern water management, water-saving technologies	Historical inscriptions and underwater cultural preservation
Unique Features	Hands-on experience with Yellow River clay	Pagoda structure, integration of traditional and modern exhibition techniques	World's first underwater museum, hydrostatic balance technique to protect relics
Limitations	Relies on traditional exhibition methods which might not engage a modern tech-savvy audience	Some areas still use conventional exhibition methods despite innovative efforts	Accessibility might be limited due to the unique structure; maintaining the technology-intensive environment might be challenging and costly

3. Project Description

Our project of Jinan Quan Shui Cultural Hall is designed to elevate and reinterpret Jinan's rich and distinctive spring water culture, blending traditional cultural experiences with digital technology. This design project aims to revolutionize the way spring water culture is presented and appreciated by integrating it into the fabric of local life and showcasing it through advanced digital interfaces. We aim to create an immersive cultural experience that educates visitors about Jinan's unique springwater heritage and engages them through innovative interactions and digital visualizations of the dynamic springwater landscapes. It has the following features:

Cultural Integration:
The hall will highlight how Quan Shui (spring water) is intertwined with the daily lives of Jinan's residents, presenting historical and contemporary uses and the cultural significance of the springs (Stevens et al., 2021). Artifacts, photographs, and narratives will depict the evolution of spring water utilization in local customs, crafts, and community practices.

Interactive Experience:
The project will offer digital visualizations that include AR and VR immersive environments (Harrington et al., 2021) where visitors can explore environmental impacts and understand the hydrological cycle specific to Jinan.

Cultural Impact:
By merging traditional cultural insights with modern technology, the Jinan Quan Shui Cultural Hall will serve as a beacon of cultural preservation and innovation. It will attract visitors from around the world and serve as an educational platform for the local community, enhancing their appreciation and understanding of their natural heritage (Selkani, 2023).

4. Design Process

Our design process integrates a blend of traditional methods and modern technology, centered on the theme of Jinan's spring water. We start with a foundation built on strong design concepts and principles that emphasize immersiveness, educational enrichment, and cultural preservation. Traditional design methods guide our material and aesthetic choices, ensuring authenticity and a deep respect for cultural heritage.
In Hall 1 and Hall 2, we harness advanced AR and VR technologies to create dynamic, interactive experiences. At the same time, the exhibition's design is carefully crafted around a color scheme inspired by the clear, refreshing hues of spring water, promoting a serene and engaging environment.

4.1 Design Concept and Principle

The Quan Shui Cultural Experience Hall is specially designed to reflect Jinan's unique spring water culture and urban vibrancy, often referred to as Quan Cheng (City of Springs).

The project leverages innovative design strategies that integrate advanced design techniques with traditional cultural symbols and regional characteristics. The goal is to provide a more tangible and interactive form of expression that introduces new forms, new technologies, and new experiential emotions to Jinan's renowned spring water culture.

The design principles of the Quan Shui Cultural Experience Hall masterfully integrate Jinan's historic spring water culture with modern technological advancements, creating a seamless blend of tradition and innovation. We combine traditional cultural motifs and elements from Jinan's ancient architecture with contemporary materials and digital interfaces, bridging the gap between past and present. State-of-the-art immersive technologies such as AR, VR, and interactive multimedia installations are employed to enhance emotional and educational experiences, deepening visitors' connections to the spring water narrative. These technologies and meticulous spatial designs make the cultural content vivid and engaging, offering an immersive glimpse into the life surrounding Jinan's springs. Interactive elements encourage active participation in the cultural narrative, transforming visitors from passive observers into engaged contributors, thereby enriching the collective understanding of the culture. Additionally, the project introduces innovative interpretations and recreations of traditional elements, using modern design techniques to dynamically present Jinan's spring water culture in ways that resonate with both contemporary audiences and traditional values.

4.2 Design of the Cultural Hall

Our design of the museum is planned to be a large, three-story structure, with the design focus primarily on Halls 1 and 2 as exemplary cases. These two halls are crafted to showcase the breadth and depth of the museum's offerings, each occupying a distinct level and embodying a unique thematic and technological approach to the exhibition of Jinan's rich spring water culture. This structuring optimizes space within the expansive museum and allows for a coherent, immersive journey through the cultural and historical narratives that define Jinan.

Hall 1: Historical Culture Exhibition Hall (First Floor)

The museum's first floor is designed as the Historical Culture Exhibition Hall (see Figure 3). This hall is dedicated to educating visitors about the spring water culture, offering a traditional exhibition style that provides ample time and space for a deeper understanding. The main hall collects historical photographs and artifacts from Jinan to give visitors an introductory understanding of the city. A cultural display wall is strategically placed within the hall, arranged chronologically to depict Jinan's history through a combination of text and imagery. This traditional setting is similar to many cultural museums and is designed to facilitate knowledge dissemination and enhance visitors' comprehension of local culture.

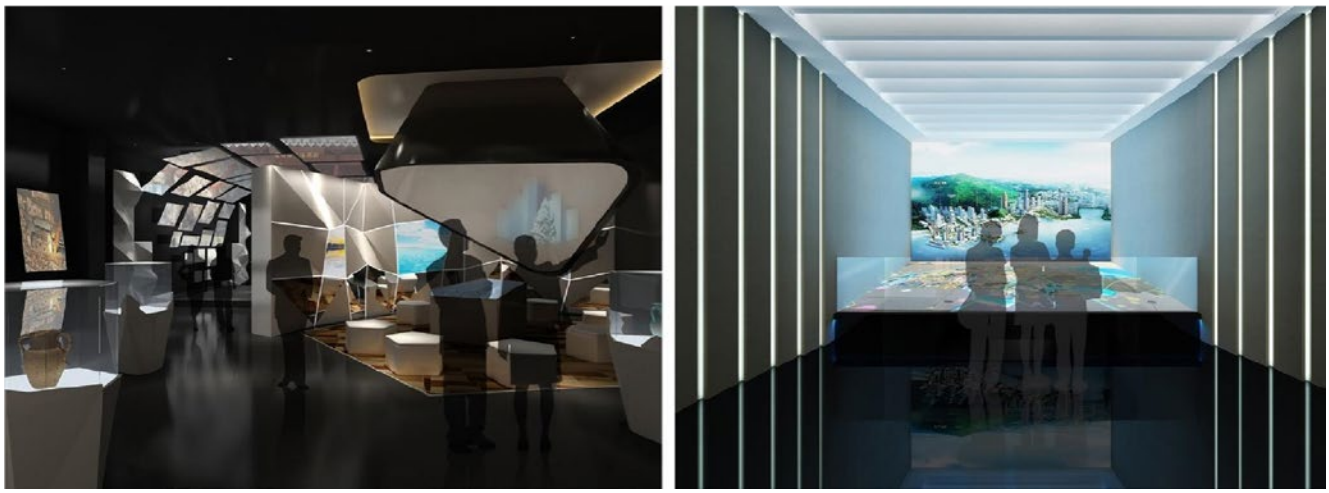

Figure 3. The Design of Hall 1.

Hall 2: Immersive Experience Exhibition Hall (Second Floor)

The second floor hosts the Immersive Experience Exhibition Hall, which features two distinct immersive works utilizing VR and AR technologies:

VR Installation:

The centerpiece of this installation is a virtual spherical screen surrounded by interactive displays designed to create an immersive, dynamic visual experience that captivates the senses (see Figure 4). Visitors are equipped with state-of-the-art VR headsets, such as the Apple Vision Pro, to explore global water resources uniquely engagingly. This VR experience presents the Earth in a stunning 360-degree panorama, providing viewers with an encompassing view of the world's water distribution, including both surface freshwater sources and hidden underground springs.

Figure 4. The Display of VR in Hall 2.

As part of the VR journey, the historical development of these water sources is explored in depth. Visitors can witness the geological processes that have shaped these springs over hundreds or even thousands of years, displayed through rapid visual presentations that combine high-definition graphics and interactive timelines. This installation educates and allows visitors to experience the sensation of traveling through time and space to understand the evolution and importance of water resources on our planet.

AR Interactive Exhibit:

Adjacent to the VR installation, the AR Interactive Exhibit offers a different but complementary experience (see Figure 5). This part of the hall features a large, interactive platform outfitted with multiple digital screens arranged along a historical timeline. These displays invite visitors to engage directly with the exhibit by tapping on specific time nodes. Each tap reveals detailed narratives about old Jinan's historical context, cultural significance, and the daily life surrounding its renowned springs.

Figure 5. The Display of AR in Hall 2.

Visitors can utilize a specialized app or an iPad to activate the exhibit's AR features. Scanning images on the displays triggers real-time videos and 3D animations of Jinan's springs, virtually transporting visitors to each location. This AR experience enhances the viewers' understanding of Jinan's unique water culture. It bridges historical data with modern technology, allowing a deeper appreciation of how Jinan's culture has evolved around its water sources.

These two halls within the museum preserved the rich history of Jinan's spring water culture and used modern technology to create a more engaging and interactive visitor experience. The VR and AR installations form a comprehensive and interactive exploration of water cultures, both globally and locally. By integrating advanced digital technologies with educational content, the exhibits aim to transform how cultural heritage is experienced, making it more accessible, engaging, and informative for visitors of all ages. The design integrates educational content with interactive technology to create a dynamic environment that caters to both historical enthusiasts and tech-savvy visitors.

4.3 Exhibition Design

The Spring Water Cultural Hall adopts a color palette that mirrors the natural hues of its theme, predominantly using shades of blue and white, such as 0AAFF1, 72A2C0, F2EAED, 80ADD7, F1F3F2 and C2D3DA (see Figure 6). These colors were chosen to evoke the clarity and purity of water, aiming to create an atmosphere of tranquility and freshness that enhances the thematic focus on spring water within the museum.

Figure 6. The Selected Colors.

The original layout intended to replicate the spread of Jinan's 72 springs but was revised to focus on the city's old streets and alleyways for richer content and practical implementation. This design approach allows visitors to traverse a path that mimics walking through Jinan's historic streets, providing an immersive experience that highlights the cultural and historical context of the area (see Figure 7). The first hall's design is inspired by Jinan's renowned Black Tiger Spring, featuring curved LED screens and winding paths alongside water flow simulations. This setup is crafted to give visitors a lifelike experience of Jinan's environment, making it feel as though they are exploring the city itself, complete with the sights and sounds of its bustling streets and flowing springs. And the wall panels are strategically designed to narrate Jinan's historical stories, display scholarly references about the springs, and showcase distinctive photographs of the local water sites. The background of these panels uses irregular white surfaces to symbolize the fluid movement of water, aiming to visually convey the dynamic and ephemeral nature of Jinan's spring waters and enhance the visitor's sensory experience of the exhibition.

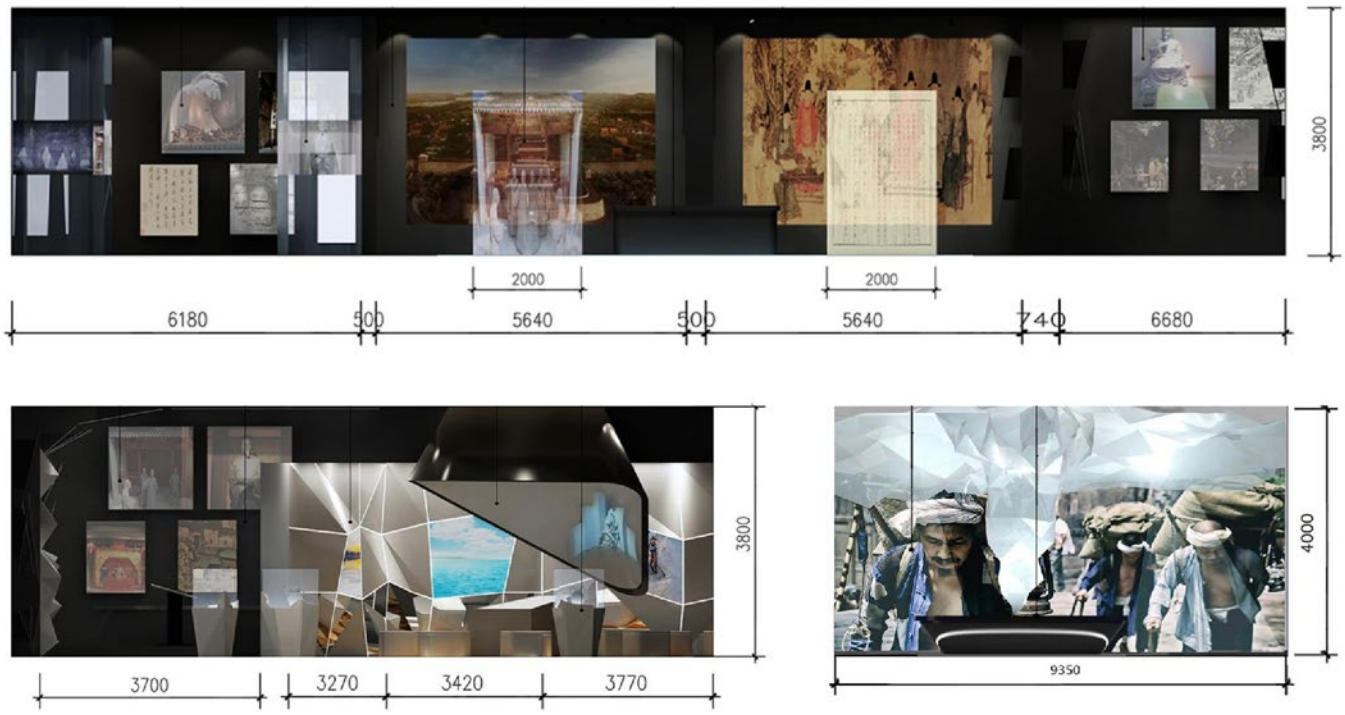

Figure 7. The Exhibition Display.

5. Limitation and Further Development

The current design of the Spring Water Cultural Hall, while innovative, encounters certain limitations, primarily in the scope of interactivity and the depth of narrative delivery. Despite their technological enhancements, the first two exhibition halls have confined the visitor experience to visual and minor interactive elements. These limitations may hinder the depth of engagement and comprehension among visitors with varying interests and technological comfort levels.

Integration of Film and Digital Media in the Third Hall

A third exhibition hall will be proposed (see Figure 8), focusing on the use of film and digital media to advance cultural dissemination. This hall would utilize cinematic presentations to tell the stories of Jinan's springs, combining historical footage, reenactments, and digital storytelling to create a multi-layered narrative experience (Liu & Lan, 2021). This method can help bridge the gap between traditional cultural transmission and modern media consumption, offering visitors a more dynamic and engaging way to interact with the content (Nie et al., 2023).

Figure 8. The Hall 3.

Technological Enhancements in VR and AR

On the technological front, significant enhancements are planned to elevate the interactivity within the exhibition spaces. VR setups will be upgraded using Unity software for high-fidelity modeling, with testing conducted on Apple Vision hardware to ensure a seamless and realistic user experience. This will allow for a more immersive portrayal of Jinan's spring environments that visitors can explore virtually.

Further, AR components will be advanced through the implementation of motion capture technology. This will enable the system to detect and respond to visitor movements, adjusting the visual effects of the spring water accordingly. Such responsive AR experiences will enhance visitor interaction and deepen the educational impact by dynamically demonstrating Jinan's spring waters' natural properties and cultural significance, thereby providing a truly interactive and personalized museum experience.

6. Discussion and Conclusion

Digital technologies, particularly AR and VR, have revolutionized the way cultural heritages are preserved and experienced (Barbara, 2022; Xu et al., 2024). As demonstrated by the Quan Shui Cultural Experience Hall in Jinan, these technologies enhance the visitor experience and serve as vital tools in the education and preservation of cultural heritage. Integrating AR and VR into the Quan Shui Cultural Hall has proven to bridge the gap between traditional cultural appreciation and the expectations of today's digitally attuned audiences, ensuring that the cultural essence of Jinan's spring waters is preserved and revitalized.

The findings from this study underscore the importance of interactive technologies in engaging modern audiences. Immersive technologies have facilitated deeper connections with the heritage and ensured that these traditions are passed down to future generations in an engaging manner (Mendoza et al., 2023). Furthermore, the case studies of similar projects around the world, such as the Horizon of Khufu and the augmented exhibitions of Notre-Dame de Paris, provide compelling evidence of the global applicability of these technologies in cultural heritage conservation. These projects highlight the potential of digital media to make cultural and historical education more accessible, engaging, and comprehensive. However, challenges such as technological disparities and the need for continuous content updates and maintenance also need to be addressed to fully realize the potential of these technologies.

In conclusion, the application of AR and VR in cultural heritage sites represents a series of narrative shift towards a more interactive and engaging form of cultural preservation. The Quan Shui Cultural Experience Hall's success is a testament to this approach's effectiveness, providing a framework that can be adapted and implemented in other cultural contexts. This study contributes to the broader discourse on cultural heritage preservation, offering insights and practical frameworks that can enhance visitor interaction and educational outcomes across the globe. As we continue to advance technologically, it is imperative that we remain mindful of our cultural roots and harness these innovations to ensure they are preserved for future generations in a manner that is both educational and engaging.

Finally, it is worth to initiate a discourse on the sensory aesthetics of VR and AR in relation to real-world visual experiences in future scholarly dialogues. This exploration will involve a thorough investigation into perceptual nuances, facilitating the utilization of data-driven environments to establish spatial narrative contexts. The findings from such research are poised to significantly contribute to the advancement of innovative curatorial practices within museums and gallery spaces.

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CARE OF NEW KNOWLEDGES — EDUCENE.

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ABSTRACT | **Care of New Knowledges – Educene.**

Education I.e. the idea of ducere, in the sense of guiding and therefore of e-, which indicates a movement towards the outside, in the sense of "bringing out, extracting", Instruction, I.e. derives from in and strùere (to stack, erect), is construction, formation of the person, as clearly appears in the German 'bildung'. Knowledges, I.e. Sanskrit noo as kwnon and Greek gnoos as intellect.

It is the era of change, among the twenties of the twenty-first century we stay with a trouble in the Anthropocene and the Chthulucene. We are all in the time of the right choice at the right moment (the greek-christian time of kairos) which is why the care of new knowledge becomes necessary. Knowledges is not fixed anymore is more related to the ability to speculate. We are obliged to deconstruct imaginaries. We must abandon the rear-view mirror syndrome and analyze the present-future with the artist's posture.

Speculative design returns, heir to the Italian Radical Design. Speculative narratives retrieves the science-fiction so it's a fiction-theory and narrative. We must see if the future will be utopic, distopic, or ucronic.

We are in Spaceship Earth facing new imaginaries. We all are turning into maintainers of a cosmic wreck, planetary engineers. Design is facing the challenge of new imaginaries.

At the center resides the teacher-student dyad, the teacher understood as the 'guardians of the ruins' and the youngsters students as 'the creators of new narratives'. The creation of these two rhetorical figures allows the triggering of a speculative dynamic (mirror) that produces analysis of the present.

The artistic side of design fight back, because It is necessary assume a mind-divergent posture to deconstruct scenarios in search of submerged futures and with the aim to produce new nonnewtonian cartographies.

The Care of New Knowledges aims to think a connection between the artificial and the natural. It is inspired by the work of the keen international artist Michelangelo Pistoletto with his “Formula della creazione”, based on art-sign Trinamics, towards a multidisciplinary approach to the future. It is a new pedagogical model of design resulting from, as chair of Sociology of Change, designing new courses at the Intituto Superiore Industrie Artistiche -ISIA Roma Design in Rome/Pordenone, from personal research developed among the years as founder director of the Scuola di Nuove Tecnologie dell’Arte alla Nuova Accademia di Belle Arti di Milano, NABA, from expereinces with the English educator Roy Ascott and and today with the artist Michelangelo Pistoletto and his academy of art & design.

For the sake of designing Habitus, Politics, Meetings, Architecture, Theatre, Art, Information, Music, Science, Design, Religion, Market, Economy, Literature, Food, Philosophy (Progetto arte, M. Pistoletto, 1995-96)

KEYWORDS | ART & DESIGN, THIRD PARADISE DESIGN, TRINAMIC, DYAD TEACHER-STUDENT, SPECULATIVE DESIGN, NEW IMAGINERIES, NARRATIVE EDUCATION.

Care of new knowledges — Educene

0- proem — prooemium

Education, from latin *ducere*, in the sense of leading and hence e-, which indicates a movement outwards, in the sense of 'to bring out, to extract'; hence Istruction, which derives from latin *in* and *strùere* (to stack, to erect), is construction, the formation of the person, as appears clearly in the german 'bildung'. All for Knowledge, i.e. Sanskrit *noo* as kwnon and Greek *gnoos* as intellect.

In Italy, Academies of Fine Arts are organised in similar way to universities and award equivalent degrees. The curriculum is divided into a first three-year cycle - BA - which is followed by a two-year master's degree - MA - and a third research cycle - PhD - (which can also be carried out in association with other institutes). In Italy there is also the ISIA Istituto Superiore per le Industrie Artistiche - Higher Institutes for Artistic Industries- which were born like the Academies of Fine Arts, but with a vocation towards Design and contemporary research. In fact, they represent the first and original schools of Italian Design and have authority to activate chair on call.

My work in the first decade of the 2000s at the New Academy of Fine Arts in Milan, NABA, was foundational (among other italian academies) for the establishment by the Italian Ministry of Universities of the Academic Degree Class in 'New Technologies of Art'.[1] It was an important training ground for the elaboration of art and design education and research. Ideas, theories and practices of contemporary Italian art & design education were derived from this experience.

In 2005, a doctoral programme in Art & Media was introduced. It was, in fact, transdisciplinary, replicating the model developed by cybernetic artist, curator

[1] This foundation was part of the establishment by the Italian Ministry of University and Research, MUR, of the Class DAPL08- School of New Technologies of Art, the NABA School of New Technologies of Art was founded and directed by me from 2001 to 2013.

and educator Roy Ascott. This was first implemented at the University of Whales under the name CAiiA - STAR and subsequently at Plymouth University known under the name Planetary Collegium.[2]

The PhD M-Node Planetary Collegium Programme was established in Milan at NABA.[3] In fact, the offer was expanded both quantitatively, i.e. by endowing the School with the complete cycle of study, i.e. BA, MA and PhD, and qualitatively in a circular scheme in which doctoral research fell on teaching at BA and MA level, thus emphasising the frontier role of Art and Design transforming the School into a very sensitive apparatus for education and research in the global 21st century.

The design of the full-cycle Art & Design academic courses was a practice field of research and experimentation on a new pedagogy, a design that continued in 2013 when I move to collaborate on the design of the School of New Technologies of Art at the Accademia Costume e Moda di Roma[4], which materialised in 2018. (In addition to these activities of design and teaching, academic direction and research, there are a whole series of academic experiences in doctoral and various schools to which I refer elsewhere as they are not included in this essay). Then the Chair in Sociology of Media at the Istituto Superiore per le industrie artistiche ISIA Roma Design, Pordenone branch - later doubled by the Chair in Sociology of Change at the Rome branch - and the design of the Academy Unidee of Fine Arts, an academy that is an expression of the international contemporary artist Michelangelo Pistoletto.

These experiences have been a training ground for research into the forms of the new education for the 21st century. This care of new knowledges deals with a new pedagogical model of design as a result of teaching and of the design of new courses at ISIA Roma Design in Rome/Pordenone, and from the research carried out over the years mainly of the School of New Art Technologies at NABA in Milan, and from the experiences, at PhD level, with the English educator Roy Ascott and today with the artist Michelangelo Pistoletto and his Academy Unidee of Art and Design.

To design Habitus, Politics, Meetings, Architecture, Theatre, Art, Information, Music, Science, Design, Religion, Market, Economy, Literature, Food, Philosophy (Progetto arte, M. Pistoletto, 1995-96)

[2] This doctoral programme, labelled M-Node (in Milan) and then T-Node (in Trent), ran from 2005 to 2018, doctoring over 15 researchers including artists, designers, sociologists, musicians and even anthropologists. It was characterised by a more theoretical dimension than the original model; this specificity was due to the continental tradition of the Italian academy, which differed from the english pragmatic tradition.

[3] My PhD thesis was a thesis in education for the 21st century, the supervisor was the Director of the Planetary Collegium Prof. Roy Ascott himself. The thesis titled *Outline of a Subversive Technopoetic: for a Libertarian Pedartgogy*, was the subject of a mention by Leonardo Isast MIT in 2013, Top-Rated LABS Abstracts – https://direct.mit.edu/leon/issue/49/5.

[4] Again Class DAPL08- School of New Art Technologies, MUR, Italy.

I — when - quoniam

The 20st century are over and a quarter of the 21st century has ended, is this the century of **the end of the modern**?

The modern was born with the mechanical reproduction of the book in the mid-15th century. This invention allowed the conditions for the establishment of calculating thought and the industrial revolutions to appear. (1) With the first industrial revolution mercantilism related to production was born, the consequence of which was the exploitation of resources within a neoMalthusian environmentalist vision: the more people are born the more they consume the more there is waste. (2) With the second, the exploitation of the planet's resources increased exponentially and a global, ubiquitous world characterised by a planetary market was generated. (3) Then it was atomic energy, astronautics and information technology that characterised the third revolution. (4) With the fourth revolution, we enter the 21st century under the hallmark of autonomous systems and artificial intelligence (Schwab, 2016).

We are in the midst of the **Anthropocene**, an era in which the environment becomes transfigured by the accelerated effects of progress. And we are in the Capitalocene, which is a useful reference to say that 'anthropocene' is a theme that obscures rather than clarifies the understanding of socio-ecological changes. It represents the inequality and multi-species violence of capitalism, suggesting that human beings would be responsible for the problems created by capital. It is therefore the capitalist structure and its socio-ecological transformation activities that must be called into question to understand the 21st century (Moore, 2016) We are also in the Chthulucene, from the etymology of H.P. Lovecraft's tentacled monster Cthulhu and the spider Pimoa Chthulu, a spider that actually exists unlike the imaginary creature of the famous American writer.

An hendyad appears between the fictional monster and the real spider: on the one hand the unavoidable catastrophe, the weird, the eerie, the unheimlich, (Fisher, 2017) on the other hand the slow and patient work of weaving, reconstructing the web, the skein game, the common web, the sympoiesis.[5] From the Greek khthon, a word referring to that which belongs underground, hence chthonic, obscure. It is therefore the era of subterranean connections. (D. Haraway, 2016) This new era no longer considers the

[5] This concept is mutated by Haraway from the work of one of her students, Beth Dempster, who coined it in the 1990s: the notion that living systems are not self-sufficient, or autopoietic, but that the living, the inorganic, nature and culture co-evolve in constant intra-action. Haraway is sympathetic to foundational Lynn Margulis's idea in Symbiotic Planet (1998) that life emerges through symbiosis and symbiogenesis which leads to the increasing complexity of life forms. Haraway defines her notion of sympoiesis as a specific practice of "making-with," or "becoming-with" in D. Haraway The Companion Species Manifesto (2003) and in Staying with the Trouble (2016). In Italy in F. Timeto, Bestiario Haraway, per un feminismo multispecie, Mimesis, 2020, sympoiesis implies a shared responsibility-responsibility, a becoming-with, and this is what seems to emerge in the dialogue between two thoughts in this case.

human as the only player on Earth, but as part of a whole of life, animal and plant, which now also involves computer algorithms. The Cthulhu monster is the artificial abomination that has taken up residence on Earth in the 21st century to manage new semantic, cognitive and productive functions, i.e. life plus the Internet of Things (IoT) and artificial intelligence (AI).

Thus we have arrived at the Anthropocene, Capitalocene, C(h)thul(h)ucene with the planet reduced to a burning spaceship adrift in space. (Buckminster Fuller, 1968) As the launch of the Chat **Generative Pre-trained Transformer large language model (LLM)** - GPT - on 30 November 2022 closes the modern era and opens the era of Hypermodernism.

II — what - quid

This is the era of change, with the end of the first quarter of the new millennium we remain with difficulty in the Anthropocene and Chthulucene. We are all in the time of the right choice at the right time (the Greek-Christian kairos time) and that is why the Care of New Knowledge becomes mandatory. We are thus obliged to deconstruct imaginaries, and knowledge is no longer fixed, but is determined by the ability to speculate.
We must abandon the rear-view mirror syndrome (McLuhan, 1964) and analyse the present-future with the posture of the artist. **Speculative Design**, heir to Italian Radical Design, is back. Speculative narratives reclaim science fiction so they are a theory and a narrative of fiction. We must see if the future will be utopian, dystopian or uchronic.

It is the coming of hypermodernity that has produced a fragmentation and targeting of truths (Stiegler, 2021). Since the 16th century, the centrality of the dialectic reappears (Culianu 2006). Education can no longer lead to a single goal and can only be a continuous dialectical tension between several truths. Educere no longer has only one destination, but consists of many landing points of truth or destinations of knowledge. This is because the aesthetics of victory, the foundation of truth that was realised after the world wars as the popular form of the ideological framework of human socio-political cultures, falls apart because the very ideological framework on which it was founded no longer exists. Today we no longer have a telelological point of arrival, but undetermined and recursive global liquid cartographies.

We live in the age of verisimilitude and truthfulness: according to Critical Theory, history ended with the fall of the Berlin Wall in ‘89, a single thought is created based on a hyper-progressive and economic view of life (Fukuyama, 1995). In this ‘pandemonium’ of verisimilitudes and narratives, the political system describes a super-democracy within a Western modernist tendency, whose techno-scientific, economic, socio-political currents are increasingly interrelated by causal connections produced by the fiction of narratives of a corporate-managed public (Kotler, Sarkar, 2021).

This leads to a demo-bureaucratic culture

grounded in zealous ideological memes that lend their bias to a plot-driven fiction that sees industrialisation as the basis for progressive democratisation. This produces cycles of reinforcement of a folkloristic social science theory, for which the maturation of societies in a democratic direction is determined by wealth thresholds. In this context, technology spreads a system of information that envelops the planet in a curtain of global effects. Truth multiplies in a babel of truths that produce the multiplication of imaginaries and makes the old forms of knowledge obsolete.

The *Care of the New Knowledges* aspires to contemplate a connection between the artificial and the natural. It is inspired by the work on socially based art of the international artist Michelangelo Pistoletto with his Trinamica-based 'Formula of Creation' towards a multidisciplinary approach to the future that hybridises with speculation in the age of technology, i.e. techno-ethics, by the British artist Roy Ascott.

Ascott's work defines a never-ending dynamic relationship between the human being and technology, defining a moist, emulsified environment, i.e. where the vital wet element is indistinguishable from the technological dry, composed of the wet , life and human, and another element, the dry-, technology (Ascott, Shanken, 2007).

Michelangelo Pistoletto's Trinamics, is founded on the dynamics of the three that always represents a birth, which occurs by chance, or intentional combination, between two subjects (teacher and learner). Trinamics happens in the process of: joining, connection, combination, conjugation, interaction, fusion of two elements that are simple or complex in themselves. The Trinamic phenomenon occurs in chemistry and in physics, extends to the physiology of bodies and can even be applied to social life in its cultural, political, economic and religious aspects. The sign-formula of Trinamics, also used as the symbol of the Third Paradise, and named today as 'Formula of Creation', consists of three circles in a line. The two outer circles represent all opposites and any kind of duality. In the also called Theorem of Trinamics the middle circle, generated from the conjunction of the two outer circles, represents a third and previously non existent subject. Trinamics acts in the natural sphere as well as in the artificial one, including every area and aspect of human society. We find it at work for example in the reaction between oxygen and hydrogen that gives rise to water; in the interaction between masses of warm and cold air, causing thunderstorms; in the connection between positive and negative poles which produces electric power; in the union between male and female that generates a new being; in the dialectic between thesis and antithesis that produces synthesis; in the fusion of the opposing political models of absolutism and anarchy out of which democracy has developed.

The Formula of Creation is the science of

relationships and equilibrium. But it is first and foremost the principle of intellectual, artistic, political and cultural design for the 21st century. It is the method that every educator and designer must take as the basis for all research, teaching, artistic and aesthetic practice, making it the design science of relationships and equilibriums. (M. Pistoletto, 2017 and 2022) In a global world where truth is multiplied, planes intersect and multipolarism is produced. The most convenient operation is to assume, like an artist, a 'multiple point of view'. Here the educational method is precisely a **multipolar method**. It is the combination of two units that gives rise to a third, distinct and unprecedented unit.

III — everywhere - ŭbĭcumquĕ

The primordial human, faced with the so-called 'numinous', i.e. the terror caused by the anguish of nature, creates art, which he already had as an instinct, and constructs the imaginary worlds where he shifts to live. And one thing is the Earth where he lives but also dies, one thing is the World where he lives and never dies because then there is Paradise or there is another life (Monico, 2020). Humanity inhabits three places: the earth, the world and the planet. In fact today there is also the possibility of a world-without-us, i.e. the Planet, the earth without the human being, which is only conceivable by abstraction or through predictive models, which tell us what it will be on a geological and conceptual level. It is therefore a spectral and speculative world like deep space and dark matter. It is not reducible to the human species and it is not in the human species. The importance of the Planet concept lies in its being a negative concept, that which remains after the human (Thacker, 2011-2015).

Here appears the precious artistic concept of Michelangelo Pistoletto's: the Third Paradise (Pistoletto, 2003). It is the fusion of the first and second paradise. The first is the one in which human beings were totally integrated into nature. The second is the artificial paradise, developed by human intelligence to the global dimensions reached with science and technology. This paradise is made up of artificial needs, artificial products, artificial comforts, artificial pleasures and every other kind of artifice. A veritable artificial world has been formed that, with exponential progression, generates, parallel to the beneficial effects, irreversible processes of degradation and consumption of the natural world. The Third Paradise is the third phase of humanity, which is realised in the balanced connection between artifice and nature. The Third Paradigm means the transition to an unprecedented stage of planetary civilisation, indispensable to ensure the survival of the human race. To this end, it is first necessary to reform the principles and ethical behaviour that guide our common life. The Third Paradise is the great myth that leads everyone to take personal responsibility in the global vision. The term paradise comes from the ancient Persian language and means 'protected garden'. We are the gardeners who must protect this planet and care for the human society that inhabits it. The symbol

of the Third Paradise, a reconfiguration of the mathematical sign of infinity, consists of three consecutive circles. The two outer circles represent all diversity and antinomies, including nature and artifice. The central one is the interpenetration between the opposite circles and represents the generative womb of the new humanity.

IV — the story became flesh - verbum caro factum est

This dialectic of the Formula of Creation is a real engine because the dynamic between two elements produces an interaction, the mechanical one of the action, reaction, reciprocal influence of causes, phenomena, forces, elements, substances, natural agents, physical, chemical, and, by extension, psychological and social, and thus a relationship when it begins to generate a discourse on this primordial interaction; in fact, the biosphere and the individual are not two separate realities, but rather two aspects of the same fundamental natural reality.

The biosphere is not simply a series of lifeless mechanisms, but is inherently a dynamic creative force in a continuous process of self-development, which, through various stages of complexity, encompasses and is encompassed in the basis of life and human being consciousness (Emerson, 1849). This progressive development can thus be seen as nature becoming increasingly self-aware (Schelling, 1804). The concept of polarity is fundamental, as in the Third Paradise and the Formula of Creation. All things exist in a dynamic tension between opposites, such as attraction and repulsion, light and darkness, matter and spirit. These polarities are not static but generate interaction which in a state fitted with artistic imagination becomes relationship. The narration thus possesses a kind of intelligence that manifests itself in its relational processes and structures. This intelligence develops until it becomes thought and thus structures a consciousness. In this sense, story 'becomes thought' when it is reflected in the human being by producing an imaginary that is the relationship produced by interaction insofar.

The human being inserted in a polar dialectical scheme manifests itself in a narrative process, because this same narrative process founds its binding to things by producing precisely the World (imagination). The emergence of human consciousness therefore represents the point at which narrative becomes capable of reflecting on the human. **Narrative** is a formidable system of adaptation and pre-adaptation to the world, arising from the biosphere and simulating environments in the biosphere has allowed humans to accelerate and differentiate their evolutionary response to the biosphere In this way, human perceptions are largely based on prediction, which allows them to read the world through speculative images to which a small amount of immediate sensory information is added with minimal cognitive effort (Gottschall, 2005).

Traditional scientific definitions of intelligence

take the human being as the yardstick against which all other species in the biosphere are measured, so that, according to these anthropocentric definitions, the human has always been ranked first, followed by animals such as the so-called superior primates - chimpanzees, bonobos, gorillas - then the other 'superior' animals, and so on, in a hierarchy of intelligence formulated by the ancient Greeks and which constitutes the backbone of modern Western thought. This controversial hierarchy, still one of the foundations of modern thinking, begins to falter in the Anthropocene because by questioning it, the disastrous approach with which we relate to the Earth may begin to change. Indeed a human, ergo a speculative designer, is made up of more microbes than cells and there are more bacteria in our guts than stars in the galaxy (Costello et All, 2009). We are in symbiosis with the biosphere, which is a collection of ecosystems among which we are embedded. To understand the scope of the narrative, we have to remember the way contemporary physicists describe the universe: the universe is about 13.8 billion years old, Homo Sapiens about 300,000 years old, and only since 100,000, with the discovery of the first forms of burial, i.e. the 'aesthetic' act, can we say that it has become a speculative animal, hence a narrative animal. We are in fact telling a story backwards from a percentage representation such that we are in the knowledge for 0.0007246% of 13.8 billion. And if that were not enough, again for physicists, more than 95% is 'dark matter and dark energy' of which we know nothing, although we know it is there, and includes dark biology and therefore dark life. A large number of scientific concepts, e.g. time, or those of chemical bonds - Goethe's famous 'Elective Affinities' - lack definitions, but are fundamental categories for thinking. "We" are ecosystems that transcend boundaries and transcend categories. Our thinking emerges from a complex tangle of interrelationships. Narrative can thus be seen as one of the forms through which the biosphere becomes self-aware, through intelligere, that is, binding itself to things, where 'biosphere' and 'culture' are two sets that blur into each other and vice versa. The emergence of the in-intelligere, or bonding to things, which is the opposite of rationality as a sequence of measured inferences that moves away from things towards their subjugation and exploitation. The intelligere, not only in the sense of its traditional etymology, from the Latin "intus"-"legere" "to read within", but as an "intus"-"ligare", a binding oneself intimately to things (Monico, 2020).

And so it is all a matter of Imagination, which in scientific circles is called 'speculation': the tangle of our conjectures, fantasies and metaphors has helped shape our knowledge because imagination is the foundation of the humanbeings (Vico, 1710 and 1725-1744). Imagination is part of the everyday work of investigation and scientists, as humans, are emotional, creative, intuitive people who bring together things that cannot be associated. Imagination is analogical thinking, i.e. it is the ability to associate things that cannot be associated, and it is shaped through storytelling. The development

of the biosphere is, at the same time, the development of the imagination. Human knowledge is, therefore, a form of self-knowledge of nature itself and its form is narration.

This is why a fundamental axis of the Care of New Knowledge is narratives. And it is precisely narration that we observe in the above-mentioned School of New Technologies of Art at NABA in 2005, and then always returned to in the courses of narratology and creative writing in the subsequent teaching and speculative design programmes in which there were collaboration and direction, such as the Isia Roma Design.

V — how - quo modo

This is because the end of the modern means the end of an entire way of thinking, educating, designing, imagining. The modern has embraced calculative-rational thinking and a teleological view of human thinking and doing, which is speculative - therefore science fiction - and technoscientific. It is a metaphysical approach, which represents things abstractly and rationally and thus enables calculative-rational thinking and thus techno-scientific acceleration, the thought of technology and science. That is to say, modern theory is an analytical approach that separates and externalises problems, producing technoscience, which is why the Anthropocene, Capitalocene, C(h)thul(h)ucene came about.

We are domesticated, that is, we do to humans what we do to animals; anthropotechnics is the practice by which humans transform themselves through cultural and disciplinary techniques. The Theory of Anthropotechnics focuses on the idea that human beings continuously modify themselves through cultural, technical and disciplinary exercises, reflecting a process of selfdomestication and self-optimisation. Anthropotechnics is thus the set of exercise-based mental and physical behaviours by which human beings have attempted to optimise doing and thinking in the face of the need to think about themselves. It not only concerns the use of technical tools, but also and above all the set of educational practices that shape the individual. Thus adolescents (which are the humanbeing's present participle), i.e. those (students) who are not yet adults (which are the humanbeing's past participle), are domesticated to rational thinking with an average of 10 years of compulsory schooling followed by as many years of higher education and research. By means of anthropotechnics, the human involves the self-production, maintenance or improvement of performance in a true *Humankind-Design*.

In the 21st century, the problem of thought becomes a dialectic of non-thought and selfproduction, this dialectic becomes critical and urgent because of the Anthropocene, Capitalocene, C(h)thul(h)ucene. In fact, in today's world, the only fact of universal ethical significance is the idea, increasingly widespread everywhere, that things cannot go

on like this any longer (Ibid., 2010). We are in Spaceship Earth facing new imaginaries. We are all turning into planetary maintainers of a **cosmic wreckage** (Buckminster Fuller, 1969). Design is faced with the challenge of new imagery. There is no escaping this imperative, for with the appearance of Spaceship Earth, a new configuration of the absolute imperative has appeared in the world, which is addressed to all and sundry in the form of a stern warning: change your life! Otherwise, sooner or later the complete unravelling of the crisis will show what was missed at the time of the preliminary signs.

The Anthropocene is the product of a devaluation of a natural and sensitive Earth in favour of a transcendent and progressive World. We can argue that this devaluation has directly led to the current systemic collapse of the Earth.

As a remedy to this transcendence, here is **the teacher-learner dyad**, or rather the adolescents who in the 21st century become central, no longer an higher education based on the authority of the teacher towards a learner who listens, but a teacher who assumes the role of witness to the ruins of the anthropocene while dialoguing with the adolescent learner who is an active participant in the same process of education because he is the creator of new narratives in a circular process that without denying theory does not overheat it in an absolute and mere transcendence but recovers praxis.

At the centre lies the teacher-learner dyad, the teacher intended as ‘guardian of the ruins’ and the learner as ‘creator of new narratives’. The implication of these two rhetorical figures triggers a speculative (mirror) dynamic that produces a speculative analysis of the present. The artistic side of design reacts because it is necessary to take a mental divergent attitude in order to deconstruct scenarios in search of submerged futures and with the aim of producing new non-Newtonian cartographies.

Students as adolescents are central to the process of creating new narratives and visions for the future. They possess an innate energy and creativity that make them capable of imagining and building new worlds. This ability to generate new narratives is particularly important in an era of rapid social and technological deconstruction such as the 21st century. Adolescents, freed from the constraints of past traditions, can explore new ideas and solutions, contributing significantly to cultural and social deconstruction and reconstruction.

The teacher, on the contrary, is adult, that is the past participle of the learner who is the present participle, the adolescent, the making of the new. The teacher is an adult and for this reason is a witness to the ruins, the guardian of facts, projects, and imaginaries that are now ruins and like all ruins - this is a very Italian thing - are testimonies and teachings. But these ruins have no force if not inserted into new narratives, which we must activate in collaboration, in the creation of a ‘whole’ with

the learner-adolescents.

In this scheme, adults are described as guardians of the ruins, custodians of past traditions and knowledge. This role does not imply a simple passive preservation, but an active action of safeguarding values, memories and social structures that, although they may seem obsolete, still contain valuable lessons. Adults act as a bridge between the past and the future, offering stability and continuity while integrating the innovations proposed by adolescents.

To imply innovation we must rely on the learners, in the sense of relying on the new narratives that in their completed form are always studies of the ruins. The theory emphasises the importance of the interaction between these two groups. Adolescents bring change and innovation, while adults offer experience and models. This continuous dialectic between innovation and preservation is essential for a society that wishes to advance without losing sight of its historical and cultural roots. In the encounter between new imaginaries, the students, and ancient knowledge, the teachers, a new imaginary of the 21st century will emerge (Monico, Campagna, 2021).

VI — why - quārē

The Earth is collapsing, if we do not change we will witness the appearance of the Planet, i.e. we will no longer have a chance to inhabit the Earth (Thacker, 2011). Human society is called upon to radically change its actions; to do so, we must change our thinking, and designers have a mandatory responsibility. Today, the imperative is sustainability directed towards a general ecology, which is the reason why design turns into Socially Engaged Design and triggers the question: what if to de-construct and re-construct a new imaginary for the 21st century we used the techniques of Design, no longer applying them to products, but to society itself? What if we built strategic tools of public utility, to help society and the politics that govern it recover what progress has produced, causing damage to the planet and all its inhabitants, some of which is already irreversible? Systems Design has the ability to decipher complexity and devise open and resilient solutions. The same design languages and techniques that lead us to compulsively consume can guide society to become aware and change its patterns of life. An urgent reversal is needed, because time is running out and the consequences could be dramatic for all inhabitants of planet Earth, be they humans, animals or plant species. We are all in the same wreck together.

This is why we developed the Tippe-top design in our work at ISIA Roma Design (Monico, Datti, Damiano, 2022). The ISIA training model is functionally characterised by a selected and motivated student body, which guarantees efficiency and performance, and by a teaching staff made up of professionals and artists selected not only on the basis of the curriculum, but also with respect to the emerging needs of teaching, production, the spread of new technologies, and social change. The didactic experience of the

students of the three-year course in Design, suggests that the point of the new generations should be in tune with deconstructing and reconstructing the imaginary, i.e. changing the point of view. This led to the idea of a seminar + workshop. The participants were third-year students of the three-year ISIA Roma Design course, academic year 2020/2021. Members of Generation Z with a background in design, who debated with the lecturers of the same institute and the Italian Minister of University and Research, Prof. Lorenzo Fioramonti, the Member of Parliament and scholar of educational forms Alessandro Fusacchia, and Dr. Michele Torsello of the Italian Ministry of Infrastructure, this meeting aimed to work on *"The political role of systemic design in contemporary society"* and offered a new point of view to imagine the new "welfare systems" (Isia Roma Design, 13 September 2021).

Because values determine human choices, both individual and collective, not necessarily in a rational manner (in branding this is well known and the induction to targeted consumption is the consequence), Tippe Top's methodology is Speculative Design and thus aims to identify those practices consistent with the value field generated by the insertion or production of a **new imaginary** with respect to the previous one. The value field traces the types of route we take to move from one Imaginary to another.

The aim of the Tippe Top methodology is to induce positive change, both shared and radical, gradual but intensely progressive, capable of re-forming compromised systems, particularly from an ecological (in its broadest sense) viewpoint. Nowadays, the axis of the imaginary is in precession to the axis of technology, from which we assume our needs, desires and expectations. The more we use technical devices, the more this precession prevents us from grasping change and becomes stronger. That is why we no longer have to solve the problem within the conditions posed by the problem itself, i.e. in a convergent manner, but rather analyse and design in a divergent manner, beyond the conditions posed by the problem itself, which means widening the range of possible solutions by generating ideas without fear and restrictions. Today, in the 21st century, we must think of the world not with our eyes turned towards the past, but with our eyes projected towards a contemporary that is not yet given. *Tippe Top Design* is founded precisely on the speculative effort to see things from opposite points of view, according to the logic that we have to get out of an obsolete imaginary in which we are immersed and put ourselves in a position to act out an always already new 21st century. It is a design-perceptual artifice that aims to bring the designer 'out of the automatism of perception'.

It is a deliberate disorientation of the designer, the purpose of which is to accustom the subject to a mental openness towards new, unexpected and alienating aspects of a project. It is a training that allows new perceptions and aesthetic experiences through which subjects and objects are reconfigured. Design thus becomes the

occasion for a transformation, also political, of the designer, who is therefore endowed with a new awareness.

The name is derived from the particular *Tippe Top* spin, which, unlike 'normal' spins, adds the effects of frictional forces to the forces of rotation and gravity, so that the spin suddenly turns over on its own axis of rotation. The rotation axis of the Tippe Top is not fixed, but free. This is why the spinning top turns in the same direction for the outside observer and in the opposite direction for the gnome inside. This led to the theorisation of Tippe Top Design, i.e. a particular design method that deals with changing freedomly the point of view of the observer-designer, which is to say that the designer, whether a senior designer or a student, must change his or her imagery in order to equip himself or herself to face the 21st century. Where the inner gnome of the spinning top is the configuration of the background of effects, the reality of a present that we are not normally given to perceive, since we are immersed in the shared cultural narrative and therefore always obsolete.
In fact, Tippe Top Design is a speculative radical systems design that overturns points of view and seeks to be re-volutionary, that is, to reverse the point of view on things by updating it

conclusion - fīnītĭo

Faced with the end of the 20th century narrative, with the coming of globalisation and thus the redefinition of socio-economic arrangements, we have entered the 21st century and must reformulate new narratives, this task belongs to the artist and designer. Everything is either true or untrue, true and untrue, neither true nor untrue; there is no more truth because the future has run out and we cannot look back because it is that backwardness that has led the world to its decline, we must therefore rewrite the future and rethink the world.

Today we have to cure new knowledge inside an empty space, a dialectical place between opposites, a process of a continuous becoming of theses that become antitheses and immediately mutate into new theses. Because as the modern ends, ideological visions and attachment to an idea of truth come to an end. Truth becomes an empty space at the centre of opposing tendencies (dialectics), it becomes the space for the negotiation of new knowledge. It is a positive nihilism insofar as it consists in the transvaluation of all values in the discovery of submerged futures and is to be implemented **in fashion, politics, architecture, theatre, art, information, music, science, design, religion, the market, economics, literature, food and philosophy**. (Progetto arte, M. Pistoletto, 1995-96)

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summary

1. Everything is either true or untrue, both true and untrue, neither true nor untrue;
2. Adults are the guardians of the ruins, teenagers are the creators of new narratives;
3. There is no difference between thinking and doing, the design of thinking and tools as well as society and the human itself belongs to the same whole;
4. Education and thinking, artifice and theory are thus the same thing;
5. Product design and speculative design must act together;
6. We are stories, the mind defines itself in narratives. Education is narrative;
7. The *Formula of Creation* as a thesis-antithesis-synthesis scheme that therefore produces theses that immediately imply an antithesis, is the continuous dialectic of the process, is the space for the negotiation of new knowledge, and is the most viable method for 21st century design.

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CO-DESIGNING FOR EQUITY: ADDRESSING ANTI-BLACK RACISM IN THE ARTS IN CANADA- A WORKING PAPER

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ABSTRACT | The Make Some Noise: Hidden Stories of Black Creatives in Canada was a co-design research study with Black creatives across Canada that represented diverse disciplines of design, visual and performing arts, film and spoken word. The central research question of the study was, "What are the barriers that Black creatives encounter in Canada?" The study mapped the ecosystem across Canada of barriers and facilitators affecting the progression of the creative practice of Black creatives. The study gathered perspectives from artists and designers self-identifying as emerging, mid-career, or established.

In total, 68 Black creatives participated in ten virtual co-design research consultations. They were asked to map their journeys from emerging creative to established creative and to map the locations where they encountered structural barriers or the facilitators on their journey map. Twenty-two of the Black creatives also took part in speculative co-design sessions to inform the design of a resource tool that would support their creative practice, strengthen their creativity and overcome the barriers they reported. Participants in the speculative co-design sessions worked in small teams in which they envisioned the shape, content, and key functions of a resource tool. In addition to identifying essential characteristics of the resource tool, they speculated on how the tool would be accessed and how it might be used now, and in the future. All consultations were conducted using the online collaboration tools, "MIRO," and "Microsoft Teams" between October 2023 and January 2024.

This research unraveled the stories of the lived experiences of Black creatives through the practice of Endarkened Storywork. The inclusion of their stories and their voices was central to the co-design of a resource tool. Key themes that emerged from the stories they shared are: 1) institutional anti-Black racism, 2) lived experience with racism, 3) protective factors and empowerment, 4) creating opportunities for ourselves, 5) overcoming institutional barriers, 6) finding creative solutions: opportunities, successes, economic sustainability, and 7) resources needed.

The study provided the evidence needed to create an equitable landscape and create funding opportunities and other resources to support Black creatives. The study also investigated the feasibility of co-designing a "crowd-sourced" resource tool. The participatory design approach recognized participants as subject matter experts with lived experience knowledge to inform best practice. The study empowered participants to be agents of change.

This study contributes to the discourse on design's role in fostering positive societal change.

KEYWORDS | CO-DESIGN, RACISM, EQUITY, PARTICIPATIVE DESIGN, CANADA

1. Background

The work of Black creatives is underrepresented in Canadian art galleries, museums, theatres, music venues and the design industry. It is crucial to understand why Black creatives are underrepresented in various art forums to advance diversity and inclusivity within cultural and artistic spaces in order to pave the way for more vibrant, creative cities in Canada (Canada Council for the Arts, 2021). Black creatives have reported experiencing barriers to accessing resources to support their creative practice and opportunities to showcase their work (Toronto Arts Council, 2023). Therefore, the central research questions of this study were, 1) what are the characteristics of the barriers that Black creatives encounter in Canada and 2) at what stage in their creative practice are barriers encountered?

The United Nations Proclamation of the International Decade for People of African Descent 2015 - 2024, was adopted in recognition of the fact that people of African descent experience many forms of discrimination (United Nations 2014). In this research, we sought to uncover the hidden stories of Black creatives' experiences as they navigated structural barriers when attempting to access resources needed to advance their creative practice in Canada. The research also investigated the relationship between barriers encountered and racism. Moreover, the research sought to examine the cultural ecosystem to identify whether the barriers are structural by design. Cabana et al (2020) found a gap in the literature of studies of cultural ecosystem mapping, highlighting the underrepresentation of arts categories in ecosystem mapping studies. This study addresses the gap by engaging Black creatives in the process of mapping the arts landscape to provide evidence for reforms needed for equitable support of Black creatives.

Using co-design, a participatory research method, the research mapped the arts ecosystem barriers in five Canadian regions and their impact on the creative practice of Black creatives across Canada. Factors that supported and strengthened career progression and creativity were also studied using codesign. Co-design research

emphasizes collaboration, inclusivity, and shared decision-making. According to the literature on co-design, this approach is more beneficial for driving systemic change than other forms of research because it allows diverse perspectives to be included in the research process, leading to more innovative and effective solutions (Calvo & Sclater, 2020). Codesign research can play a vital role in driving systemic change by providing evidence of and challenging inequalities to inform policies that foster a more equitable and inclusive cultural landscape (Calvo & Sclater 2020).

Findings from this research can inform policy aimed at addressing disparities (Blomkamp, 2018), promoting equity in the arts, advancing strategies for increasing representation, improving access to resources, and fostering inclusive artistic environments. Furthermore, exploring the experiences and perspectives of Black creatives contributes to a deeper understanding of cultural identity, community resilience, and the role of art in social change. Research aimed at co-designing for equity in the arts sector is essential for enriching cultural discourse and ensuring that artistic spaces reflect the diversity of society. This study contributes to the discourse on design's role in fostering positive societal change. The research was approved by OCAD University Research Ethics Board REB number 2022-70.

2. Theoretical Framework

The theoretical frameworks underpinning this research are Critical Race Theory (CRT) and Nguzo Saba. The multilayered barriers revealed in the shared stories of the participants are explained in the context of CRT. CRT explains that racism is structural and is a means by which society allocates privilege and status (Stefanic & Delgado, 2017). The economic landscape and social fabric have racism as its roots, and therefore, racism is hardwired into racial inequality (Carbado & Roithmayr, 2014). CRT provides a critical analysis of the dynamics of power and privilege characterized by white supremacy (Delgado & Stefanic, 2017) that impact the experiences of Black creatives.

Nguzo Saba is an African framework that comprises seven principles (Figure 1). They are Umoja (Unity), Kujichagulia (Self-determination), Ujima (Collective Work and Responsibility), Ujamaa (Cooperative economics), Nia (Purpose), Kuumba (Creativity) and Imani (Faith). The Nguzo Saba framework encompasses African diaspora epistemologies such as Ubuntu. The framework's guiding principles are grounded in Kawaida Theory, a liberatory ideology for social change (Karenga, 2000, 2017; IBW21, 2012).

The research is also viewed through a lens of the African philosophy of Ubuntu. Ubuntu is anchored in community, interdependence, compassion and belonging (Muwanga-Zake, 2009). Ubuntu embraces collective responsibility to contribute to

humanity (Muwanga-Zake, 2009). Several Black creatives in this study designed and developed creative, culturally based solutions to the barriers they encountered for themselves and fellow Black creatives, for which the Ubuntu lens is explanatory. Ubuntu fosters the inclusion of diverse cultural perspectives. The Ubuntu Indigenous knowledge "is based on the idea that as human beings we depend on other human beings to attain ultimate wellbeing" (Halifax Regional Municipality, 2021).

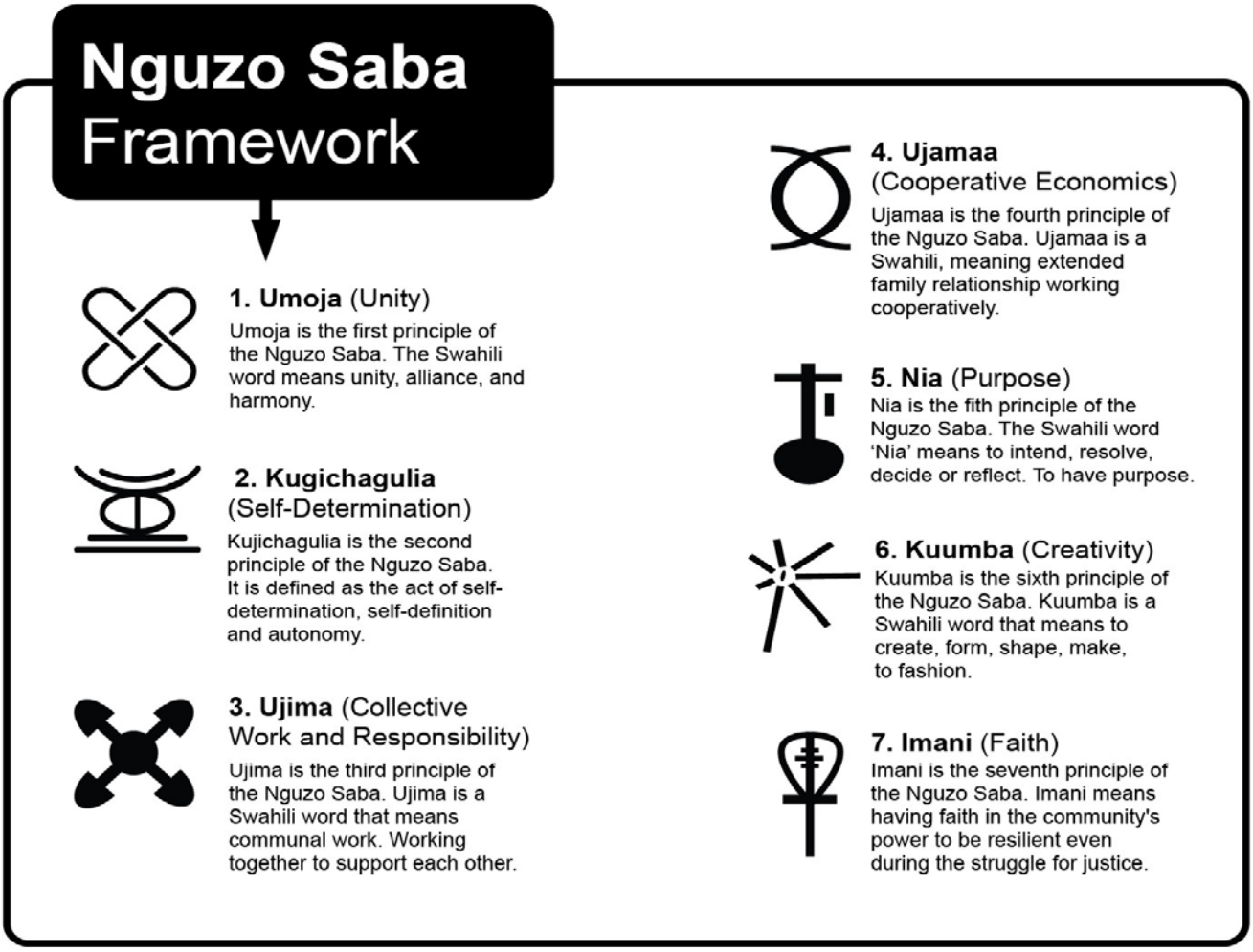


Figure 1. The Seven Principles of Nguzo Saba. Adapted from Nguzo Saba (The Seven Principles), Karenga, M. 1999, Accessed 28 July 2024 from https://digital.libraries.psu.edu/digital/collection/blackhistory/id/16/

3. Methodology

The Make Some Noise study was designed as communitybased emancipatory and liberatory research (Figure 2). A convenience sample of 68 Black creatives across Canada participated in one of ten regional co-design research consultations across five study regions. The 5 study regions were Atlantic Canada, British Columbia, Ontario, the Prairies/Territories, and Quebec. Separate consultations were held with visual artists/designers and

performance artists to investigate similarities and differences between the experiences across a range of creative practices. Performance artists included musicians, DJs, actors, filmmakers, spoken word artists, and singers. The distribution of Black creatives participating in this study by region and creative practice is shown in Table 1.

Table 1. Distribution of Black creatives by region and creative practice

	Quebec	Prairies	Ontario	Atlantic	British Columbia
Visual Arts & Design	8	8	10	5	7
Performance Arts	6	6	7	5	6

All participants contributed to the Phase 1 consultations and twenty-two of the Black creatives also took part in one Phase 2 speculative co-design session that aimed to inform the design of a resource tool to support their creative practice, strengthen their creativity and overcome the barriers they identified. In total, twelve 3-hour consultations were held between October 2023 and January 2024.

All consultations were conducted using the online collaboration tools "MIRO" and "Microsoft Teams."

The research methods included: facilitated small group discussions, journey mapping, priority mapping, and speculative co-design. Emancipatory research methods, such as speculative co-design, democratize the design process by empowering participant agency, advancing diverse perspectives and fostering participatory design (Calvo & Sclater, 2020). Similarly, Livingston (2023), found that arts-informed research methodologies encouraged experience sharing in their study of Black male's university experience using mixtape methodology. The research methods selected positioned the participants as subject matter experts whose lived experience and understanding of the world around them could inform policy, resources, and tool development to support Black creatives. As such, study participants served the dual role of consultant and co-designer.

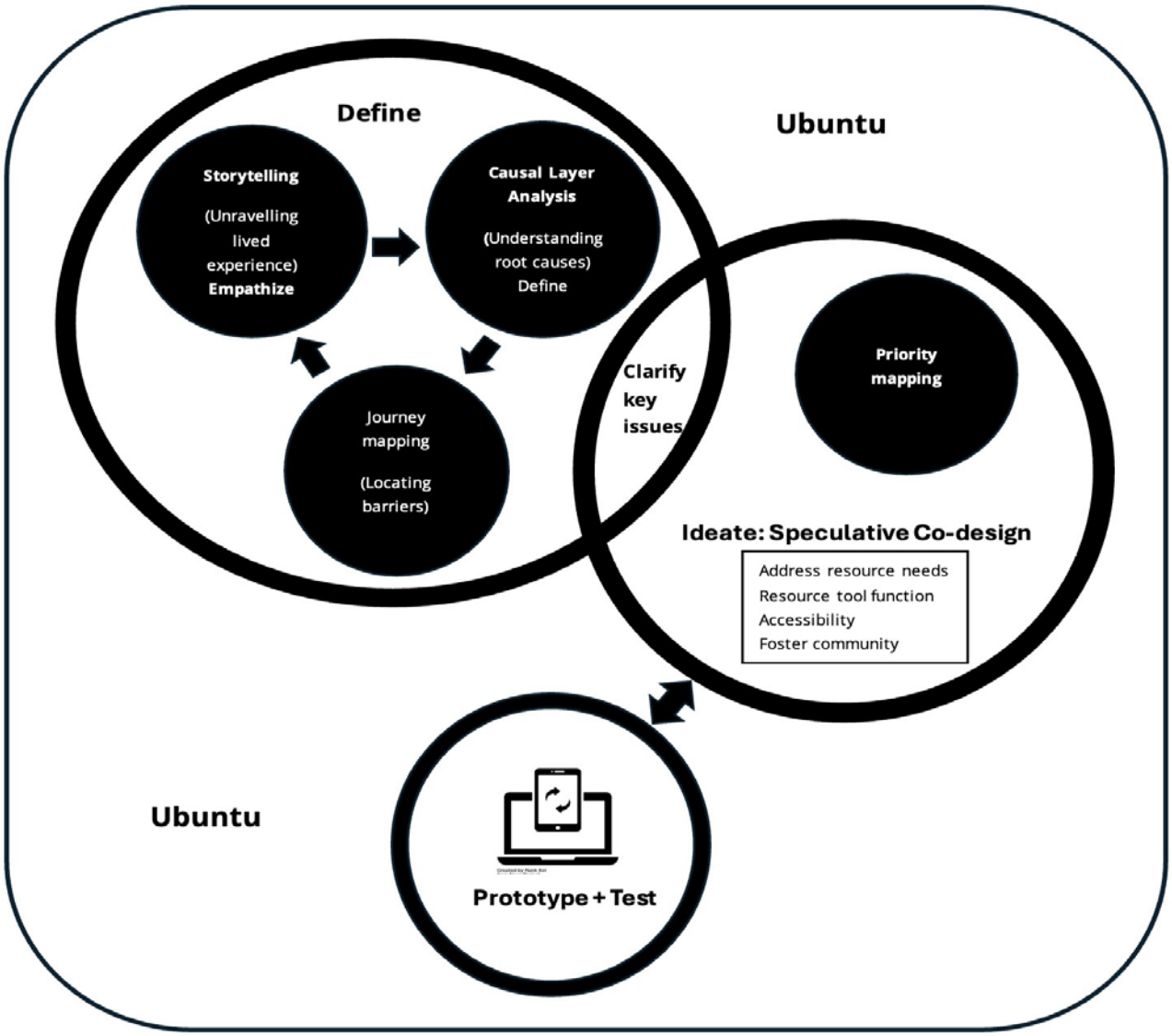


Figure 2: Emancipatory Co-Design Process

Phase 1- Defining the Problem: Black creatives across Canada mapped the ecosystem of the barriers and facilitators affecting the progression of their creative practice. They also mapped their individual journey within the ecosystem. Qualitative mapping is a research method that involves illustrating a journey or process and then describing the illustration in an interview or conversation (Marx, 2023). The research method centers the participants' stories, experiences and perceptions (Marx, 2023). In this study, the mapping activity was employed to understand the characteristics of an ecosystem(s) that is determinant of successful career progression, as well as barriers that disproportionately affect Black creatives' creative practices.

The journey map prompt was:
Reflect on the barriers you have encountered

and create a journey map showing the stage in your creative practice where the barriers were most prevalent. How would you categorize the barrier(s) (e.g., funding, opportunities to showcase work, racism, skill building, access to maker tools, other)? Show on your journey map where policy might remove barriers or support your creative practice.

The individual journey mapping activity was also a story mapping method used to stimulate dialog about participants' overlapping experiences and prompt the cocreation of a list of priority areas for change. Story mapping is an accessible, userfriendly research method. Story maps integrate narrative and visual information (Cabana et al., 2020). They can communicate complex, impactful perspectives and can be created with simple analog tools. Story maps integrate narrative and visual information (Cabana et al., 2020). Through storytelling, participants' ideas, thoughts, suggestions, and recommendations emerge (Tolliver, 2022). In this study, stories were shared, via a "Think Aloud" process (Van Someren et al., 1994), through which participant's designs and ideas for addressing the barriers they encountered were revealed. The inclusion of their stories in their voice was central to codesigning the resource tool.

Phase 2- Co-designing solutions: The participants in the speculative co-design sessions worked in small teams to envision the shape, content, and key functions of a resource tool. Open communication was encouraged, emphasizing a "no bad idea" approach. In addition to identifying essential characteristics of the resource tool, participants were asked to speculate on how the tool would be accessed and how it might be used now and in the future. The speculative co-designed sessions were consistent with Black Feminist Afrofuturism that supports acts of discovery, co-design, crowdsourcing, and documentation of time, history, place, and the expression of freedom through storytelling (Toliver, 2022).
Speculative co-design prompt:
It is the year 2024 and you have been appointed to be a part of a team that is tasked with designing a resource(s) that will support Black creatives at all stages in their career. Your team has been assigned a persona of an emerging creative, midcareer creative, or established creative and asked to reflect on the needs of the creative in the specific stage of their career. You may design the resource(s) using any materials of your choosing.

1. What shape should the resource or tool take?
2. How do users access the resource(s)?
3. How can the resource build community and/or foster networking
4. How do you see yourself and/or other users contributing to user-generated content?
5. How do you keep the resource(s) current?

Qualitative data analysis included content analysis of the co-design group discussions, causal layer analyses and priority sorting data activities. Transcripts were read iteratively and coded, and key themes were identified using Atlas ti v14. Intercoder reliability was checked by assigning 2 or 3 researchers to code each transcript. The key themes that emerged from the stories participants shared were: 1) institutional anti-Black racism; 2) lived experience with racism; 3) protective factors and empowerment; 4) creating opportunities for ourselves; 5) overcoming institutional barriers; 6) finding creative solutions: opportunities, successes, economic sustainability; and 7) resources needed. The key themes emerging from this study are described in the results section. Their intersectional relationship to the Nguzo Saba theoretical and analytical framework is also contextualized.

4. Results

The stories told by Black creatives in this study illuminated the pervasiveness of anti-Black racism in the arts sector in Canada and its effect on the economic viability of their creative practice. This was due in part to barriers to accessing grants and other funding streams, limited opportunities and spaces to showcase creative work, and undervaluation of the creative works they produced.
The research also revealed resilience in overcoming the barriers encountered that was fostered by self-empowerment and Black community support.

4.1 Institutional Racism: Black Creatives Lived Experience with anti-Black Racism

The study found that Black creatives experienced widespread, pernicious, and covert anti-Black racism within the arts sector. This racism impacted their economic sustainability by limiting their access to grants and other funding, reducing their visibility, excluding them from opportunities, and undervaluing their work. Implicit biases and stereotyping also hindered their career progression and viability due perceived gatekeeping and reluctance of arts venues showcase Black-identified work. Black creatives expressed that the emotional toll of anti-Black racism, made them feel marginalized, tokenized, and led to burnout. A comprehensive map of anti-Black racism's manifestations is shown in Figure 3.

Anti-Black racism affected emotional well-being, financial well-being and directly impacted creative practice. Anti-Black racism was perceived as a systemic barrier by participants collaborating in the causal layer analysis mapping activity. They mapped anti-Black racism beneath the surface of the iceberg, highlighting its hidden yet insidious nature. One Quebec performing artist shared that covert antiBlack racism left them feeling uncertain about labelling their experience as racism because no one explicitly stated that racism was the cause for the denial of opportunities.

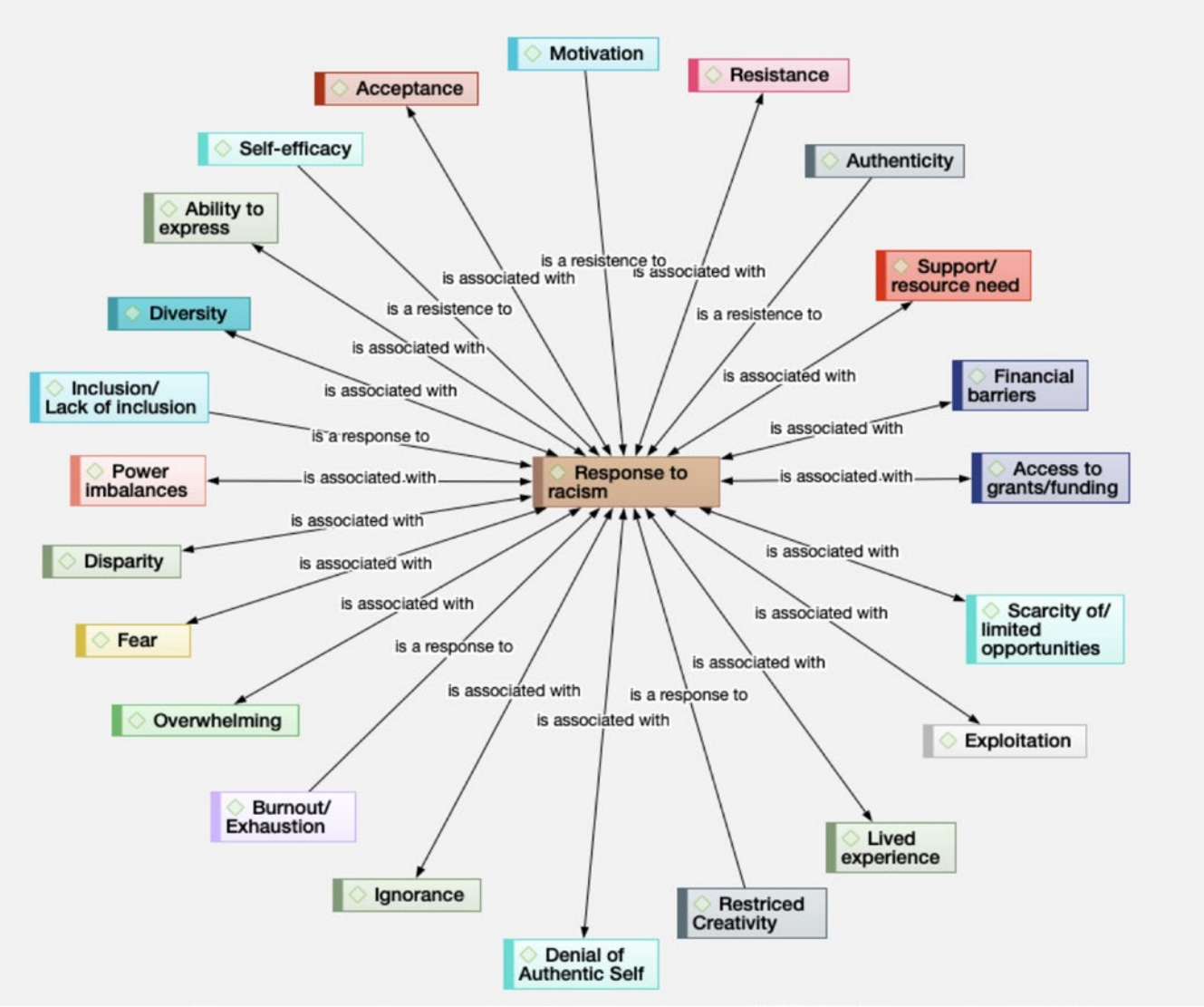


Figure 3. Effects of Anti-Black Racism

"...it's part systemic...the system deprioritizes Black people, Indigenous people and people of colour... one of the things for me about Canada is that racism can be very insidious... like when you're asking yourself, is it because I'm Black? It's usually because they didn't say it's because you're Black."

(QUEBEC PERFORMANCE ARTIST)

Anti-Black racism was described as a reason for creating things that were palatable for [white] people who are supporting the art and predominately white venues and galleries where work might be shown. One British Columbia participant shared that they feared losing opportunities to showcase their work if they were authentic, thereby limiting their artistic expression.

"...it's like a tug of war of like, are you being authentic as an artist and are you, or are you just playing into what everyone wants you to see? And there is kickback and resistance I feel too, especially as a black male within artistic spaces of just obviously don't be too aggressive. Don't be too loud. Like policing my body and policing my expression and then, you know you're not expressing from this the center of who you are..."

(BRITISH COLUMBIA ARTIST/DESIGNER)

They shared experiences whereby predominantly white mainstream galleries and venues outside of urban centres were reluctant to showcase work depicting Black culture because it would not be accepted by their clientele. In contrast, other participants talked about their creative practice being objectified. "Black art" has been reduced to a restrictive category of representational art by a majority White audience, and there is a "failure to understand that we're not cookie cutter. We're not gonna create cookie-cutter experiences of art for our audience to consume." (Quebec Performance Artist).

Microaggressions were encountered regularly by Black creatives participating in this study, which was described as exhausting.

"Having microaggressions and all of that thrown at you constantly and that wears on you. And that really wore me down to a point where I didn't know if I wanted to work in film...if it's this toxic environment."

(BRITISH COLUMBIA ARTIST/DESIGNER)

In the next section, participants' responses to the anti-Black racism that they experienced in their creative practices, are described using the Nguzo Saba African framework.

4.2 Umoja (Unity)

Umoja is the first principle of the Nguzo Saba. The Swahili word means unity, alliance, and harmony. Black unity, cooperation, collaboration, and community were described as important to progress in one's creative journey and were linked to the key theme: protective factors and empowerment. Umoja embodies a practice of coming together as a Black community for mutual benefit. Community was identified as a key theme in this study. Being connected to a Black community of creatives was cited as a mechanism to address systemic barriers and combat the negative effects of anti-Black racism.

"All of this, all of the things that we're experiencing, all of the oppression we're experiencing is a distraction for us not to create, for us not to thrive and not to [have] drive and not have joy. So, the importance is for us to keep giving each other spaces to create, to love, to have

joy, and to live still and to thrive. I think [that] community can really do that."

(QUEBEC ARTIST/DESIGNER).

Community was also described as a resource for work opportunities, mental health support, encouragement, funding, mentorship, information, and opportunities to learn skills. Being associated with a community of Black creatives helped to build confidence in one's practice and self-concept, held space for conversations where individuals' voices could be heard, and experiences would be validated. Participants expressed the importance of reciprocity, whereby they had a responsibility to contribute to the Black creative community and many saw this as a call to action to create opportunities for themself and other Black creatives especially in regions like British Columbia where the Black creative community is sparse. The effects of isolation or exploitation have led some to entertain thoughts of giving up a career in the creative field.

"The disjointedness of our community has a direct relationship to the economic precarity as artists."

(BRITISH COLUMBIA PERFORMANCE ARTIST).

Black artists/designers in Ontario and Quebec described what they perceived as impediments to building a collaborative community. Silos between peoples of the African diaspora (Caribbean, Black Nova Scotians, Brazilians, Spanish speaking communities), as well as Anglophones and Francophones, created barriers that, if removed, would foster a "really unified Black artistic community [that] would allow Black creatives' creative practice to flourish in Canada and internationally because we're all in the same boat and we kind of want some of this community where we can all help each other rather than work like fighting against each other." (Ontario Artist/Designer).

4.3 Kujichagulia (Self-determination)

"I feel like I'm the most effective, efficient, creative, powerful being that has ever existed. And I hold that optimism within my spirit, and I do not allow anything to compromise that. But I am aware that others do not see me that way."

(BRITISH COLUMBIA ARTIST/DESIGNER).

Kujichagulia is the second principle of the Nguzo Saba. It is defined as the act of self-determination, self-definition and autonomy. The principle of Kujichagulia encourages individual and community empowerment to tell their story, shape their own destiny and assert their voices in the broader society (International African American Museum, 2023).

Black creatives recounted their experiences with precarious employment, funding and resources to support their creative practices and "seeing things that are blocked and saying I have to create this for myself and create it for others because otherwise it's just not going to happen" (Quebec Performance Artist). The scarcity of opportunities led many of the Black creatives in this study to take a leadership role to advocate for and create

opportunities to showcase Black creative arts in their city. In this study, we found that creating a Black-led support system was connected to leadership, advocacy, community, collaboration, grassroots organizing, unity and empowerment. These characteristics were aligned with the key themes of protective factors, empowerment and creating opportunities for ourselves. In this study, advocacy and activism were shown to be strongly connected to Black leadership. Black creatives advocated for exhibition space, resources, and funding to support their own creative practice and for others. One visual artist from Winnipeg stated that "they have been uplifting other black creatives in the city, including music artists and media artists." One participant shared a story of a Black female DJ in British Columbia who raised money on Instagram to give to artists in need during COVID. The storyteller stated they received $700 in much-needed support. They commented, "Wow, look at this individual who wasn't gonna wait for an organization to do it…took matters into their own hands and just posted on Instagram and helped so many people."

Writing one's own story of success left some participants feeling discouraged and exhausted. They commented that they lacked leadership training and knowledge to create their own artist-run centre.

"I'm just thinking that again, this whole lack of leadership, leadership training, you know, when we talk about the establishing artist-run centers, yeah, how, where do we get the knowledge? So, for me, the iceberg is about knowledge… And so, although I want to start an artist-run center, I just don't have the strength. I don't have the knowledge…So that's a deterrent in a lot of ways."

(PRAIRIES ARTIST/DESIGNER)

Others shared that advocating for oneself and other Black creatives felt like a constant campaign effort. One British Columbia Artist/Designer queried, "Who is the artist with the resources and the time and the energy?" They noted that constant self-advocacy can negatively impact the sustainability of a Black creatives' practice because of the amount of time required.

4.4 Ujima (Collective Work and Responsibility)

Ujima is a Swahili word that means communal work. Within the Nguzo Saba framework, Ujima is interpreted as collective problem-solving to improve conditions and working together to support each other and the Black community. In the context of this study, participants described being supported by Blackfocused, Black-led organizations and support systems. Our analysis showed a relationship between Black-focused organizations and advocacy, Black leadership, cooperation and collaboration, empowerment, and joy. Two key themes emerged from the data related to Ujima. They were protective factors, empowerment and creating opportunities for ourselves.

Black-led organizations and Black arts collectives were described as safe spaces to express oneself without feeling judged or suffering microaggressions. Examples of Black-led organizations that were cited as providing supports, such as connecting emerging creatives with established artist mentors, peer support, networking prospects, and opportunities for Black creatives to showcase their work were: Black Artist Network in Dialog (BAND), Nia Centre for the Arts, and Vibe Arts in Toronto, Afro Van Connect and the Vancouver Black Library (Vancouver), the Black Arts Centre (Surrey), Black Artists Network of Nova Scotia (BANN), and Black Theatre Workshop (Montreal). Riverdale Hub (Toronto), a non-Black led centre was also described as beneficial.

"I'd also say Riverdale Hub is a great organization that provides workshops and the ability to showcase your work as newcomers, marginalized women specifically. I recently started a textile workshop through them, and they provided all the materials for free. There were three instructors ranging from dyeing to embroidery arts and we received free access, like free tickets to the Textile Museum."

(ONTARIO ARTIST/DESIGNER)

Black artist collectives have emerged as hubs to showcase Black art and foster recognition of Black Artists. The emergence of Black arts collectives was described by one Prairie Visual artist as 'beautiful' because "we're able to pull [together] resources and also advocate for each other in particular ways." In the spirit of Ujima, one Ontario Artist/Designer queried, "How do we advocate for abundance? Meaning there is more than enough for you, for you, for you, for me. We don't have to feel like we're grabbing and trying to claim this thing before you can."

4.5 Ujamaa (Cooperative Economics):

Ujamaa is a Swahili word, meaning extended family relationships. It formed the basis for socio-economic policy in Tanzania under President Julius Nyerere. Ujamaa was characterized by cooperative village economics (Swahili-English Dictionary, 2023; Ashly, 2020). In the Nguzo Saba, Ujamaa teaches the importance of shared work, shared wealth and making decisions for community benefit and sustainability (IBW21, 2012). The key themes emerging from the data related to Ujamaa were finding creative solutions, opportunities, successes, and economic sustainability as well as protective factors and empowerment.

This study's Black creatives shared their stories of balancing employment with their creative practice when income earned from their practice was not economically sustainable. They found that building a network of community relationships provided support when resources were limited. A visual artist from the Prairies described working to create a hub for Black artists to showcase their work and increase visibility, like collective art spaces in Nigeria.

"Yeah, so I encouraged this thing when I came here, I noticed that they didn't have like [a] group of artists together. You know a collector can visit an artist in his studio and see another artist's pieces or artist's works. So that could be like marketing for the other artists. So that was this kind of space we had in Universal Studio of Arts in Nigeria where you have sculptors, you have painters, you had people into visual art space that were practicing tirelessly."

(PRAIRIES ARTIST/DESIGNER)

They also encouraged purchasing services ands needed skills from each other to improve economic viability and wealth. For example, one participant stated their willingness to pay a percentage of a grant's value in exchange for help writing the grant.

"So, to be able to give them a percentage is keeping that wealth in the Black community and that was very amazing. And through that experience I learned it's all about unity and working together that's basically what I got for that."

(PRAIRIES ARTIST/DESIGNER)

4.6 Nia (Purpose)

The Swahili word 'Nia' means to intend, resolve, decide or reflect (Swahili-English Dictionary, 2023). In the Nguzo Saba, Nia is contextualized as having a purpose, and, in this study, 'purpose' was identified as empowerment to create independent self-run organizations and support groups when little or no support for their creative practice was found. Black creatives also sought ways to empower themselves by seeking to become members of relevant decision-making organizations. Empowerment refers to the positive attitudes that strengthen an individual's sense of agency. In this study, key themes related to empowerment were resilience, pride, celebration, community, encouragement, acceptance, selfadvocacy, self-care, self-reliance, peer support, support from allies, family support, as well as generational wealth.

"There is a huge opportunity for the art sector in not only Canada but in Alberta and Edmonton to explode … It's just gonna be on the sweat and tears of the people who are like me. But it's fine, as long as there's a progression along, there's progress in our communities. I am willing."

(PRAIRIES ARTIST/DESIGNER).

However, of the few Black creatives who shared their perspectives on having a sense of control over the decisions affecting their creative practice, only the individual that described themself as being mid-stage to established in their career perceived degrees of freedom to choose or opt out of an opportunity to showcase work when the opportunity felt undervalued or exploitive. Emerging creatives felt a need to accept everything offered.

"One big thing, really where we are now is accepting the 'no's' and actually being

okay with saying no to opportunities cause not every opportunity is a good one. And not every money is good money or money that aligns with the value of what we wanna do, with the gifts that we have."

(QUEBEC PERFORMANCE ARTIST)

Those who had found success in sustaining their creative careers still experienced struggles related to undervaluation of their work and not being paid the same remuneration as their white counterparts.

"I've been able to circumvent or balance things out by having an interdisciplinary practice. So, one part of my practice could help in chipping in for another part of my practice. For example, my painting practice could fund my installation practice or whatever, my ceramic practice or my sound practice."

(PRAIRIES VISUAL ARTIST/DESIGNER)

4.7 Kuumba (Creativity)

Kuumba is a Swahili word that means to create, form, shape, make, or fashion. Black creatives found ways to be resourceful when they did not have access to resources. They maximized the use of the community services available. Local libraries played a big role in giving access to software such as professional industry-standard Adobe Creative Suite, film, animation, audio and artwork production software. The library provided access to computers and software that allowed them to compete in their industry and or complete their creative projects. They shared that a library card enabled them to take advantage of online education, masterclasses, and access databases for research. One Ontario Artist/Designer shared, "I know the Public Library downtown on Yonge [Street], also. Once you have a library card, they have the full Adobe suite on their computers. If you do not have any of those, because they are really expensive to try and get yourself, they do. You can have access to it." Another shared, "They also have free access to some master classes through Hoopla. ...really cool drawing classes actually...and there are a couple of great movies about artists that I have a list now that I'm gonna watch and that can inspire me." Key themes that emerged from the stories they shared were finding creative solutions, opportunities, successes, and economic sustainability. To increase sustainability, they shared information about environmental practices and where to find inexpensive materials and access sustainable materials in their work.

4.8 Imani (Faith)

Imani means faith in Swahili (Swahili-English Dictionary, 2023). In the context of the Nguzo Saba, Imani means having faith in the community's power to be resilient even during the struggle for justice. Key themes that emerged from the stories participants shared, that were associated with Imani were: protective factors and empowerment, creating opportunities for ourselves, and overcoming institutional barriers. Despite lived experiences of anti-Black racism within the creative

industries in Canada, Black creatives in this study exhibited optimism and hope grounded in a sense of belonging, acceptance, and connection to the community that they saw as a resource to continue moving forward. One participant noted, "It's good to feel uplifted by people who face the same challenges as you but also who can distract you from that. And inspire you to not be distracted by the oppression and the struggle" (Quebec Artist/ Designer). They held faith in the community of Black creatives to guide and support them and sought mentorship opportunities.

"I said [to the Edmonton Arts Council], is there anybody that you can introduce me to so that not only can I have someone that I know that's like me, but that my imagination could be stimulated, and my creativity doesn't have to be stifled? And so, they introduced me to a bunch of artists...a bunch of poets and musicians, which is all I've been looking for. And Black people like when we're in this type of space where we don't have a lot of people, we do gravitate towards each other. So, I found that we give each other opportunities, especially when it's like there's nobody there."

(PRAIRIES ARTIST/DESIGNER)

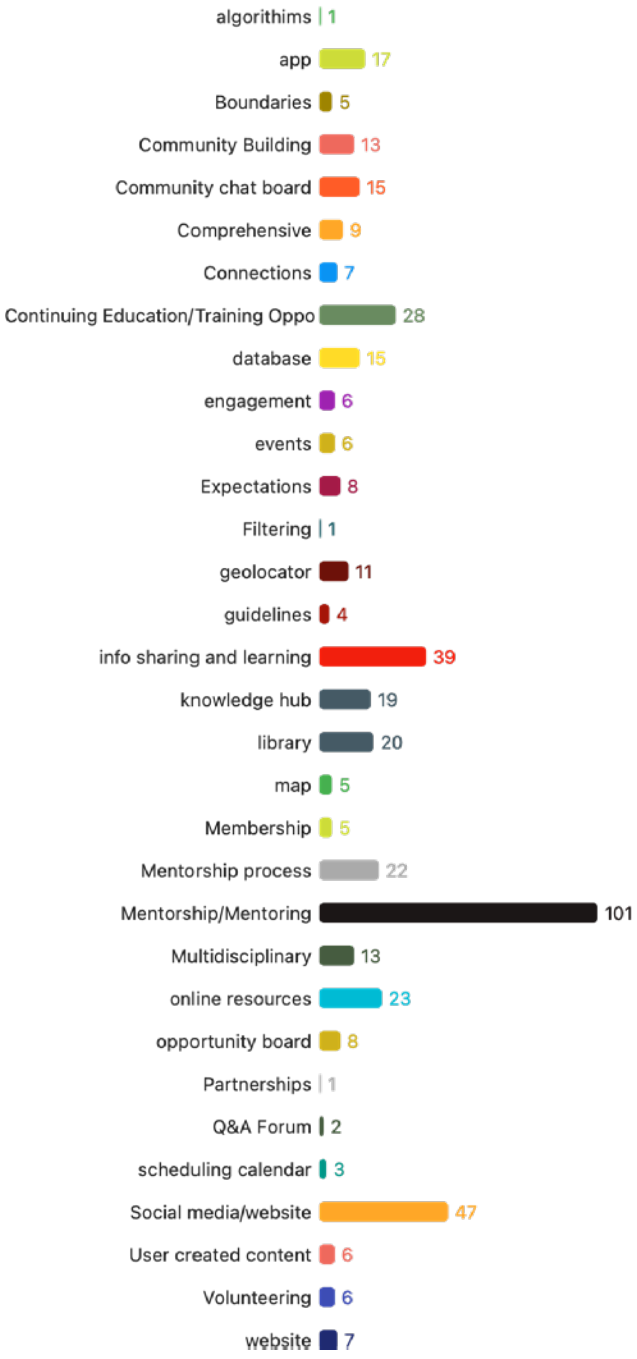
4.9 PHASE 2: CO-DESIGNING SOLUTIONS

Resource needs was a key theme that emerged from the stories Black creatives shared about progressing in their creative practice. They disclosed that they had a significant knowledge gap in key areas they believed could help them progress. The gap could be reduced by creating an accessible centralized knowledge hub.

"A centralized hub, I think it would be more effective in dispersing that information while also serving as a way to connect with each other."

(ONTARIO ARTIST/DESIGNER).

Black creatives participating in the speculative co-design session were invited to use any tool of their choosing (e.g., pencil & paper, Miro, sample wireframes or other options) to ideate on the characteristics and function of the resource tool now and in the future. They shared ideations centered on a tool that would function as a centralized hub. They highlighted the need for an online resource tool with a responsive design whereby participants could connect via a mobile phone or device. Their designs were modeled after the public library, facilitating easy, free access to its resources. The tool would be a knowledge hub for continuing education and training, information sharing, mentorship, a Q&A forum, and other resources. Figure 4



shows the key characteristics identified.

Figure 4. Characteristics of Co-designed Resource Tool

To foster community building, the resource tool would also act as a multidisciplinary community connector for Black creatives to search for partnerships, collaboration, and engage in socializing about their creative practices. To overcome regional isolation, participants speculated on designs that could connect Black creatives across Canada, facilitating collaboration. Ideas were shared for maintaining content currency, who would be authorized to moderate content and how content might be moderated. However, additional research is needed to develop concrete ideas for a crowd-sourced resource tool and test them in the prototype.

5. CONCLUSION

The International Decade of Peoples of African Descent has sought to celebrate the worldwide contributions of people of African descent and "...advance social justice and inclusion policies, eradicate racism and intolerance, promote human rights, and assist in creating better, more prosperous communities" (United Nations 2015). This study increases the understanding of systemic barriers encountered by Black creatives and provides the evidence needed to create an equitable landscape and create funding opportunities and other resources for support.

This study contributes to the discourse on design's role in fostering positive societal change. The study's participatory co-design research methodology recognized the participants as subject matter experts with lived experience and knowledge to inform best practice. This study empowered participants to be agents of change. Our research shows that emancipatory research methods were effective in empowering Black

creatives to actively engage in speculative co-design processes with robust outcomes. The impact may be further enhanced when studies are conducted by researchers who can uniquely understand the lived experience of Black creatives. The Ubuntu philosophy was fundamental to how we designed this research, our work as researchers, and how we connected with those we openly invited to work with us. The Ubuntu approach to the research (i.e., fostering connectedness and humanity), African diasporic frameworks and research methods were purposely selected to foster participation and address general distrust of researchers by the Black community related to negative historical engagement and exploitation (Farmer, Jackson, Camacho, & Hall, 2007).

The research increases awareness of Black creatives' lived experience with racism and exposes anti-Black racism as a barrier to career progression. In exposing the way anti-Black racism is manifested in the creative sector policy makers have evidence to inform policy decisions that will more strongly advocate for resources to support Black creatives. Studies have shown that mere-exposure can affect preferences or aversions; the impact increasing with the amount of exposure (Bornstein & Craver-Lemley, 2017). Exposing the effects of anti-Black institutional racism on creating inequity, can lead to policies that reduce the barriers, advance diversity and inclusivity within cultural and artistic spaces to pave the way for more vibrant, creative cities in Canada (Canada Council for the Arts, 2021).

6. KEY RECOMMENDATIONS

Key policy recommendations emerging from the research and co-design sessions with Black creatives is Canada are shown in Table 2.

Table 2. Key Policy Recommendations

· Increase Black representation in Canadian arts councils
· Provide infrastructure and long-term funding for Black creatives live/work, studio & performing arts spaces.
· Align organizational procedures with equity and inclusion, recognizing the unique needs of Black creatives.
· Incentivize the development of Black-led creative hubs and Black cultural Centres including funding of networks for mentorship.
· Fund the development of Black theatres, galleries, Black arts marketplaces & collectives to showcase the work of Black creatives.
· Develop continuing education/training opportunities to address knowledge gaps in areas such as grant writing and business skills.
· Facilitate trans-regional connections/ partnerships with Black creatives and arts organizations across Canada.

7. LIMITATIONS

The researchers unsuccessful in recruiting Black creatives practicing in the Canadian Territories for this study. Therefore, their lived experience with racism, its impact on their career progression, as well as inputs on the co-design of resource tool remain unknown. More research is needed for user testing of the prototype of the co-designed resource tool.

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EXPERIENCE PROTOTYPING WITH AN EDUCATIONAL ROBOT PLATFORM: DEVELOPMENT AND PEDAGOGICAL REFLECTION FROM AN INTERACTION DESIGN COURSE

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ABSTRACT | Design students in higher education often lack hands-on understanding and tools for designing Human-Robot Interaction (HRI). While many commercially available educational robot platforms require users to have extensive training or prior experience, we developed ADA, an entry-level robot prototyping platform, for design students without any previous background in robotics and programming to better explore and conceptualize HRI design concepts in the early stages of design processes. This paper reports on the design and development of AIDA, along with our pedagogical reflections on its implementation with bodystorming techniques in an interaction design course over the past two years. Our findings show that using AIDA with bodystorming enabled students to rapidly prototype HRI concepts by tinkering with available materials, generate design concepts in situated contexts, and foresee potential unintended HRI consequences from a user's perspective. For platforms with similar goals, our study suggests that hardware and software accessibility is important for designers to easily conduct HRI concept exploration and prototyping. The tinkerability of the platform proves handy particularly when used in bodystorming for designers to identify interaction problems and rapidly prototype and test solutions. The in-situ perspective, where designers "become the robot" and dynamically switch between the roles of user and robot, facilitates a tacit understanding of what robots can and cannot do when interacting with users in their activities.

KEYWORDS | HUMAN-ROBOT INTERACTION, DESIGN EDUCATION, BODYSTORMING, PROTOTYPING, INTERACTION DESIGN

1. Introduction

Robotic applications are gradually permeating all facets of society and affecting people's everyday lives. The growing interest and recent advancements in embedding AI-powered features into robotic applications highlight the importance of future design education in Human-Robot Interaction (HRI). However, existing studies suggest that many higher education institutions are falling short in equipping design students with the necessary learning opportunities needed to develop hands-on skills for future HRI design challenges. When it comes to designing human interaction with robots and other types of smart products in everyday life contexts, designers often struggle to prototype and envision how these products can effectively solve user problems and how the interactions might be experienced by users (Holmquist, 2017; Yildirim et al., 2022; Zamfirescu-Pereira et al., 2021). Therefore, from a pedagogical perspective, design educators need to provide students with a comprehensive set of toolkits, comprising not only hands-on practical tools but also design techniques that can be applied with the tools, to better prepare students for HRI design practices.

In terms of hands-on tools, several commercial robot platforms, such as the Mbot robot, Lego Mindstorm, and NAO Robot, offer educational kits for users to learn to program and implement their robotic applications. However, in higher education contexts, these platforms are often used by dedicated researchers for research purposes or by teachers and students in STEM (Science, Technology, Engineering, and Mathematics) educational programs with a specific focus on developing programming skills and AI literacy (see e.g., Kumar, 2004; Williams et al., 2024). They are not specifically tailored to design education, where students may lack a solid knowledge background in robotics and programming. Moreover, these existing platforms might not fully students in design processes where the emphasis is on exploring the problem space and iterating on various design concepts rather than delivering a final engineering solution.

In terms of design techniques, this paper examines an instance where students prototype experiences using a robot learning platform. Experience prototyping is an

umbrella term for prototyping experiential elements or qualities of design situations (Buchenau & Fulton Suri, 2000). One type of experience prototyping techniques specifically suggested for exploring future technologies and contexts is Bodystorming (Oulasvirta et al., 2003) which is a technique where design questions represent "the phenomenon as a problem in the events, experience, and/or practices of users" (ibid., p. 126). The bodystorming technique was based on enactments and performances described by Burns et al. (1994), where hands-on approaches to problem solving were suggested.

To meet the need for design-oriented prototyping tools and techniques, we developed an entry-level robot prototyping platform called AIDA. The goal of AIDA is to support design students in developing a hands-on understanding of HRI, enabling them to better explore and conceptualize HRI design ideas in combination with bodystorming during the early stages of design processes. This paper reports on the design and development of AIDA and our pedagogical reflection on its use, combined with bodystorming, as an experience prototyping method in an interaction design course over the past two years. A total of 128 graduate students used AIDA to prototype HRI on the topic of autonomous delivery robots (ADRs), resulting in 26 group projects. We reviewed the project reports and analyzed the design processes and outcomes in relation to the use of AIDA.

This paper will briefly describe the development and key characteristics of AIDA. Following that, we will report on how AIDA was implemented in the interaction design course and the results from student projects. The paper concludes with our reflections on the effects of AIDA on students' learnings and practices of HRI, along with recommendations for future similar pedagogical explorations.

2. Related work

Designing HRI poses unique challenges for designers, as it requires a fundamental shift of view from a conventional command-and-response interaction model to an intervention-based interaction model (Schmidt & Herrmann, 2017). Robotic applications, powered by advanced features such as object recognition, object tracking, speech detection, and speech synthesis, are becoming increasingly autonomous. This autonomy spans multiple interaction stages, from acquiring information, analyzing and reacting to changes in the surrounding environment, selecting decisions, to implementing proper actions (Parasuraman & Sheridan, 2000). From an HRI point of view, interaction designers need to consider how to incorporate various interaction modalities, such as visual, verbal, and tactile, to effectively communicate robots' intentions to users during different stages of interaction. Moreover, the integration of AI further introduces another layer of complexity to HRI design. Robots with AI and machine learning capabilities often tend to give the misleading impression of being intelligent agents capable of independently

making decisions and performing actions. This misalignment between user expectations and the actual capabilities of robots thus challenges interaction designers to consider, in the early stage of the design process, how to position the role of robots in the specific users' activities in which they are intended to be used, and how to distribute and balance control between users and robots in various use contexts (Rozendaal, 2016).

Therefore, supporting designers in exploring various design concepts, rapidly prototyping robot behavior, and observing how proposed interactions might unfold from a user perspective is crucial for successful HRI design (Hartikainen et al., 2022; van Allen, 2018). With a broader perspective on the interaction between users and intelligent products, existing studies have pointed out that designers often face challenges in ideating, sketching, and prototyping intelligent system behaviors, particularly in the discovery and definition phases of the design process (Dove et al., 2017; Mccardle, 2002; Yang et al., 2020; Zhou et al., 2020). Translating the insights into HRI design, it is essential to support designers in:

- Articulating what robots can and cannot do to meet specific needs and address specific problems in user activities.
- Envisioning how people may react and respond to robots in various situations.
- Foreseeing potential unintended consequences of HRI.

To address the challenges listed above, we identified three key characteristics that an HRI prototyping platform should offer to enable interaction designers to better explore and rapidly iterate design concepts:

Encouraging tinkerability: According to Resnick and Rosenbaum (2013), tinkerability is a playful, experimental, and iterative process in which makers are encouraged to improvise with available materials during artefact-making. The focus of tinkering is not on producing a final prototype, rather, it is the process of tinkering itself that matters in design. The tinkering process consists of two main elements: 1). using readily available materials to freely craft prototypes, and 2). engaging participants – including both users and designers - in sharing their lived experiences during the prototype crafting process. The value of tinkering has been previously highlighted in interaction design. For instance, in the context of designing AI-powered products, van Allen (2021) stated that tinkering by conducting informal experiments to test different AI features helps designers gain a tacit understanding of the capabilities of AI, which serves as a fundamental step in the design of intelligent products.

Developing in-situ perspectives: Adopting an in-situ perspective can allow designers to directly experience how robots perceive and interact with the human world, which helps designers translate their insights into design concepts that better support users in their activities (Dow et al., 2005; Maulsby et al., 1993). For instance, in a study conducted by

Malsattar et al. (2019), design participants were provided with a prototyping tool to customize a chatbot to respond to different objects in various scenarios (e.g., garbage classification, mindful break reminders, and door-closing alerts). This prototyping tool enabled participants to see how objects were interpreted by the chatbot in real-time, allowing them to prototype interactions by directly setting chatbot messages, subsequently testing out the prototyped interaction on the spot. Similarly, Thellman et al. (2017) developed a VR-based wizard control interface with a motion-tracking system for robot operators/wizards to see what the robot sees. Devendorf & Ryokai (2015) developed a digital-physical hybrid fabrication 3D fabric printer that allows users to become part of the machine and co-produce artistic objects with the machine. These studies all highlighted that adopting an in-situ perspective not only helps designers better understand the specific contexts of user interaction with robotic and intelligent systems, but also enables them to develop an immersive and authentic sense of what it feels like to be a robot interacting with its users.

Accessibility: Many existing HRI prototyping platforms on the market feature advanced hardware and software control systems (see Table 1 for examples of commercially available robot educational and prototyping platforms). However, these platforms often require users to receive extensive training or technical background to be able to use them, making them less suitable for design education, where students usually lack the resources or technical expertise to master the complex operation of robotic systems. Therefore, to support design students in better exploring HRI concepts and developing prototypes, it is crucial that such a robot prototyping platform is both accessible and requires minimal technical skills from the user. One example is the mobile app-based tool Object Responder developed by Malsattar et al. (2019), which enables designers to rapidly prototype and test chatbot responses without needing to learn complex software control frameworks. Similarly, the social robot prototyping platform FLEXI allows designers to customize robot functions and appearances by using cardboard, 3D-printed accessories, and a set of electronic kits, providing an accessible and hands-on way to prototype the robot. (Alves-Oliveira et al., 2022a, 2020b).

Table 1: A list of examples of the existing commercially available robot educational platforms on the market.

Platform	Manufacturer	Release year	Goal/Targeted implementation case(s)	Technological features e.g., remote control, AI vision, speech synthesis)
Edision Robot V3	Microbric	2024	Learning programing (block and Python)	- Sensors for scanning ground lines and barcodes
Vex IQ (gen 2)	Innovation First	2021	Learning programing (block and Python, C++) Robot building	-Steering with game controller -Optical and proximal sensors
Thymio 2	Mobsya	2012	Learning programing (block and Python) Develop an understanding of AI/ML	-Sensors (proximity, ground line following, temperature) - Programable led lights microphone -Use prebuilt AI features/behaviours -Remote controller (tv-like) -Virtual robot simulator
Makeblock	Makeblock	2015	Learning programing (block	-Obstacle avoidance
mBot			and Python) Learning by playing games Develop an understand of AI /ML	-Pose recognition - Audio & image recognition (AI/ML) -Emojis on screen for display emotions -Remote controller (tv-like)

3. AIDA platform development

3.1 AIDA development and key characteristics

The concept of AIDA originates from a course project where a robot mock-up was built to represent the conceptual design of a receptionist robot. During the project, we learned that students faced challenges in finding suitable platforms for generating, representing, and prototyping their HRI design ideas. Without any access to any existing prototyping platforms, the students decided to build a robot mock-up using materials such as Lego and mobile phone screens to represent and test their design ideas.

Drawing insights from this student project, we recognized the need for a low-entry and hands-on robot educational prototyping platform to meet students' practical needs in their HRI design practices. AIDA was thus created to address the needs. Both the hardware setup and the remotecontrol application of AIDA have undergone three major iterations. The initial version, AIDA 1.0, was completed in May 2022. It comprises an off-the-shelf six-axis mini-industrial robot arm, a tablet attached to the arm, and a Raspberry Pi computer (see Figure 1). AIDA

1.0 is controlled via an Android app installed on the tablet, allowing users to manually operate the robot arm by inputting parameters such as position and angles, which are then transmitted to the Raspberry Pi for execution. In order to enable users to simulate robot behavior and responses, AIDA 1.0 also offers the user three entry-level AI-related functionalities: object recognition, allowing the system to recognize common objects; object tracking, allowing the arm to follow the movement of the designated object once marked; and speech synthesis, allowing users to specify speech input and output.

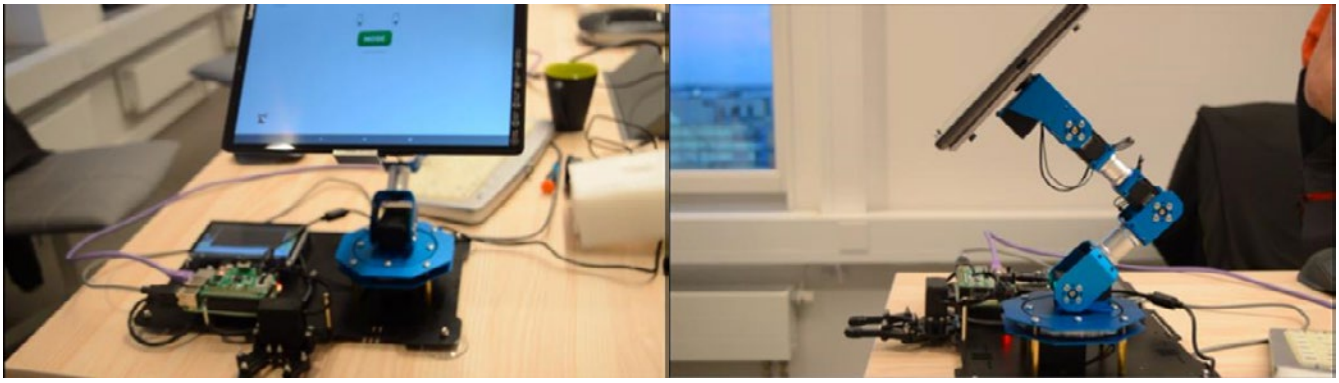

Figure 1: An overview of AIDA 1.0, which was developed in May 2022.

Following the initial development, AIDA underwent two more iterations (AIDA 2.0 and AIDA 3.0) between June 2022 and January 2023. A new base platform was integrated into AIDA 1.0, transferring it from a stationary platform to a mobile and portable platform AIDA 3.0 (see Figure 2). In addition, an off-the-shelf application was introduced to manage the motion control system of the mobile platform, allowing users to control AIDA via a phone or tablet. Another important upgrade in AIDA 3.0 is its modular design feature. With plastic pallets and 3D printed clips on the mobile base, users can easily attach various add-ons, including a mini-industrial robot arm, mobile network modules, multiple cameras, lightweight lidars, speakers, and mini projectors, onto the platform. Furthermore, the remote-control app allows users to access real-time video and lidar feeds from the sensors mounted onto the platform. Figure 2&3 shows an overview of AIDA 3.0 (hereinafter directly referred to as AIDA) with various add-ons and a full list of available input and output devices. In summary, AIDA consists of:

- Detachable mini-industrial robot arms that can be placed on top of the platform.
- A tablet that can be attached to the robot arm, acting as the "head".
- A mobile base platform serving as the main frame or "body", featuring a modular structure.
- Various input and output devices/add-ons that can be mounted to the main frame.
- Remote control apps for controlling the behavior of both the mobile base platform and the robot arm.

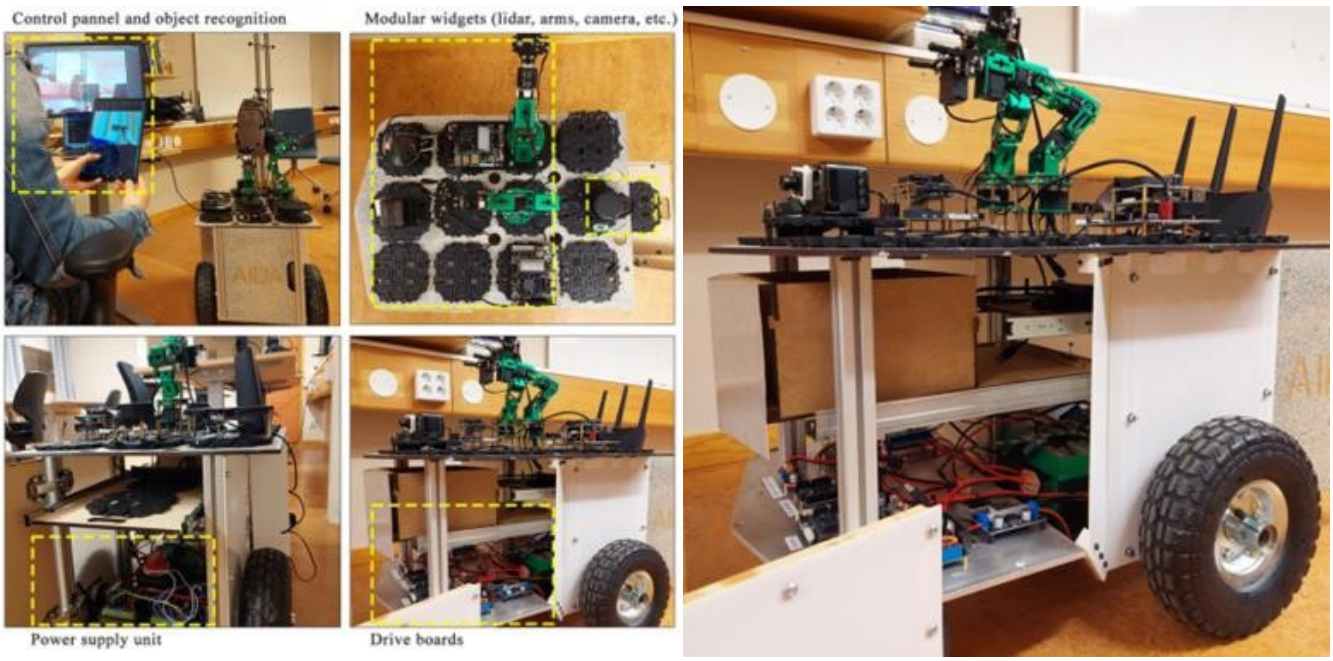

Figure 2: An overview of AIDA 3.0, which was completed in January 2023.

The design and development of AIDA was guided by three key principles: encouraging tinkerability, developing in-situ perspectives, and ensuring accessibility.

· Encouraging tinkerability: AIDA's modular design, both in its hardware and user control system, allows design students to easily add input and output devices, as well as the corresponding remote-control applications of the devices, to adapt to the specific needs of each design case and scenario. For instance, if students want to add a lightweight lidar sensor to AIDA, they can simply clip the lidar onto the plastic pallets atop AIDA and connect it to AIDA's main computing board. This tinkering process is designed to be as simple and intuitive as possible with only a few steps for configuration. Students don't need to have any prior knowledge of mechanical engineering or computer science to modify AIDA's setup.

· Developing in-situ perspectives: Building upon the tinkerability feature, AIDA also

· facilitates the designers to embody the roles of the "robot" and develop more authentic experiences, via visual and auditory means, of how robots perceive the surrounding environment and user actions. This enables students to simulate robotic responses in real-time, creating more immersive and situated environments for students to understand HRI from different perspectives.

· Ensuring accessibility: By incorporating off-the-shelf robotic components into the hardware and software system of AIDA, we aim to lower the technical bar for student designers to quickly and easily deploy the platform. AIDA's remote control app also allows students to employ commonly used HRI design methods such as Wizard-of-Oz (see e.g., Goncalves Freitas et al., 2021;

Green et al., 2004; Zamfirescu-Pereira et al., 2021) and marionette/puppeteering (e.g., Wang et al., 2017) to rapidly prototype and test various design concepts.

Figure 3: Left: AIDA with various detachable sensors. Right: The remote-control apps and station of AIDA.

4. AIDA implementation in a course

AIDA was deployed in an interaction design course given to design graduate students in 2022 and 2023. Most of the students had little to no prior experience of working on HRI. The course aims to help students combine theoretical knowledge on design methods, reflection, and criticism with various practical design activities, including sketching, bodystorming, storyboarding, prototyping, and user testing, to better understand how to work with design problems and develop alternative design solutions.

As part of the course, students were given the group design project and individual design project assignment on designing user interaction with Autonomous Delivery Robots (ADRs). Students were asked to follow the Double Diamond design process in their projects. In the first phase of the project, they collaborated in groups during the discovery and definition stages to identify problems and explore design alternatives. In the second phase, students worked independently during the development and delivery stages to refine their design concepts and evaluate

final prototypes. AIDA was mainly used with bodystorming to facilitate divergent thinking. Specifically, it was used with the goal of supporting students in exploring the problem space during the discovery stage and generating ideas to tackle the identified problem during the development stage.

In the course, bodystorming sessions with AIDA were conducted in two separate teaching sessions. Each teaching session lasted approximately two hours. The first session was held indoors in a classroom and corridor setting, while the second session took place outdoors, simulating real-world environments where human interactions with ADRs may take place. During these bodystorming sessions, each group took turns using AIDA. All AIDA widgets were made available for the students to choose from. Additionally, students were provided with common design ideation props such as postit notes, cardboard, tapes, chenille stems, and plastic foams, which can be used alongside AIDA during their bodystorming sessions.

5. Methods and materials

To gain a better understanding of how AIDA supported and affected both the design processes and outcomes of students' HRI design, we conducted a systematic review and analysis of the groups' project reports.

In terms of the design process, students summarized insights from relevant literature and reflected on their learnings regarding the use of different design techniques, such as sketches, bodystorming, storyboarding, and prototyping, in their projects. Our analysis focused on three main questions concerning the design process: 1). How was AIDA employed in the design process? 2). How did AIDA facilitate the exploration of HRI problem space? and 3). How did AIDA contribute to generating different HRI concepts? In terms of design outcomes, we examined not only the final design proposals but also the problem formulations, statements, and design alternatives students generated throughout different stages of the design process. Our analysis focused on three main questions regarding the design outcomes of each project: 1). What were the overall problem formulations, statements, and design alternatives proposed in the project? 2). How did AIDA contribute to informing or influencing these design outcomes? 3). Were there any limitations or constraints that AIDA may have imposed, and if so, what were they?

We conducted a thematic analysis of the data collected from the reports, following guidelines adapted from Braun and Clarke (2006). First, relevant raw data were extracted from the reports into an Excel document. We then labeled the data with different codes. These codes were subsequently grouped into themes, which were further reviewed, refined, and linked to the aim and research question of this study. It is worth noting that since AIDA was primarily used in bodystorming sessions, we did not intend to separate the effects of AIDA from the effects of bodystorming as a design technique. Instead, we evaluate them collectively as part of the same process.

6. Student project results and pedagogical reflections

128 students have used AIDA (53 in 2022 and 75 in 2023) to design user interactions with ADRs, resulting in 26 group project reports. The students were in their fourth year of design and product engineering studies. The design concepts generated in student projects mainly cover the following topics on users' interaction with ADRs:

- Delivery monitoring: Facilitating the interaction between ADRs and pedestrians, while providing end users with updates on the robot's status and real-time location.
- On-site meet-up: Helping end users locate the robot at the designated delivery site.
- Item retrieval: Assisting end users in retrieving items from the robot's storage
- compartment
- Delivery confirmation: Ensuring users can confirm the successful delivery and retrieval of items before the robot departs.

6.1 Foresee the potential unintended consequences from a user perspective

Nearly all the groups reported that using AIDA during bodystorming sessions supported them in foreseeing scenarios where potential undesired or unexpected outcomes of HRI could take place. By acting out their scenarios with AIDA, students were able to further break down the scenarios into more specific problems that users may encounter when interacting with ADRs in different contexts. For instance, what if the ADR arrives at the delivery destination, but the user struggles to locate it; what if the user accidentally sends the command for the ADR to open its storage compartment while the delivery is still in progress; or what if the ADR initiated its return sequence before the user has retrieved all the items.

These potential undesired HRI scenarios later became central to the design solutions the groups explored. One group of students noted, "New problems could be identified that the group had not previously considered. The problems discovered were documented to form the basis of potential solutions during idea generation." A list of "what if" HRI scenarios generated by students is shown in Table 2.

Table 2: A list of "what if" HRI scenarios that may lead to unintended outcomes.

Delivery monitoring	AIDA gets stuck by road obstacles; it is looking for human assistance.
	AIDA is blocked by other pedestrians on the street who are curious about it.
	The end user is worried exactly when and where AIDA would arrive.
Meeting on-site	The end user cannot find AIDA on the delivery site.
	For how long AIDA should wait if no one comes to pick up the parcel.
	AIDA has arrived but is in a place that is hard to spot.
	When there is multiple AIDA presence at the same time, the end user is likely to get confused about which AIDA is carrying their parcels.
Item retrieving	The QR code on AIDA is damaged, preventing users from scanning it to unlock the transport compartment.
	AIDA closed the lid before the package had been picked up.
	AIDA opened the transport compartment without users being there.
Delivery confirmation	The lid of the transport compartment won´t close or the user forgets to close it after retrieving the parcel.
	The end-user walked away from AIDA without fully acknowledging the completion of the delivery process.
	AIDA left before the end user has retrieved all the parcels.

6.2 Articulate what robots can do and cannot do in user activities

During the bodystorming sessions, we provided students with additional design materials for prototyping interactions with AIDA. The materials can be divided into two groups: 1). electronic widgets that can be mounted onto the AIDA platform, such as cameras, speakers, lidars, mini robot arms, and 2). props commonly used in design ideation, such as post-it notes, pens, chenille stems, and cardboard.

In terms of tinkering with electronic widgets on AIDA, we observed that students used various widgets and integrated them into AIDA to generate different HRI design ideas in bodystorming sessions. Examples include mounting a panoramic camera on AIDA which allows end users to view what the ADR is seeing in real-time through an app; adding an external speaker for users to play sound in case they could not spot it at the delivery site; Creating a mock-up of a weight scale that automatically detects whether the delivery item has been taken out from ADR's storage compartment; conceptualizing electronic locking mechanism capable of automatically opening, closing, locking, and unlocking the compartment through motion-detecting sensors.

In terms of tinkering with design props, we found that the tinkerability feature of AIDA allowed students to explore different HRI modalities and expand their design solution space. For instance, in a scenario where users forget to close the storage compartment lid and confirm delivery completion, students

developed concepts of using both auditory and visual feedback for the ADR to remind users of this missing action. As for visual modality, post-it notes with "Close me when done" were placed on the lid of the storage compartment, simulating how a digital screen would display text to users. Other props, such as paper and chenille stems were also applied on AIDA to mimic physical buttons and LED lights that change color in response to user actions. Moreover, one group used cardboard to represent a digital screen with various facial expressions to convey the ADR's emotions and system status to users. As for auditory modality, some groups added external speakers onto AIDA to play confirmation sounds once the delivery has been confirmed by users. Similarly, another group used speakers to simulate speech prompts, such as "waiting to be unlocked" when the robot is waiting for users to unlock the storage compartment, "box open" when the compartment is about to open, "thank you, have a nice day" upon confirmation of the delivery.

Reflecting on the use of the electronic widgets and design props on AIDA, we found that AIDA's tinkerability enabled students to explore and articulate what robots may or may not be capable of in supporting user activities, as one group stated: "We came to the conclusion that there are many possibilities for creating clear communication for end users, and it can be beneficial to use sound, light, and images." Similarly, another group noted that "with the use of props such as cardboard cell phones (showing the actor different steps of the interactive sequence), the actors and people analyzing the interaction could more easily find flaws in the interactive sequence and take note of where flaws may arise."

6.3 Envisioning how users may respond to robots in situated contexts

Engagement and improvisation were frequently mentioned by students when describing their experiences using AIDA to identify HRI problems and generate design concepts. The process of problem identification and concept generation in bodystorming sessions with AIDA often followed an iterative pattern. Initially, students started identifying HRI problems through bodystorming with AIDA, which led to various early-stage design ideas. Leveraging AIDA's tinkerability feature, the proposed design ideas were quickly turned into low-fidelity prototypes for implementation and user testing. After that, the feedback gathered from these "quick and dirty" tests often informed the discoveries of new HRI problems, which in turn further led to another iteration of concept generation and problem identification.

This rapid problem identification and prototyping that the students demonstrated in their HRI design process was facilitated by the in-situ perspective that AIDA aims to bring to its users. As previously presented, the in-situ perspective, as one of the three core design principles of AIDA, allows designers to operate the platform in a situated context, enabling them to embody the role of the

robot and simulate robotic responses by directly manipulating the robot in the scene. We observed that the dynamic switching of perspective between robots and users in situated contexts helped design students understand, envision, and test interaction sequences from both the end user and the robot viewpoints. The effects of this perspective switching in situated contexts through AIDA, as documented in student's reports, are twofold. Firstly, building upon the "what if" scenarios students previously identified in their bodystorming sessions, prototyping with AIDA enabled students to gather feedback and identify the potential problems that may emerge in their design concepts from a user perspective. One group explicitly stated, "Bodystorming sessions were held where the group was able to test and get immediate feedback from our design ideas as well discovering new flaws in the systems that the group did not previously think of." Another group shared similar insights: "To continue breaking down problems, the process continued with brainstorming and discussion to map out solutions to different scenarios perceived. This resulted in many solutions where additional problems emerged which should be addressed". For example, faced with the scenario where a user struggles to locate the ADR's exact location at the delivery site, one group initially proposed using sound as an auditory cue to guide users. However, after testing this idea on AIDA in the actual context, the group quickly realized that this idea might be ineffective in environments with significant background noise. Thus, they expanded their solution to include other interaction modalities, such as allowing users to access the camera view of the ADR and observe the surrounding area, making it easier for users to find the robot.

Secondly, AIDA's tinkerability enabled students to easily engage in "quick and dirty" prototyping on AIDA in situated contexts. One group pointed out that "the bodystorming session focused on creating physical mock-ups and prototypes which represented AIDA's functionality. By doing this we created a space which allowed the group to play with and interact with the ideas in a more performative way than just merely discussing which functions that AIDA should contain and provide, which allowed the users to use their imagination in a more performative way as well." For example, with a focus on designing interaction for users to unlock the ADR's storage compartment, one group initially proposed the concept of using a numerical code input panel for users to type in the code they received from their delivery service provider. After the group prototyped AIDA with props to simulate their envisioned user input behavior and subsequently tested the prototypes in the bodystorming sessions, they quickly discovered unexpected problems in the user interaction flow, such as what would happen if the user accidentally entered the wrong code multiple times. This led them to immediately start improvising the solution on the spot with AIDA.

6.4 Limitations imposed by AIDA

We found that students generally appreciated using AIDA in their bodystorming sessions to identify potential HRI problems that may occur and explore corresponding design concepts for solutions. As previously mentioned, this problem identification and solution process is supported by AIDA's tinkerability, in-situ perspectives, and accessibility features. However, the current technological constraints within AIDA's hardware and software set-ups may also impose limitation to the design space and the quality of HRI concepts that students explored. One group of students elaborated on this issue, noting that AIDA may have "applied an inadvertent psychological limit to the imagination of the designers, further limiting the possible solutions due to some potential ideas never being explored due to this prerequisite." Although AIDA's current limited technological capabilities meant that students could not explore certain HRI concepts in depth, it still served as a window for design students to peek into what robots can do and cannot do in addressing specific problems in human activities. For instance, several projects explored issues such as verifying users' identities, ensuring the correct delivery of goods, guiding users to correct locations, and considering the impact of external factors including weather and road conditions, which were made possible by combining the use of AIDA and the bodystorming technique.

7. Conclusion and future work

In this study, we developed AIDA as an entry-level robot prototyping platform to help design students better explore and conceptualize HRI design ideas during the early stages of the design process. This paper reports on the design and development of AIDA, along with our pedagogical reflection on the implementation of AIDA with bodystorming technique in an interaction design course over the past two years. Our findings show that using AIDA in combination with bodystorming enabled students to:

- Rapidly prototype HRI design concepts by tinkering with available props and materials,
- Generate design concepts in situated contexts,
- Foresee potential unintended consequences of HRI from a user perspective.

In addition, we found that AIDA allowed design students to embody the role of "robot" by directly simulating and improvising robotic behavioral responses in real-time on the scene. This feature enabled them to dynamically switch between the perspectives of the robot and the user to better understand and design interaction sequences from both viewpoints. However, we also found AIDA may pose limitations to design outcomes as the current technological setup of the platform might restrict students from exploring certain HRI design concepts in depth.

Overall, this study highlights the importance of employing entry-level robot prototyping platforms in combination with experience prototyping techniques to enhance students' hands-on understanding of HRI. Our findings and reflections suggest that, when developing similar HRI prototyping or educational platforms in the future, hardware and software accessibility of the platform is essential for facilitating the exploration and prototyping of HRI design concepts. Tinkerability of the platform is handy for designers to identify interaction problems and rapidly test solutions. Moreover, offering an in-situ perspective allows designers to "be the robot" and dynamically switch between the roles of user and robot, fostering a tacit understanding of what robots can and cannot do when interacting with users in human activities.

In terms of the future development of AIDA, we plan to continuously upgrade the technological capabilities of the hardware and software of the platform to meet the diverse needs of HRI design prototyping. This includes expanding the range of input and output devices connected to AIDA, as well as better leveraging the platform's modularity feature. Besides, we also aim to incorporate more AI-powered features, such as advanced object recognition and speech synthesis, into the software system and the remote-control app of AIDA. Future research projects will involve conducting workshops and gathering insights from professional design practitioners to further explore how AIDA can be used to support HRI design in industry settings.

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ONLIFE. EXHIBIT DESIGN IN THE TIME OF THE MANGROVE SOCIETY.

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ABSTRACT | The paper focuses on onlife exhibit design, a design mode in which digital technologies, Artificial Intelligence and the Internet of Things, are integrated with exhibition design strategies that enable the interconnection of physical and digital spaces, trying to outline new innovative approaches by understanding how Extended Reality (XR) can create new levels of interaction between exhibit and visitor. Designing exhibits with an onlife perspective would create a circularity between the different interaction contexts: generating not only "enriched" paths for the public, but creating temporary exhibitions that thanks to "the introduction and technological advancement related to the diffusion of new technologies make it possible to experiment new levels of interactivity and involvement of visitors in the exhibition spaces" (Del Puglia S. 2022) An exhibition today is a conscious spatial arrangement of a more or less coherent set of objects which, on the basis of more or less succinct selection criteria, will enter into a documentary interrelation for the duration of the event. This interrelation, according to the intentions of the book Narrative Spaces, "will produce a cohesive narrative potential capable of giving the whole its expressive power and clearly addressing the audience. Other perspectives may of course be valid, but since the exhibition is the result of an interdisciplinary effort, we opted for a formula that involves all parties involved in the realisation of exhibitions, regardless of the conventions of the profession or the various backgrounds of the experts in the field. In this way, it is intended to establish a common central position that, for the sake of the medium itself, will push the boundaries and lead to greater collaboration between disciplines'. (H. Kossmann, S. Mulder, F. den

Ousten, 2012) In order to investigate how the technologies is changing our lives, the philosopher Luciano Floridi coined the word Onlife, a neologism that serves to indicate that in most industrialised societies there is a fusion of online and offline, digital and physical. "These are not two distinct worlds but two inextricably intertwined layers that inevitably have strong repercussions on experience design as well." (Floridi L., 2017)

Since 2004 Dotdotdot has been investigating and implementing strategies to create true experiential exhibitions, refining project after project their digital know-how in the service of storytelling; consolidating an approach to exhibition design and digitalisation by outlining new paradigms and proposing innovative types of storytelling and visitor experience. In Italy there are a multitude of small realities, such as archives, which through digital exhibitions can become an important means and resource to tell their story, their connection with a territory, their research activities and transformations that, without digital technologies and Interaction Design, would remain inaccessible. The ambition is to demonstrate how new technologies and communication methods can showcase any type of subject matter, making it accessible and comprehensible to everyone. By providing a more in-depth and focused contribution to the field, for find a new approach for emphasizes the potential to amplify the value of exhibition content. It confirms that experience and interaction are indispensable elements in the creation and successful engagement of an exhibition.

KEYWORDS | DIGITAL, ONLIFE, TECHNOLOGIES, EXHIBIT, NEW MEDIA

1. Redefining experience: the intersection of real and virtual spaces in post-pandemic design

The need to investigate at a critical and design level aspects of the multiplicity of bodies and spaces and their interactions stems from Maldonado's reflection on the meaning of the word virtual and the relationship between real and virtual space. « He seeks the meaning of illusory reality, in which man produces images that he deludes himself into believing to be real. A practice that goes back to primitive man's ability to depict symbolic worlds rather than a novelty triggered by technological progress »[1]. (Maldonado T., 1992)

The sudden push of the Covid-19 pandemic updates the theme by bringing our physical bodies into virtual spaces for interaction. The field of post-pandemic exhibit design has sought to understand the ongoing change and develop new designs without sacrificing the value of experience. To enable a clear reading of this, philosopher Luciano Floridi coined the word Onlife a neologism that serves to indicate that in most industrialised societies there is a fusion of online and offline, digital and physical. « These are not two distinct worlds but two inextricably intertwined layers that inevitably have strong repercussions on experience design as well ». (Floridi L., 2017). Hsin-Chien Huang, an internationally renowned artist specializing in the creation of immersive content and artworks that combine virtual reality, interactive elements, performing arts, and installation art, to better define his approach to art and new media, during the conferenc[2]e held on November 9th at the MEET Digital Culture Center in Milan, briefly presented the history of digital tools, highlighting how the technological and communication sectors have shifted from a storytelling-focused rhetoric to what he calls « story-living ». Hsin-Chien Huang thus focused

[1] Maldonado, T. (1992). Reale e virtuale. Milano: Feltrinelli.

[2] Floridi, L. (2017). La quarta rivoluzione: come l'infosfera sta trasformando il mondo. Milano: Raffaello Cor>na Editore.

on how the distance between viewers and digital content, and hence the screens, has shortened, from 4-5 meters in cinemas, to 15-20 centimeters with smartphones, down to 2-3 centimeters with VR headsets. He emphasized how this change is related to the increasing level of interactivity demanded by users. « People no longer want to be spectators », explains the artist, « they want to be closer to the content they consume, they don't want to just hear a story, they want to be part of it, to participate in it. For this very reason, in my work, I use new media and virtual reality to define an artistic and narrative experience where interaction absorbs the reader's thoughts and memories, as if they were playing a video game, thus making them the protagonist of the story, a part of the Art itself »[3].

2. Bridging worlds: the role of bodily presence in onlife exhibitions

The 'onlife' exhibition mode represents a crucial development direction for the future. Through careful planning and development, an onlife exhibition can contextualize cultural objects, including those impossible to display physically, to communicate through a tailor-made narrative. A key element to consider is the concept of 'sense of presence,' which plays a key role in generating a strong connection between people and the virtual environment. Unlike the traditional physical exhibition space, where exhibitions were predominantly static, the digital environment offers an enhanced experience to the public. Maurice Merleau-Ponty, a phenomenological philosopher, placed significant emphasis on the importance of bodily experience in acquiring knowledge and perceiving the world around us. In his main work, Phenomenology of Perception, Merleau-Ponty argues that « the body is not simply an object in the world, but rather the instrument through which we experience and understand the world itself »[4].

According to the author, our experience of reality is intrinsically linked to our bodily experience, to "gestures," as it is through our senses and bodily perceptions that we come into contact with the surrounding environment. Consequently, the body acts as the bridge between our consciousness and the external world, becoming our « first and last reality » as it is the foundation upon which all our experience and understanding of the world are based.

The concept outlined by Merleau-Ponty is particularly relevant in the context of communication and art as it emphasizes the importance of considering the body as an integral part of the design process and, therefore, of understanding the content.

[3] Rossi D. (2023). Hsin-Chien Huang, il media guru che coniuga il gaming con la cultura taiwanese. Retrieved November 13, 2023, from hHps://www.elledecor.com/it/tech/metaverso/a45818890/hsin-chien-huang-storia-opere/

[4] Merleau-Ponty M. (2003). Fenomenologia della Percezione, Feltrinelli, Milano, p.120

Nicolas Bourriaud, French art critic and philosopher, argues that « gestures are not only means of individual expression but also tools for creating connections and meaningful relationships between artists, artworks, and the audience »[5]. It is well known that the chosen medium for communication is not simply a vehicle for transmitting content, but profoundly influences the way the content itself is perceived and interpreted, as Marshal McLuhan, a sociologist and author famous for his statement « the medium is the message »[6] asserts. If we apply this theory to the concept of "gesture" in the context of exhibit design, we can consider the human body both as an actor, in the case where the visitor is called to actively participate in an action, and as an audience, when it becomes merely a spectator of an activity that conveys meaning. In both cases, the "gesture" becomes a carefully designed element to foster meaningful interaction with the content of the event.

With the advent of the Internet, not only has the approach to exhibition design changed, but there has also been a questioning of the value of the exhibition venue. In the past, the location was simply a frame for the exhibition, but now it becomes not only a container but also a content that interacts and connects with both the audience and the exhibition and the object itself.

to redefine cultural spaces to adapt them to the social and economic context of the coming years. This challenge can be addressed through the new design approach of Exhibit Design Onlife. The digital environment offers the opportunity to make cultural content accessible in innovative ways, thanks to immersive strategies and immersive technologies such as artificial intelligence (AI), augmented reality (AR), mixed reality (MR), visors, interactive displays, dynamic lighting, eye-tracking, stimulating visitors through entertainment, education and training, taking advantage of new technological resources. In addition, the digital integration of temporary exhibitions enables seamless circular experiences: the experience can start at any point and continue without interruption, offering the public richer experiences. Today, studios such as Dotdotdot, Art+com, and AKQA are recognized as leaders in interactive, immersive, and digital exhibit design. Their work demonstrates how to create truly interactive exhibits and experiences by leveraging new technologies and tools to support storytelling. These studios effectively create synergies between tools, content, and visitors

[5] Bourriaud N. (1998). EsthéAque relaAonnelle, Les Presses du Réel, Parigi, p.87 - in Merleau-Ponty M. (2003). Fenomenologia della Percezione, Feltrinelli, Milano, p.168

[6] Cfr. McLuhan M. (2023). Gli StrumenA del Comunicare, ilSaggiatore, Milano, [McLuhan M. (1964). Understanding Media: The Extensions of Man, McGraw-Hill, New York]

3. From physical to digital: how technology is shaping the future of cultural exhibitions

The research in this work is essential and the inspirations come from many directions, from the world of art to the world of technology, and of course design and architecture. The advent of technologies and innovations has not erased the physical vision of temporary exhibitions or museums, but rather added to it a digital space that is complementary to them, providing technologies and services to enhance the visitor experience, creating an alternative space in which the various cultural actors can interact with each other (Teece, 2018)[7]. These are exhibitions that put the viewer at the centre, no longer the work of art, focusing on arousing emotions and involving the viewer in all his senses. They are therefore easy to enjoy, and involve a broader segment of viewers. With immersion and interaction tools, in which the visitor is immersed in a new world, in which works of art are projected onto the walls, ceilings and floors of museum rooms, accompanied by audio narratives or matching music. Today, technology is a presence taken for granted when enjoying exhibitions, but if the use does not meet our expectations, we are disappointed. Since 2004, the Italian-based studio Dotdotdot has been investigating and implementing strategies to create true experiential exhibitions, refining their digital know-how project after project in the service of storytelling.

They have consolidated an approach to exhibition design and digitization by outlining new paradigms and proposing innovative types of storytelling and visitor experiences.

Dotdotdot emphasizes, "we design innovative human experiences". In Italy, there are a multitude of small realities, such as archives, which can become important means and resources through digital exhibitions. These digital platforms enable them to tell their stories, showcase their connection with their territories, and highlight their research activities and transformations, which would remain inaccessible without digital technologies and interaction design. The incorporation of new technologies into the promotion of culture, the on-site experience, and the approach to exhibition design has fundamentally transformed how exhibitions are conceived, presented, and experienced. These advancements have expanded the reach and impact of cultural institutions, making art and culture in general more accessible and engaging for a diverse audience. By embracing digital innovation, exhibition designers can create more interactive, immersive, and memorable experiences that resonate with visitors and foster a deeper appreciation of culture. The application of new technologies has predominantly revolutionized three different areas: the promotion of culture, the on-site experience, and the approach to exhibition design.

[7] Teece D.J. (2018) ProfiAng from innovaAon in the digital economy: enabling technologies, standards, and licensing models in

4. Digital transformation in exhibition design: enhancing cultural promotion, on-site experiences, and design approaches

4.1 Promotion of Culture

In the realm of exhibition design, the promotion of culture has been profoundly transformed by digital technologies. Museums and galleries now leverage social media, virtual tours, and interactive websites to attract and engage a global audience. Digital platforms enable institutions to showcase their exhibitions far beyond their physical locations, reaching audiences who might never visit in person. As Alessandro Baricco aptly puts it, « The challenge today is to build experiences, not just to provide information »[8]. This shift underscores the importance of creating engaging and memorable cultural experiences through digital means.

Virtual tours, for instance, can offer a preview of exhibitions, enticing potential visitors to experience them physically. Additionally, social media campaigns can highlight key exhibits, share behind-the-scenes content, and facilitate online discussions, thus generating buzz and fostering a deeper connection with the audience. Matthew Ball, a leading thinker in the digital space, notes that « the virtual world can extend the life and reach of physical exhibitions »[9]. This digital outreach not only amplifies the cultural institution's visibility but also creates a dynamic and interactive platform for cultural promotion, making art and history more accessible and engaging.

"Ore Streams" is an ambitious investigation into the recycling of electronic waste developed by Formafantasma over the course of three years. First as a commission at the NGV2 Triennial in Melbourne in 2017, curated by Ewan Mc Eoin and Simone Le Amon, and then in 2018 for the XXII Triennale 'Broken Nature', curated by Paola Antonelli (senior curator of Architecture and Design at MoMA in NY). It uses a diversity of media (objects, video documentaries, and an animation) to address the topic from multiple perspectives, and reflect on how design could be an important agent for more responsible use of resources[10]. In the case of this study, the theme "sustainability" as the theme of exhibition is represented by the figure of the designer which is evolving, oriented towards the concept of ecological transition.

[8] Baricco A. (2018); The Game, Torino, Einaudi Editori.

[9] Ball M. (2022); Metaverso - cosa significa, chi lo controllerà e perché sta rivoluzionando le nostre vite; Milano, Garzan>, 2022 the wireless world, Research Policy, 47(8). DOI: https://www.sciencedirect.com/science/ar>cle/pii/S0048733318300763 (open access).

[10] Valenti A., Trimarchi A., Farresin S. (2023); Design e pensiero Ecologico; in Agathon n.13, pag. 19-30. (hHps://www.agathon.it/agathon/ar>cle/view/342/376)

A dynamic in continuous movement, as Andrea Trimarchi and Simone Farresin argue that the concept of transition is stimulating because it represents a condition of continuous change, which reflects how we should live today (2022). Humans have mined the Earth's surface for millennia in search of metals and minerals to fulfill production demands. In fact, forging metal changed the course of history: bronze empowered humans to weaponize, and gold facilitated local, then global, trade. At this very moment, new cavities are being hollowed out, while existing excavated sites are abandoned or refilled with new Earth – a superficial recompense. By 2080, the most significant metal reserves will not be underground but above the surface, as ingots stored in private buildings or otherwise circulated within products such as building materials, appliances, furniture, and consumer electronics. Imagining the future, what would archaeologists of tomorrow think of our era if they were to explore the sites of our current cities? They would encounter numerous landfills filled with waste, as argued by Marianna van Helvert[11] (2019). The eighteen channel Ore Streams video installation aims to offer global strategies for the design of products that lend themselves to more efficient repair and recycling. It includes a series of interviews the Studio conducted with practitioners in the recycling sector, including European e – waste recyclers, academic researchers, electronics producers, NGOs working in developing countries, and members of Interpol. The installation also includes a video collecting historical and contemporary examples of planned obsolescence in electric and electronic objects at the centre of class – action lawsuits. One video explains recycling systems and technologies for sorting waste, and two videos show a selection of electronic products being carefully disassembled and recomposed.
In the animation, Formafantasma uses 3D rendering to visualize possible strategies to improve repairing and recycling[12].

[11] Van Helvert M. (2019). The Responsible Object: A History of Design Ideology for the Future. Berlin, Valiz, pag. 220. 12 Valen> A., Trimarchi A., Farresin S. (2023); Design e pensiero Ecologico; in Agathon n.13, pag. 19-30. (hHps://www.agathon.it/agathon/ar>cle/view/342/376)

[12] Teece D.J. (2018) Profi>ng from innova>on in the digital economy: enabling technologies, standards, and licensing models in the wireless world, Research Policy, 47.

4.2 On-Site Experience

The on-site experience of exhibitions has undergone a significant transformation with the integration of Digital technologies in exhibition design. Interactive displays, augmented reality (AR), and virtual reality (VR) have revolutionized how visitors interact with exhibits. For instance, AR can overlay historical context onto artifacts, providing deeper insights and a richer understanding. According to David Teece, « Technological advancements are not just tools, but enablers of new ways of thinking and experiencing»[12]. This highlights how AR and VR can immerse visitors in historical events or artistic environments, creating an experiential narrative that goes beyond traditional static displays. Interactive touchscreens and multimedia installations allow visitors to engage with content in a hands-on manner, making the learning experience more dynamic and personalized. These technological advancements ensure that the on-site experience is not only informative but also immersive and memorable, enhancing visitor engagement and satisfaction. The ability to tailor experiences to individual preferences and learning styles makes the exhibition more inclusive and appealing to a broader audience.

The ArtScience Museum of Singapore, in 2019, for example, has design an immersive experience and interactive exhibition based on stunning content from "Our Planet", a new Netflix original documentary series, created in partnership with the World Wide Fund for Nature (WWF). "Our Planet" is an eight-part documentary series from the team behind "Blue Planet" and "Planet Earth", released on 5 April 2019 on Netflix, filmed over four years in 50 different countries. The exhibition "REWILD Our Planet" then uses cutting edge technology to transport you into the landscapes featured in this ambitious documentary. At the exhibition at ArtScience Museum, people were able to dive into the deepest oceans, visit the most remote forests and take a journey over vast ice caps. Blending stunning IMAX style projections with spatial soundscapes and a soundtrack. This is Singapore's first Augmented Reality social experience which allows multiple visitors to interact with digitally-created environments, whilst examining how climate change impacts all living creatures[13].

[12] Teece D.J. (2018) Profi>ng from innova>on in the digital economy: enabling technologies, standards, and licensing models in the wireless world, Research Policy, 47.

[13] Cfr. Rewind our planet (2019) Comunicato stampa. URL hHps://www.marinabaysands.com/museum/rewild-our-planet.html 15 Baricco A. (2018); The Game, Torino, Einaudi Editori.

4.3 Approach to Exhibition Design

The approach to exhibition design itself has been revolutionized by new media technologies. Designers now have access to advanced tools and software that allow for greater creativity and flexibility in planning and executing exhibitions. Projection mapping, for instance, can transform ordinary spaces into dynamic, immersive environments that change in response to the narrative being presented. Alessandro Baricco's concept of « narrative intelligence »[15] is highly relevant here, as it emphasizes the need to weave compelling stories that resonate with the audience through innovative use of technology. It plays a crucial role in the modern approach to exhibition design. Baricco posits that narrative intelligence is the ability to understand, create, and use stories to make sense of the world around us. This concept extends beyond traditional storytelling, encompassing the use of narratives in various forms of media and communication to engage and educate audiences. In the context of exhibition design, narrative intelligence involves crafting a cohesive and compelling story that ties together the various elements of an exhibition[14]. This can include the physical artifacts, digital displays, interactive elements, and overall thematic structure. By weaving these components into a unified narrative, designers can create a more immersive and emotionally resonant experience for visitors. Baricco emphasizes the importance of creating narratives that are not only informative but also emotionally engaging, as this connection can significantly enhance the impact of an exhibition. For example, in a historical exhibition, narrative intelligence might involve creating a storyline that follows the journey of a particular individual or community, using artifacts, multimedia, and interactive displays to bring their story to life. This approach helps visitors to connect with the material on a personal level, making the history more relatable and memorable.

Interactive installations and responsive environments engage visitors in new and innovative ways, creating a participatory experience. Furthermore, the use of digital tools in the design process enables detailed simulations and virtual walkthroughs, allowing designers to experiment and refine their concepts before implementation. As Teece suggests, « Digital tools are not just for creation but also for continuous iteration and improvement »[15]. This digital-first approach not only enhances the aesthetic and functional aspects of exhibition design but also allows for continuous improvement based on visitor feedback and interaction data.

[14] Ibidem

[15] Teece D.J. (2018) Profi>ng from innova>on in the digital economy: enabling technologies, standards, and licensing models in the wireless world, Research Policy, 47.

The theme of the next Milan Design Week 2025 it's going to be "Connected Worlds", which it's going to be a participatory and generative design process through the integration of artificial intelligence[16]. This theme encourages reflection on how design connects various aspects of our lives, from the natural environment to advanced technologies and from cultural traditions to future innovations. It emphasizes design's role in fostering unity and global cooperation. This theme explores the connection between physical and digital worlds, enhancing life quality through AI and smart devices. It highlights cultural exchange, ecological design, and sustainable technologies in urban contexts. It underscores the importance of designing public spaces that foster social interaction and installations that promote inclusivity and dialogue. Additionally, it examines urban mobility innovations and the sharing of information across disciplines. Milan Design Week 2025 aims to celebrate relationships and engagement through design, showcasing how hybrid skills and immersive experiences can transform our ways of living, working, and interacting with the world.

5. Adaptive design: the role of intelligence in the built environment

To develop our project, we drew inspiration from the 2025 Venice Biennale project curated by Carlo Ratti. The nineteenth International Architecture Exhibition of Venice, in fact, will be dedicated to the built environment and the numerous disciplines that shape it. Architecture is at the center of these, but not alone: it is part of an extensive ensemble that must integrate art, engineering, biology, data science, social and political sciences, planetary sciences, and other disciplines, connecting each of them to the materiality of urban space.

« The titles of the International Architecture Exhibitions are usually announced in both English and Italian. However, in 2025, the title will be condensed into a single word for both languages, invoking their common Latin origin: Intelligens. From intelligens comes the modern ‹intelligence›; this choice, however, also indicates an expansion of associations in meaning. Translated separately, the final syllable, ‹gens,› means ‹people›: from this emerges an imagined alternative root, suggesting a future of intelligence that is more multiple and inclusive, escaping the excessive limits of today›s focus on AI »[17].

[16] Cfr. Salone del Mobile 2025 (2024) Comunicato stampa. URL: hHps://www.salonemilano.it/en/exhibi>ons/saloneinternazionale-del-mobile

[17] C. Rah (2024) Biennale architeRura 2025: il Atolo è intelligens. naturale. arAficiale. colleXva. hHps://www.labiennale.org/it/news/biennale-architeHura-2025-il->tolo-è-intelligens-naturale-ar>ficiale-collehva

The built environment is among the major contributors to atmospheric emissions. In this sense, architecture can be blamed for much of the environmental degradation of our planet. In the face of the accelerating climate crisis, must we resign ourselves to this role, or are we still able to offer substantial, not cosmetic, solutions that are effective and quick to implement? The Exhibition will attempt to chart new paths for the future, suggesting a range of solutions to the most pressing problems of the present. It will bring together a collection of experimental design proposals, inspired by a definition of "intelligence" as the ability to adapt to the environment starting from a limited set of resources, knowledge, or power. The exhibition, in particular, imagines architects as "mutagenic agents", capable of triggering evolutionary processes and directing them in new directions. Learning from multiple scientific disciplines, and advancing through trial and error, this exhibition aims to accelerate the transformation of the present in the search for better futures. Objects, buildings, and urban plans will be arranged along the axis of a multiple and diffused intelligence, dividing the space into three main thematic areas related to natural intelligence, artificial intelligence, and collective intelligence. Some ideas are destined to fail. But others may point us to promising paths.

5.1 Natural Intelligence

Architecture, whose original function is to shelter humans from natural elements, now relies on nature to re-orient its action. Bringing vegetation back to the heart of our cities is one of the most effective ways to combat extreme temperatures. Organic materials can store carbon while also preventing further emissions through insulation. Biomimicry reminds us that the best designs are the product of millions of years of evolution. Will we one day be able to design a building as intelligent as a tree?

5.2 Artificial Intelligence

Vast networks of connections and sensors link our metropolises, creating a digital infrastructure that spans the entire planet. Despite their energy consumption, these technologies can be used to mitigate the environmental impact of urban development. Thanks to real-time feedback loops, the built environment is beginning to respond like a living organism. At the same time, artificial intelligence could disrupt the traditional role of architects. How will the profession change when generative models can produce construction details from a simple textual input?

5.3 Collective Intelligence

Since prehistoric times, architecture without architects has been able to devise sustainable solutions in response to environmental pressure. From the Machiya of Kyoto to the Dogon rock dwellings on the Bandiagara Plateau, and from the Trulli of Alberobello to the vast array of settlements classified as "informal" that are still the main drivers of urban growth today, collective intelligence speaks to us of adaptation: working with nature, not against it. How can we connect the old and the new to harness the endless possibilities of collective intelligence?

6. Innovative pathways: methodologzy for integrating digital tools in exhibition project

Carlo Ratti, Artistic Director of the Architecture Sector of the Venice Biennale, invites students, graduates, and emerging professionals under 30 (from architecture, urban design, engineering, interior design, landscape architecture, and built environment) to submit projects that utilize natural, artificial, and collective intelligence to combat the climate crisis[18].

From this global pool of applications, the Artistic Director will select up to 16 projects to be developed in the Biennale College Architecture program. Selected candidates will be invited to participate in a 10-day workshop in Venice in September 2024 to further develop their proposed projects, including production plans and budgets. The workshop, led by Carlo Ratti along with a group of curators, architects, tutors, and mentors, will feature both group and individual sessions, as well as meetings with visiting professors and cultural operators.

A final selection of up to 8 projects will be chosen by Carlo Ratti himself. Each selected project will receive a grant of 20,000 euros for production and will be presented out of competition at the 19th International Architecture Exhibition. The goal of this project is, among other things, to expand opportunities for emerging young professionals by sharing their work with a wide audience. The Venice Biennale has long supported the productions of emerging talents in the fields of Art, Cinema, Dance, Music, Theater, and the Historical Archive of Contemporary Arts.

The methodology chosen for the project selection will specifically include four main areas:

- **Transdisciplinarity:** Architectural projects will promote collaborations among different professionals, with the goal of advancing scientific knowledge wherever possible.

[18] Ibidem

· **Living Lab:** In 2025, the Central Pavilion at the Giardini will be under renovation. Consequently, it will be replaced by a series of special projects designed to transform portions of Venice and the external areas of the Biennale exhibition sites into Living Labs, where multiple forms of intelligence can converge.

· **Idea Collection:** Adopting a collaborative approach to design is crucial, especially in times of crisis. On May 7, 2024, the Biennale website will open a space for collecting ideas to expand the diversity of voices, visions, and suggestions.

· **Circularity Protocol:** The Exhibition aims to achieve particularly ambitious circularity goals. Through the development of a Circularity Manifesto, precise guidelines will be established, setting a new standard for future cultural events.

7. Sustainable synergies: exploring through interdisciplinary collaboration

The project draws inspiration from the criteria chosen by Carlo Ratti for the Venice Biennale 2025, focusing on the integration of new technologies and the importance of sustainability in materials and production processes. The exhibit aims to explore how advanced technologies, such as Artificial Intelligence, Augmented Reality (AR), Virtual Reality (VR), and the Internet of Things (IoT), can enhance awareness and understanding of the urgency to develop sustainable materials and processes. The goal is to create an interdisciplinary dialogue between art, engineering, natural sciences, social sciences, and technology, promoting innovative solutions to address the climate crisis and reduce the environmental impact of the production sector.

The chosen methodology thus follows the one developed by Carlo Ratti and is structured around four fundamental criteria:

· **Transdisciplinarity:** The project will promote collaboration among professionals from various disciplines, including architects, designers, engineers, material scientists, biologists, and technology experts. The objective is to develop scientific knowledge and practical solutions that integrate sustainable approaches into design and production processes.

· **Living Lab:** Part of the exhibition will be organized as an interactive "Living Lab," where visitors can experience firsthand the applications of new technologies in sustainable production processes. Dedicated spaces within the exhibit will allow for the observation and participation in practical demonstrations of innovative production techniques, such as 3D printing with recycled materials, biofabrication, and the use of natural and renewable materials.

- **Idea Collection:** A virtual space will be created on the exhibit's website to collect ideas, proposals, and suggestions from professionals, students, and the general public. This space will serve to stimulate an open and collaborative dialogue, broadening the diversity of voices and visions on the topic of sustainability and innovation in materials.

Circularity Protocol: The exhibit will adopt a Circularity Protocol, establishing precise guidelines for waste reduction and the promotion of reuse and recycling of materials used in the setup. This approach will not only minimize the environmental impact of the event itself but also serve as a model for future exhibitions and cultural events.

Similarly, the event will be divided into three thematic sections:

- **Natural Intelligence:** This section will explore the use of natural and biomimetic materials, showing how inspiration from nature can lead to sustainable and innovative solutions. Examples of biodegradable materials, fabrics derived from living organisms, and structures inspired by natural processes will be displayed alongside interactive demonstrations.

- **Artificial Intelligence:** Here, visitors will explore how AI can optimize production processes to reduce waste and improve energy efficiency. Projects using AI to monitor and manage the lifecycle of materials will be presented, as well as examples of generative design that create optimal structures with minimal resource use.

- **Collective Intelligence:** This section will be dedicated to collaboration between communities and professionals to develop shared solutions for sustainability. Examples of community recycling and reuse projects, circular economy initiatives, and knowledge and resource exchange platforms will be showcased. Visitors will be invited to actively participate through workshops and brainstorming sessions

8. From awareness to action: immersive technologies for interdisciplinary design

In conclusion the role of the designer involves shaping and enhancing practices that promote the circularity of actions, materials,products and event.

The project aims to raise public awareness about the importance of sustainability in materials and production processes through an innovative and interactive approach.

Under these circumstances, both designers

and society must be aware of the origins of materials and enhance the use of those that reduce environmental impact and promote awareness and change. To define and increase the application of these materials, fostering processes of valorization, understanding, and implementation, it is essential to examine how to represent the value and significance of materials in relation to the theme of sustainability.

Inspired by the methodology of the Venice Biennale curated by Carlo Ratti, the event will promote interdisciplinary collaboration and the use of new technologies to create educational and engaging experiences. This will encourage visitors to reflect on their choices and the environmental impact of their daily actions. The exhibit will leverage Extended Reality (XR) technologies to create immersive and interactive experiences. Using AR and VR, visitors will be able to explore virtual environments that demonstrate the impact of sustainable materials and innovative processes in various contexts, from industrial design to urban architecture. The integration of IoT sensors will create a responsive environment, where displayed objects and installations react to visitors' movements and interactions, making the experience more engaging and memorable.

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AIGC AND VERNACULAR CREATIVITY: A STUDY OF CHINESE RURAL CHILDREN'S AESTHETIC EDUCATION FROM THE PERSPECTIVE OF CAPABILITY APPROACH

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ABSTRACT | In recent years, AIGC has developed rapidly and has assisted human creative thinking. Since 2023, China's Ministry of Education has recognized AIGC as an important technological tool for empowering education and promoting creativity, encouraging its widespread use throughout the country, including rural areas. However, the application of AIGC in Chinese rural children's aesthetic education presents both opportunities and challenges. On the one hand, AIGC can help children expand the possibilities of creative thinking. On the other hand, the existing AIGC is generally characterized by insufficient data of the Global South or marginal regions, aesthetic homogeneity and difficulties in involving tacit knowledge related to embodied cognition. All of these challenges the endogenous traditions of local culture which are with rural children as the main cultural subject and characterized by vernacular creativity. From the perspective of the Capability Approach proposed by Amartya Sen, this study considers AIGC as a capability sensitive design and explores its impact on vernacular creativity in the aesthetic education of children in rural China. In this study, vernacular creativity represents creative actions that non-experts may engage in every day, as opposed to professional creativity, and is characterized by improvisation, embodiment, situation and materiality. The study was conducted in a remote rural elementary school in Southwest China with an aesthetic education class. The class theme was rural papercutting creation. Through the A-B testing, interviews, observations and expert assessments, the study was conducted on the four phases of the teaching process (discovery-define-develop-deliver) and researching on the paper-cutting works created by the children. The changes in characteristics of vernacular creativity which are associated with the learning of paper-cutting in rural areas under the AIGC are analyzed. Finally, it is proposed that orienting to the Pluriverse what should we do when AIGC intervenes in indigenous culture in the future, ensure rural children have the capability to choose their own future and promote the sustainable development of indigenous culture.

KEYWORDS | CAPABILITY APPROACH, AIGC, VERNACULAR CREATIVITY, CHINESE RURAL CHILDREN'S AESTHETIC EDUCATION, PLURALISTIC 1.

1. Introduction

Rural children grow up in an environment characterized by nature and rural folk culture, supplemented by modern culture. They are highly malleable, energetic and good at learning new things. They are a group characterized by the infinite potential of children and the heterogeneous cultural background of the countryside, and can be regarded as the initial stage of villagers. However, as the modernization process has brought many complex problems such as cultural heritage disruption, environmental damage, economic imbalance and other issues to remote areas in the global South and villages, "Design for a pluralistic world", "Resilient society", "Self-governance" and other design perspectives that turn to the ontology of marginalized areas have gained attention, providing new epistemologies and methodologies to help people face an uncertain future.

Among them, many researches argue that transformation and innovation in vulnerable areas should not rely solely on radical external interventions, but should start from the interactions of subjects, relations and processes in daily life to explore endogenous power (Manzini, 2019; Zhang, 2023; Middha Bhavna & Horne Ralph, 2024). Therefore, this paper focuses on the subjectivity and endogenous power of rural children as villagers in the rural context, seeing them as dynamic and creative subjects in the rural network, as well as the subjects of Vernacular Creativity.

Vernacular creativity represents the non-professional, non-exceptional, creative actions embedded in the daily life of the villagers, as opposed to big creativity. It is an ability to help villagers effectively respond to the complex problems that arise in their daily lives (Zhang, Shangguan, 2023). It aims to enable the villagers to achieve a better life and well-being. This well-being is not only to bring economic and material satisfaction at the primary level of demands, but also aims to achieve dynamic and sustainable development in the rural space through the network involved in the process of village practices, which has a renewing effect on the explicit and invisible subjects such as vernacular creativity itself, the subjects of the

villagers, local knowledge, material carriers, and rural places.

Artificial Intelligence (AI) has revolutionized people's lives. Artificial Intelligence Generated Content (AIGC) such as ChatGPT, Dall-E, Midjourney, Stable Diffusion, etc. are widely used in the field of creative exploration, assisting people in their creative activities, but the prospect of its exploitation and impact in many segments is still as unknown as Pandora's Box. Modern children grow up accompanied by AI devices. Applications based on AI technology and AIGC are already common in the supply of educational resources and the front end of products. For example, some artificial intelligence educational robot toys have entered the K-12 educational stage of many children's families in Chinese cities, and primary school art classrooms in first and second-tier cities will use AIGC to generate images to assist in teaching, and so on. AI has taken on the task of dialoguing and interacting with children as well as artistic enlightenment in education. In contrast, rural children only have smartphones and computers as means of smart education.

The Capability Approach theory proposed by Amartya Sen and Martha Nussbaum provides a pluralistic perspective on judgments of individual well-being and social progress, rejecting uniformity and economic supremacy, advocating capability relativism and equity of choice, providing an ideological basis and instrumental framework for empowerment in marginalized regions (Robeyns, 2005).

Therefore, under this theoretical perspective and design practice, this paper considers AIGC as a capability-sensitive design for empowering vernacular creativity. It also employs a case study of rural children's aesthetic education, providing them with equal access to AI tools as urban children. The experimental process and paper-cutting works are qualitatively analyzed through A-B testing, anthropological ethnography and participatory observation and interview methods.

Through the intervention of AIGC in different parts of paper-cutting, the four characteristics of vernacular creativity revealed in the children's creative behaviors and the presentation of the final works are observed to comparatively analyze and explore the impact of AIGC on rural children's creativity. Finally, the interaction between AI technology, design and rural children's creativity is discussed in the context of the "Technology-Human Capability" relationship framework under the Capability Approach. It also discusses the possible paths for AI to enter the education of rural children and the development of vernacular culture in the future.

2. Theoretical Perspective: The Capability Approach and Empowerment Framework for Rural Areas

2.1 Definition of The Capability Approach

The Capability Approach, which provides a multidimensional framework for analyzing human well-being and social development, was first proposed by the socio-economist Amartya Sen in the 1980s in defense of human capability development and freedom. Against the backdrop of a society predominantly shaped by industrial technology and economic globalization as mainstream developmental ideologies, the core proposition of the Capability Approach is that people's well-being and quality of life should not be judged by uniform criteria such as economic income or consumption levels, but rather by what they are able to achieve with their degree of capability (Robeyns I, 2005, 2006). The term "capability" refers to the number of effective opportunities a person can have and the degree of freedom to make choices, not to the level of competence. So the concept of capability defined by Amartya Sen emphasizes more on capability set in a person, while at the same time many social theorists based on Sen's views suggest that capability is a opportunity set that a person has.

The Capability Approach is characterized by a strong interdisciplinary nature (Robeyns I, 2005). In theory, it has been widely applied in development theory, welfare economics, policy design and political philosophy. In practice, it has also addressed a number of issues faced by the "real world". In 2006, Robeyns proposed nine types of applications of the Capability Approach in practice: (1)General Assessments of the Human Development of Countries, (2) assessing smallscale development projects, (3)identifying the poor in developing countries, (4) poverty and wellbeing assessment in advanced economies, (5) deprivation of disabled people, (6) assessing gender inequalities, (7) debating policies, (8) critiquing and assessing social norms, practices, and discourses, and (9) functionings and capabilities as concepts in nonnormative research. The integration of the Capability Approach with various disciplines encompasses nearly all aspects of human well-being, providing an interdisciplinary space to guide research in social domains such as education, social design, poverty eradication, gender equality, and decolonization. It offers practical and effective support for enriching people's lives, empowering them, and enhancing their freedom.

2.2 Opportunities for free choice and value-based decisions

A key characteristic of the capability approach is the focus on human capabilities and functions, that is, what people can do and be effectively. This implies a gradual refinement of the meaning of "competence": from "having the opportunity" to a further focus on " actively realizing a valuable function". That is, the process by which the subject moves from being given equal opportunities to being given the freedom to choose how to realize a given function. This has also enabled the Capability Approach to move from theory to practice, and has led to a clearer approach to empower in practice.

Martha Nussbaum further proposes a value determination approach to competence based on Sen's theory, divided into two parts: internal criticism and external standards, emphasizing the importance of democratic decision-making and participatory methods. This is because Sen's standard of value involves diversity. Different people and groups have reasons to cherish different things (Johnstone, 2007). Value plurality arises from individual (or group's) differences in terms of region, culture, experience, and their own cognition level. For example, for the same achievement of "alleviating hunger" to achieve happiness, many adults with nutritional knowledge perceive the value of being well-fed as being healthy, and choose well-balanced foods to satiate their stomachs. For children, who are not yet cognizant, the value of being full is more about taste, so they choose "fast food or snack". This implies that the judgment of value and the realization of function are related to people's intentionality, and that people have the freedom to choose "what is valuable" and how to realize "valuable".

The Capability Approach with respect to issues of justice, equality and empowerment, on the one hand, gives people freedom, on the other hand, provides a theoretical framework that offers designers a consciousness of normative standards. It emphasizes substantial freedom rather than directing people to live according to a particular model envisioned by the designer (Robeyns, 2006). It requires designers to focus on people's potential with a pluralistic and interconnected perspective, respecting people's freedom and right to make decisions to achieve the lifestyles they value. Instead of viewing people in marginalized areas as vulnerable with preconceived absolute standards and changing their daily lives through paternalistic intervention.

2.3 The Extension of Capabilities and Ethical Considerations- AIGC as a Capability Sensitive Design

The ultimate goal of the Capability Approach is to expand people's capabilities, and we need to focus on how to expand and what comes out of that expansion, both in terms of process and ethics. Johnstone (2007) argued that the expansion of people's capabilities is not only an internal process of natural maturation, but also needs to be supported by external resources and empowering

environments, such as the availability of choices to use the same technology (tools), inclusive and pluralistic values etc. Ilse Oosterlaken (2009) suggests that design, technology, and engineering have an obvious relevance to the expansion of capabilities, as reflected in the values of privacy, security and justice inherent in all three. As well as the impact of the material artifacts produced by their interactions on social progress and the expansion of human capabilities. Thus, if discussed for the purpose of expanding human capabilities, we need to carefully consider the character and relevance of the roles of the three, consider the moral implications of the resulting artifacts in relation to the technical design rethinking involved behind them and ethics and politics elements in design. Design provides innovative perspectives, ideas and layouts. Technology is the means to realize the design. Engineering ensures that design and technology can be implemented in the real world.

The interaction of the three contributes to change and progress in society, and the capability approach provides ethical norms and goals for their interaction, that is design for responding to the population majority of the world, with an inclusive and pluralistic value judgment perspective, and with the enhancement of human capabilities and freedom of choice as the ultimate goal. This enables designers to consciously incorporate ethical elements and the goal of enhancing human capabilities into the design process, giving rise to the emerging field of "Capability Sensitive Design".

A framework under Capability Sensitive Design

The internal logic of capability-sensitive design is the relationship between "technological/engineered artifacts and ethical-design- capability". Johnstone's (2007) proposes four objects about future technologies and human capabilities: (1) specific groups or individuals (2) specific capabilities (3) specific contexts or situations (4) specific interventions (technologies, artifacts). It can be found that these four objects are involved in different relational interactions of "technology, engineering, design - capability". Therefore, based on the four dimensions of participation, a relational framework (Figure 1) between technology and human capability research can be summarized, which can focus on how a specific technological object affects the specific capabilities of a specific group of people through the interactions between technology, engineering and design and human capability research with the material and the ethical two impacts.

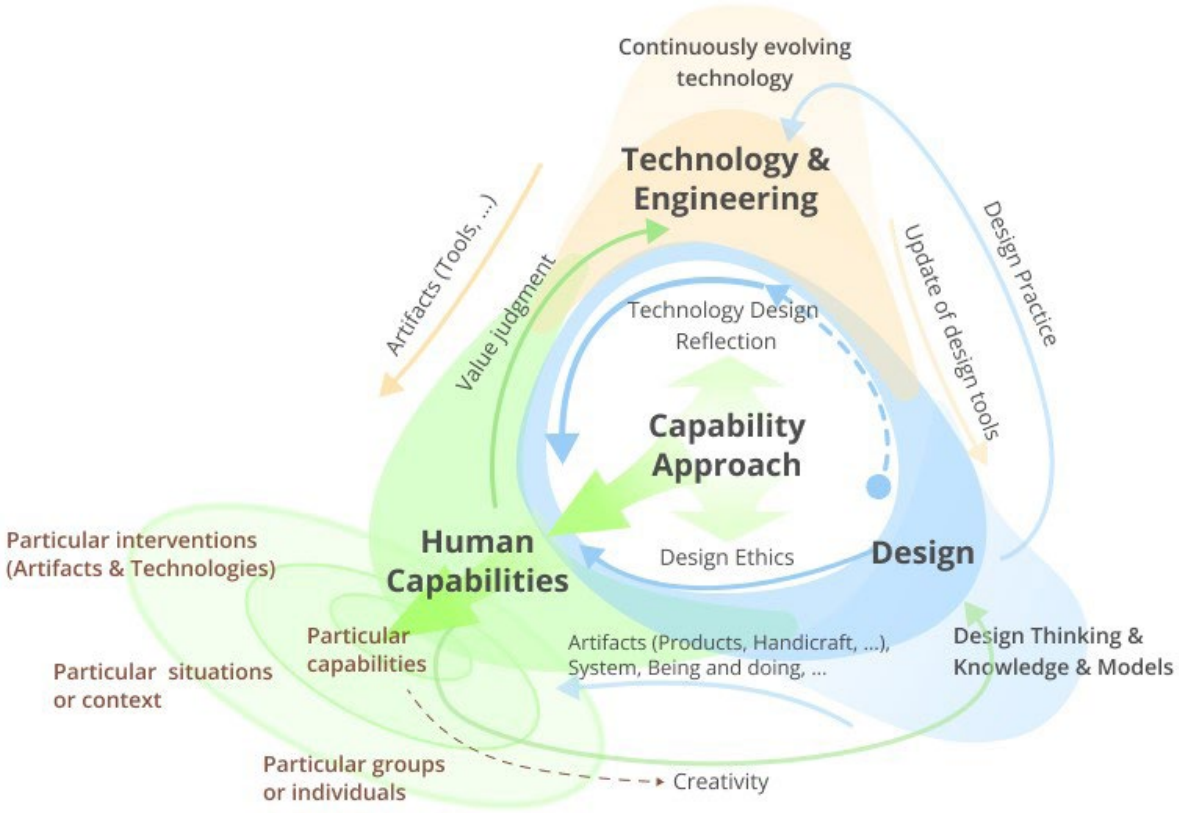

Figure 1. Framework for the Study of the Relationship between Technology and Human Capabilities from the Perspective of Capability Approach.

AIGC as Capability Sensitive Design - Tools, Materiality and Ethical Risks

As artificial intelligence is now in vogue, AIGC is considered as a Capability Sensitive Design. This recognition arises from its functions as a tool and its dual role in digital production that engenders a critical thinking. Artificial Intelligence Generative Content (AIGC) refers to the utilization of machine learning techniques to learn from elements within existing databases (text, images, audio), integrating and creating content that is both similar to and distinct from the original data.

On the one hand, AIGC serves as a content integration and decision-making and intelligent design tool in the creative industry, enhancing work efficiency and assisting creativity. AIGC has made many advances in the generation of graphic content such as paintings and drawings, and is gradually maturing in the creation of 3D content, which has enabled many Chinese folk cultures based on graphic arts to have a new tool for generating content.

In Addition to the creative field, AI has caused educational revolution in China. The big data, large-scale models, robust computational power and integration behind AI subvert the traditional paradigms of knowledge innovation. Knowledge production not only comes from human experience, but also can come from data-based generation by AI. Therefore, AI can break the limitation of marginal knowledge transmission and innovation by the amount of knowledge of the inheritor and the learner, broaden the new knowledge production pathway. Based on cultural databases, empowering education and culture through human-computer collaborative knowledge.

AI's attributes of a tool are also characterized by its materiality. Although AI is a digital tool, its data are generated from solid-state physics, generating content and knowledge need to be presented, disseminated and perceived by human multisensory senses with the help of digital devices and other artifacts, and intervening in human creative behavior and social development.

On the other hand, under the ontological turn in Design, the use of AI has triggered critical thinking about "ways of being", resulting in a lot of ethical risks in terms of values, intellectual property, etc. For example, many design activities now prioritize using AI over the need to solve problems or other better solutions. It needs to be clarified whether AI is a tool to assist people or a design purpose. Amartya Sen distinguishes between means and ends of well-being and development, providing a discursive perspective. Where the ends embody the intrinsic value of functional realization, the means are tools to achieve well-being, justice and development (Robeyns, 2005). This identifies AI as a tool to assist people, rather than a designed end to avoid ethical controversies because of the ambiguity about its identity during development.

In addition, existing AI generation tools also have many contradictions between the context of application and achievable goals, e.g., the database behind AIGC lacks data from the global South or remote regions, the generation content is biased towards Western narratives, the generation style is aesthetically homogeneous, and the generation method is limited to the dismantling of surface symbols and random combinations. In fact, the units and configurations of many Chinese folk motifs have a sequence of meanings, and contain craftsmen's embodied knowledge and improvisation. These make AIGC able to generate similar forms with traditional expressions, but the deeper meanings cannot be scrutinized. Therefore, there's still much space for the application of AIGC in the creation of minority cultures such as folklore, but we don't deny that AIGC has the potential to promote marginalized cultures and expand human capabilities.

3. Vernacular Creativity

3.1 The Definition of Vernacular Creativity

The word "Vernacular" in Vernacular Creativity is widely interpreted as the non-official language used by local people in daily lives. It's also used to describe folk styles in architecture, art, design, music and other fields. The concept of Vernacular creativity therefore naturally carries connotations of community, folklore, informality, daily life, pluralism and social inclusiveness. It proposes an opposite argument to 'Extraordinary Creativity' and 'Big-Creativity', i.e. creativity is not for a specific minority, nor should it be viewed restrictively as the ability to produce groundbreaking ideas, programs and works in specialized fields of art, business and science (Amabile, 2014). It should be present in everyday, non-economic, non-productive and valuable creative behavior (Vermeeren, 2022).

Studies of Vernacular Creativity regard everyday life as a space, which belongs to the study of everyday creativity. Thus Vernacular Creativity also represents a typical kind of everyday creativity (Zhang, Shangguan, 2023). Vernacular Creativity is the ability embedded in the creative experiences of people in their daily lives (Amabile, 2017; Silvia, 2014). It encompasses a wide range of creative actions in everyday life, which can involve people's hobbies, like writing poems or paintings, or ways of coping with everyday tasks (Richards, 2007). Tim Edensor defines Vernacular Creativity as the creative actions presented by ordinary people in specific behaviors. What shows the same essence between the two concepts of creativity. Therefore, we can see the connection between the two in terms of concepts, characteristics, research frameworks and creativity assessment. Differently, Vernacular Creativity emphasizes more on the relationship between specific regions, cultures, people and creative actions (Edensor, 2018). Even it has a trend to explore the world from the perspective of the Other.

Vernacular creativity has the meaning of adaptability, which is recognized as an ability to help people cope with complex situations. Tim Ingold suggests that "design's creativity is not in a preconceived plan, but in the ability that inhabitants can respond precisely to changing circumstances". Ezio Manzini also proposes the concept of "Gestaltswitch", which refers to the process of exploring, and reassembling collected materials to apply them to the environment like a mosaicist. It contains the anthropological process perspective of "the improvisation with their surroundings and materiality" and the Capability Approach of "People have the ability to freely choose to realize the life they desire" are both involved. Design Anthropology proposes social innovation through designing the process, which can engender "newness" not only through the creative nature of design, but also through the Vernacular creativity stimulate improvisational responses. For instance, facing the inevitable domination of technology, Gaskins (2021) develops "Techno-vernacular creativity", which argues that

marginalized and poorly resourced groups can utilize technology to counteract the forces oppressing them, by mixing technology with local culture, values and practices to develop technology indigenously. Vernacular creativity allows for the adaptation of mainstream technologies, transforming unfavorable situations into endogenous power for favorable development, and provides a guiding direction for the application of AIGC in rural folk culture.

Therefore, combining the Capability Approach and the case study of rural children's aesthetic education in the following section, it is clear that the Vernacular creativity proposed in this paper refers to the ability of the villagers to make immediate, appropriate and innovative responses to the complexity of daily changes. It is also a kind of ability that is influenced by the local traditions, folk customs and upbringing, and is universally existed, constantly generated and emerging in the villagers' daily life.

3.2 Four characteristics of Vernacular Creativity

According to the definition of Vernacular Creativity, we find that it exhibits four characteristics: improvisation, materiality, embodiment, and situation (Zhang, Shangguan, 2023), which interact with each other to influence the creative actions of the villagers.

Improvisation

Vernacular creativity is characterized by improvisation and has two aspects: flexible response and temporality. Flexible response corresponds to the meaning of adaptability in its conception, which refers to improvisation oriented to the complex world. Folk craft is a special kind of improvisation in the everyday rural world, is a kind of artistic creation by "thinking while doing", which reveals the dual temporality of Vernacular Creativity pointing to the immediate and the millennium (Vermeeren, 2022). Vernacular creativity is rooted in the history, folklore and ideology of the vernacular society that has been developed over thousands of years, and is expressed in the moment through immediate behavior, and the results of the creativity will become experience and culture. This reveals the dynamic renewal pattern of existence, generation, emergence, and accumulation under the appearance of improvisation of Vernacular creativity, so as to maintain the continuity of the rural daily life and to cope with the challenges.

Embodiment and Materiality

Vernacular creativity is "immaterial", but it emerges through the interaction between "people and things". The process cannot be separated from the material medium as a carrier, and therefore has a material nature. The first is the human body serving as the carrier of Vernacular creativity, storing knowledge and skills, and that Vernacular creativity emerges through the embodied

creative action of multi-sensorial linkage of human being, and it also has embodied nature. The second is that, Vernacular creativity requires material places and artifacts as carriers to build space, provide materials, tools, and create outcomes (artifacts) for human's creative action. The outcome is the concrete presentation of creativity, depending on the limited material form of the tools and materials. But its transformation of the tacit knowledge in creativity, the embodied knowledge of the human being, is infinite and again manifests itself through the subsequent material creation.

Situation

Creativity arises from the interaction of humans, tasks, and situations (Tromp, & Sternberg, 2022). Vernacular Creativity is more influenced by the term "Vernacular", which emphasizes the contextual influence of the society, place, and culture in which it occurs, with specific territorial and spatial constraints. Creativity is always collective, emerging and connected (Escobar, 2018), it cannot be separated from the social culture and situational contexts in which it is located, so it also affects the value judgment of creativity. The situations are therefore an important basis for judging the value of creativity under the Capability Approach, which represents creativity in a specific geographical area with specificity.

3.3 The relationship between AIGC and Vernacular Creativity

The relationship between AIGC and Vernacular Creativity is intricate, marked by both similarity and interactivity. Initially, both Vernacular creativity and AIGC rely on material carriers to manifest existence and content. Vernacular creativity is expressed through human creative actions and the creation of artifacts, while AIGC serves as a tool that can intervene in the creative process. AIGC's digital representation on physical entities provides visual cognition, concrete imagery, and contextual frameworks, correspondingly influencing the embodied, material, and contextual characteristics of Vernacular creativity, thereby affecting its development. Moreover, the impact of AIGC on Vernacular creativity also lies in its inherent randomness, which, when it generates presentations different from initial imaginings, brings surprises that stimulate curiosity and mobilize tacit knowledge for comparison and exploration, potentially sparking creativity. Based on this interaction, we can discuss the interplay between AIGC technology and the four characteristics of Vernacular Creativity among rural children and their creations, extending the discussion to Vernacular creativity.

4. Case Study: Children's Paper Cutting Aesthetic Education Class in a Rural Village in Southwest China

Based on the Capability Approach, Vernacular creativity, and the framework of technology and human capability interaction, it is worthwhile to explore what impact AIGC, as a Capability Sensitive Design into the countryside, can have on rural children's creative behaviors. Therefore, the study conducted a participatory rural paper-cutting aesthetic education class in a remote rural elementary school in Southwest China. The main intention of this Aesthetic Education Class is to explore the following questions:

1. What is the attitude of rural children exposed to AIGC?
2. Does AIGC promote or inhibit Vernacular Creativity among rural children?
3. What characteristics of vernacular creativity are affected by AIGC? What is the impact?
4. What impact will AI tools have on rural children's paper-cutting creative process, artwork output and their own subjectivity? In what parts of the intervention will it have an impact?
5. Beyond the classroom, what is the impact of AI on rural education and on rural crafts?

4.1 Experimental Background

The study was conducted in an elementary school in an ethnic minority village called "Hua Yao". Located deep in the mountains, the village is rich in natural and cultural resources, and their ethnic patterns are colorful, diverse, and have a unique artistic style. Village children, our experimental subjects, grow up in such an environment, being nurtured by ethnic culture and getting to know the world. Children get inspiration by observing the surroundings, so the pattern of paper-cutting is the carrier of children's creativity, which can show children's daily focus, thinking and aesthetics. Moreover, paper-cutting is a representative Chinese handicraft, with easily accessible tools and materials, easy-to-grasp skills, and flat-based patterns suitable for AI creation, making it a suitable material medium for this study.

Participants

A total of 12 students and three researchers participated in this art class, with two researchers assisting with the experiment and one researcher recording the entire class, which lasted nearly two hours. The participating students were all from the same rural elementary school and ranged in age from 7-12 years old.

Theoretical foundation

Based on the "Double Diamond Model" by the British Design Council, we propose a similar framework for AI participation in the craft

creation process (Figure 2), dividing the paper-cutting creation process into Discover, Define, Develop and Deliver, with the corresponding papercutting processes as follows:

- Discover: Conceptualizing the theme and allegorical content of paper cutting.
- Define: Determine the theme and content of the paper-cutting.
- Develop: Conceptualization of specific paper-cutting patterns, graphical and figurative content.
- Deliver: Do the paper-cutting in person.

Due to the two "diffusion-contraction" features in the model, it was categorized into two stages: abstract creation (Discover and Define) and figurative creation (Develop and Deliver). According to other studies (Sreenivasan, 2024), we believe that the AI's intervention in the Discover and Develop stages has an impact on children's paper-cutting creation behavior.

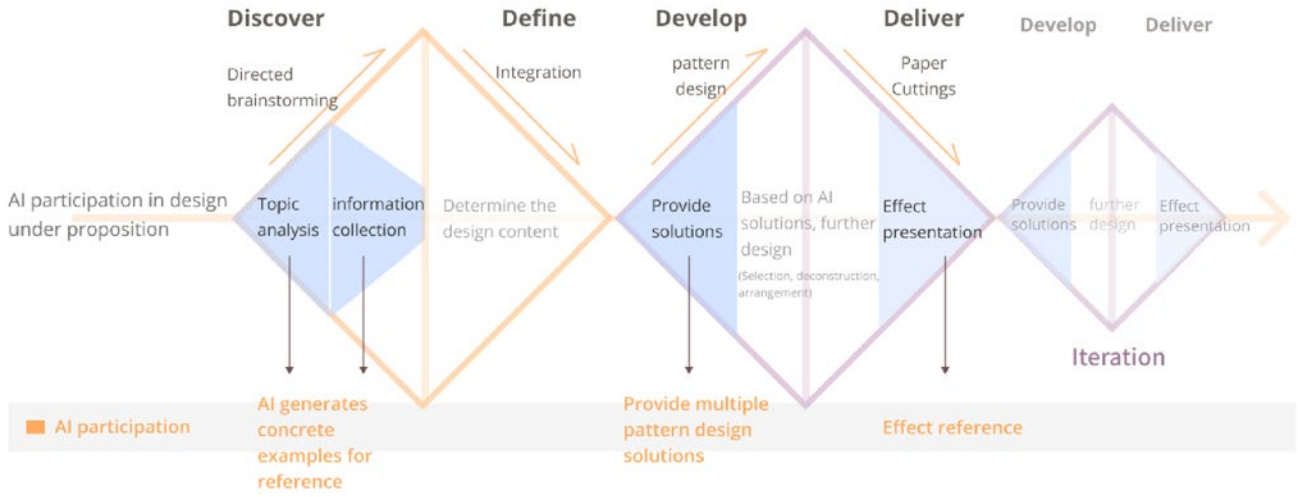

Figure 2. Diagram of AI intervention in handicraft creation process based on double diamond model

Preliminary

The usage of AI: Through previous interviews with art teachers in this school, we learned that digital devices are used for teaching, but only computers and not use AI and AIGC software.

Place: This school has a special traditional culture classroom (handicraft classroom), but due to the curriculum, it is seldom used.

Preparation: The preparations for this class are recruiting students, borrowing the classroom, providing handmade materials such as paper, children's scissors, and display paper, a laptop, Midjourney software, and a Chinese aesthetic AIGC software "QIYU".

4.2 Experimental Process

Warm-up

First, the event is explained to the students participating in the class. The topic of the paper-cutting was "plants". Afterwards, the students were led to a free discussion where they were asked, "What plants would you choose to create?" to understand their creative intentions and to learn about the students' cognition of plants and local natural resources.

A-B Testing

The experiment was divided into two rounds of paper-cutting stages. First, in the first round, all participants were given a freehand based on the theme of "plants" as the initial output of Vernacular Creativity. In the second round, the students were divided into two large groups of six students each, with the ages of the two groups averaged out as much as possible. The first group was to create freely in the abstract stage (Discover and Define), and to add Midjourney in the Develop stage of the figurative stage, which was further subdivided into two groups, A and B. Group A was to create freely on the basis of the theme, and to get "My paper-cutting" (this session could be overlapped with the first round). Students will be asked to describe their work, express the meaning and graphic imagery, and use Midjourney's "text to picture" to generate paper-cutting images for students to view, and then create their paper-cutting works. Group B, based on the propositions to create their own works, and get their "My paper-cutting" works (same as Group A). The researcher will take photos of students' works and upload them to Midjourney, and input keywords, "picture + text" to generate paper-cutting images, and let students watch to make papercutting creation for the second time. The second group was involved in Midjourney from the beginning of the abstract stage (Discover), and was divided into Groups C and D. In Group C, students were guided to view the "plant" theme paper-cutting images generated by Midjourney that the researcher had prepared in advance, and then carry out the conceptualization and figurative creation of paper-cutting symbols; Group D, based on the process of Group C, added the session of taking pictures of students' paper-cutting works and uploading them to the Midjourneygenerated pictures, and then carried out the third paper-cutting stage.

Evaluation

The AI-generated paper cut patterns, the students' free-created drawings (anonymized), and the cocreated drawings with the AI were laid out. Students were organized to have a discussion about"Tell me which of the paper-cutting you think is good, and why?". The work was then evaluated by design researchers and elementary school art teachers at the end of the class.

Figure 3. Recordings of children's paper-cutting class: top left-warm up briefing, top right-second largest group of students looking at AIGC-generated images, bottom left-groups A&B, bottom right-groups C&D

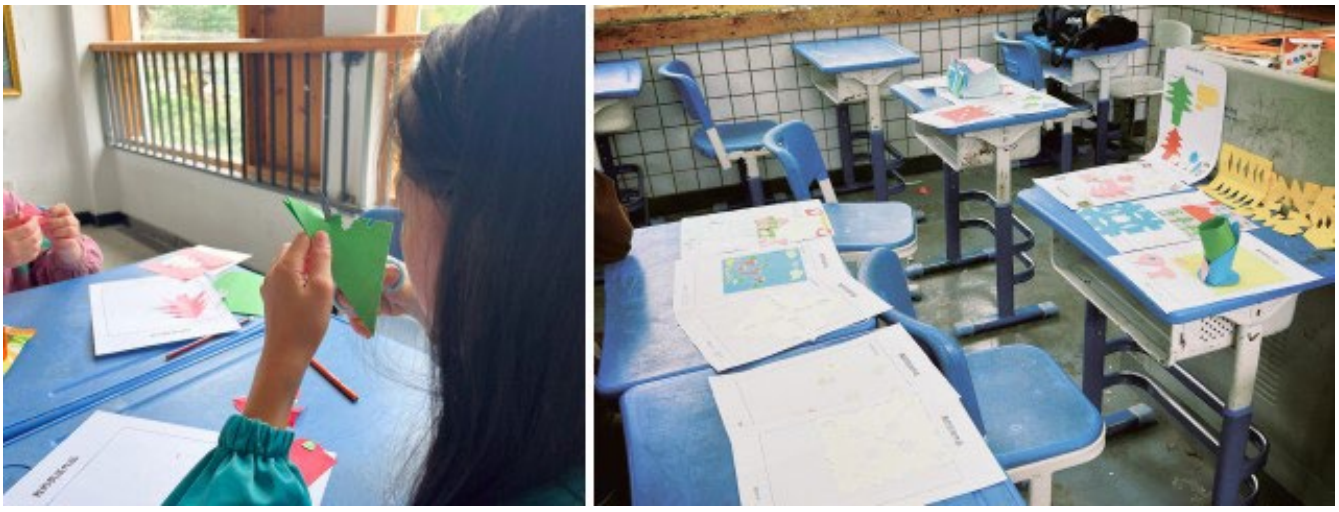

Figure 4. Left one-A student working on paper cutting, right one- Work evaluation sessions were conducted in classrooms

4.3 Findings

Cognition and situation

First of all, in the communication before paper-cutting, we found that although the countryside has the advantage of natural plant resources, the children are still influenced by external plant knowledge and personal aesthetic judgment. They choose plants such as roses and tulips or abstract flower shapes as the prototypes for their creations. Moreover, according to the communication with the art teacher before the class and the actual observation of the children's performance in the paper-cutting handicraft workshop, we found that the children in the countryside like paper-cutting, this traditional handicraft form. They had a high degree of concentration and immersion in the process of paper-cutting creation.

The attitude of rural children exposed to AIGC

In their engagement with AI technology and the Midjourney application, the rural children showed a bland or neutral attitude, neither actively wanting to use the AI nor rejecting to be guided by the researcher, referring to the pictures generated by Midjourney or QIYU for their creations. This may be a manifestation formed by the imperfect knowledge of the material world and technological tools of the rural children, who are unable to recognize in time the functions that the AI software can achieve for them.

AIGC's materiality affects improvisation of creation

Another example is that, in Groups A and B, before the Development stage, students elaborated on the design of their independent paper-cutting works and were assisted by the researcher in summarizing the keywords and the generated patterns. Comparing the interaction between the children's embodied paper-cutting and AI recreated patterns, it is found that, due to the limitations of children's paper-cutting skills, their patterns were inclined to be simplified and utilize abstract botanical shapes of symmetry. However, the patterns generated by AI would become complex and detailed based on the keyword instruction "plant", and therefore, after referring to the AI creation, although the children showed a more introverted attitude, saying "it is too complicated", "I can't cut it out". The children showed the non-adoptive attitude, but in the second paper-cutting round, almost all of them found that the paper-cutting works were subconsciously influenced by the generated patterns, which made the children's works have less white space and more openwork patterns. This reflects the influence of AIGC on children's improvisation, paper-based material vehicles, and embodied cognition.

	Human	AI	Paper Cuttings
The role of materiality	The carrier of knowledge storage and creation	tool	The carrier of outcome
Interaction that generates creativity	The body stores knowledge and experience	Human use tools	Human create objects
The states of materiality	Non-Materiality	Materiality	Materiality
The Dynamics of Creativity	Existence ⟶	generation, emergence ⟶	emergence

Figure 5. The emergence relationship of creativity

Unexpected gains

There were a few surprises in this experiment. Because the researcher, as a cognitively mature adult, had an inherent understanding of the term "paper-cutting" as a paper craft with an openwork technique such as "Chinese windowpane". Therefore, the term "paper-cutting" was used directly when explaining to the children, and no examples were given to show them, as there was concern that giving examples would limit the children's creativity.

However, in the subsequent paper-cutting sessions, it was found that the children presented a variety of paper crafts, including cut-outs, collages, origami, and even 3D construction of paper crafts. Then the researcher adjusted the experiment immediately and standardized the papercutting forms of rural children through demonstrations. But some children still did not care about the fixed forms of paper-cutting and created according to what they wanted and wished to create. Although this had a certain impact on the experiment, the author believes that this is a form of vernacular creativity and a natural development of the experiment, which is characterized by the children's less stereotyped thinking, strong self-expression, and willingness to do things.

Finally, in a mutual evaluation meeting of the children's internal works at the end of the class, they selected what they considered to be the best works, but found that the selected works did not share common aesthetic characteristics, apart from neatness of the picture and harmony of the colors, and may have been influenced by the mutual selection of their partners.

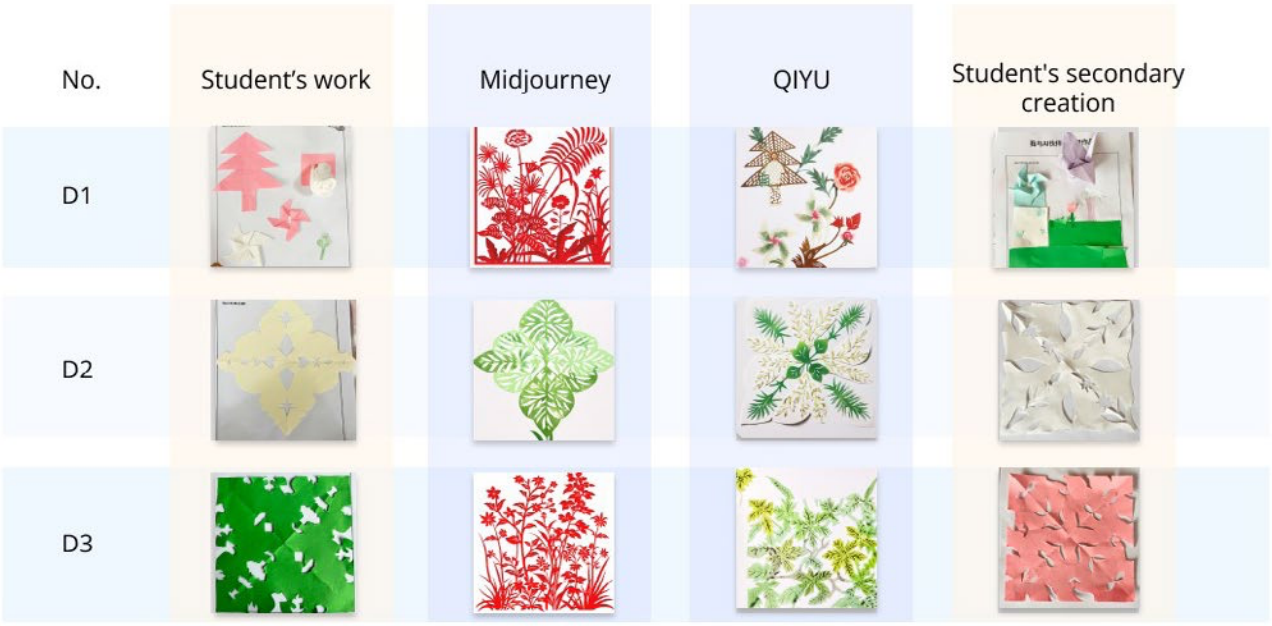

Figure 6. The comparison of student cutouts and AIGC work, student secondary cutouts influenced by AIGC images

5. Conclusion

Paper-cutting is a craft characterized by improvisation, materiality, embodiment and situation. First of all, children are given the theme to create in view of the fact that situation helps children to focus their creativity so that they are better to call upon their own accumulation in life and interests for artistic expression. However, pictures are a more accessible form for children than textual expressions. Image Generation AI generates figurative patterns based on prompts, guiding children's creative situations from vague to concrete, giving directional references and influencing their embodied cognition. At the same time, we are concerned that children may be limited by the thinking of the generated pictures, imitating rather than innovating, but this depends on the differences between individual children's psychology and personality.

Further, both AI and paper-cutting have materiality in themselves, and both need to rely on material carriers to realize pattern presentation and creation. Human, AI and paper-cutting respectively undertake the roles of knowledge storage and creation carrier, tool and creative outcome carrier. They form a series of implied creativity existence, generation and emergence process, which revolves around the interaction of the three: human storing knowledge and experience, human using tools, and human making things, and implies embodied behaviors and knowledge transformations. Therefore, AI acts as a tool, the decision-making power based on the big data behind it can indeed facilitate the generation and emergence of creativity, but one needs to be wary of the authenticity of the AI-generated data. Whether it affects

the new tools used for rural cultures, causing culture mutation or extinction between human embodied creations and materiality transformations. That would deprive us of the possibility of receiving the right kind of knowledge and experience, and the existence that we rely on every day would be unknown. Expanding cultural databases and perfecting a few cultural motifs may avoid the risk of such alienation, but it involves the security of cultural information and the ethical controversy of intellectual property rights.

Paper cutting is an improvisational creative activity, forming indeterminate patterns as the scissors improvise and twist on the paper, conceptualizing as they go. The intervention of AI is a pre-conceived limitation to improvisation, hindering the random of the paper cuts, which is the surprise of the random aesthetics of the paper-cutting. It is reflected that AIGC-generated images serve as normative, figurative guidelines for paper-cutting creation. But sometimes the randomized results generated by AI stimulate interest, promote improvisation and tacit knowledge, and inspire creativity.

AIGC has different effects on the four characteristics of vernacular creativity from different aspects. AIGC makes the goal of creativity clear by assisting situational figuration. AIGC and creativity share a common demand for materiality, so that we can start from the overlapping material carriers and better provide design solutions to promote the human-AI collaboration in recreation; AIGC has a direct effect on the "seeing" of embodied behavior, and indirectly affects the "doing" and embodied knowledge cycle from materiality, expanding more possibilities for embodiment. Finally, AIGC has both advantages and disadvantages for improvisation, destroying its immediacy and stimulating its randomness and adaptability. These four features intertwine, Vernacular Creativity emerges, and human dynamic activities are carried out as a result. Although there are still many risks and ethical issues associated with the application of AI, AIGC, overall, has a positive effect on vernacular creativity when considering current practices.

There are differences between the images generated by Midjourney and the Chinese-style AIgenerated software, which is the effect of different algorithms and databases. The viewer can see the difference in image style because of the details, which is often the essence of traditional Chinese graphic arts including paper-cutting, such as the color and graphics that make Chinese cultural characteristics more distinct. Moreover, considering the students' sensitivity and acceptance of AI-generated images, those that align with their cognitive characteristics and scope can bring them a more positive influence on creation. This insight inspires designers to utilize AI technology for design activities targeted at specific groups, under the perspective of AIGC as a capability sensitive design. For instance, exploring small-scale databases of regional characteristics and children's perspectives, and the implication of those for vernacular creativity are pivotal areas for future research.

We should also hold an open attitude to face the possibility of technology in marginal cultures and try localized ways of technology development to empower marginal areas. While giving the same technological opportunities, we should pay attention to the interactions and relationships in the rural dynamic network, to explore the great potentials that heterogeneous cultures have, and to promote the endogenous development of the countryside and the world towards pluralism.

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‘RE-WILDING’ THE CULTURAL LANDSCAPE. BRERAPLUS, AN ETHICAL AND NO BORDERS MUSEUM EXPERIMENT.

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ABSTRACT | Climate change represents a serious threat to humanity, with air travel and tourism significantly contributing to excess carbon dioxide emissions. In response, contemporary museums are adopting ecological concepts such as sustainability, diversity, and ‘re-wilding’ to restore cultural landscapes, foster new community relationships, and offer alternative experiences. Traditionally focused on education, museums have shifted over the past fifty years towards a ‘leisure industry’ model, prioritizing visitor numbers and revenue, which has led to new museum construction, blockbuster exhibitions, and international marketing. While economically advantageous, this model often clashes with the museums’ original missions and environmental stewardship needs. Although museums have implemented measures including LED lighting and recycling to reduce their carbon footprint, addressing emissions from visitor travel remains challenging. The pandemic altered museum practices by drastically reducing international travel and accelerating digital adaptation. Museums quickly expanded their online presence, making content accessible from home. This paper explores the design ethics at the Pinacoteca di Brera over the past eight years, culminating in BreraPlus, an online platform that provides 24/7 access to the museum. This initiative illustrates how museums can achieve greater inclusivity and sustainability, remaining relevant and accessible while promoting empathy and intercultural understanding.

KEYWORDS | MUSEUM; CULTURE; DIGITAL; DIVERSITY; INCLUSIVITY; RE-WILDING; SUSTAINABILITY.

1. REFLEXIVE DISCUSSION. Museum, Leisurely Flânerie, and Emission.

Climate change is the most significant challenge to the continued survival of humankind, as the planet's dominant species. If this fact can be agreed upon, then it stands to reason that the only morally acceptable position for humankind to take now – in the early 21st century – is to address the causes of global warming, the foremost of which is carbon emissions. Air travel, and hence economies based on tourism, are among the largest contributors to excess carbon dioxide. International tourism has a statistically and economically significant detrimental effect on the environment by increasing CO2 emissions (Cevik, 2022). Although these emissions are currently not well quantified, the rapid increase in tourism demand is surpassing the pace of technological advancements aimed at decarbonizing the tourism sector (Lenzen, et al., 2018).

Modern museums, which emerged during the French Revolution, were not primarily intended as venues for leisurely flânerie but for popular education, research, and study. Moving away from their origins as private collections of the aristocracy, these institutions were designed to be accessible and inclusive, rather than simply objects of admiration for an exclusive group. This mission is now being positively reaffirmed in a world where the community to which the museum's holdings belong has become increasingly diverse. Tourism growth remained relatively limited until the introduction of wide-bodied jet airplanes in the 1970's (Gossling & Peeters, 2009) . Before the late 19th century, tourism was a slower-paced activity, largely dependent on trains and ocean liners. It was not until the 1950s, with the simultaneous development of the automobile, the highway system, and increased leisure time, that more people had the opportunity to conveniently visit holiday destinations, both near and far.

Now, for over fifty years, museums have been exhorted by politicians, abetted by journalists and economists, to consider

themselves part of the 'leisure industry' (Foley & McPherson, 2000), measurable in terms of visitor numbers and direct and indirect revenue, which in most European countries pre-COVID-19 contributed a substantial sum to the Gross Domestic Product (GDP). This contribution has become the justification for building new museums, creating 'blockbuster exhibitions', and marketing museums as a destination for international tourism. While this approach may have made economic sense in the short term, it poses a long-term challenge to the original mission of museums and contradicts the pressing need to reduce carbon emissions.

In response, museums have initiated efforts to understand how to reduce their carbon footprint (Müller & Grieshaber, 2023). Measures include replacing old lighting with LEDs, utilizing well water for climate control systems, lowering temperature settings, and promoting recycling. However, these steps are insufficient. Similar to how the carbon footprint of food must account for its production, transport, and preparation, a museum's carbon footprint must also consider the emissions associated with bringing visitors to the museum.

2. ETHICAL QUESTIONS. How to re-wild the cultural landscape?

"I now suspect that just as a deer herd lives in mortal fear of its wolves, so does a mountain live in mortal fear of its deer. And perhaps with better cause, for while a buck pulled down by wolves can be replaced in two or three years, a range pulled down by too many deer may fail of replacement in as many decades. So also, with cows. The cowman who cleans his range of wolves does not realize that he is taking over the wolf's job of trimming the herd to fit the range. He has not learned to think like a mountain. Hence, we have dustbowls, and rivers washing the future into the sea. […] We all strive for safety, prosperity, comfort, long life, and dullness. The deer strives with his supple legs, the cowman with trap and poison, the statesman with pen, the most of us with machines, votes, and dollars, but it all comes to the same thing: peace in our time. A measure of success in this is all well enough and perhaps is a requisite to objective thinking, but too much safety seems to yield only danger in the long run. Perhaps this is behind Thoreau's dictum: In wildness is the salvation of the world. Perhaps this is the hidden meaning in the howl of the wolf, long known among mountains, but seldom perceived among men." (Leopold, 1948, p. 132)

Aldo Leopold (1948), Ed Ricketts (1941), were pioneers of what we now call 'ecology' – seeing all life on the planet as a single related whole, where changing one element triggers effects throughout the system. Ecology teaches us that altering a single aspect of a complex whole is extremely risky, and the consequences can be alarming and unforeseeable. These ecological principles offer invaluable insights for contemporary museum thinking, centred around the

concepts of sustainability, diversity, and now, rewilding. Rewilding means working to bring back the natural balance and wildness to an area. It's about protecting the environment and its natural processes. Rewilding focuses on returning a place to its original, wild state, which might require active human intervention and people to get involved and help make it happen.

With the advent of COVID-19, this third concept has emerged forcefully, reshaping how we view museums and their role in society. In a mere three months, the pandemic not only accomplished what environmental activists had struggled to achieve in decades – a significant reduction in international travel – but forced museums to reevaluate their practices, especially as physical visits became restricted or impossible. This situation has demanded swift adaptation and accelerating technological transformation (Dal Pozzolo, 2021; Sacco & Calveri, 2021). Cultural institutions responded to the lockdown by extending their cultural offer beyond their traditional buildings, reaching their audience in their homes by means of the Internet (Bollati et all., 2024)

3. PRACTICE-BASED EXPLORATIONS

3.1 PRACTICE-BASED EXPLORATIONS. Brera, from visit to subscription

The pandemic encouraged museums to reconsider their relationship with visitors, the community, and the environment. In a post-COVID-19 world, museums were challenged to:

1. Shift emphasis from the museum 'visit' – the phenomenon of viewing the objects in person - to the museum experience – the 'valorisation' of the museum's collections, which we realized during the lockdown could occur increasingly online. Both experiences are equally valid and necessary, complementary but fundamentally different. The museum's identity has long been confused with that of its collection, akin to confusing a score with performance;
2. Recognize that the in-person museum visit is now more precious than ever, and the art of slow looking (Reed, 2017; Watts, 2019) – "an approach based on the idea that, if we really want to get to know a work of art, we need to spend time with it" - is fundamental (Han, 2017) to getting the maximum value from seeing the original. Pre-visit preparation is more important than ever and tools such as labelling encourage visitors to look more closely and extract more meaning, which are more fundamental than ever. We must also consider the insights of the American psychologist Abraham Maslow (1908-1970) – the visitor has to feel safe, respected, included, and comfortable, making even the act of having a coffee in the café at the end or start of a visit an important condition of experiencing the collection fully (Abraham, 1943).

COVID-19 taught us that neither the total number of visitors nor the revenue these visits generate are appropriate parameters to measure the value of a cultural institution (Bollati, 2021); "Museums have become victims of the equation, more = better" (Kenneth, 1996, p. 122). More importantly, if the museum's activities are also readily available online, the way to involve and welcome users and the community to a museum by merely letting them enter its spaces or enjoy its contents and collections in situ is no longer characterized by a conventional ticket, which is only the permission to access a physical space. If the enhanced online content is sufficiently rich and representative, the practice of purchasing a ticket to see the permanent collections could be transformed into an annual subscription – in effect, a membership – which includes access to the museum both in person and 24/7 online. In this way, as Kenneth Hudson argued, the museum can be seen like a private club (even more than a disco) with its ambitions remaining modest and its financial health based on its membership base (Kenneth, 1996).

Thus, whereas tickets expire at the end of a visit, a card is all-encompassing and longer-term. It allows visitors to organize their visits according to their desires and needs at different times, inviting them to return by developing a sense of familiarity with the spaces and the collections. Not only does this card gives visitors access to what the museum has, possesses, and preserves but it also allows them to experience the museum's constantly evolving cultural activities and proposals.

In this manner, the online museum experience—which encompasses preparation for the visit as well as post-visit activities and events throughout the year—becomes the comprehensive museum experience, wherein the physical visit to view the original artifacts is a treasured opportunity. Consequently, the revenue from ticket sales becomes inconsequential, rendering the museum effectively free to all, but only through membership in the museum community. By shifting away from using the single visit as a measure of its quality, the museum can now focus on its primary mission: to transform visitors by encouraging them to stay longer and see more of the objects in the museum's permanent collections. The museum's value can be measured not by visitor numbers but by subscribers to its creative output – by what the museum does, not from what it has. The museum becomes a verb, not a noun.

Figure 1. The fifth re-installation of the Pinacoteca di Brera, room 36. The image exemplifies how the museum presents itself during a traditional visit. Ph. Cesare Maiocchi.

The Pinacoteca di Brera exemplifies this approach, having evolved in this direction through various changes in recent years. Over the past eight years, the institution has undergone a comprehensive reorganization, reclaiming its cultural and social roots by enhancing its artistic, human, and historical heritage, following the legacies of its former directors Ettore Modigliani, Fernanda Wittgens, and Franco Russoli. The latest advancement is BreraPlus, a versatile cross-media platform accessible 24/7 from any location, designed to seamlessly enhance and enrich real-life experiences without attempting to duplicate them (Mandarano, Pagliaro, & Mataloni, 2008). This initiative arises from the recognition that, while the authenticity of encountering an original work of art is irreplaceable, a digital visit can serve as a valuable complement to the physical encounter, as underscored by the pandemic. The digital platform allows for the exploration of aspects that a physical visit might not provide but can be fully appreciated in a virtual format. The online experience can act as a catalyst for subsequent in-person visits or provide post-visit insights, fostering a relaxed and curious exploration of the museum's offerings. (Russoli, 2017) (Modigliani, 2019)

Through the BreraPlus annual subscription, the museum has effectively integrated digital and physical experiences to create a holistic museum offering. By acquiring the BreraCard, users gain access to BreraPlus's online content for one year and can visit the museum for three months at their convenience. This model, established in public libraries for decades and recently adopted by digital newspaper subscriptions, illustrates a shift towards more versatile user engagement. BreraPlus serves as a digital extension of the museum's offerings, allowing subscribers to access a range of content including unpublished stories, interactive documentaries, experimental films, and scholarly studies. Additionally, subscribers can participate in concerts, premieres, live-streaming events, and engage with historical narratives, read books in their original language, and interact with other users.

The BreraCard was first introduced in 2020, but it was in 2023 that a second release of BreraPlus was effectuated with all content available in dual languages. Examining the data from the last two years, 2022 and 2023, it is evident that the number of reused BreraCards (indicating individuals who returned at least once within 3 months with the same card) in 2023 increased by 16%, compared to 2022. Additionally, the number of multiple entries rose from 19% to 24%. In 2022, among the 19% of redemptions, some individuals visited the museum up to 8 times in 3 months; in 2023, this increased to 10 visits in 3 months. In both years, most initial returns were by individuals alone or in pairs, with a minimal percentage returning in groups. Subsequent returns were predominantly by individuals, highlighting a personal relationship with the museum. The transition from a single physical ticket to a card or subscription model that encompasses both in situ and online museum activities has transformed the nature of museum engagement. This shift has repositioned the museum from a static entity to a dynamic participant in a continual dialogue. By functioning as a 'verb,' the museum engages actively with its collections through diverse activities and fosters ongoing interaction with its audience. This transformation facilitates a reciprocal exchange between the institution and its visitors, extending cultural experiences beyond physical boundaries and into the digital domain, thereby enhancing the museum's influence both within the city and within individual homes. The museum starts a dialogue with its public made of users, not just with visitors (Author 2, 2001). To clarify, the terms 'visitors' refers to people who visit the collections in person, while the term 'users' signifies a person who can interact with the museum in a wide range of ways.

3.2 PRACTICE-BASED EXPLORATIONS. BreraPlus, A 24/7 Living Museum.

BreraPlus represents a transformative innovation in the realm of museum experiences, operating as a cross-media platform accessible 24 hours a day, 7 days a

week. This platform is meticulously designed to extend the museum experience both spatially and temporally, offering curated content that introduces fresh perspectives and diverse voices. It integrates various media forms, including experimental films, interactive documentaries, concerts, backstage content, storytelling, and readings in their original languages.

The conceptual framework of BreraPlus distinguishes the museum experience from traditional film viewing. Unlike films, which possess a predetermined and finite duration, the length of a museum visit is inherently flexible. Films follow a linear, narrative-driven structure with controlled emotional peaks, whereas museum visits are non-linear, characterized by chance encounters and social interactions. The emotional impact of film is largely personal and individualistic, while the museum experience is profoundly social and communal. This distinction is analogous to contrasting a meticulously planned amusement park ride with a leisurely stroll through a park, replete with unexpected discoveries.

Operating on the premise that museum visits are elastic, ever-changing, and unpredictable in duration (Falk & Dierking, 2012; Black, 2012; Hein, 1998; Hooper-Greenhill, 2006), BreraPlus offers a diverse array of interconnected content designed as an 'open' narrative experience. This platform allows users to navigate through videos, images, texts, audio recordings, digital versions of original books, high-definition paintings, original music, contemporary reinterpretations of classical artworks, and unpublished stories. Such a structure empowers users to explore, revisit, and continue their journey seamlessly, akin to participating in an endless, immersive game. It fosters an innovative approach to storytelling, providing a dynamic environment conducive to browsing, learning, excitement, and sharing. It replicates the characteristics of a living museum (Wittgens, 1956), through its online platform.

The dynamic and flexible nature of the BreraPlus experience is primarily ensured through the inclusion of supplementary content alongside the main videos. These additional features— VideoPlus, SpotPlus, HighDefinition Plus, DeepPlus, and BookPlus—serve to extend and enrich the narrative experience. As users engage with the main content, these extras appear, offering the option to explore further or continue with the primary narrative, based on the user's preference at that moment. This system is analogous to boarding a train, where users have the autonomy to embark

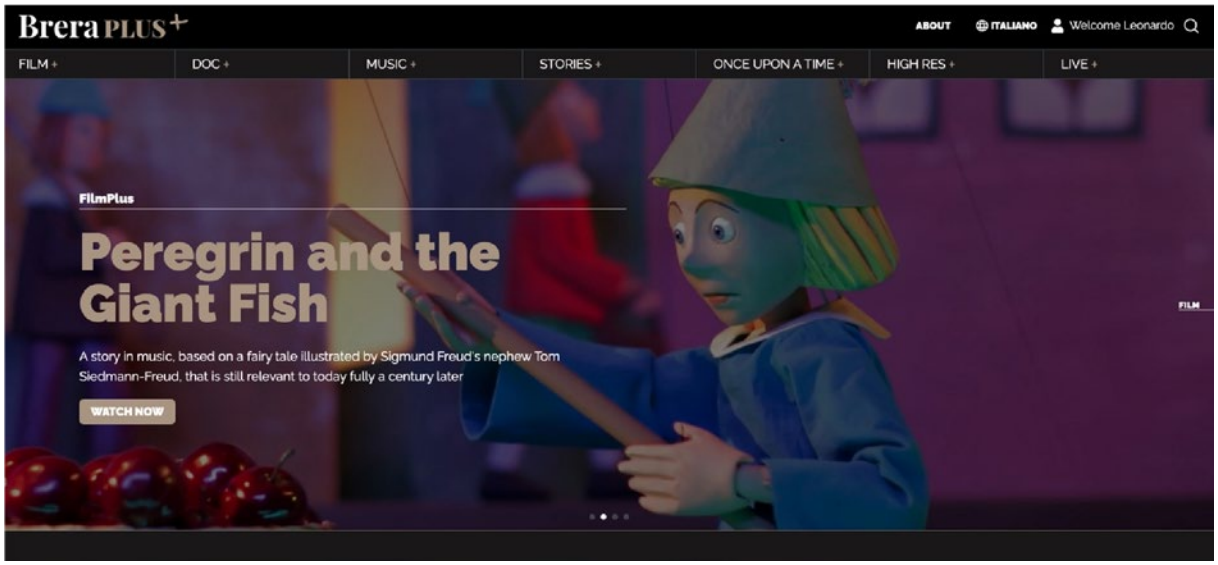

Figure 2. breraplus.org homepage features a preview of Peregrin and the Giant Fish, a musical narrative based on a fairy tale illustrated by Tom Seidmann-Freud, the nephew of Sigmund Freud. This figure exemplifies the platform's second release in 2023.

and disembark, explore intermediate stops, and engage with different segments of the journey. Each piece of content is designed to be consumed in a single session or revisited for deeper exploration and understanding.

Since its inception in 2021, BreraPlus has progressively expanded its content library, now boasting over 100 pieces of content, with new additions introduced monthly. The platform evolves in tandem with its audience, striving to maintain an ethos of openness, dynamism, and inclusivity akin to that of the physical museum. Currently, it encompasses seven distinct sections, acting as a repository of memories, innovations, voices, videos, images, and music:

1. **FilmPlus:** Experimental films produced by the Pinacoteca di Brera, including interactive theatre plays and puppet operas.
2. **DocPlus:** Documentaries that go beyond traditional narratives, incorporating untold stories with additional interactive content.
3. **MusicPlus:** Compositions by renowned musicians, performed by top-tier artists, exploring the interplay between visual arts and music.
4. **StoriesPlus:** Oral histories presented through words, music, and videos, tracing the historical narratives of Brera's connected locales and personalities.
5. **Once Upon a Time Plus:** Narratives presented in their original languages (Italian, English, Russian, Dutch) by prominent figures, blending the pleasures of reading with elements of fantasy and theatricality.

6. **High Resolution Plus:** Masterpieces showcased in ultra-high definition, revealing intricate details and pigment nuances.
7. **ChatPlus:** Interactive discussions and messaging features that allow users to share comments and insights on the artworks.

BreraPlus also includes a LivePlus section, offering live online coverage of special events at the museum, such as concerts, premieres, and conferences. This feature enables remote participation in Brera's initiatives. In June 2023, for the first time, users were invited to participate in a meeting of the museum's Board of Trustees, transforming them from mere visitors into stakeholders. Approximately seventy-five attendees had the opportunity to observe the live presentation of the museum's strategic directions and contribute suggestions via a chat system. This process embodies the social role the Pinacoteca aspires to fulfil, promoting a sense of sharing and belonging, different from mass tourism. A record of the proposals communicated by individual users through chat was drafted, facilitating constructive exchange and dialogue.

BreraPlus exemplifies how digital innovation can enhance and redefine the museum experience. By merging the flexibility of physical visits with structured digital content, BreraPlus creates an engaging, immersive, and inclusive platform, enabling users to interact with art and culture in novel and meaningful ways. It is no coincidence that data from 2023 further indicate that the acquisition of the BreraCard and subsequent activation and use of BreraPlus for accessing online content frequently correlates with physical activities organized by the institution. For instance, the temporary exhibition in the library dedicated to Otto Prutscher, A Golden Thread (1900-1938), linked to a dual documentary on the Viennese architect available on the platform, exemplifies this connection. Additional peaks in first logins to BreraPlus were recorded during the members' assembly in July and the December screening of the film Peregrin and The Giant Fish at the MAXXI in Rome, demonstrated cross-institutional engagement.

4. ETHICAL AWARENESS. Towards A Sustainable Museum.

The concept of rewilding the cultural landscape has emerged as a crucial imperative at the beginning of this paper, while BreraPlus stands as a pioneer project in this endeavour. The Brera approach embodies the shift towards reestablishing the authentic role of museums as integral to their local communities while reducing dependence on unsustainable mass tourism and the leisure industry.

BreraPlus has demonstrated that an ethical design of a museum hybrid, accessible, and sustainable cultural offer is possible. It clarified, by means of a practical example, what rewilding could mean and how it could be translated into real museum actions:

1. **Reasserting the Museum's Links to the Local Community:** BreraPlus emphasizes the importance of connecting with the local community in all its diversity. This includes not only providing access to historic collections but also expanding them to encompass the full range of the community's experiences. This approach necessitates engaging with all stakeholders, involving them in decisions about acquisitions and displays, and incorporating them into the ongoing governance of the institution. It involves rethinking existing museums rather than constructing new ones and focusing exhibitions on contributing to ongoing research or serving the community, rather than merely boosting attendance
2. **Providing Targeted Access to the Museum's Collection:** BreraPlus aims to serve the local community, scholars, and researchers without encouraging mass tourism. Recognizing that casual tourists do not require access to the entirety of a collection, the platform facilitates specialized audiences' access through organized, open storage that is available when needed rather than being displayed continuously. Additionally, it supports innovative projects outside the museum's physical space, such as in community centres, hospitals, elder care homes, and peripheral schools.
3. **Creating Remote Museum Experiences:** The global COVID-19 pandemic underscored the importance of online access to museum resources previously thought to require physical visits. BreraPlus offers access to deposits, interactive experiences, innovative interpretation forms, and new ways to engage with collections, making the museum accessible 24/7. This shift not only enhances access and creates new opportunities but also transitions the business model from ticket-based to subscription-based, allowing stakeholders to participate in ongoing governance, akin to shareholders in a corporation.

Returning to the specific data related to the concept of rewilding the cultural landscape, it is evident that following the second release with dual language support and the international press launch in June 2023, there was a notable increase in foreign BreraCard holders. Initially, foreign users constituted 35% of the total until June 2023, which subsequently rose to 47%. Additionally, among Italian users, the number of BreraPlus subscriptions used outside Milan and Lombardy increased by 7%. This data underscores the fundamental role of online engagement in establishing the first point of contact or maintaining an ongoing

Figure 3. Thirteen renowned artists' masterpieces adorn a 360-square-meter hospital wall, revamping waiting rooms and hallways. High-resolution images from Brera Museum welcome hospital visitors, patients, and staff in the Brera in Humanitas project (2023), strengthening the museum's ties with the diverse local community.

relationship with the museum after the initial visit. It also highlights how such engagement can occur without encouraging mass tourism motivated solely by the desire to check off a famous destination from one's list. This approach exemplifies the social role the Pinacoteca aims to fulfill, fostering a sense of sharing and belonging that is distinct from the dynamics of mass tourism.

In this paper's ethical questions and dilemmas for museums have intersected with design research and practices to create a fully worked example at the level of an internationally recognized Italian state cultural institution. This alone merits the consideration and critical attention of museum professionals around the world.

"No important change in human conduct is ever accomplished without an internal change in our intellectual emphases, our loyalties, our affections, and our convictions". (Leopold, 1948)

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DESIGN-DRIVEN INNOVATION FOR NATURAL CAPITAL: MAPPING CRITICISMS AMONG CONSERVATIONBODIES TO IMPLEMENT ACCESSIBLE TECHNOLOGICAL TOOLS FOR CONSERVATION.

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ABSTRACT | The conservation of Natural Capital is becoming one of the most critical challenges for the upcoming generations in preserving the health of the planet and the human species. Innovative technologies, such as IT sensors, software, and AI, play a significant role in monitoring, managing, and protecting natural ecosystems. However, their integration into environmental sciences to address climate change and ecosystem preservation faces challenges like data accessibility, reliability, and the need for features supporting long-term growth in volatile environments subject to rapid changes. Additionally, the diversity in conservation objectives, cultural backgrounds of practitioners, fragmented nature of information, and lack of coordination contribute to a disorganized data ecosystem and the development of problem-specific solutions that are difficult to transfer to other conservation scenarios. This study employs Human-Centered Design tools to examine the complexities faced by conservation organizations. Through field analysis with six Italian and international organizations and involving 145 operators managing protected areas, the study maps operational criticalities and compares them to identify potential advantages and challenges of using innovative technologies for natural capital management. The research proposes a paradigm shift towards a design philosophy in the environmental sector that prioritizes accessibility and usability, instils confidence in data for decision-making, and strengthens collective conservation efforts. It underscores the need for technological tools to cater to users with diverse abilities, goals, and cultural backgrounds focusing on flexible and tailored solutions. Emphasizing user involvement in design processes, such as personalization and co-design, the study highlights the pivotal role of design techniques in enhancing the effectiveness of digital solutions for environmental conservation.

KEYWORDS | ENVIRONMENTAL CONSERVATION, ACCESSIBILITY, HUMAN-CENTERED DESIGN, USER EXPERIENCE, NATURAL CAPITAL

1. Introduction

1.1 Climate Crisis and Natural Capital

Within the last two decades, extreme natural events connected with climate change are becoming more common. Scientific Academia widely recognises that our planet's climate is drastically changing at an unprecedent speed, and the consequences are affecting the natural equilibrium of ecosystems, biodiversity, and human life (IPCC, 2022). To fully understand how climate change and biodiversity loss affect human life on Earth, it is essential to highlight the interplay between these three elements.

As it is possible to see in the Figure 1 produced by the International Panel for Climate Change within the Summary for Policymakers, there is a strict interdependency between Climate Change, Human Society and Ecosystems, including biodiversity. These three elements are a clear risk for humanity and must be considered in planning and policymaking in the coming years as each change in one area strongly affects the other variables (IPCC, 2022).

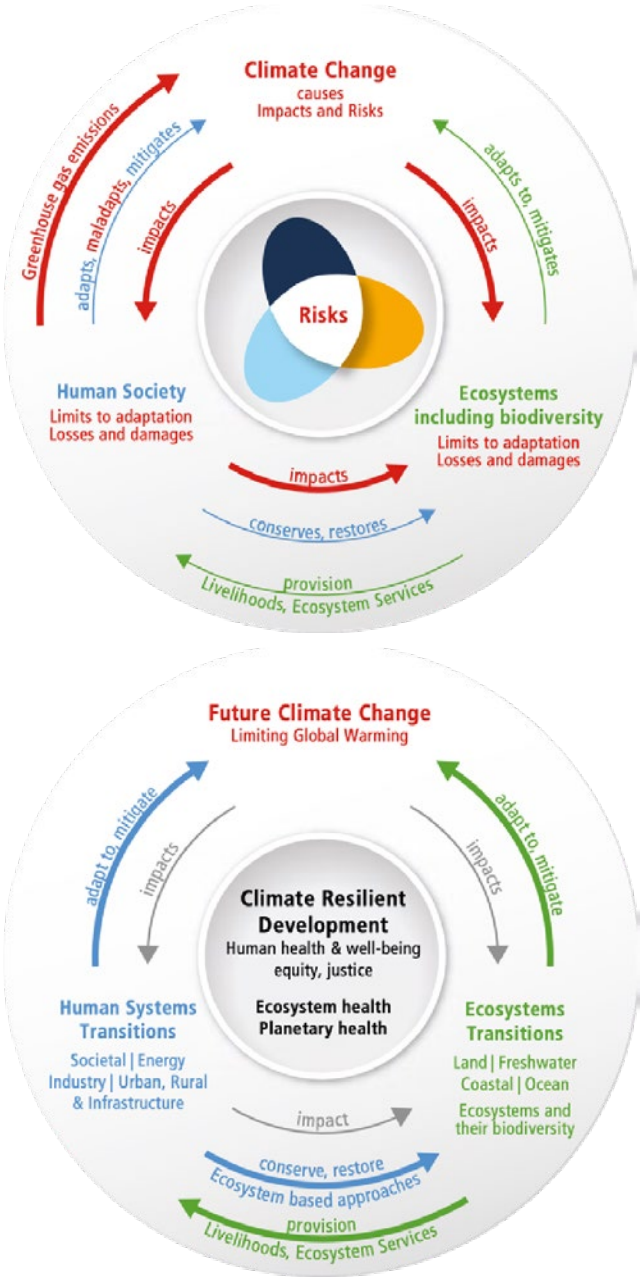

Figure 1. Infographic extracted from 'Summary for policymakers', IPCC, 2022.

As the natural ecosystem and biodiversity play crucial roles in the planet and human well-being, it is essential to develop policies that consider the protection and conservation of Natural Capital. Observing Fig.2., it is possible to see how to stage a Climate Resilient Development, which ensures human health & well-being, equity and justice, it is essential to limit global warming through human and ecosystem transitions (IPCC, 2022). The paper will focus mainly on the latter, as the object of the research is to focus on the management and conservation of natural ecosystems. Indeed, to start an effective ecosystem transition, it is fundamental to focus on the preservation and restoration of the planet's ecosystems and their biodiversity, both on land and water, commonly defined as Natural Capital. However, the equilibrium among these factors is continuously changing, and natural ecosystems, which rely on the delicate balance between organisms, are heavily modified by human activities, sometimes extremely fast and other times slower. For these reasons, it is pivotal to understand how to predict, manage, and mitigate these changes, an area in which technology can play a crucial role.

Defining what Natural Capital is crucial before proceeding with the analysis. The first definition of Natural Capital was given by Schumacher in 1973; he describes the Natural Capital as the exhaustible resources of nature (Schumacher, 1973). Schumacher considers the whole stock of the planet's natural resources, including geology, soil, air, water, vegetation and all living organisms.

Environmental issues affect countries and policymakers worldwide; this paper will focus on areas interested in conservation measures, such as national parks and marine protected areas, home to a wide range of different natural ecosystems. Indeed, the 5° report of Natural Capital in Italy from the Natural Capital Committee states that action is needed to protect this heritage and mitigate threatening events, such as soil erosion or forest fires (Comitato Capitale Naturale, 2022). This phenomenon of an increasing focus on natural capital protection and valorisation interests' policymakers worldwide who are adapting local policies to international guidelines. Indeed, the interest of governments' joint effort to protect the Natural Capital is confirmed by the vast array of national and international conservation strategies, such as SDG goals created by the United Nations. Within this action plan, more than 160 states are working together to follow those guidelines and receive different scores depending on their commitment. More than half of the SDG's goals are related to the health of Natural capital and its conservation (United Nations, 2023).

A valid example of this approach is the PNRR plan in Italy, the most critical environmental policy implementation plan of the next decade. The plan will invest more than 190 billion euros in new policies, with the ecology transition and digital innovation accounting for more than half the budget (Comitato Capitale Naturale, 2022).

1.2 Interplay between Nature and

Technology and the Role of Design

Before starting the critical analysis, it is necessary to highlight the role of technology in this process. Indeed, cutting-edge technologies are being developed within natural resources management to produce more commodities and services with less raw materials.

Indeed, the interplay between nature and technology has become pivotal in monitoring, managing and protecting the natural ecosystem, a phenomenon that has already given excellent results in different fields, such as Agriculture 4.0 (Klerkx, Jakku, & Labarthe, 2019).

These new implementations apply not only to the production and manufacturing sector but also to the observation and data collection related to biodiversity and ecosystems. Indeed, new tools, such as IT sensors, software, and AI, are being implemented in the Environmental Sciences to better understand climate change and how to defend delicate ecosystems (Weersink, et al., 2018) Furthermore, the environmental sector has come to appreciate the pivotal role of credible, objective, and real-time spatial information. This recognition is particularly evident among managers of protected areas, who understand the value and necessity of such scientific information and data. It serves as the foundation for making informed and effective conservation and management decisions, highlighting the significant impact of researchers' work in the field (Fancy & Bennetts, 2012).
Although the development of these new technologies is proceeding at an unprecedented speed, the implementation of these tools in the field of natural capital conservation still needs to reach its full potential and presents many criticisms. This phenomenon contrasts with the thoughts of environmental managers, who recognise the need for reliable data and information on the status and trends of the critical resources they manage as a basis for conservation planning and determining if the management practices have the desired effects (Fancy & Bennetts, 2012).

Over the years, design has evolved from the design of physical and intangible objects to the design of systems to the design of complex adaptive systems. This evolution has shifted the role of designers from central planners to participants in the systems in which they operate (Ito, 2016). In this field, the designer figure is beginning to appear alongside the researchers and developers, with the aim of minimising the gap between two words that seem so different. In highly innovationoriented fields, thanks to their ability to facilitate relationships and an extensive body of knowledge in the project area, they can act as 'connectors' by linking distant situations and people from different subject areas. This ability contributes to stimulating the spark of innovation, frequently determined by novel associations that open up 'lateral thinking', technological, expressive, scientific and cultural transfers (Gladwell, 2000).

A valid example occurs when presenting

data within the environmental area, which carries a more significant challenge because it usually takes into consideration several variables, particularly temporal data and maps. These two variables are critical factors for environmental data visualisation; however, using high-dimensionality, they create unique visual communication challenges (Weersink, et al., 2018). Opportunely, visual design applications within applied environmental research are beginning to emerge, particularly within geological, climate change, sustainability and landscape planning contexts, ecological decision-making and management (Grainger, Mao, & Buytaert, 2016). This application has made it possible to create novel solutions with design by developing more accurate and complex data visualisation means.

This process has introduced another crucial issue where design can be a facilitator: the involvement of the final user. When deciding on visualisation methods, designers should always consider their objectives and audience needs (i.e., overall functionality) (Cairo, 2013). This statement not only highlights the importance of the final user in the design process but emphasises their integral role as well. The user is not just a recipient of the design but a valued contributor to its creation, a fact that will be further analysed later.

Those examples demonstrate that Design can be a powerful instrument for creating new techniques and technologies, as well as a decisive way to boost the innovation processes. Indeed, an effective way to employ Design as a tool to innovate new technologies and environmental conservation is the design-driven innovation approach proposed by Roberto Verganti. This approach could be a gamechanger when developing innovative tools for ecological conservation. According to Verganti (2009), involving key interpreters in the process is crucial when introducing innovation within a sector to create new solutions and meanings. This approach was applied during field research to identify the criticisms and challenges that designers face when developing new tools for environmental management.

2. State of the Art

Before presenting this research's methodology, goals, and innovation, it is important to present to the reader the panorama in which this study positions itself. The innovation processes within the environmental conservation scenario are subject to an unprecedented flow of investments, both in the public and private sectors. However, as it happens for many emerging markets, they are experiencing some criticism.

2.1 Data accessibility and trust

The first issue is data accessibility and trust. As previously mentioned, managers and policymakers strongly believe in the power of objective data to provide support for planning and policymaking, and some pioneering institutions, like the National Park Service in the United States have already started this

innovative process to support management and conservation with new IT tools (Fancy & Bennetts, 2012). However, this is a virtuous example within a sector that lacks many features to support long-term growth in a volatile environment, which is subject to fast and hard-to-predict changes. Indeed, to be trusted, the information needs to be relevant - with clear and defined goals; reliable - supported by scientific information; and committed - part of long-term programs (ibidem). For several reasons, many of the conservation bodies fail to meet these requirements - particularly regarding the relevance as the conservation goals are different among conservation bodies - resulting in information and data that are not trusted and rarely employed to support decisionmaking.

Additionally, the data end-users cultural, institutional and disciplinary backgrounds vary between each conservation body, resulting in the urgent need for easily digestible information. When the information is too complex or outside the user's knowledge area, it can overwhelm the user, leading to a false understanding or lack of trust. Therefore, it is crucial to deeply investigate the end user characteristics and maximise the understanding of the information (Mastrandrea at al, 2010).

2.2. Innovating the Environmental Sector

It is clear that there is a high demand for reliable and consistently collected data from long-term studies to develop quantitative models to inform conservation and action plans for addressing the ecological consequences of rapid climate change (Mastrandrea at al, 2010).

However, within the environmental sector, there is a somewhat disorganised and fractured data ecosystem as government bodies, corporations, and universities are focusing on specific conservation issues (Weersink et al., 2018).

One of the reasons is that the innovation process happens at a local level without coordination, stimulating problem-specific solutions, which are difficult to translate to other conservation goals or transfer into other conservation environments. These issues highlight the urge to start coordinating these innovation efforts, trying to stimulate a sector innovation, rethinking its meaning and features, and avoiding the creation of many independent small innovations. Indeed, there is the urge to start a sector-wide innovation process, stimulating partnerships among key interpreters such as conservation bodies, institutions, companies, researchers and technicians to ensure technological advancement and innovation of meanings. This could lead to exponential changes that could benefit the whole sector by providing tools that are implemented with the knowledge of many users and stakeholders, which could be adaptable to many conservation challenges and individuals with different backgrounds.
Finally, throughout the natural parks and protected areas, there is a low level of digitalisation and innovative tools used for

the management and conservation of natural capital, in addition to a lack of ability to aggregate and interpret data in such a way that it results in inefficient decision-support tools (Weersink et al., 2018).

Defined the most significant issues of this fast-growing sector; the goals of this research will be presented in the next chapter, introducing the methodology undertaken during the field research to focus those criticisms better and explore new possible solutions driven by Design.

3. Goals and Innovation

3.1 Mapping criticism & Innovating through Design

The purpose of this study is to define the significant challenges that developers, scientists, and managers face when developing and implementing new technologies for environmental monitoring and management. However, the environment in which this process takes place is highly diverse and in continuous change, as each protected area has a different ecological balance, biodiversity, conservation goals, natural elements, topography, anthropic pressure, funds, human power and juridical nature. The same technology or tool cannot work for a marine protected area in the middle of the Pacific Ocean or for a highly anthropised national park in the mountains, which gets several million visitors yearly. Besides, it is possible that the same technology could work in two different scenarios if it is flexible enough or with an additional implementation process. A valid example might be the LIDAR mapping tools that drastically changed how remote areas are monitored or mapped.

Conservation bodies have widely used this technology to map the habitats and vegetation cover at Yosemite National Park, California (Kane, et al., 2014). The same technology has been used in Micronesia for cloud analyses, habitat mapping, and mangrove cover analyses in the Republic of Palau's marine protected areas (Cairo, et al., 2020).

Within this context, Design could be a highly effective double-headed solution. On the one hand, the Design could help the process of mapping criticism to define the areas where intervention is needed; on the other hand, it could be a powerful tool for developing practical solutions for those challenges and facilitating the relationship between technicians, such as developers and the final user, such as the biologists.

For the first goal of this paper - mapping the challenges of innovating this emerging sector - design offers a valid solution in terms of methodology and process. Indeed, for this purpose, the design thinking approach proposed by Design Council (2024) has been employed, particularly the discover and define phases, which helped to gather additional information to get to the problem definition. Additionally, the exploration phase could help to better define the state of the art where the data available are disorganised

and fragmented (Weersink et al., 2018). This process of exploration was fundamental during the field research to define the major challenges through 145 semi-structured interviews with stakeholders.

The other objective is to understand how to create solutions through Design to solve those issues and stimulate sector improvements and further research in this field. Once again, Design could offer the right tools for those objectives, particularly in a sector where the cultural and social variety of the end-users is substantial. Design studies, such as co-design, personalisation, and HCD, could help explore and understand the user's point of view better.

This focus on the utiliser can ensure the creation of innovations embraced and accepted by a vast array of final users (Norman, 2013; Papanek, 1971). Additionally, starting a dialogue with the key interpreters of the sector is essential to stage a technological innovation as well as an innovation of meaning (Verganti, 2009).

To summarise, this research's innovative approach is to apply solutions through and with Design to optimise the development of a fast-growing sector where interplay between different disciplines is essential. In this scenario, where developers, biologists, managers and scientists need to work together, the multidisciplinary nature of Design and its role as a facilitator is essential tools to define criticisms, create solutions and ensure effective implementation and improvement (Manzini, 2015). This paper aims to offer the reader an innovative way of thinking about Design as a tool for innovating the environmental sector. On the one hand, it is a problem-finding tool to better define what challenges to tackle; on the other hand, it is a problem-solving tool that tries to offer solutions for managers and scientists. In conclusion, the interplay between nature and technology is possible and can lead to exponential improvements, as has been demonstrated in other fields like agriculture 4.0 and bioengineering. However, it is fundamental that Design acts as a moderator of this relationship to create adaptable solutions that improve management and conservation to ensure a future for our species.

4. Methodology

The preliminary research phase, conducted using Design Thinking tools, involved 145 participants with pivotal roles within protected natural areas in Italy and internationally. These scientific and cultural stakeholders, along with key interpreters, are instrumental in the management, conservation, and monitoring of Natural Capital.

Through the use of multiple tools, a comprehensive analysis of the problems encountered in the management of Natural Capital by the main actors was conducted. This involved understanding the operators who face the issues on a daily basis and collecting specific data concerning a large number of natural parks in the Italian and international context.
The field research used a qualitative approach

based on observation to understand the operators' experiences and viewpoints, as well as a quantitative approach supported by the analysis and comparison of the numerical data obtained during the meetings.

Through closed-ended questions, it was possible to obtain specific and easily quantifiable answers, test hypotheses, and draw statistical conclusions. This allowed objective data to be obtained, answers to be standardised and, above all, easy comparison between groups. The qualitative approach, which involved focus groups and interviews, aimed to collect in-depth opinions from experts and actors in the field to identify hidden issues that had not yet emerged in detail from the state-of-the-art analysis.

In particular, the process was organised in five stages:

1. *Institution selection criteria*: in order to define a sample that could best represent the variety of contexts in Natural Capital management, institutions were selected according to the following criteria: type, level of complexity, and context. Two types of organisations dealing with different aspects of Natural Capital were included: marine protected areas, which deal with the protection of marine ecosystems, and national parks with a focus on terrestrial management. Finally, bodies with different levels of complexity were considered. Various aspects, such as size factors, level of technological development, age of the park, number of workers, anthropic pressure, presence of endemic endangered species, and level of conservation, came into play in defining this parameter. In order to facilitate the comparison of the technological development of environmental management tools and to overcome the scarcity of information, the involvement was extended from an Italian context, where funds dedicated to environmental management are lower, to an international one, through the invitation of protected areas outside national borders.

2. *Contact with directors and stakeholder selection*: The process of contacting and selecting the figures to be involved within the various bodies has been made in collaboration with the directors of the protected areas. The stakeholders interviewed were selected to interact with all the key figures involved in the management of national parks and marine protected areas.

3. *Involvement*: Stakeholders were contacted by telephone or email to agree on a meeting lasting 45 'to 60' for interviews. The contact modality chosen for the interviews was in person, within the protected area's workplaces. This modality aimed to establish a relationship of greater trust with the figures involved and to allow further field investigations with human-centred design tools such as direct observation and contextual observation of the users. In particular, we made use of indirect observation through the use of objective analysis tools.

4. *Interviews*: Interaction with stakeholders took place through face-to-face meetings of varying lengths of approximately one hour, depending on availability and topics covered. During the meeting, a semi-structured interview was conducted, consisting of a first part in which information was gathered on the characteristics of the users (personal details, skills, role); a second part, characterised by fixed questions which were the same for all the operators (22 closed-answer questions and 8 open-answer questions), which offered the possibility of going into specific points of interest in greater depth; a final part in which, starting from the topics addressed in the open-answer questions, the interviewee was freely involved in order to bring out latent and detailed problems, not identified in the interview design.

5. *Analysis of results and restitution*: The results of the interviews and the information from the various meetings were finally analysed and discussed to define and mapping of the main issues. The analysis of the quantitative data collected through the interviews was carried out through the use of descriptive and inferential statistics. Through the combination of the results of the quantitative and qualitative analyses, it was possible to arrive at a comprehensive understanding of the research topic. This helped to confirm the findings or provide multiple perspectives on the topic of the report.

5. Results

Table 1.

		MARINE PROTECTED AREA	TERRESTRIAL NATIONAL PARK
COMPLEXITY	HIGH	Palau International Coral Reef Centre & Palau National Marine Sanctuary	Yosemite National park
	MEDIUM	Nettuno Marine Protected Area	Abruzzo Lazio e Molise National Park
	LOW	Santo Stefano and Ventotene islands Marine Protected Area	Casentinesi, Monte Falterona e Campigna National Park

By applying the criteria defined in Table 1 for the selection of the entities involved, six different organisations interested in natural capital management were approached. For the MPAs, Regno di Nettuno (Ischia and Procida islands, Italy) was selected, which is vast and characterised by solid

anthropic pressure as it is close to several coastal urban centres. The MPA of Santo Stefano and Ventonene islands, located in the Tyrrhenian Sea more than 30 miles from the coast, is small and characterised by the presence of integrated management with a focus on cetaceans and migratory birds. Finally, Palau International Coral Reef Centre and its Palau National Marine Sanctuary are, respectively, one of the centres of excellence for marine research and one of the largest MPAs in the world. They were selected for their relevance on the international scene, substantial scientific and technological development work, and advanced fish stock management.

Concerning protected areas focused on terrestrial management, the following were selected: Foreste Casentinesi, Monte Falterona e Campigna National Park, in Tuscany, a recently formed protected area established in 1993. This body was selected for its young age, focus on forest management, anthropic activities, and medium size. The second entity is the Abruzzo, Lazio e Molise National Park, the oldest national park in Italy, which boasts the presence of several endemic highrisk species, such as the Marsican brown bear. It is an institution with strong anthropic pressure as it hosts around one million visitors a year. Finally, the last conservation authority selected is Yosemite National Park in California, one of the world's most famous parks characterised by mass tourism that reaches 5 million visitors per year. This institution was selected for the high number of workers involved in management and monitoring and for their role as pioneers in scientific research and technological development.

All the protected areas involved responded positively to the invitation, although with varying degrees of involvement. The relationship with the following bodies was developed through direct contact with the figure of the director, thanks to whose involvement it was possible to define in advance the areas of greatest interest and criticism for each park and the most appropriate figures to involve. The possibility of working with the management levels of the protected areas was aimed at establishing clear and rich relations to implement a radical collaboration. This method made it possible to establish a dialogue over the long term and allow for feedback and updates in the subsequent stages of the research, a fundamental process for the innovation process (Verganti, 2009). Through discussion with the directors, the figures involved in the project were identified and selected from each institution. They mainly were technical-scientific figures, researchers, management figures, policymakers, decision-makers, politicians and community representatives, surveillance and control, search and rescue, and technological and cultural developers. Following the discussion with the director, individual stakeholders were contacted in order to gauge their interest in participating in the interview and long-term bilateral dialogue.

The stakeholder engagement strategy yielded a high success rate, with 80.68% (145 out of 173) of the contacted stakeholders

expressing interest and consenting to participate in the project.

The choice was made to meet the operators in the field, in their working environment, to stimulate the sharing of real day-to-day management problems, to carry out analysis and verification of critical issues and to analyse conservation contexts through direct observation and shadowing. The face-toface meetings helped participants to open up more and share their thoughts freely, as well as to conduct an in-depth analysis of the problem and verify the accuracy of the information gathered through the other methods.

5.1 Semi structured interview results

From what emerged from the personal data analysis of the sample investigated, the Italian protected areas are characterised by a higher age and a lower generational turnover. In fact, the age in the national territory is higher, with 27,85% aged between 25 and 40, 43,04% between 40 and 55, and 20,25% between 55 and 70, while internationally, 53,03% are between 25 and 40, 28,79% between 40 and 55, and only 6,06% are over 55.

Table 2.

Age	National	%	International	%	Overall	%
18-25	7	8,86	8	12,12	15	10,34
25-40	22	27,85	35	53,03	57	39,31
40-55	34	43,04	19	28,79	53	36,55
55-70	16	20,25	4	6,06	20	13,79

Concerning the scope of operation of the different operators in the protected areas, 52,41% belong to the scientific-technical area, 19,31% to politics and the local community, 13,73% to surveillance and control, and 14,48% to management. Table 3 summarises the diversity of the organisation's stakeholders and highlights a variety among the operators with a predominance of technical and scientific figures.

Table 3.

Expert Domain	Number	%
Technical and Scientific	76	52,41
Politics and Local Community	28	19,31
Surveillance	20	13,79
Management	21	14,48

5.2 Closed and open questions

Through the use of closed questions, it was possible to validate or disprove the hypotheses arising from the state-of-the-art analysis and to obtain qualitative data to be analysed later.

The first part was aimed at investigating the context of digital innovation for environmental management, the state of the art and the need to integrate processes with technological tools. The results showed that 89.69 % think that climate change is affecting management and monitoring. Contextually, 77,24 % of the operators believe that the number of operators in the protected areas needs to be increased, and 77,93 % think that technological tools could help improve the situation. The second part of the research focused on the willingness to adopt new tools, the user's requirements in terms of functionality, objectives, and accessibility, and potential future scenarios.
Notably, a high percentage of 97.3% expressed their willingness to use new tools, with 91.03% showing interest in being part of the creation and development process of these technologies.

The third part of the research was dedicated to identifying critical issues in the development of new technological tools for environmental monitoring. This was achieved through the use of open-ended questions, which allowed for a comprehensive mapping of these issues. Subsequently, the answers to the open-ended questions were processed using textual analysis techniques to quickly analyse and extrapolate quantifiable data. By analysing the recurrence of certain keywords, Table 4 was constructed, which provides a summary of the critical points found.

Table 4.

CHALLENGE	NATIONAL	%	INTERNAT.	%	OVERALL	%
GENERATIONAL	17	12,59	14	8,45	31	10,33
DIGITAL CULTURE / EDUCATION	34	25,19	20	12,12	54	18,00
COSTS	10	7,41	21	12,73	31	10,33
BUREAUCRACY	14	10,37	8	4,85	22	7,67
FEAR OF CHANGE	0	0,00	8	4,85	8	2,67
IT SKILLS / CAPACITY / TRAINING	20	20,59	46	27,88	74	24,67
SOFTWARES	1	0,74	6	3,64	7	2,33
COMPLEXITY	1	0,74	10	6,06	11	3,67
COORDINATION	11	8,15	3	1,82	14	4,67
CONNECTIVITY	5	3,70	7	4,24	12	4,00
SECURITY & RESTRICTIONS	0	0,00	2	1,21	2	0,67
LACK OF PERSONNEL / DIALOGUE	14	10,37	5	3,03	19	6,33
POLITICS	1	0,74	1	0,61	2	0,67
DATA FRAGMENTATION	0	0,00	5	3,03	5	1,67
FLEXIBILITY	0	0,00	6	3,64	6	2,00
USER ACCESSIBILITY	0	0,00	2	1,21	2	0,67

5.3 Open dialogue part

In this phase of the interviews, opinions and comments were collected, which were not noted in the preparation phases but had a major impact on the continuation of the project. This form of interview allowed us to delve more deeply into specific topics or devote more time to some topics rather than others. This part was crucial in order to gain insight into the behaviour, attitudes, and habits of the operators (and indirectly also of the developers) and assess the potential satisfaction and acceptance of the new approach in the market. This qualitative analysis revealed the following criticisms:

- an excessive number and complexity of specific software for environmental

management;

· a lack of training and development that focuses on the needs of the end user;

· absence of coordination and dialogue between the developers and the end users (biologists, scientists, developers, technicians, and managers).

At a later stage of the research, meetings with technology developers and technical figures will be held to define possible directions for research and development.

6. Discussion

Even if the interviews highlighted a wide array of issues that need to be tackled to preserve Natural Capital, this study aims to focus on the challenges that the end users must face when using technological tools for management and conservation.

Some of the information collected during the interview and the fixed questionnaire helped to understand that it is essential to tackle this issue tempestively. Indeed, 97.24% of the operators think it is necessary to integrate management and monitoring with new technological tools, and more than 42.7% have available funds to invest in employing those technologies.

However, the most interesting outcomes of those interviews relate to the criticism and challenges those operators have been or are facing when undertaking this innovation process. Even if the contexts where the field research took place are so diverse, those protected areas share many common challenges, as well as some specific ones that come from the variety of goals, conditions, and geography of those places.

Among the challenges, those are the ones that have been mentioned more frequently among all the stakeholders involved in the sample: lack of digital culture and education (54 times 18%), generational issues (31 times 10.33%), costs and funding (31 times 10.33%). While the third is strictly related to the financing of the organisation and the policymaking, the first two elements highlight a pivotal element: there is a variety of cultural and educational backgrounds among the stakeholders.

Indeed, this variety is among figures with diverse skills that usually do not require a high level of technical skills or digital culture. Most of the employees in protected areas are managers, conservationists, biologists, researchers, and scientists, and they do not necessarily have a digital mindset. Often, they still use analogical means to carry on their work. The generational issue strengthens this element as more than 50% of the employees are over 40 years of age, and many of them have started working with analogical tools and are less keen to use digital tools than newer generations.

However, as it is possible to observe from Table 4, the most critical challenge among the stakeholders is the low level of IT skills and lack of training (74 times 24.67%). This differs from the digital culture and education

because these are specific IT skills needed to use the software and hardware employed to improve monitoring and management. While the digital culture refers to the propensity of the user to employ digital tools, specific IT skills are needed to use the technological tool employed for management and monitoring effectively. This lack of IT knowledge could make the user feel overwhelmed, resulting in a reluctance to use those new tools and a lack of trust in the information that should support the planning and decision-making processes (Mastrandrea et al, 2010). Additionally, being a novel sector, the software and interfaces are very specific and intricate, and the accessibility has not yet been improved for an audience with different backgrounds and IT skill levels. This element highlights the importance of user research, user experience, and interface design, which are pivotal tools for making the digital ecosystem accessible and useful (Bollini, 2001).

Even if the situation seems similar worldwide, there are a few differences between the national and international contexts. Indeed, in some cases, those criticisms have a different weight in each context; for example, digital culture is a key issue in Italy (mentioned 34 times), while internationally, it is smaller (mentioned 20 times). Also, coordination and lack of dialogue between biologists and developers have different importance. The former is a big issue in Italy as it has been mentioned 11 times against the 3 times of the international protected areas, and the latter has been highlighted 14 times against 5 times abroad.

Those elements allow us to confirm that the situation is different for each scenario and that a flexible and adaptable solution is needed. This statement is confirmed by differences and specific issues among parks. Indeed, the lack of IT skills is a more significant issue among marine parks (mentioned 14 times) than terrestrial parks (only 5). These need for flexibility and personalisation are substantiated by the questionnaire results, as 92.41% of the users would like to be able to customise digital tools, and 98,62% would like to personalise the visualisation of information and data.

An accurate understanding of end-users' behaviours, needs and limitations is essential for effective design (Norman, 2013). Jesse James Garrett (2010) emphasises that the user experience must be at the core of the design, as ensuring a smooth and intuitive interaction with technological tools is crucial for their adoption and continued use. For natural capital management, this implies a detailed analysis of the needs of operators in the field, who must be informed and involved from the earliest design stages. The co-design process argues that actively involving all stakeholders, managers and biologists, including end-users and experts, in designing technological tools is crucial to developing beneficial and accepted solutions and ensuring they are aligned with their needs and goals (Manzini, 2015). In the iteration and testing phases, Buxton (2007) points out that design must be a continuous process of prototyping, gathering feedback and improvements. This approach

is crucial to ensure that tools for natural capital management are refined through real use and direct user observations. In addition, it is necessary to design sustainable and adaptable solutions. Papanek (1971) emphasises that design must consider not only immediate effectiveness but also long-term impact and ability.

Finally, flexibility, user accessibility, and software complexity have been mentioned more often at an international level (14 times in total) and not at a national level again (1 time). These issues have been also mentioned during the open talks as the operator is not able to customise and adapt to their specific goal the tools provided.

This highlights the fact that technological tools and software are more frequently employed within international bodies. Consequently, there is a higher awareness of the issue and a greater urgency to improve user accessibility in those environments.

These elements that emerged from the field research could help to focus on critical challenges that are still blurred in the novel sector of technological tools for environmental monitoring. The findings suggest that there are significant differences between conservation bodies in terms of typology, location, and the unique specificity of conservation issues. However, even if they have significant dissimilarities, those bodies share many common challenges.
This means that to effectively develop accessible technology for natural capital management, it is necessary to focus on accessibility among diverse users, improve flexibility, and adapt those tools to specific needs, goals, and different levels of complexity. Design offers practical solutions for these criticisms tough co-design, personalisation and human-centered design.

7. Conclusion

Among the Natural Capital conservation bodies, there is a variety of end users with different skills, goals and backgrounds. To face these issues, developers and designers need to deeply understand the user's point of view while developing these new tools through co-design and human-centred design. The designer, therefore, must facilitate through his action the co-creation of individual awareness and collective consciousness through the involvement of all actors (Rizzo, 2009) and by directing personal choices towards social responsibility (Leonardi et al, 2023). These tools are an effective solution to establish a long-term dialogue with stakeholders and key interpreters to ensure that the innovation process follows the protected areas' needs and goals. It is crucial to shift the attention to the final user to prevent managers and scientists from losing faith in the data and ensure that they employ the information presented by IT tools - software, hardware, interfaces, IoT - to support decision-making processes for holistic management of Natural Capital. Indeed, creating flexible interfaces and improving personalisation elements among these tools could help to create trust among decision-makers and ensure that they use data

to make informed and strategic decisions.

Moreover, it is fundamental to create a long-term structured dialogue among developers and end users to ensure those criticisms are considered during the development and implementation processes. Indeed, one of the major issues mentioned during the interviews is the lack of dialogue and co-design among technicians and biologists, resulting in tools that are not aligned with conservation goals and user characteristics.

Additionally, as highlighted by different stakeholders, climate change is affecting the way those protected areas are managed and monitored, an element that is enhanced by the ever-changing equilibrium of natural ecosystems. This scenario makes it pivotal to develop tools that are adaptable and resilient to change. Emphasising the need for these tools should reassure the audience of their effectiveness and instil confidence in their potential.

Successfully staging a design driven innovation in this sector is critical as policy-making and major investments are interested in protection and conservation of Natural Capital worldwide. Failing to successfully scale up the management and conservation of protected areas could result in loss of biodiversity and failure to stage Climate Resilient Development for the survival of our species. However, the role of technology in driving this innovation should inspire and motivate the audience and design could be the right tool to ensure effectiveness.

This paper presents a snapshot of the state of the art in creating accessible technologies to manage natural capital, highlighting the challenges and criticisms in staging this development. By providing possible solutions driven by design to the issues that emerged in field research, this study aims to offer a baseline and guidelines for developers, conservationists, and scientists and to stimulate further research in this field.

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PASTRY AS A MEDIUM: DESIGN FOR SOCIAL INNOVATION OF CATERING SERVICE IN A CHINESE NURSING HOME

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ABSTRACT | In China, the focus of elderly catering service has shifted from "eat enough" to "eat healthy" and "eat happily". The indigenous concept of "dietary health preservation" and lifestyle stimulate the transformation of elderly catering service as a cultural foundation for social innovation. This article introduces the catering service design and social innovation for Outang Nursing Home by a student team. Through observation and interviews with both elderly residents and staff at the nursing home, issues among the elderly, such as monotonous diet services, feelings of loneliness and boredom as well as lack of sense of value were identified. The nursing home has adopted a "three meals plus two snacks" catering service model, aiming to reduce digestive burden on the elderly through smaller meals between main ones. In response, an innovative proposal was made to introduce dining as a means for socializing while incorporating dietary health preservation concepts to promote healthier, happier, and more healing dining experience for older people. The project used pastries, a traditional Chinese healthy delicacy, as a medium and was implemented in three stages: designing a healthy pastry brand; organizing a pastry-making activity; constructing a pastry catering service system. From healthy food products to dietary concepts to dining activities, it completed a comprehensive transformation from product innovation to lifestyle advocacy aimed at enhancing older people's dining experience and overall quality of life. By tapping into the value of older people while promoting indigenous healthy eating concepts, the project explores a sustainable and replicable nursing home catering service model within the Chinese context.

KEYWORDS | SOCIAL INNOVATION, CATERING SERVICE, NURSING HOME, THE ELDERLY PEOPLE

1. Introduction

In the context of China's aging population, the country promotes "community-embedded elderly care". By integrating elderly care institutions into communities, it combines the advantages of communitybased and institutional elderly care, meeting the desire of the elderly to be cared for in their local area. Consequently, an increasing number of elderly people are choosing to live in community nursing homes. With the improvement of health awareness, dietary health concepts and healthy eating lifestyles are favored. The focus of elderly care catering service has shifted from simply "eat enough" to prioritizing "eat healthy" and "eat happily". The current catering service model in nursing homes is unable to meet multi-level needs and requires innovative changes.

Social innovation leads to a sustainable future by introducing new ways of living and production (Manzini, 2015). To achieve this goal, it is important to not only focus on individual well-being (Zhong, 2024) but also on cultural concepts and social context (Li et al., 2023). China has a rich tradition of dietary health dating back to the ancient medical classic "Yellow Emperor's Canon" from the Qin and Han dynasties. In this book, the concept of "dietary therapy" is introduced, which posits that traditional Chinese medicine is equivalent to natural food and that ingesting food according to the season can maintain good health. The theory of Chinese dietary health holds practical value and can be applied effectively in modern life through cultural and lifestyle innovations (Jin & Li, 2020), offering opportunities for healthy aging and promoting sustainable change (Li et al., 2023).

This article presents a social innovation practice implemented by a student design team at a nursing home in China. It explores how to create a more positive dining environment for elderly residents by incorporating local culture and promoting healthy lifestyles while developing a sustainable catering service model. The OU Pastry Catering Service Project was initiated as part of an elective course for first-year postgraduate students at the School of Design to optimize the existing catering service at Outang Nursing Home.

Outang Nursing Home is the first community-embedded nursing home in Jiangsu Province that integrates medical care and elderly care. It was officially open on December 1, 2022, and mainly admits elderly people with limited mobility and decreased ability to live independently. The nursing home provides professional medical services, including health assessment, daily living assistance, nutritional meals, diagnosis and rehabilitation treatment, long-term care, and chronic disease management. Currently, there are 71 elderly individuals in the nursing home, with the majority requiring high-level care, accounting for 66%. Among them, 33 elderly people need to use wheelchairs for mobility while 29 require long-term bed rest. Within this group, seven individuals are completely disabled. Many of the elderly residents suffer from chronic diseases such as hypertension (56%) and diabetes (27%). The nursing home currently operates a "three meals plus two snacks" catering service model which involves serving two snacks between three main meals. All food is prepared by the nursing home's cafeteria following principles of healthy eating to ensure low sugar, low oil, and low salt content. Elderly individuals with mobility usually go to the dining room for their meals. For bedridden residents, caregivers deliver the meals and assist with feeding if the elderly have difficulty swallowing solid foods.

Before proceeding to our design plan, we posed three goals:

- Propose a customized catering service for Outang Nursing Home to optimize the "three meals and two snacks" mode.
- Shift the elderly from passive recipients of service to active participants in the service system.
- Explore the value of dietary culture to promote sustainable service system construction.

2. Research and Discovery

In order to gain a comprehensive understanding of the service model at Outang Nursing Home and to explore the daily life needs and emotional states of the elderly residents, we conducted three field surveys. We employed semi-structured interviews alongside random interviews with nursing home staff, while also observing birthday celebrations and rehabilitation training activities for the elderly.

In the first survey, the director of the nursing home provided an overview of its organizational structure related to public construction as well as insights into its unique service characteristics that integrate medical care with nursing services. The director also shared information regarding the nutritional standards and meal recipes implemented in the facility.During our second survey, we participated in a birthday celebration for one of the residents, which allowed us to gain

deeper insights into their living conditions and emotional expectations. In our third survey, we observed rehabilitation training sessions and assisted rehabilitators in conducting these activities.

Additionally, we conducted random interviews with nurses and caregiving staff to learn more about the daily routines experienced by elderly residents. Through interviews with elderly residents and staff, observation of dining scenes and rehabilitation activities, we identified areas for improvement as follows:

Dining:

The current dietary arrangement in the nursing home is monotonous and fails to address the personalized nutritional needs of elderly residents. The facility provides a fixed menu consisting of "three meals and two snacks," which includes three meals served in the morning and two snacks offered between meals. This weekly menu is designed according to dietary guidelines to ensure adequate nutritional intake for the elderly; however, it tends to be relatively bland and unvaried. Given the low daily energy expenditure among older adults, stimulating their appetites proves challenging.

Activities:

Limited engagement opportunities contribute to insufficient communication between the elderly and their caregivers, ultimately leading to social isolation.The nursing home adopts a closed management model with strict restrictions on outdoor activities for the elderly. As a result, they have limited options for engagement, often confined to watching television indoors, walking in the corridors or participating in exercise classes after dinner each day. Additionally, there is a weekly rehabilitation training activity led by therapists where residents are assigned tasks without much interaction among themselves.

Emotional well-being:

Lack of social activities and insufficient emotional support significantly impact the mental health and overall well-being of elderly individuals. Many elderly residents have reported feelings of loneliness and expressed a strong desire for increased social interaction. Some even articulated sentiments of 'feeling worthless.'

Figure 1. Rehabilitation training activities in Outang Nursing Home.

Figure 2. Excerpts from interviews with nursing home staff and older people.

To address feelings of loneliness and worthlessness among residents at Outang Nursing Home fundamentally.We analyzed the root causes of these issues. Firstly, upon entering the nursing home, elderly individuals were separated from their children, neighbors, and friends - effectively disconnecting them from their previous social relationships. Furthermore, highly structured schedules within the institution force changes in those individuals' established routines, so the elderly need to rebuild a new way of life. However, due to the focus on physical health rather than mental enrichment within Outang Nursing Home, elderly people lack the opportunity to create value or build new relationships, resulting in negative emotions.

In response to the identified needs, we have resolved to empower the elderly by fostering positive lifestyles through enhanced social connections facilitated by dining activities and identity transformation aimed at creating value. Our approach focuses on generating value by reinforcing social ties and reshaping identities through catering initiatives, thereby promoting a more active lifestyle for older adults and enabling their participation in social engagements that allow them to realize their personal worth. To this end, we propose two key strategies: "diversified diet" and "enriched social activities."

Socializing through dining:

Dining activities contribute significantly towards maintaining good health amongst older adults (Tao, 2024). Specifically in an eldercare setting, enjoyable dining experiences promote individual appetite stimulation and nutritional intake(Dunbar, 2017), enhancing opportunities for making friends and fostering group belongingness (Curch 2004; Wright et al., 2006).

Empowerment through new identities:

Shifting perspectives by viewing older adults as "capable individuals" who actively contribute towards service provision (Manzini, 2015) strengthens their autonomy and agency, thereby elevating proactive well-being levels along with self-esteem (Dong, 2022).

3. Project Proposal Development

We have innovated the catering service at Outang Nursing Home to make it more interactive and dynamic. By incorporating Chinese pastries into the "three meals plus two snacks" model, we enhance the "two snacks" with pastry-making activities as an "afternoon tea" for the elderly. Our approach is rooted in service design and social innovation, placing seniors at the center of our system. This innovation guides lifestyle changes for residents through a reformed catering model. Using service design thinking, we aim to transform nursing home catering services based on principles like "user-centered," "co-design," "tangible and intangible services," "systematic," and "sustainability." To ensure sustainable implementation, we divide the project into three stages: 1.0 Brand Definition, 2.0 Local Construction, and 3.0 Co-creation by Multiple Parties. This corresponds to a gradual transformation of the catering service from establishment to practical promotion. To build an effective service system, we integrate various means of service design and social innovation—such as brand design, event planning, and system innovation—across different dimensions to provide seniors with a positive catering experience. The content progresses layer by layer to meet their physiological needs while fostering social connections and self-realization.

Through these efforts, we aim to connect various stakeholders and establish a healthy pastry living laboratory centered at Outang Nursing Home. This initiative will promote the concept of healthy eating across the community.

3.1 Brand Definition

In phase 1.0 of the project, we aim to build a brand centered on elderly users. This initiative is informed by an analysis of the dietary digestion abilities, habits, taste preferences, health conditions, and special needs of older adults as identified in our survey. We have selected pastries as a medium for promoting dietary health culture.

Specifically, we focus on Chinese pastries due to their embodiment of traditional dietary and health concepts while being commonly consumed in contemporary diets. Renowned for their exquisite appearance and rich nutritional profile, Chinese pastries feature a soft and glutinous texture with moderate sweetness that facilitates ease of chewing and digestion. Their low sugar and oil content renders them particularly suitable for elderly consumers. The selection of ingredients and production processes employed in making Chinese pastries reflects key dietary health principles such as "food therapy" and "eating according to the seasons," which are integral to Chinese culinary traditions. These pastries often incorporate traditional medicinal ingredients like poria cocos, coix seed, and lotus seeds—each serving specific functions aligned with Traditional Chinese Medicine Theory; these include tonifying the spleen and kidney, eliminating dampness while promoting diuresis, as well as nourishing the heart and calming the spirit. Moreover, Chinese pastries adapt well to seasonal ingredients; for instance, individuals in Jiangnan (Southeast China) prepare mung bean cakes during summer using mung beans combined with osmanthus sugar or mint leaves known for their heat-clearing properties. In

terms of production techniques, there is a strong emphasis on preserving both nutrition and flavor through methods such as mixing, grinding, sieving, molding, and steaming.

Based on the nursing and health maintenance characteristics of Outang Nursing Home, medical care is integrated with dietary and nutrition care to provide comprehensive diet therapy. This approach not only meets the taste enjoyment needs and nutrient intake of elderly people but also promotes dietary health concepts and methods while guiding them to cultivate healthy eating habits.

Brand Naming: We have named the brand "OU pastry". The "O" is derived from the initial letter of Outang Nursing Home, while the "U" symbolizes a smiling curve, representing vitality and healing. In Chinese, "OU" sounds like "We have", so "OU pastry" conveys the meaning of "We have healthy pastry" (Figure 3).

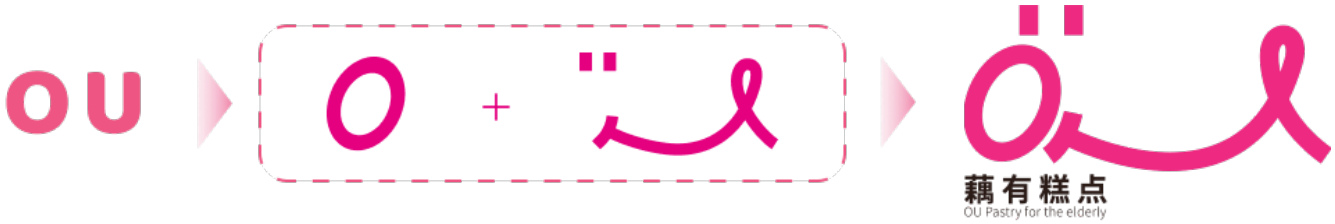

Figure 3. The design process of OU Pastry logo.

Brand Concept: Introducing the 3H concept of "Healthy, Happy, Healable". Our goal is to establish a living environment at Outang Nursing Home that promotes healthy, happy, and healable for the elderly. Building upon this concept, we developed brand IP and visual materials to foster a welcoming and lively brand image (Figure 4).

Figure 4. OU Pastry brand design.

Pastry research and development: We proposed five standards for age-appropriate pastries, which include "the use of healthy ingredients", "easy-to-chew", "delicious taste", "visual appalling", and "high-quality control". We used seasonal healthy ingredients such as yam, red dates, peanuts, etc., in pastry recipes. Additionally, we consulted relevant literature in food science and made a pastry sensory evaluation form. (Figure 5).

Figure 5. Pastry sensory evaluation form and the process of pastry-making.

3.2 Localized Practice

In Phase 2.0, we establish environments and mechanisms that promote collaboration, initiating dietary activities aimed at facilitating lifestyle transformation for the elderly. At this stage, the aim is to enhance elderly participation in activities, strengthen positive social interaction and promote positive emotions. On the afternoon of April 16, 2024, a themed activity called "Pastry Drifting Program" was held at the restaurant activity space on the third floor of Outang Nursing Home. Fourteen senior citizens, four family members (including one child) and five medical staff participated in the activity. During the event, pastries were made by elderly people as an interactive medium, creating an opportunity for communication between senior citizens and comakers. The pastry-making space served as a platform to foster connections and created a warm atmosphere to ensure the smooth development of the event.

Create Spaces to foster relationships

Pastry-making space is crucial. Space provides conditions and atmosphere to make human behavior and interaction possible (Manzini, 2022). Therefore, space design can be seen as a form of "relationship design". The pastry-making space should aim to cultivate a warm and pleasant atmosphere that encourages communication and interaction among the elderly. In our approach, we put long tables in a row in the activity space to facilitate face-to-face communication among the elderly. Additionally, we decorated the space with brand posters and brand materials to create a sense of ceremony (Figure 6).

Figure 6. Creating a warm and pleasant pastry-making space.

Create new social relationships

In the nursing home, we have established a supportive social network centered around the activity of pastry-making. The elderly residents derive joy from coming together to create pastries, and the interpersonal connections formed during these activities enhance their feelings of support and care. Socializing through pastry-making enables seniors to cultivate new and positive relationships with others. Following the co-design principle of service design, this stage involves collaboration among elderly residents, family members, community workers, and care home staff to foster a supportive social network through interactive pastry-making.

In this context, pastries serve as both a medium for engagement and a pathway for connection. By participating in these activities, elderly individuals transition from being passive beneficiaries to active contributors in the co-creation process, thereby establishing new social networks. This collaborative endeavor encourages older adults to feel valued and supported, further reinforcing their sense of belonging and overall well-being. Notably, some participants spontaneously share the pastries they have made with staff and family members as a means of expressing affection.

Beyond the confines of the nursing home, we developed a recruitment mechanism for pastrymaking activities to attract residents from surrounding communities to participate in pastry activities and build a community collaboration network. We have devised a process involving "registration - participation - credits exchange" along with an associated platform for community members to sign up for and receive rewards for their involvement in these activities (Figure 7).

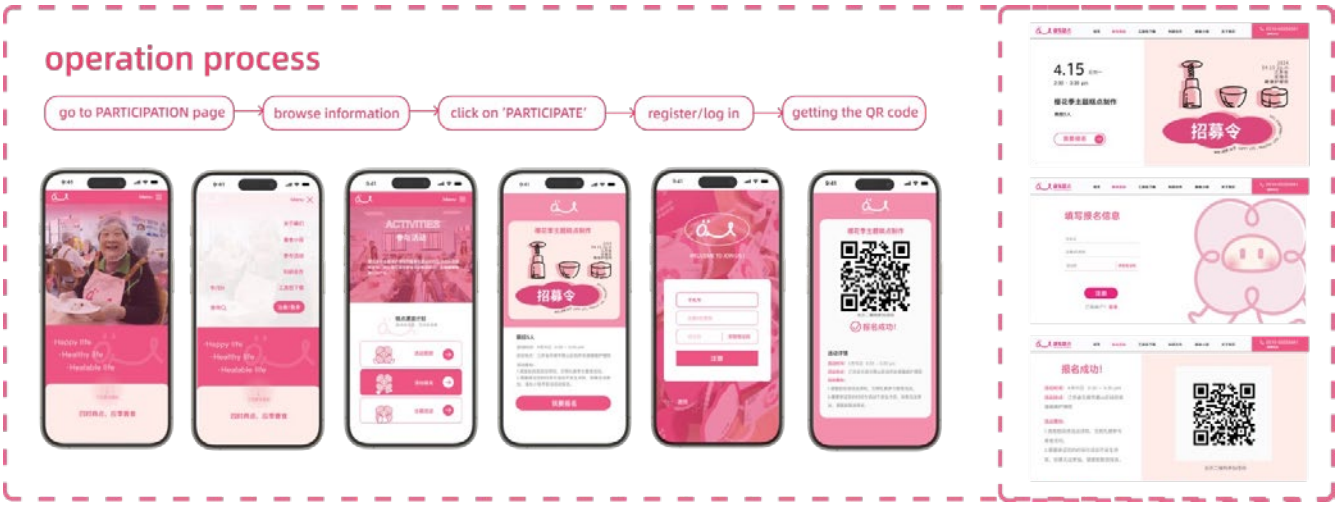

Figure 7. Mobile and PC interfaces for pastry-making activity recruitment.

Positive emotion

The OU pastry initiative integrates both tangible and intangible services designed to cultivate positive emotional experiences for the elderly. To facilitate pastry-making process and alleviate cognitive load, we pre-portioned the crust and filling for each participant. As elderly individuals fill molds with crusts, press them into shape, and remove them from molds, these participants take pride in crafting beautiful pastries by hand. By streamlining the steps involved in pastry making, we empower elderly individuals to successfully complete their pastries, which enhances their self-esteem and sense of achievement.

Furthermore, our approach involves allowing the dough to mature prior to shaping it, enabling participants to taste their creations without extended waiting time. This design enhances happiness through timely feedback; participants can savor the pastries they have made themselves. Such uplifting emotional experiences encourage older adults to spontaneously showcase their work, further reinforcing their positive feelings and social engagement (Figure 8). It is noteworthy that the Pastry Drifting Program serves not only as an on-site construction practice but also as a prototype testing process. We collected tasting scores and feedback from participants who provided encouraging remarks such as "very happy" and "very interesting."

Figure 8. Photos of the "Pastry Drifting Program".

3.3 Co-creation by Multiple Parties

In the Project 3.0, to ensure the sustainability of the service model for OU Pastry, we propose the establishment of a service system that integrates multiple resources and stakeholders through a research and development network. The concept of a Living Lab has been introduced, wherein Outang Nursing Home will collaborate with universities and social food research institutions to create a sustainable reasarch and design network. Within the OU Pastry catering service system, Outang Nursing Home serves as the central hub, integrating research and development, new product tasting, activity expansion, and feedback iteration (Figure 9).

In this living laboratory centered around Outang Nursing Home, social volunteers, universities, food research institutions, and other nursing homes form a cross-border collaborative governance model. The role of elderly residents at Outang Nursing Home will transition from caretakers to pastry tasters; their feedback will be invaluable for food research institutions in fostering the sustainable development of elder-friendly pastries. The OU Living Lab facilitates collaboration across various fields, disciplines, and cultures while integrating diverse knowledge bases, resources, and capabilities. This approach not only promotes the dissemination of healthy dietary concepts

but also supports the creation of age-appropriate healthy pastries— providing robust support for the overall sustainability of this service system. Through cooperation that transcends industry boundaries as well as disciplinary and cultural divides, we aim to disseminate healthy diet concepts while cultivating new lifestyles and environments. Our goal is to transform this service system into a vibrant cultural framework with enduring vitality (Lou, 2013).

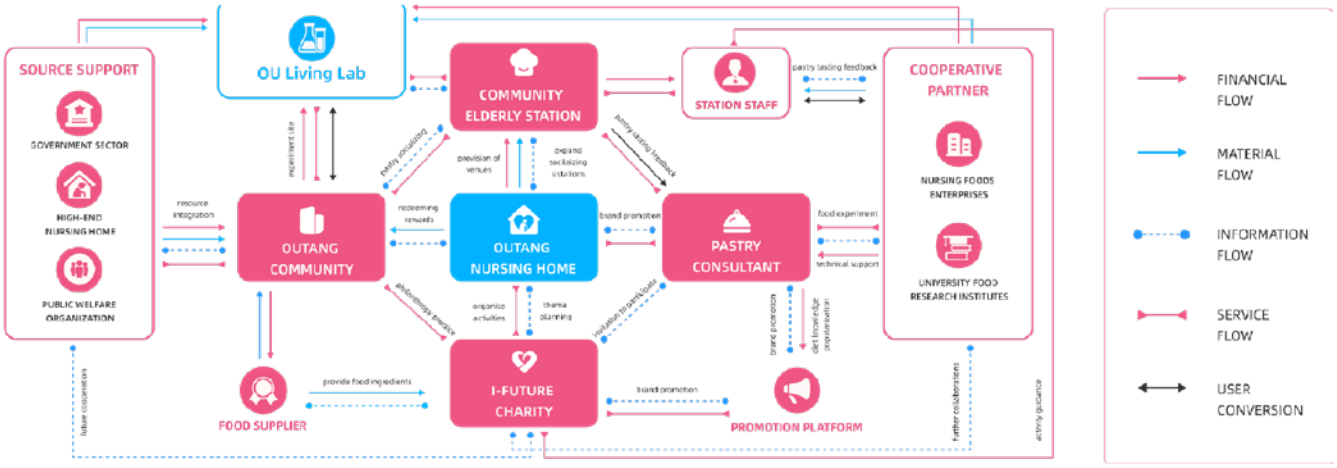

Figure 9. OU Pastry catering service system map.

4. Discussion

Service design thinking and social innovation facilitate systematic and integrated approaches to fostering innovation. The principles of service design facilitate the creative integration of service resources and elements, thereby playing a crucial role in addressing the complex social issue of elderly care. The OU Pastry project adopts a cateing service approach to support older adults, promoting reforms in the service model for nursing homes and evolving into a practice of sustainable social innovation. In three stages of this project, the essence of social innovation lies not only in tackling immediate challenges but also in establishing a sustainable system capable of long-term self-optimization and development. We consistently implement a "user-centered" approach that focuses on the genuine needs and emotional experiences of older adults. Our objective is to enhance the overall quality of elderly care services through systematic design methodologies while emphasizing both effectiveness and sustainability within the service system. Through this project, four key elements of social innvation warrant discussion:

Reorganizing existing resources to create new functions and value.

OU Pastry Catering Service Project integrates multiple resources, including space and service resources in the nursing home, dietary health preservation resources, especially the elderly who were originally served as value

creators. Through active value creation, older people became the key element in maintaining the sustainable operation of the catering service system.

Creating new social connections and encouraging positive interactions.

Positive social relationships build a sustainable society (Li et al., 2023). After socializing by making and eating pastries regularly, older people are able to establish and maintain good social relationships, thereby maintaining positive interactions with others. This not only fundamentally addresses issues of loneliness and worthlessness among the elderly, but also empowers them to some extent.

Replicating and disseminating the service model.

Based on the outcomes of our practice, we have further contemplated the potential for replicating and scaling up the project. To disseminate our concept, we designed promotional websites optimized for both mobile devices and computers. Through social media promotion and targeted publicity efforts, we aim to increase awareness of the OU pastry project among a broader audience. Concurrently, to ensure that this model can be effectively replicated, we have developed a comprehensive toolkit for OU pastry activities to standardize the implementation process.

Cultural innovation for a sustainable future.

As a bottom-up social innovation project, OU Pastry presents a path for design discipline to explore sustainable lifestyles. Culture is rooted in people's consciousness, and excellent traditional culture is the essence of culture, which provides a steady stream of impetus for innovation and development. Combine traditional dietary health preservation culture with the needs of the new era and life scenes, there will be gradual changes in the behaviors, perceptions, and ways of life of individuals and even entire communities through project implementation (Li et al., 2023), ultimately leading to a more humane and sustainable future.

5. Conclusion

This paper proposes a cultural intervention to promote an active lifestyle among the elderly. It outlines a pathway for social innovation within a cultural framework, leveraging Chinese food culture and traditions as starting points. The initiative addresses social issues by gradually shifting perceptions, behaviors, and lifestyles in individuals and communities, ultimately enhancing quality of life while supporting sustainable development. OU Pastery serves as both the design object and guiding system. By integrating food with a social space through services that connect the elderly with participants, it translates values and culture into social norms. Social innovation operates on both local and global levels. Localized projects have an

"acupuncture" effect, initiating change at critical points to influence broader processes and foster sustainable social change (Lou, 2013). Our project is an exploratory pilot of Chinese-style aging but has potential for wider application. Pastries act as a medium to disseminate health concepts and healthy lifestyles across different ages and cultures while inspiring creativity among social innovators. We hope our work will promote further collaboration and lead to more practices for active aging in the future.

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AUGMENTING THE DOUBLE DIAMOND: CRITICALLY INTEGRATING GENERATIVE AI IN THE CREATIVE PROCESS

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ABSTRACT | The introduction of generative Artificial Intelligence is transforming the creative landscape. However, the challenge lies in moving beyond the arbitrary use of numerous generative AI tools towards a structured integration that amplifies human creativity. This paper investigates the potential evolution of the Double Diamond design process and related methods through the lens of AI. We forefront three key insights obtained through case-studies that are central to our approach of developing an AI-augmented double diamond model: friction as a virtue, the AI-efficiency paradox, and (inter)play as a mode of engagement with generative AI technologies. Building on this foundation, we propose an augmented Double Diamond that addresses the benefits and challenges of incorporating generative AI tools in the design approach with varying levels of AI-engagement. The proposed model encourages critical reflection on the design process and embeds ethical and societal considerations throughout the process.

KEYWORDS | DOUBLE DIAMOND, GENERATIVE AI, DESIGN PROCESS, HUMAN-AI SYMBIOSIS, ETHICS

1. Introduction

Building on decades of research into Artificial Intelligence, generative Artificial Intelligence has seen a spectacular rise. Generative Artificial Intelligence encompasses algorithms that generate new content, both textual and visual, and with the widespread adoption of tools such as ChatGPT and Midjourney, it is impacting many industries. Large Language Models, such as ChatGPT by OpenAI and Claude by Anthropic, facilitate tasks like reviewing written texts, autonomously drafting texts with simple prompts, generating concepts, or ideating various copywriting proposals. Text-to-image latent diffusion models, like Stable Diffusion and Midjourney, enable us to generate new images and combine concepts with a simple prompt, and can adapt to existing or newly trained styles.

The creative sector has always been at the forefront of adopting new technologies and methodologies. With the advent of generative AI, capable of generating new images, texts, and concepts (Girotra et al., 2023), there is talk of a potential paradigm shift in how creative professionals will perform their work. These recent developments raise concerns about the possibility of machines replacing human creativity, with the designer becoming subordinate to the machine. At the same time, creatives have explored the potential of generative AI technology, often experimentally. For instance, Kyle McDonald was one of the first artists to experiment with Google DeepDream (McDonald, 2015).

In the last two years, however, generative AI is transitioning away from the experimental domain to becoming a tool for creative professionals, who now engage with as Creative Support Tools (CSTs) – digital tools that facilitate the work of creatives. These tools are increasingly seen as another resource in the creative toolbox, and traditional CSTs are steadily integrating generative AI into their applications. This marks a paradigm shift in the creative field, as we move away from technology that help us produce outputs towards technology that can produce (generate) output almost independently. Consequently, the relationship between people and their tools is changing,

and calls for an examination of how creative professionals' workflows are evolving. As McLuhan's contemporary, Culkin, stated (Jouhki & Hurme, 2017), "we shape our tools, and thereafter our tools shape us." (Culkin, 1967). Therefore, it is important to investigate how these new tools are used, when they are used, and how they alter our interactions with CSTs. In this paper, we dissect three explorative case studies and extrapolate our findings into an augmented Double Diamond model, and examine the implications.

2. Explorative case studies

1. Methodology

In this section, we review three explorative case studies that emerged from our Research-throughDesign approach. Research-through-Design is a methodology that helps researchers "to investigate the speculative future, probing on what the world could and should be" (Stappers & Giaccardi, 2017) by employing the "methods, practices, and processes of design practice with the intention of generating new knowledge." (Zimmerman & Forlizzi, 2014). Each case-study helped to capture insights in the creative process when engaging in various ways with generative AI technology, and enabled to form the basis of our proposition for a potential new or updated Double Diamond framework.

2. Case studies

The first case-study consisted of a half-day workshop led by a design agency in which approximately 30 first-year design and development students were challenged to tackle a creative brief from a realworld case. This workshop was held twice, each time with a different group of students. The students had almost no prior design knowledge, and very limited knowledge of generative AI. In the preparation of the workshop with the industry partner, we established that the workshop, whilst focusing on generative AI, should not fully be AI-driven. A set schedule was developed with distinct stages to guide the students through the workshop. Students were asked to develop a visual concept for an industrial product in the B2B market, building on a larger, overarching concept, provided by the design agency. The overall goal of the workshop was to explore a hybrid approach between human-led ideation and the utilization of generative AI tools in the process of designing the output. The ideation phase took place in groups and allowed the students to sketch out different ideas on how to communicate their visual concept that highlighted the qualities of the product. As first-year students in their third week of college, it was clear that this was still challenging. However, with some guidance of the tutors, most groups managed to arrive at a concept that could be translated visually. The students were then asked to imagine, and sketch out, the art direction of their concept. This would be the basis for the generation of their concept image in Midjourney. After a short introduction into Midjourney and how to prompt, most of the students quickly iterated on their visual concept. Throughout the workshop, we noticed that students often

treated the generative AI as a slot machine. We speculate that their lack of expertise with editing tools was basis for frustration, as we found many prompts to fix a singular problem in their generated image, while this could have been an easy solve with Adobe Photoshop. We were surprised how close the students adhered to their initial art direction choices – while embracing the unexpected.

The second case-study consisted of a full-day workshop with 23 participants with a relation to the product design field. In this workshop, the participants engaged through a variety of generative AI tools with the creative process – from ideation to final product design. Here, in contrast to the first workshop, all creative endeavors were supported by generative AI powered CSTs, to acquaint the audience with employing AI tools in their creative processes by exploring their limits and possibilities. The participants were tasked with developing a protective gear garment, which could range from ski-helmets to protective shin-padding. With a larger range of generative AI tools, using ChatGPT, Midjourney, and KREA, the participants could execute their 'product design' process fully using generative AI tools, from ideation to creating concept images. Besides the participants getting acquainted with the different tools, it was the connecting of different generative AI tools and use them to their strengths that stood out for participants in the workshop. As stated by one participant, the most beneficial was "the workflow for integrating AI and using the various tools to complement each other." This also strengthened our hypothesis that often, generative AI tools are heralded as 'the solution'; but it requires a foundational approach to get the most out the results.

The third case-study consisted of two generative AI focused design projects. The first project was developed by two professors in the digital design and development field, and consisted of developing a projection mapping utilizing generated video. In both of the projects, technical knowledge played a key role in setting up the right environments for the production of the videos. In the first project, ComfyUI was used to create a workflow to generate videos, confirming to the limitations of the mapping, as well as adhering to the art direction that was set out. One part of the challenge was to move away from the 'slot machine' feeling, and developing a workflow that adhered to design choices, while still embracing the hallucinations in latent space. The other challenge was in finding solutions to technical challenges, from noise and quality issues to smooth animations. The second project consisted of a real-time interactive generative AI installation, with a workflow using the StreamDiffusion Touchdesigner (Carrington, 2024) plugin. The goal of the installation was to allow the visitor to control a prompted generation through movement. To accomplish this, a webcam input was taken which tracked the body position. Subsequently, this input was translated to a physics solver which was used to create a water simulation. Finally, the moving image of the water simulation was used as input for the StreamDiffusion. In both projects, we found that the collaboration

between a more technical oriented creative developer and a designer led to the best results. Especially when wanting to move away from closed environments to creating more custom projects, it is essential to have technical knowledge of the domain as the tools get more complicated.

These three case-studies, diverse in their application of generative AI technology in various sections of the creative process, leads us to distill 3 insights that are central to our approach to developing a new way of engaging with generative AI in the creative process.

3. Insights gained from case studies

1. Friction as a virtue

The fear of the blank page – the initial hesitation or creative block when starting a new project—can be alleviated by the utilization of generative AI. Generative AI tools can provide initial concepts, suggestions and imagery, serving as a catalyst for creativity and breaking the inertia that creatives often face. However, there is a risk that this leads to an increased dependency on generative AI, and reduces the human designer's engagement and potentially stifles their creative problem-solving skills. Research by Buçinca et al (2021) already highlighted that the dependency on AI might make people less thoughtful; and especially in the creative process, the latent processing of the challenge is part of the creative process. In the initial conversations with the industry partner from the first case study, they underwrote the importance of ideating concepts with pen and paper. The casestudy further emphasized that this is a learned skill.

Therefore, we argue that this friction should not be entirely removed. Rather, it should be managed to maintain a level of challenge that fosters deeper engagement and innovative thinking. This means that when we are introducing a variety of generative AI tools into the creative process, we also need to account for a mode of engagement with these tools – as it becomes increasingly enticing to 'skip the hard part'.

2. The AI-Efficiency Paradox

Innovations often come with the promise of optimizing and streamline processes – shortening production cycles and therefore cutting down on costs. This is especially the case with generative AI tools, allowing to exponentially reduce the time to form new ideas or produce sketches and highdefinition renders of these ideas. In the context of the design industry landscape, these optimizations are naturally welcomed, yet to stay a leading design or advertising agency, the quality of ideas (and execution) matters, as evidenced by the positive outcomes of obtaining a Cannes Lions (Meléndez-Rodríguez & Roca, 2023), one of the most prestigious prizes in the advertising world. While in specific tasks (such as tedious editing tasks or creating high-definition concept images) generative AI cuts down on the time that is needed, the integration of generative

AI at other stages of the creative process, such as ideation stages, might increase the needed time, which is what we dub the AI-efficiency paradox.

Let's take, for example, the use of Large Language Models (LLMs) in idea generation. Large language models such as OpenAI's GPT or Anthropics' Claude are increasingly used in the idea generation process. These LLMs are capable of generating fluent and coherent texts, and ideate solutions based on given prompts and prior information. As highlighted in Ideas are Dimes a Dozen: Large Language Models for Idea Generation in Innovation (Girotra et al., 2023), these tools are capable to generate hundreds of ideas in a fraction of time a human would be able to do so. The paper makes the case that these ideas often are better than human (student) product innovators, rated higher quality measured through purchase-intent surveys. However, Rick et al., (2023) states: "current generative AI systems by themselves are often not capable of producing uniformly high-quality ideas, a very promising possibility is to let generative AI systems rapidly generate ideas for humans to consider." While underwriting these conclusions, we argue for an approach wherein the creative (or creative team) autonomously executes an idea generation or brainstorm exercise themselves as well, without it being AI-driven from the start. This allows the creative team to bring out their first observations, building on the (latent) expert knowledge of their organization, product or society. Especially with complex briefs, needing overarching concepts, the limitations of idea generation with LLMs comes to the forefront, often lacking in empathy, originality or applicability to the design brief. By executing the idea generation phase twice, once human-driven and once AI-driven, the most promising ideas can be selected, tweaked, or combined. However, this undeniably means that more time and effort go into these stages, as the conventional approach still must be executed (be it in a more minimal form); but to acquire results that are meaningful, time should also be invested in researching the right models and prompts, pertinent information needs to be briefed or pointed at, as not to generate ideas that are dismissible from the get-go.

3. (Inter)Play

In Play it Again - A Genealogy of Machine Learning, Reigeluth (2023) explores the relationship between humans and machines in contrasting two normative regimes: play and automation. They state: "Whereas automation pushes us to consider machines as ideally working by themselves and thus replacing humans, play involves a social and affective engagement whose outcome is always partially unpredictable." (Reigeluth, 2023) Taking the concept of play – or interplay – between human and machine, allows us to understand how we can, as creatives, relate to generative AI in the creative process. This concept highlights the importance of a collaborative process where both human and AI inputs are valued and iteratively refined. (Inter)play involves a continuous exchange of ideas, where AI-generated suggestions inspire

human creativity, and human insights guide the refinement of AI outputs, and vice versa. This symbiotic relationship encourages a fluid and adaptive design process, allowing for the exploration of diverse concepts and solutions. As stated by Liu & Nah (2020) "In the future, the boundary between humans and computers is bound to become increasingly blurred. The two are interdependent, and indispensable to each other. Man–computer symbiosis is an irreversible trend." Encouraging play as a mode of engagement can enhance the creativity of the team, ensuring that AI acts as a co-creator rather than just a tool.

4. Augmenting the Double Diamond

1. Creativity and the Double Diamond framework

Creativity, is defined as the ability of generating novel and valuable ideas (Boden, 1998), and as a nonlinear, iterative process. Originally often positioned as 'intuition', this led to the belief that creativity was "unconscious thinking" or "unconscious processing" until the appearance of an idea or insight. These theories "demonstrated the mysterious nature of creativity" (Wu et al., 2021), and lead people to believe that creativity is something to 'have' or 'not have'. However, measurement psychology suggests that every individual can be creative, involving 'divergent' and 'convergent' thinking. In broad strokes, everyone can be creative, and we can encourage creativity through creative actions that open up the process – making creativity less a discussion of 'have' and 'have not'. Wallace was the first to create an overview of the creative process (Interaction Design Foundation, 2024) and identifies four stages of creativity in The Art of Thought (Wallas, 1920). These are:

- **Preparation:** Wallace, quoting Helmholtz, describes this as, "The stage during which the problem was 'investigated … in all directions'." Various exercises and methodologies can be part of this preparatory phase to immerse oneself in the problem. It's an active mode of working.

- **Incubation:** This stage involves "not consciously thinking about the problem." Actively relaxing your mind – be it by going on a walk or focusing on an unrelated activity allows your brain to digest the information.

- **Illumination:** As Wallace describes the third phase: "The appearance of the 'happy idea'...". It's the moment where the active preparation and incubation come together with a potential solution.

- **Verification:** Wallace: "The validity of the idea was tested, and the idea itself was reduced to exact form." We see two parts in this verification process - the validity of the idea and the exact form. This comes down to testing each hypothesis – through prototypes and alpha versions, gathering feedback, and iterating until the 'exact form' has been distinguished.

The stages of creativity identified by Wallace can be seen as the intuitive steps creatives

takes. The Double Diamond framework, popularized by the Design Council (British Design Council, 2024), has become ubiquitous to define the four stages further, and is implemented in many design agencies as the proposed methodology to tackle creative wicked problems. The framework is named after how it takes shape, consisting of two distinct spaces: the Problem Space and the Solution Space. Both spaces (diamonds) are represented by a divergent and a convergent phase. The diamond consists of two diverging lines and two converging which represent how to mentally engage each phase in the diamond. Each converging and diverging section is a specific phase.

The Discover phase focuses on understanding the problem or challenge. Insights are gathered through primary and secondary research, including stakeholder interviews, market research and data analysis. In the subsequent phase: Define, the gathered insights are synthesized, and a core problem or challenge is defined. The third phase is Develop. In this phase potential solutions are brainstormed and refined further. Finally, the Deliver phase, the most valuable solution or design is created and distributed. With the advent of generative AI, each phase of the design process is impacted by new methodologies and tools. To effectively leverage these advantages and address the associated challenges, it is necessary to reevaluate the design process and the Double Diamond.

2. The augmented Double Diamond framework

Building on the Double Diamond framework, we propose a preliminary model of a modified Double Diamond that incorporates the three concepts derived from the previously reviewed case studies. In the subsequent sections, we deconstruct the newly proposed model. Three distinct changes are introduced to the model. Firstly, the existing diamonds (the Problem Space and the Solution Space) are each compartmentalized in four diamonds: two vertically stacked diamonds in solid lines and two horizontally aligned diamonds in dotted lines. Each of these diamonds introduces specific elements, which will be detailed later in this text. Secondly, specific attention is given to the roles of AI and the designer within the Double Diamond by dividing the diamond along 3 horizontal axes: the human-axis, the AI-axis as well as the human+AI axis. The human+AI axis expands as a gradient towards both the human-axis and the AI-axis. Thirdly, two new phases are introduced at the start and end of both overarching diamonds. These phases are Prepare and Synthetize.

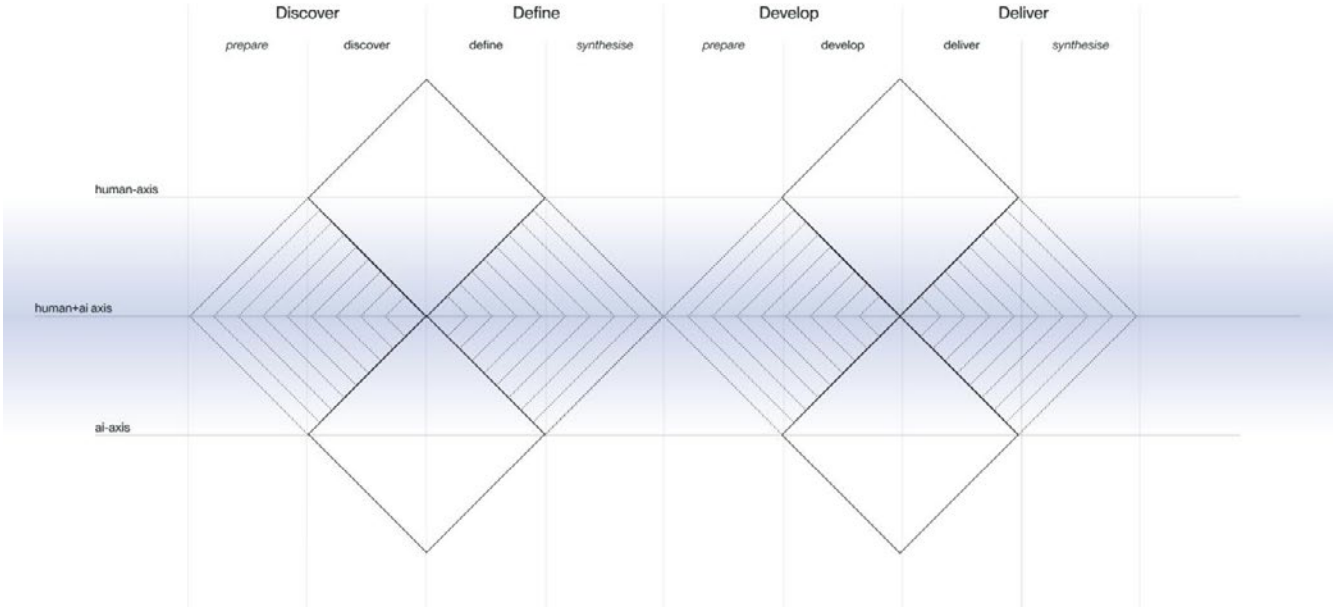

Figure 1. The proposed augmented Double Diamond framework. The three horizontal axes indicate the mode of engagement. The phases are labeled at the top of the image, expanding on the traditional phases of Discover, Define, Develop, and Deliver. Each overarching diamond begins with the newly introduced Prepare phase and concludes with the added Synthesize phase.

First, we examine the first newly created dotted-line diamond that aligns with the human+AI axis. This first dotted-line diamond opens the diverging lines of both overarching diamonds and is situated in the Prepare-phase. Here, specific attention is given to the role of generative AI in the creative process, as well as the role of the designer and their team. This approach underscores the importance of critically considering where, how, and when generative AI should be integrated into the creative process. By initially defining the approach in the Prepare section, creatives can reflect on their process before starting. This phase touches on all three of the aforementioned concepts that shape this model. The creative team can consider at which moments friction is a virtue – at what point generative AI tools should not be the starting point. The team can appoint moments of high (inter)play between humans and generative AI. By mapping out these considerations, we can take the AI-efficiency paradox into account. By developing the approach from the start, the creative team gains an understanding of which stages will cost more time (e.g. having both a human-led ideation process and an AI-led ideation process) and which aspects will be more efficient (e.g. drafting concept images using a diffusion model).

Additionally, the ethical dimensions of generative AI technologies should be considered at this stage.
As by Benjamin et al., (2024) state, "it is now widely understood that AI technologies can discriminate against particular protected categories (e.g., gender, ethnicity, nationality, sexual orientation)". Intellectual property

aspects should also be considered, as content scraping strategies often infringe on intellectual property rights. The environmental impact of employing generative AI should be considered as well, from the planetary costs of artificial intelligence (Crawford, 2021) to energy consumption and carbon emissions associated with training and utilizing the technology (Luccioni, Jernite & Strubell, 2024). For example, the shift towards multi-purpose models for discriminative tasks consumes more energy compared to task-specific models for the same tasks (Luccioni, Jernite & Strubell, 2024). Additionally, the unseen human labour of exploited "ghost workers" labelling data (Gray & Suri, 2019) is another aspect to consider before turning to AI. While these are numerous considerations, and the lack of transparency from generative AI technology developers and the black-box nature of the models complicate the process, organizations and governments have been developing ethical guidelines (Balasubramaniam et al. 2023) and policy documents such as the EU Artificial Intelligence Act, which can serve as reference documents.

Concurrently, this preparatory stage should be used to consider the constellation of the design team, identifying skill gaps and determining which profiles should be onboarded. The second dottedline diamond appears at the end of the overarching converging double diamonds, and falls under the phase of Synthesize. We will review this phase after evaluating the horizontally stacked solid-line diamonds.

Within the Discover phase, we encounter the diverging lines of the smaller diamonds located respectively on the human-axis and the AI-axis. By visually representing these diamonds on the human-axis and the AI-axis, we can situate different type of approaches within the Double Diamond framework. The diamond on the human-axis takes a human-led approach. At the top section there is minimal to none AI utilization; this might include primary research through user interviews to discover latent needs of the target audience. As we move towards the human+AI axis in the bottom section, the discovery phase remains human-led but AI-supported, exemplified by tasks such as summarizing interview transcripts. Conversely, the diamond on the AI-axis reverses these roles, adopting an AI-led approach. The top section, closer to the human+AI axis, includes discovery tools and techniques that that are AI-led but require significant human intervention and input. In the lower section of this diamond, we move towards tools and techniques that extend beyond our human capabilities such as AI-driven data gathering and analysis. It is important to note that when discussing an AI-led approach, we advocate for a human-in-the-loop (TELUS International, 2024) mode of engagement. The theoretical background exemplified within the Discover phase applies to each subsequent phase of the traditional Double Diamond framework: Define, Develop, and Deliver.

By having these separated, stacked diamonds, and a gradient towards a symbiotic human+ai

mode of engagement, we can also delve deeper about the concept of (inter)play. As indicated in the second case-study, using various tools to complement each other was found to be beneficial. Building on this, insights, ideas, or sketches gathered from both the human-led and the AI-led approaches can inform each other, bringing the end results further. Finally, the second dotted-line diamonds on the human+AI axis represent the integration of results from both processes. In this Synthetize phase, the creative team takes the lead, reviews the most promising avenues and decides on how to move forward. These phases also serve as moments of reflection on the tools used, the strategies employed, and on the ethical considerations highlighted at the start. Additionally, they provide opportunities to consider how combining the results might give rise to new ethical concerns.

5. Conclusion

Recognizing the varying degrees of AI involvement in creative practice, it is essential that we examine how creative professionals' workflows are evolving, as "we shape our tools, and thereafter our tools shape us" (Culkin, 1967). To this end, we applied a research-through-design methodology and conducted three case-studies with diverse participants: digital design and development students, creative professionals from the product design field and professors with background in digital design and creative development. Each case-study provided insights in the creative process through interactions between the creative practitioners and generative AI technology. These insights form the basis of our proposition for an augmented Double Diamond model. This modified model acknowledges the varying degrees of AI involvement, allowing for a flexible and dynamic approach to integrating AI in the design process. By considering the (inter)play between human and AI contributions, the model promotes a more holistic and adaptive methodology, and includes critical reflection on the methodology and tools used. Although our work is informed by three limited, yet diverse case-studies and the proposed model has not been extensively tested in real-world settings, it contributes to developing a critical reflection on the integration of generative AI tools in the creative process. Future work should expand on the proposed Double Diamond model and test it across a diverse range of creative practices and support the approach with qualitative data. However, the proposed model already stimulates critical reflection and can help students, professors, and practitioners in the creative field to ground their approach and thoughtfully consider the implications of utilizing various generative AI tools in their creative practice.

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ECO-DATA INFORMED PROCESSES. NATURE AS A CO-DESIGNER TO FACE ENVIRONMENTAL CHANGE.

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ABSTRACT | Change is a feature of the Earth's evolution, manifesting itself through imperceptible shifts or radical transformations that spread across time and space. However, the climate crisis introduces alterations of unprecedented scale and speed, challenging the natural order. The goal is to address crises by preserving the environment and exploring new paradigms in ecology, society and technology, translating scientific insights into design to address social and environmental challenges. This research embraces the transformative potential of integrating natural processes with design to address pressing global challenges.(Haraway, 2015; Kohn, 2021)

Nature has long been a muse and mentor in design, inspiring innovative and sustainable solutions. This research explores how emerging biodesign and biofabrication technologies can be harnessed to create digital design processes, specifically data visualization, that not only respect ecological balances, but also promote principles of interspecies cooperation. Techniques such as Living Building Materials (LBM) (Alemu et al., 2022), Engineered Living Materials (ELM) (Wang et al., 2022) and others are discussed to explore how they could be implemented in the DIKW (data-knowledge-information-wisdom) process of data visualization.

This approach, part of the transition to the circular economy, defines a post-Anthropocene future (Rognoli et al., 2021), emphasizing co-creation with natural processes. It presents ecologically informed design as a methodology that can integrate digital and biological innovations to promote the embodiment of processes that respect the rhythms of nature in design practice.

Based on these considerations, we investigate the possibilities of incorporating bioinspired strategies in the digital domain, particularly in the field of data visualization. Our goal is to study how these processes can advance the domain, fostering a deeper connection with and for nature. The research aims for a shift in design paradigms to include more holistic, nature-

informed processes that align with environmental sustainability models and promote the use of natural strategies as a key component for innovation. In addition it aims to integrate these practices in the educational field, preparing the next generation of designers to think critically about the environmental impact of their digital work.

The contribution proposes the development of Data-Informed Ecological Processes, which combine digital technologies with biomimicry principles to create innovative and sustainable alternatives to conventional data visualization methods. The research proposes the development of data-driven ecological processes, integrating digital technologies and biomimetic principles to create innovative and sustainable alternatives to traditional data visualization methods. These processes will culminate in the development of an application methodology, leading to the realization of a workshop for design students in the later stages of the research. This scientific contribution will introduce new practices and processes in the fields of design and education. The methodology will act as a catalyst for further applications, including new design courses in which solutions inspired by nature and its strategies will be explored and integrated into data visualization processes.

In conclusion, this contribution advocates for a future design paradigm where nature and technology harmonize, utilizing biofabrication and biomimicry to develop sustainable design solutions. This approach aims to transform data visualization practices, promoting an eco-conscious and integrated design methodology that offers low-energy solutions, thereby advancing conventional data visualization methods.

KEYWORDS | DATA-VISUALIZATION, CLIMATE CHANGE, BIOMIMICRY, NATURE, SUSTAINABILITY

1. Introduction

Humanity is facing a global emergency due to climate change and biodiversity loss, which threaten both the environment and social structures. To address this crisis, technological solutions alone are not enough; a fundamental change in thinking and lifestyle is required.

Design plays a crucial role in this transformation, acting as a catalyst for change. Designers must adopt an interdisciplinary approach to envision a sustainable future, integrating technology with purpose and promoting a renewed relationship between humanity and nature. This new paradigm underscores the importance of innovative design in overcoming challenges and leading us towards a better future for the planet. In this context, there is a need to establish a new shared narrative that encompasses overcoming global crises, a critical reflection on the contribution of new technologies, increased awareness of sustainability challenges, and a rethinking of our current development model. (Lotti, 2021)

Building on these premises, we explore the potential synergies between design and biodesign. Specifically, this contribution investigates the possibility of integrating biodesign strategies into the digital domain, particularly in the field of data visualization. The objective is to examine how these innovative approaches can advance the sector, enhancing our understanding of complex phenomena and leveraging its principles to enrich the visual representation of issues related to the global emergency.

2. Background

2.1 Bio-integrated design strategies, from emulation to integration

Change belongs to our world. In any age of Earth everything is changed sometimes little, sometimes radical, so it's the way of the things that our world is destined to change. Evolution is itself a constant change permuted during the time. The Changing is bound by two factors: time and space. The change brought by the climate crisis is anomalous,

because these two factors are anomalous: a changing too fast and too wide. From the data collected in the IPCC (Special Report on Emissions Scenarios) some experts associated the emission of CO2 with global temperature increase evaluated the rise up about 2.5 C in less than fifty years (IPCC, 2018). This speed of changes is incompatible for the adaptation of living beings, inducing on the living beings that can move, a kind of "forced transhumance", with dangerous consequences on surviving. It was observed that the majority of living beings that can move, are migrating from the protected areas, it's estimated that only 8.02% have residence expectations of 100 years at least in these areas.(Loarie et al. 2009) In conclusion, the changes brought by the climate crisis are happening on multiple levels, this means the scenario we see unfolding is not only worrying and in continuous evolutions, but also chaotic.

Amidst the challenges posed by contemporary crises, the emulation of natural processes emerges as a guiding ethos for shaping design strategies towards greater sustainability, efficacy, and efficiency. Embracing the paradigm of nature as a model, measure, and mentor (Benyus, 1997) has sparked renewed enthusiasm among designers. This has catalyzed the creation of projects that draw inspiration from biological principles, demonstrating an evolving engagement with biomimicry.

Recent growth of interest in biology has prompted designers to create design solutions that increasingly incorporate a hybrid approach (Langella, 2021). Numerous individuals have spoken their views on this issue, particularly in recent years, resulting in a significant increase in contributions. Emerging fields of study include Biomimicry design (Benyus, 1997), Biomimetic design (Vincent, 2006), Biophilic design (Wilson, 1986), Biodesign (Myers & Antonelli, 2012; Ginsberg & Chieza, 2018; Dade-Robertson, 2020), and Bio-integrated Design (Cruz & Parker, 2022).

The concept of biodesign is complex and multifaceted, as demonstrated by the numerous views presented by academics and experts in the discipline. It can be defined as the integration of biology into design processes, with the aim of improving functionality. The growing interest in the principles of biodesign involves the incorporation of biological processes into numerous design disciplines, including architecture, fashion, product design and interface design, highlighting its ability to infiltrate and impact various fields (Myers & Antonelli, 2012; Ginsberg & Chieza, 2018; Dade-Robertson, 2020).

This application of biomimesis at a systemic level has become widespread in recent years, especially within the academic design community and has led to a significant increase in companies and design studios that have an interest in entering this field. See, in this regard, the virtuous case history Officina Corpuscoli from which the brands Mogu, Ephea and, more recently, Sqim were born. These realities show how the topic of

biodesign is growing, especially with regards to biofabrication

In particular, the term "biofabrication, borrowed from medicine (Moroni et al, 2018), refers to a method for fabricating materials using living cells like, for example, microorganisms - fungi, microalgae, bacteria-. Recent biofabrication techniques offer the possibility of developing innovative types of materials such as Living Building Materials (LBM) (Alemu et al., 2022) or Engineered Living Materials (ELM) (Wang et al., 2022). This type of materials allows design to define new concepts co-created with natural processes and is part of the transition from a linear economy to a circular economy and defines a post-Anthropocene future (Rognoli et al., 2021).

The panorama of biofabricated design offers a wide range of examples that demonstrate the increasing use of microorganisms such as fungi, algae and bacteria in the production processes of materials and semi-finished products.

As an example, Mogu and Ephea are leaders in the production of indoor and fashion products based on fungal mycelium, while Solaga and Faber Futures focus on the use of microalgae for filtering solutions and natural pigments.

Biomason, on the other hand, stands out for the production of organic cement, using microorganisms to reduce carbon emissions in the construction industry.

Finally, in the textile sector, Colorifix and Living Color propose biological dyeing processes based on bacteria, offering sustainable alternatives to artificial dyes. These examples illustrate the growing adoption of bio-inspired design approaches, highlighting the crucial role of biotechnology in addressing environmental challenges and promoting sustainability in manufacturing sectors.

As we have carefully explored the impact and application of biofabricated materials in physical design, the natural question that emerges is how these methodologies can be effectively applied in the digital domain, leveraged by the livingness of microorganisms But how can we reinterpret the use of digital technologies, no longer as detached entities from our natural environment, but as integrated tools capable of mimicking, respecting and amplifying natural cycles and strategies?

2.2. Living artefacts as environmental-sensitive interfaces for regenerative ecologies.

The concept of Living artefacts (Karana et al., 2020) stands as a pivotal paradigm in biofabrication and biodesign, promoting prolonged livingness of organisms (e.g., fungi, algae, bacteria, and plants) to use time, enabling novel interactions, functions, and expressions in our daily life.

One of the core principles of Living artefacts concern the way humans experience the livingness of these objects, namely Living Aesthetic (Karana et al., 2020). This occurs by noticing the changes of different type, degree,

and duration occurring in the sensorial qualities (e.g., colour, smell, texture), form, and movement, as interface of their biological phenomenon (e.g., growth, reproduction, and decay) which is affected by environmental inputs (e.g., temperature, moisture, light). Indeed, microorganism offer designers opportunities to endow artefacts with environmental sensing and adapting abilities.

Leveraging computation to mediate these inputs broadens the spectrum of possible inputs to be used, and on the other hand allows digital systems to expand the range of outputs towards more tangible, profound, and critical experiences. Exemplary instances of these hybrid systems have been developed in the field of Bio-Human-Computer Interaction (Bio-HCI).

The concept of Living Bits (Pataranutaporn et al., 2020) is presented as the integration of microorganisms in, with and as computing systems, in the attempt of outlining and inspiring the possibility for integrating organic and regenerative living systems in human-computer interaction. This research analyzes a rich spectrum of example projects within microbial HCI. They characterized and systematically studied the utilization of microbes as biological interfaces in each project across scales and applications. They identified and compared the unique advantages between digital and biological computers, including energy sources (e.g. water, nutrients, and gas, such as oxygen) and the flexibility of microbes. Examples include producing pigments or fluorescent molecules for visual cues or releasing scents as olfactory cues. In addition, they categorize the use cases of microbes through a design rationale and proposition into different application domains of microbial interfaces, e.g. communicate and materialize. Finally, they characterized the design elements of Living Bits according to scale, including interface and interaction scales.

Living Color Interfaces (Groutars et al., 2022) explores specifically the use of Flavobacteria, able to grow in highly organized colonies producing vivid iridescent colorations. The research provides insights on the type, degree, and duration of change in Flavobacteria's expression, i.e., their living aesthetics. The study introduces a capturing tool to characterize these changes concerning form, texture and iridescent color. To support the long-term study of their living aesthetics, they designed Flavorium, a bio-digital artifact sustaining Flavobacteria for a month. Potential applications include a living monitor showing the user's physical activity by connection with their smartwatch or living label indicating a houseplant's wellbeing.

The case of Flavobacterial Displays is further explored as an example of Microbial Displays (Kim et al., 2023), generating three concepts: Flavo in Situ, a Circular canvas left open and exposed to the sea, displaying microbial growth; Flavo's Night Out, a night club dance floor, which accompanies clubbers and music with a magnified and ceiling-projected live footage of swimming Flavobacteria; and Environmental Modification, a living street

display reflecting Earth's lands and oceans shape and colors. Using genetically modified Flavobacteria, which sense air quality changes and trigger dynamic displays to raise awareness about pollution. Ultimately this research proposes a Taxonomy of Surfacing Livingness in Microbial Displays, consisting of six microbe-sensitive, tuneable mechanisms for human noticing of microorganisms: 1) Canvassing, 2) Marking, 3) Magnifying, 4) Translating, 5) Nudging, and 6) Molecular Programming.

Cyano-Chromic Interfaces (Zhou et al., 2023) tackle the issue of temporal dissonance in microbe-embedded artifacts, where the inherent "time lag" in human perception of subtle microbial metabolic changes might impede seamless interactions and timely attention to the living components within these artifacts. In addressing this challenge, they introduce Cyanochromic Interface, in which photosynthetic activity of cyanobacteria (Synechocystis sp. PCC6803) is timely surfaced by an electrochromic (EC) material. They developed different application concepts toy instantiate how the interface can be tuned for diverse functional and experiential outcomes in living artifacts, some of these are a Daylight Log, in which at low light conditions, its EC units fade its color, "requesting" humans to unfold the artifact exposing the cells to more light, and leaving a visible trace for humans to notice and to reflect on their interaction with the artifact over time and a Mushroom Shade, in which its electrochromic unit darkens under excessive sunlight, casting a protective shadow on the fungi body below, allowing users to delicately care for each cluster of fruiting bodies by "planting" the shade.

These examples make evident how biomaterials and living organisms can be used to materialize environmental data, potentially encouraging a connection between user and the environment. In this respect, the following section explores the state of the art on eco-informed perspectives for innovative data visualization processes.

2.3. Nature's Blueprint: eco-informed perspectives for innovative Data Visualization processes

Nature offers a vast array of solutions and strategies for design, promoting sustainability and impact reduction. The plant kingdom's ability to store information and make decisions is a key strength, as is its intricate communication networks (Mancuso, 2019). This collaborative effort ensures resilience even under harsh conditions. Design has been influenced by nature since ancient times, with spider web-inspired fishing nets and plant-fiber artifacts. Digital and biotechnological advances have expanded knowledge exchange beyond traditional production processes, promoting a shift towards design in harmony with nature. This connection has evolved significantly with the advent of digital and biotechnological advances.

The digital field must explore innovative strategies to balance technological advancement with environmental sustainability, particularly in resource-limited

contexts. De-digitalization, which does not mean abandoning digital technology, involves realigning it with sustainability principles inspired by nature. The goal is to achieve a harmonious integration between the technological and natural worlds, enhancing design practice's communicative effectiveness while adhering to environmental principles. This requires an eco-informed methodology for designing materials and products, addressing contemporary environmental and social challenges, and envisioning a future where design aligns with natural cycles. This approach involves employing bio-inspired and bio-based methods to enrich traditional Data Visualization processes, fostering a deeper connection with nonhumans and incorporating nature's strategies into problem framing and solving.

Historical examples illustrate the profound connections between humans, non-humans, and artifacts. The Incan Quipu system, used around 2000 B.C., employed ropes and knots as an early data visualization tool to document community life and culture (Harley et al., 1987). Similarly, Tegan Bristow's examination of Vernacular Algorithms (2021, 2022) reveals that African isizulu beadwork incorporated binary code principles, representing an early form of complex information encoding. These cases highlight the deep ties among societies, artifacts, and the natural world, suggesting that artifacts can play a role in eco-systemic and ethical communication.

Building on these examples supports envisioning a future where design and technology evolve towards sustainable and ethically oriented practices deeply connected to our relationship with nonhumans.

2.3.1. Nature-Inspired Design: Merging Digital and Ecological Systems

The integration of nature-inspired design principles into man-made artifacts is driven by several key motivations. Firstly, it fosters sustainable design by aligning creative processes with natural cycles, thus reducing environmental impact. Secondly, it enhances data visualization by addressing traditional methods' limitations in capturing ecological complexity. By incorporating natural patterns and strategies, new ways of representing data can be discovered, making it more accessible and meaningful. Finally, leveraging nature's advanced information processing systems, such as mycorrhizal networks, can lead to innovative data visualization paradigms, creating a deeper connection with users and promoting a better understanding of complex phenomena.

Previous research (Licaj & Matteucci, 2023) highlights concepts like Data Walking, which involves collecting data through walking in natural environments to foster a collaborative exploration between humans and nature. This method offers a holistic view of complex systems. Sensing Chromatism explores how color variations in nature communicate information, enhancing the relationship between design principles and non-human communication. Sound Datafication inverts traditional data-sonification by transforming

natural sounds into data for design projects. The BioViz approach advocates for Eco-Data Informed Processes, integrating digital technologies with biomimicry principles to offer alternatives to conventional data visualization methods.

Examples include "Atlantic Wonder" (Vezzani et al., 2021) and "Data Meditation", which promote nonextractive practices and deeper human-environment dialogue. NASA's use of nature-inspired color palettes enhances public engagement through "semantic association" (Crameri, 2020; Samsel et al., 2018), while Marco Loi's carpets combine Sardinian sound recordings with AI-generated textile designs, blending auditory experiences with textile art (Sbarbati, 2021). Additionally, The Material Experience Lab's FlavoMetrics (fig.1) uses microorganisms like Flavobacteria for interactive design experimentation, merging biology with digital technology (Risseeuw et al., 2023).

This synergy between digital and natural worlds has the potential to redefine information design practices, leading to a more eco-aware and integrated approach to data visualization.

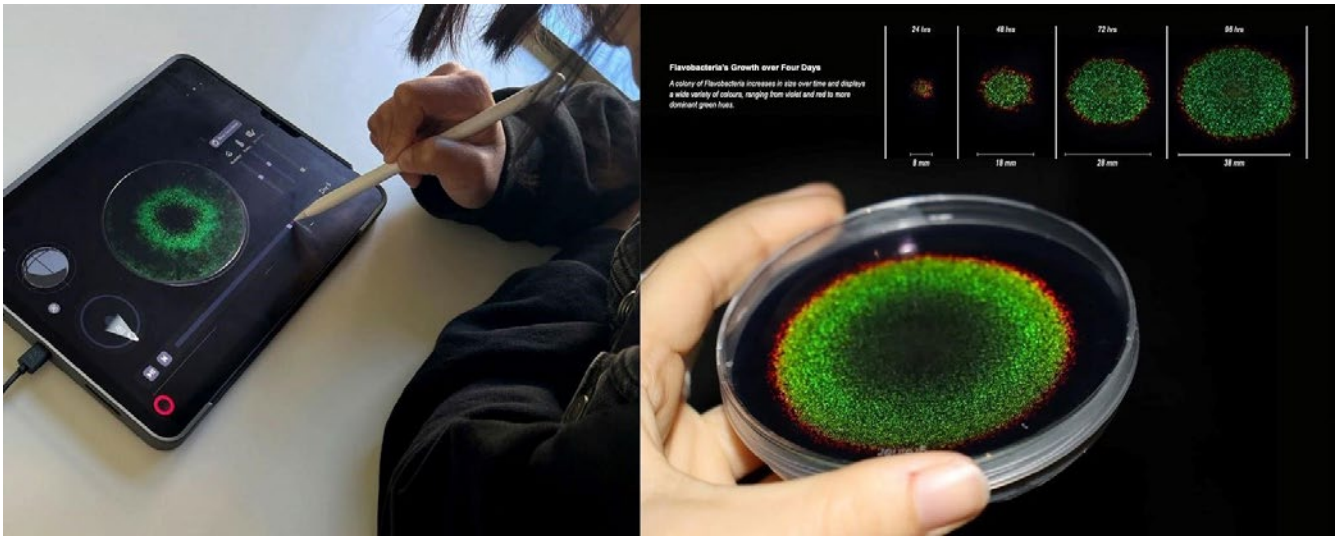


Figure 1. FlavoMetrics. On the left, the interactive digital tool that could support the design process with different living media. On the right, a colony of Flavobacteria increases in size over time and shows a wide variety of colors, ranging from purple and red to the more dominant green tones.

3. Methodology

Building on the opportunities and limitations addressed above, this paper proposes a methodological approach aiming to incorporate the principles deriving from biomimicry, biointegrated design and biofabrication, bio HCI and Living Artifacts, in the different phases of the Data Visualization through "Eco-informed" processes. This methodological proposal is rooted in the structure of the DIKW (Data-Information-Knowledge-Wisdom) model that describes how Data (D) once aggregated turns into Information (I) which then leads to Knowledge (K) of a given phenomenon and consequent Wisdom (W). According to Nathan Shedroff (2000) and Lankow et al. (2012), it is defined as the most suitable model for describing the Data Visualization process.

Through a careful analysis of selected case studies, this research aims to highlight the feasibility and effectiveness of using eco-informed strategies in the practice of Data Visualization, thus demonstrating their potential to enrich and innovate the whole process.

This approach not only emphasizes the importance of inspiration from the living world for sustainable and innovative solutions, but also promotes greater environmental awareness and holistic integration of digital and bio-innovation-inspired strategies in the field of information representation.
After the initial exploration of case studies that establish a relationship between the DIKW process and biodesign, a detailed analysis of data visualization opportunities in biodesign was conducted, focusing primarily on the Knowledge-Wisdom phase. Cases were selected based on specific criteria: the use of living microorganisms and the ability to visualize data in established forms of data visualization. These cases were analyzed by classifying them according to kingdom, species, and visualization method. The result was an initial compilation and articulation of the potential for integrating biodesign and data visualization, advancing towards ecological data visualization.

Finally, the research led to the proposal of a biodesign-inspired educational program aimed at bridging the gap between the fields of data visualization and biodesign. The course structure also included the integration of the already tested tool such as the "Biodesign Agenda" (Marseglia et al., 2024) and the development of a "BioViz Handbook", which will be further developed in the next steps of the research.

4. Results: From Data to Knowledge Eco-Informed process

Below, the various theoretical and applicative dimensions suggested by the selected examples will be examined in detail following the flow of the DIKW model, defining the following taxonomic classification of the flow of processing, translation and assimilation of the information message.

4.1. Data, the living and non-living world as a spontaneous source of Data.

In the first phase of this process, the non-human domain serves as a broad and spontaneous source of raw data. In this context, the main objective is to observe and record phenomena within ecosystems, biodiversity and biological processes, exploring the inherent patterns, rhythms and structures that regulate the balances of the biosphere. These may include interactions between species, patterns of growth and evolution, and transformation processes in their most basic form. The goal is to recognise the living and non-living world as a vast repository of data that can inform design and inform sustainable innovation.

A representative example is the "Grass Map" project (fig 2). It is an innovative approach at the intersection of urban ecology and data science, with the aim of analyzing urban grass as a natural color palette to understand the environmental characteristics of urban spaces. Treating grass color as a critical interface between humans and nature, the project hypotheses that these shades can reveal insights into the surrounding environment from both cultural and scientific perspectives. Involving the public in the data collection process, participants contribute grass samples from their areas, fostering a personalized and tangible connection to the research. The unique color palette for each zone is linked to environmental data such as the Air Quality Index (AQI), exploring the interaction between air quality and visual aspects of urban greenery. This method deepens the participatory nature of environmental research, highlighting the potential of exploiting environmental features as a source for data collection and fostering a closer relationship between community participants and empirical environmental insights.

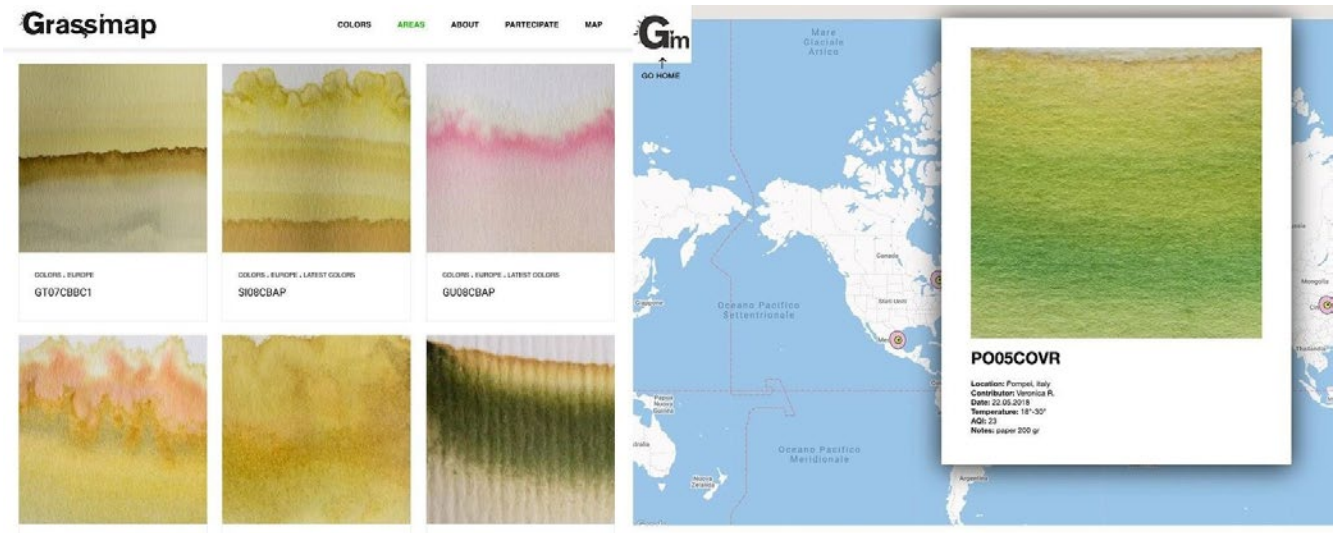


Figure 2. Grass Map project website. Every image is mapped and associated to different data as AQI (air quality index): is a number used by government agencies to communicate to the public how polluted the air currently is or how polluted it is forecast to become.

Two main approaches can be found in this first phase:

- Eco-sourcing of data: Favour data collection from natural sources or use methods that minimize its environmental impact.
- Bio-inspired data collection techniques: Employ biomimicry in data collection tools and techniques, drawing inspiration from the efficiency and adaptability of natural systems.

4.2. Information, aggregations and correlations between data

During the information framing phase, data collected from both the living and non-living realms are consolidated and examined to discern patterns, trends and connections. This phase requires the interpretation of data through the lens of human cognition to create compelling narratives about complex issues, including those related to climate change or societal shifts. A deep understanding of conservation trends and biological dynamics is crucial to devise the most effective methodologies to transform raw data into actionable insights. The ultimate goal is to uncover the symbiotic relationships that pervade the natural world, thereby extracting valuable insights to inform ecoinformed design principles.

An example of this approach is the work of Entangled Others Studio in which ecology, scientific research and generative art are fused through the skillful use of advanced digital technologies, including artificial intelligence. This creative effort focuses on articulating the intricate relationships within ecosystems, resulting in visual narratives that emphasize the concept of biodiversity.

The "Decohering Delineation" project (fig.3) in particular uses neural networks together with oceanographic data to visually represent the interconnectedness of marine ecosystems. While these projects underline the firm's commitment to fusing digital innovation with ecological issues, they also call for a critical examination of the environmental impact of digital technology. The reliance on massive computational resources and artificial intelligence underlines a tension between the aesthetic and educational ambitions of digital art and its ecological implications, inviting a reassessment of digital practices in favor of more sustainable approaches.

At this stage, the approaches used can be summarized as follows:

- Biointegrated Models: Incorporating biological principles into the design of visualization tools and interfaces, aiming for sustainability and adaptability.
- Nature-inspired Encoding: Design data visualizations that mimic patterns, structures and processes found in the natural world, improving comprehensibility and engagement.

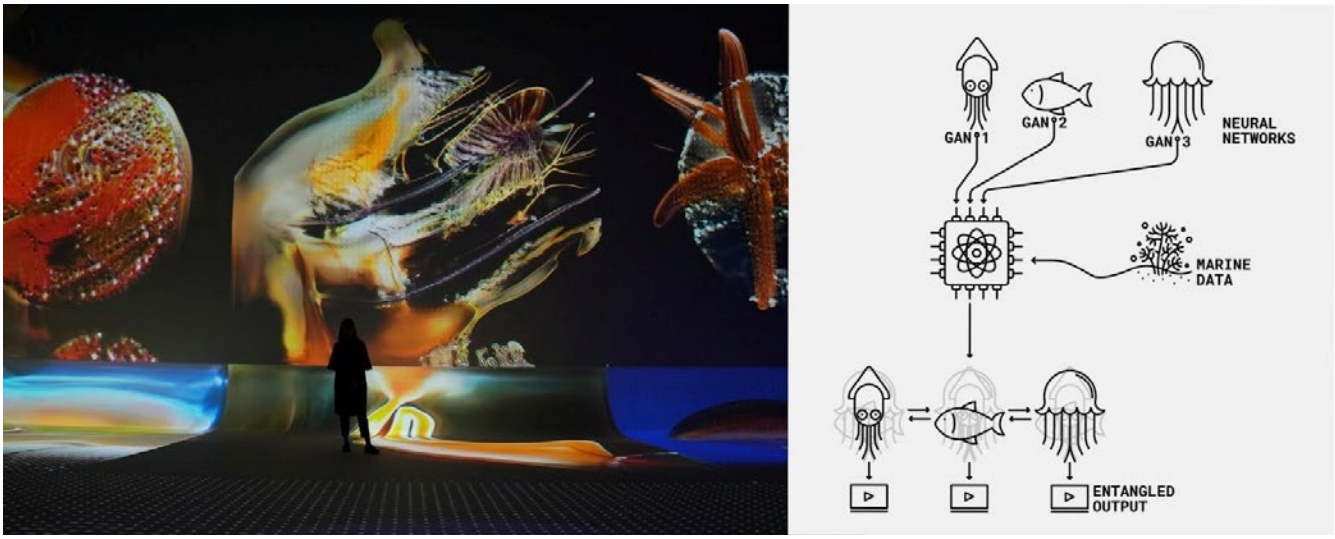


Figure 3. The Decohering Delineation project. On the left, a photo from the exhibition. On the right, a diagram of how using marine data as a driving influence, multiple neural networks are entangled through quantum computing, producing an entangled output.

4.3. Knowledge, the transposition of non-human communication models

The knowledge stage is where the aggregated information is further synthesized to develop deeper insights and frameworks that can address complex contemporary issues. This involves transposing communication models from the non-human world to human contexts, extracting principles of organization, adaptation, and resilience found in nature, and applying these to problem framing and solving. For example, studying the communication networks of fungi or the collective behavior of insects could inspire new ways of managing data, enhancing connectivity, and fostering collaborative problem-solving in human systems. The aim is to interrogate the living and non-living world in order to extrapolate the most suitable strategy to be used for the production of a communicative artifact.

An example of this approach is the experiments by Andrew Adamatzky of the Unconventional Computing Lab at the University of the West of England on Physarum Polycephalum.

Scientists at the lab discovered that the propagation process of this single-celled organism can significantly contribute to seeing and predicting certain phenomena, such as the organization of the railway network (Adamatzky, 2013) or migration routes (Adamatzky, & Martinez, 2013). These results highlight a paradigm shift towards a more organic and less digitally-centered approach to data visualization. In essence, this shift to biodesign and living artifacts represents a significant step away from traditional, purely digital data visualization techniques, embracing a more integrated, designinfluenced process

that capitalizes on innate problem-solving strategies found in nature.
At this stage, the following approaches could be identified:

· Biofabrication for Data Visualization: Using biofabricated materials and processes to create physical models of data, offering a tangible and interactive way to understand complex information.

· Bio HCI techniques: Integrating biological elements and principles into HCI to create more intuitive and natural user interfaces for data exploration.

4.4. Wisdom, sharing knowledge to raise awareness

The climax of the Eco-informed Visualization process, embodied by the Wisdom phase, represents a critical point at which the insights mentioned in previous phases converge, paving the way for innovative approaches to data interpretation and representation.
This phase traces trajectories towards unexplored domains to systematize models that are deeply influenced by both the living and non-living realms.

The aim is to experiment with new communication languages that not only convey information, but are capable of engaging the audience on a deeper and more intuitive level by exploiting the principles that govern the entire ecosystem.

Referring to this the research identifies two pathways for new solutions in the eco-informed data visualization process:

· Living artifacts integration: This approach involves the creation of artifacts for data visualization through collaboration with other living organisms, exploiting their characteristics of growth, adaptation and reaction to changing environmental conditions, thus embodying the dynamic and interconnected nature of the data to be represented. Visualizations employing living artifacts act as a tangible bridge between the abstract world of data and the palpable reality of life, offering the viewer an immersive experience that highlights the symbiotic relationship between human activity and the natural environment. By integrating biological processes into Data Visualization, these artifacts encourage a deeper understanding and appreciation of data, offering the possibility to visualize those issues that are characterized by continuous variation in time and space.

· Combining biological and technological processes: This principle emphasizes the integration between technological progress and natural processes, ensuring that the tools and methods used in data visualization coexist in balance with the principles of sustainability and ecological awareness. This vision challenges us to rethink the role of technology in design practice, proposing a model in which digital and bio-innovative strategies co-exist synergistically to enhance our understanding and translation of data and its wider implications. By taking a holistic view, this approach emphasizes the importance of considering the ethical,

environmental and social impact of our technology choices, guiding us towards more responsible and sustainable practices in data visualization.

Ultimately, the wisdom phase of the eco-informed data visualization process pushes us to look beyond the traditional boundaries of Data Visualization processes to explore new ways of solving problems by incorporating techniques inspired by the non-human world. This phase promotes the adoption of strategies informed by nature, inviting us to re-imagine the way we visualize and communicate complex topics.

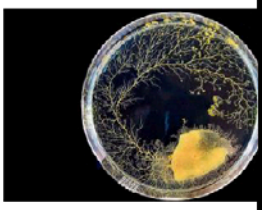
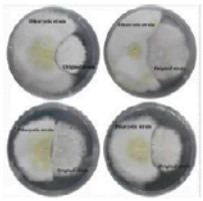
5. Discussion

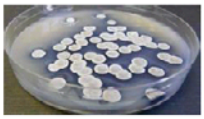
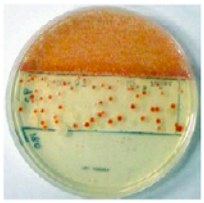
5.1. Biodesign and Data Visualization. First practical examples of BioViz

The "Visualization through biology" table [Table 1] provides a foundational synthesis of the research's original contributions, offering a practical guide for using living organisms to create innovative and bio-inspired data visualizations. It serves as a reference for students in educational programs to select specific organisms for data visualization, indicating the type of chart each organism can generate. This bio-inspired approach integrates natural elements into the data visualization process, presenting novel solutions for representing datasets.
The table categorizes information into Kingdom (biological kingdom of the organism), Species (specifies the species used), Visualization Method (describes the type of chart that can be generated), and Reference (provides the citation of the scientific article or study). It is designed to assist in identifying which organisms to use for specific datasets and the resulting type of chart or visualization method. For example we can see how, in the kingdom of Protists, the organism Physarum Polycephalum has been studied for its maze-solving abilities, as described by Nakagaki et al. (2000).

Using this organism, the position of the seeds can trace the trajectory of lines in a line chart, and other possible visualization methods include the trend line, transit map, and network chart. In the kingdom of Fungi, Ganoderma Lucidum, described by Tang et al. (2023) for its high spore yield, can be used in a bubble chart, where the weight and position of the seeds determine the size of the bubbles. Other possible visualization methods include the Voronoi chart, packed circle chart, polar chart, and radar diagram, each using seed weight parameters. In the kingdom of Bacteria, Streptomyces Coelicolor, according to Chieza and Ward (2015), can be used to develop a dot density diagram, where the chemical composition of the growth medium determines the population density of the dots. Other possible visualization methods include the Voronoi chart and the convex treemap. Serratia marcescens, discussed by Venil et al. (2021) for pigment extraction, can be visualized with a convex treemap. Escherichia coli can be used to design schemes based on

the position of the agar/seed, as shown in the project by Jelte van Abbema. Paenibacillus vortex can be used for a flow map to represent the architecture of the colony, as well as a radial area chart. In the kingdom of Plantae, Chlamydomonas Reinhardtii can be used to visualize a heat map, where the amount of light is represented by color saturation, as described by Colliaux et al. (2015).

Kingdom	Species	Visualization	Method	Reference	Fig
Protist	*Physarum Polycephalum*	Line chart, Trend Line, Transit map, Network	Seeds position = Line trajectory	Nakagaki, T., Yamada, H., & Tóth, Á. (2000). Maze-solving by an amoeboid organism. *Nature*, *407*(6803), 470-470.	
Fungus	*Ganoderma Lucidum*	Bubble chart	Seed weight+seed position = Bubble size	Tang, C., Tan, Y., Zhang, J., Zhou, S., Honda, Y., & Zhang, H. (2023). A novel strain breeding of Ganoderma lucidum UV119 (Agaricomycetes) with high spores yield and strong resistant	
				ability to other microbes' invasions. *Foods*, *12*(3), 465.	
		Voronoi chart	Seed weight+seed position = Area size		
		packed circle chart	Seed weight+seed position = Circle diameter		

		Polar chart	Seed weight = chart extension		
		Radar diagram	Seed weight = radar extension		
Bacteria	*Streptomyces Coelicolor*	Dot density diagram	Growing medium chemical composition = dot population density	Chieza, N., & Ward, J. (2015, March). Design in the age of living technology. In *Proceedings of the 2nd Biennial Research Through Design Conference* (Vol. 2).	
		Voronoi chart, Convex Treemap	Seed weight+seed position = Area size		
Bacteria	*Serratia marcescens*	Convex treemap	Seed weight+seed position = Area size	Venil, C. K., Dufossé, L., Velmurugan, P., Malathi, M., & Lakshmanaperumalsamy, P. (2021). Extraction and application of pigment from Serratia marcescens SB08, an insect enteric gut bacterium, for textile dyeing. *Textiles*, *1*(1), 21-36.	
Bacteria	*Escherichia coli (Not sure)*	Any	Position of agar/seed = Scheme design	https://www.dutchdesignawards.nl/gallery/jelte-van-abbema/	

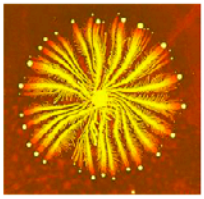
Bacteria	*Paenibacillus vortex*	Flow Map, Radia Area Chart	Position of seed = Architecture of colony	https://www.dezeen.com/2015/09/14/ori-elisar-grows-letterforms-lab-using-bacteria-filled-petri-dishes-hebrew/	
Plantae	*Chlamydomonas Reinhardtii*	Heat map	Amount of light = Color saturation	Colliaux, D., Giraud, L., Yéprémian, C., Bessière, P., & Droulez, J. (2015, July). Probing models of minimal swimming vehicules in vivo with microalgae phototaxis. In *European Conference on Artificial Life 2015*.	

Table 1. Visualizing through biology

5.2. Outlining innovative educational pathways

The contribution proposes a new educational pathway based on the integration of biodesign and biofabrication methodologies and tools with principles of data visualization.
In relation to the bio-informed processes described above, this approach lies between Knowledge and Wisdom. This initial exploration will allow for the development of further experiences at scale in the later stages of the DIKW process.

Through the development of this initial methodological proposal, the aim is to transform the conventional approach to data visualization, replacing digitally constructed processes through classic visualization software with biological strategies and biofabrication processes. The intention is to find a correlation between the function expressed by traditional graphs used in data visualization and the behavior of certain living organisms, seeking to employ this behavior to represent specific types of information or data. By learning the correlations between these conventional visualization tools and the natural processes exhibited by specific organisms, students can understand new techniques for representing information. For example, the growth dynamics of bacterial colonies or the behavioral strategy of organisms like Physarum Polycephalum can serve as graphical analogs for representing complex data sets, providing a highly communicative and biologically inspired visualization method.

This interdisciplinary and systemic approach allows for the creation of projects that represent complex phenomena related to climate and environmental emergencies.
Not only does it demonstrate the potential

of integrating biodesign and biofabrication principles into the data visualization process, but it also promotes interdisciplinary collaboration and the creative resolution of what are known as wicked problems (Rittel & Webber, 1973).

Specifically, the program of the educational pathway could be structured as follows:

1. Basics:

· Introduction to Biodesign and Biofabrication: Overview of key concepts, methodologies, and tools. Introduction to biological materials (e.g., bacterial cultures, physarum polycephalum, agar plates) and biofabrication tools (e.g., incubators, petri dishes, growth mediums)

· Introduction to Data Visualization: Review of traditional data visualization techniques (graphs, histograms, etc.) and conventional visualization softwares (e.g. Flourish, Rawgraph, Tableau, etc.)

2. Integrating Biodesign with Data Visualization:

· Theoretical Framework: Explore the relationship between traditional data visualization functions and the behaviors of living organisms.

· Case Studies: Present examples of successful integration of biological strategies into data visualization.

· Classification and selection of biological materials: Identify and select organisms based on specific characteristics—such as changes in saturation in response to UV light or growth patterns influenced by their medium—to provide innovative alternatives to conventional graphs and histograms.

· Delivery of the "BioViz Methodology Handbook": an open-source guide for integrating biodesign with data visualization. This handbook will include methodologies, best practices, and tools for developing bio-inspired visualizations. It will feature a curated selection of organisms whose unique traits can be used to craft novel alternatives to traditional data representation methods.

3. Hands-on Experimentation:

· Through the "BioViz Methodology Handbook," professors, and experts, participants are guided in the development of a bioinspired visualization process. Participants engage in laboratory work sessions to kick off their projects. Using the methodologies and tools provided, they develop their own biological data visualization projects. Once the projects are developed, each group presents their work to the rest of the students. This is followed by a feedback session, where facilitators and peers offer constructive feedback on the projects, helping to refine and improve the visualizations.

The structure of the program, from basic concepts to practical experimentation, shows a possible comprehensive application of the principles described in the paper. Moreover,

it emerges how this kind of pathway not only improves educational practices, but also promotes sustainability and responsible innovation in design. Moreover, the described pathway can be adapted to various time scales, from a short workshop to a multi-month course or even a Master's program.

For shorter formats, such as workshops, it is critical to consider the reaction times of the microorganisms involved in biofabrication such as the case of those microorganisms whose reactions become visible after perhaps seven days. This requires careful planning and, potentially, prepreparation of some biological materials to ensure that participants can observe significant results within the workshop time frame.

In longer formats, such as a multi-month course or a Master's program, there is more flexibility to delve into processes and observe the full life cycle of biological transformations. This allows for more detailed study and application of bioinspired design principles, giving students a richer and more comprehensive learning experience. By adapting the length of the program to the needs and constraints of the educational context, the educational track can provide designers with methods and tools for more sustainable and innovative design actions.

6. Conclusion

In conclusion, adopting eco-data informed processes marks a significant step towards a sustainable future, where digital and nature merge to address environmental challenges. Through the application of bio-inspired strategies, we aim to tame entropy in our design systems, fostering solutions that honor natural cycles and dynamically adapt to environmental needs. This approach not only strengthens the bond between humanity and nature but lays the groundwork for system design deeply rooted in principles of sustainability and responsible innovation.

The outlined research suggests a path where design and digital collaborate in harmony with the environment, leading us towards more sustainable and aware practices identifying a set of strategies to modify Data Visualization processes in all its key steps which: Eco-sourcing of data, Bio-inspired data collection techniques, Biointegrated Data Models, Nature-inspired Encoding, Biofabrication for Data Visualization, Bio HCI techniques.

By rethinking data visualization through these lenses, we can create more meaningful and impactful representations that resonate with natural processes and cycles. This holistic integration not only enhances our understanding of complex phenomena but also promotes a deeper environmental awareness and ethical approach to innovation.

In conclusion, merging bio-inspired strategies with digital innovation offers a transformative path for data visualization, encouraging sustainable and adaptive practices that honor and reflect the intricate dynamics of our natural world. This integrated approach paves the way for a future where design and technology work in harmony with nature, fostering resilience and sustainable development. The research also includes in its future developments a series of steps such as:

- Collection of large amounts of case studies in order to outline a database of strategies that could be used to design BioVisualizations.
- Making this catalog accessible through a platform in order to provide a useful tool to researchers and designers

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HAUNTOLOGICAL SPECULATION DEVICE: DESIGNING LOST FUTURES WITH DESIGN STUDENTS TO EXPLORE SOCIO-TECHNOLOGICAL SCENARIOS

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ABSTRACT | This paper explores the application of hauntological speculation as an innovative approach to speculative design in undergraduate design education. While speculative design methodologies have gained prominence in design curricula, they often struggle to imagine future scenarios beyond predominant apocalyptic narratives, leading to a form of "imaginative paralysis." To address this challenge, we propose integrating the concept of "hauntology" into design epistemologies. Hauntology expands ontological frameworks by incorporating "the presence of absences" - events that could have occurred but did not materialize - as factors shaping the present. This approach aims to broaden the possibilities for imagining and designing futures beyond the constraints of dominant contemporary logics.

We present two case studies of "hauntological speculation exercises" implemented in design courses. These exercises explore "lost futures" from specific historical bifurcation points, such as the invention of hot air balloons and the origins of Fordism. Students engage in counterfactual thinking to imagine alternative historical trajectories and their implications for present-day design possibilities. The integration of AI-generated imagery in these exercises provokes dialogues about plausibility, probability, and the hegemonic forces shaping our imaginaries.

By examining unrealized past potentialities, this approach enables students to question linear and deterministic understandings of historical processes and to speculate about non-evident potentials in truncated timelines. This paper argues that hauntological speculation offers a valuable tool for design education, fostering critical thinking about the constructed nature of the world and the role of design decisions in shaping historical contexts and future possibilities.

KEYWORDS | HAUNTOLOGICAL SPECULATION IN DESIGN, LOST FUTURES, UNDERGRADUATE DESIGN EDUCATION, ALTERNATIVE POTENTIALITIES, SOCIO-TECHNOLOGICAL SCENARIOS

1. Introduction

At times, it seems that we have more extensive margins of a known past which tractions backwards than possible futures to come. This can be posed as a conundrum or a problem for the future of Design, since it is a project-based discipline oriented towards the transformation of existing situations into preferrable situations (Simon, 2019). In this sense, the future projects itself as an elemental operating field for Design. Its eventual disappearance could pose a profound threat to Design's raison d'être as a discipline. However, as Hamlet, the Shakespearean character, reminds us, time is out of joint. This observation suggests the need to rethink our relationship to time and the future, considering the status of Design. This reflection is especially relevant for docents and researchers working in this discipline —it acknowledges an academic and a professional drifting. The experience at different stages of a Design education shows how upfront action against planetary crisis has become a fundamental imperative, as well as trying to address some of its implications. In the same vein, the methodologies of speculative design have emerged as a significant formative trend, addressing the task of imagining possible futures. However, a lot of these speculations tend to project predominantly dystopic scenarios, which perhaps reflects a certain "existential and psychocultural condition of the contemporary age" (Danowski & Viveiros de Castro, 2019, p. 4243) —at least in the West—. Yet, this becomes a limitation to imagining possible alternative futures. A clearly eroded world scenario raises the question of what the exertion and presence of Design is.

In this article, the problem about the future or futures that haunt Design as an expanding discipline is addressed through exploring the concept of hauntology. Hauntology could offer a renovating perspective to tackle the current methodological limitations when imagining alternative futures. Firstly, we scrutinize criticisms of speculative design, as well as its apparent difficulty to transcend the hegemonical possibility frameworks of the present. Later, we examine the concept of hauntology, incipiently developed by Jacques Derrida, as a theoretical tool to rethink Design's underlying ontology and its

relationship to time, history, and possibility. The analysis and use of this perspective —amplified by other authors— could be feasibly applied to a Design education. To this point, we present two concrete pedagogical experiences, which aim to expand the imaginative horizons of students. Finally, we discuss the implications of incorporating Artificial Intelligence (AI) in the processes of hauntological speculation, considering the opportunities and challenges that arise. The text is dotted with reflections about the possibilities that hauntological thinking can contribute to a critical teaching of Design to maintain its project-based and transformative abilities; distancing itself from the restrictions of monolithic ways of thinking that limit the imagination of alternative futures in the context of multiple contemporary issues.

2. On the Haunting Crisis: Modes of Rethinking

During a conference presented at Universidad Autónoma Metropolitana de México, Gui Bonsiepe (2011) referred to how planetary crises "are inevitably reflected in Design, its teaching, its practice, and its discourse", fomenting hopelessness and fatalism, an "attitude that no designer should concede themselves to" (p. 28). Several years later, his words still resonate within the discipline:

"Even though turbulences can cause feelings of danger, threat, insecurity, disorientation, disenchantment, depression, and even the sensation of being irreversible, a crisis allows us to see with greater precision and conscience its antagonisms and its causes, and from there it allows us to draft possible ways to overcome it"
(BONSIEPE, 2012, P. 5).

On a similar note, Adam Nocek & Tony Fry (2021) propose further exploring the construction of practical and theoretical tools for Design and its praxis with ontological alternatives that are more adequate for contemporary challenges. The authors direct their criticism towards modern human behavior that is "responsible for a big part of ecological devastation, colonial violence, and geopolitical instability" (pp. 2-3). This ontology is a byproduct of some Design actions and, at the same time, the foundation of its practice. Thus, it is necessary to rethink new ontologies that allow us to face these conflicts in favor of desirable futures, to avoid forms of impotence that freeze Design practices.

To this point, Design may be understood as something which does not yet exist but that is nonetheless possible, and that projects futures before repairing issues of the present. Despite being a "leading discipline of the future" (Von Borries, 2019, p. 107), Design has a delicate relationship with the present, as it materially replicates the predominant beliefs, identities, and social relationships (Balsamo, 2009). By being present in multiple aspects of our daily lives, it affects practices and makes them possible in diverse fields of human action. It complicates the constructed world, which is a product of project-led actions.

Annie Leonard, in her book The Story of Stuff (2011), blames designers and the decision-makers for this ethical dilemma: "While not all execrable initiatives from industry have been intentional and manipulative, a lot of products were designed for infinite markets, where efficiency was the only selective criteria" (p. 223). Therefore, it is a risk to forget the character of the "designed" and thus the designable quality of the world.

Various authors have identified that this sensation of determinist inevitability is one of the multiple ideological deformations that increment the hegemony of a determined system. For Benjamin (2008), hopelessness, anxieties, and prevailing preoccupations under a capitalist regime are attributable to fearing that there is no exit. Mark Fisher (2016) coined the term "capitalist realism" to refer to the contemporary version of this phenomenon: the belief that there is no alternative to capitalism. The famous quote by Fredric Jameson: "it is easier to imagine the end of the world than the end of capitalism" also comes to mind. This ideological torsion or instrumentalization of the concept of reality operates in conjunction with what Raymond Williams (1977) called "selective tradition"; that is to say, the emphasis on certain aspects of what has occurred. As the author says, it is "a version of the past that intends to connect with the present and rectify it. In practice, this gives a sensation of predetermined continuity" (p. 116). By this optic, history appears as a sequence of milestones, causes and consequences that are logical and, therefore, inevitable. Thus, it would appear as if the present were the inevitable result of the past, and the future would not be more than the inescapable result of that same present. In doing so, many other histories and those futures that could have seemed possible and even imminent are oppressed and eliminated on the spot (Benjamin, 1969).

However, this perspective can nullify what is ultimately "a succession of selections and bifurcations with different possibilities in conflict" (Berardi, 2019, p. 18), in a landscape of ideological disputes understood as a junction that is susceptible to critical analysis given its historical and social determinism. Going back to Bonsiepe (2011), as a historical moment, "no one will deny the omnipresent and even crushing force of the market, but it is one thing to accept it as reality and another to impose it as the only reality" (p. 6).

3. Speculative Design as an Answer to a Future in Crisis

While a crisis "offers the opportunity and imposes the obligation to revise the dominant reference frameworks in which one has operated so far" (Bonsiepe, 2012, p. 28), it seems that crisis, catastrophe, and capitalism are intrinsically linked (Luxemburgo, 2019), or even that capital today was able to extract profit from the planetary crisis (Alizart, 2020). Undoubtedly, we are currently facing a multiplicity of planetary crises, of which the ecological anthropogenic crisis has garnered the most social attention, backed by reports presented to the scientific community as

well as the general population. However, for Déborah Danowski and Eduardo Viveiros de Castro (2019), current discourses about the end of the world as the culmination of the different ongoing crises, constitute a certain mythology for the present times, which affects most areas of contemporary imagination and continue to deeply mobilize academic reflection.

In the face of this, as previously indicated, Speculative Design has gained influence as a current oriented towards imagining other possibilities for the future, inspired by Design's critical explorations prior to its deep commercialization during the years before the 21st century (Dunne & Raby, 2013). These approximations of future scenarios have not stayed exclusively within academic discussions or museographic exhibitions. Rather, they have erupted in the professional world of Design and, more significantly, they have gained ground in the discipline's education curricula. However, one of the most relevant criticisms of speculative design, to our judgement, is related to its trouble questioning the established power structures —especially those of the market—, by omitting the political connotations in which it is located; its spectacularization and aestheticizing of dystopia as well as its difficulty to imagine futures within Western norms and anxieties (DiSalvo, 2012; Tonkinwise, 2014; Prado y Oliveira, 2015; Nooney y Brain, 2019).

Confronting the interrogation about the future in which this current of Design is based, a certain incapacity appears: the inability to imagine an alternative that is different from the dystopia that we are familiar with through neoliberal culture. This strips away its potential premonitory aptitude, while we seem to be drifting in a world that we do not fully comprehend, where we are unsure of what to do. (Danowski & Viveiros de Castro, 2019). In other words, "while crises expand and gain speed, politics wilt away and take steps backward […] In this paralysis of the political imaginary, the future has extinguished" (Srnicek & Williams, 2015). In the face of this capitalist realism, Mark Fisher (2016) goes a step further by proposing the notion of "reflexive impotence" as a conscious attitude regarding world's state of deterioration, and even further realization of the fact that there is nothing to do about it. Both "imaginative paralysis" proposed by Srnicek & Williams (2015) and Fisher's "reflexive impotence" are, in our opinion, symptoms of the same contemporary affliction of Speculative Design.

4. Hauntology: Absence that Turns into Presence

Creative and project-based disciplines may address these questions of apparent inevitability or lack of alternatives to crisis (which only perpetuates the current state), during their formative process. The concept of "hauntology" may be a novel approach to apply to the process and thinking of Design, in this sense. Theoretically, it constitutes an ontological change that can be illuminating when examining and challenging certain conceptions of the progression of history (understood as lineal and immutable) and offering the possibility of rethinking social change, where Design plays a considerable part. The concept of hauntology, introduced by Jacques Derrida (1995) in his work Specters of Marx, can be explained through a linguistic play that works in English and French. It combines the terms "haunt" or "hanter" (French), with the suffix "logy" or "logie", referring to the study or logic of a phenomenon. However, the most significant aspect of this neologism is its phonetical similarity, especially in French, with the term ontology. The French philosopher structures his hauntological proposal around this term. It ultimately suggests that all existence is "based on a series of absences, which precede it, surround it, and allow it to possess consistence and intelligibility" (Fisher, 2018, pp. 43-44). Therefore, a contrast is demarcated between hauntology and traditional ontology: while the latter understands the being as a presence identical to itself, the absences (specters) that Derrida proposes are not beings per se, but rather indicate a relationship to what is no longer, what could have been and was not, or what is yet to be (Hägglund, 2008). Thus, these specters represent an agency of the virtual(ized) that exerts an influence on the present, or the actual(ized), without existing thoroughly, hence resisting ontologization (Balcarce, 2023). In essence, hauntology embodies that paradoxical presence of absences.

From an hauntological perspective, what is absent or what disappears is not a particular object, "what has vanished is a trend, a virtual trajectory" (Fisher, 2018, p. 49). They foreshadow future expectations that do not consummate by disappearing since they do not even seem possible: they simply "have evaporated" (Fisher, 2018, p. 48).

On the other hand, it is worth mentioning that these specters, absences or truncated events (besides being a part of diverse cultures throughout history) are profusely utilized tropes within a series of disciplines as a critical tool, which is the case for the contrafactual history line of research. Despite the differences that the specter figure may have in these contexts, in general, they coincide with a central aspect: representing a middle ground between presence and absence, making a "different take of the thresholds and taxonomical divisions" (Balcarce, 2023, p. 9) possible. Within these limits and categories that hauntology tensions, there

is one regarding what is possible, a critical dimension for project-based practices and for Design (Franke, 2010). As author Gabi Balcarce (2023) mentions in her book Posthumanismo espectral: "the specter interrupts temporal and ontological contiguity and inaugurates a new space in ontology as an experience of the impossible" (p. 8). This notion is "extremely plastic when applying it to the contemporary philosophical register" (Balcarce, 2023, p. 8), which allows for an incursion into other fields of knowledge. In this case, the spectral incursion that interests us points to projecting the future. In our opinion, Design has an evident privilege within these tentative explorations. By looking into the field of project-based possibility in the future's uncertainty, Design gives way for a virtual space of spectrality (Derrida, 1995) to emerge.

The concept of hauntology rises as a valuable instrument when reconsidering the underlying ontology of Design: its conception of time, its theoretical frameworks, the limits of the possible, and the circumstances that define these possibilities to consider the virtualities, persistences or re-apparitions that affect our present. At the same time, hauntology offers a temporal or historical perspective into multiple possible trajectories in dispute. In other words, history is also based on the exclusion and concealment of other histories, therefore, the past becomes a malleable category that may be explored between its absences in search for lost futures. As Gabi Balcarce (2023) has said:

"Confronting a reading of temporality which takes its metaphors from movement and ties past-present-future in an inexorable way —as is the case with linearistic conceptions of a historicist or positivist type, the discourse of progress—, here, the present is not evident, nor is the past. And their opacity or, to be more precise, their possible readings, do not always meet in the field understood as 'conditions of possibility', but rather as the weaving of the present and the past that the present intends to take for granted —a very modern pretension of certainty—"

(PP. 8-9).

Therefore, an hauntological approach does not only involve the condition of the designed and the designable, but at the same time it postulates a certain degree of agency, persistence, and accessibility to absences. This is to say, the opportunity of activating said virtualities in relation to our present is still latent, as is expanding the repertoire of its possibilities.

By appropriating and adaptating this concept and transferring it to the area of Design, we may explore different ways of learning within undergraduate courses to examine the possibilities that arise from this approach. The following are two concrete cases of the application of the concept through exercises carried out in two design modules (from higher level freshman and junior years).

5. The City of Balloons

The application of the exercise was called "Designing Lost Futures: Hauntological Speculation Workshop". Through exploring lost or unrealized pasts, as well as alternative temporal lines (yet imminently possible if looked at from that past), students will be able to comprehend the influence of logics of power, dominant technologies, trendy imaginaries, and other forces and social energies in certain historical periods of Design. Likewise, understanding how Design conditions back these socio-technical subjectivities.

The preceding operates in an analogical way in relation to the present, functioning as a sort of moral takeaway. By prompting a critical look at how influential the constrictions that did not allow for certain designs or products to emerge are, we may question their agency in current possibility horizons.

This also intended to take on some of the criticism towards Speculative Design to "look beyond given socioeconomical and political structures and look into how and why our societies have gotten to that point in the first place" (Prado & Oliveira, 2015).

The workshop was divided into three instances: a brief theoretical introduction, a group selection of a historical bifurcation point from which to speculate about possible alternative future expectations (that is to say, a lost future), and finally, a projection and description of the scenario through possible systems/artifacts/services in that lost future. Its objective was to present the theoretical context and the fundamental notions of hauntological thinking, which are necessary to work on the activity (see figure 1).

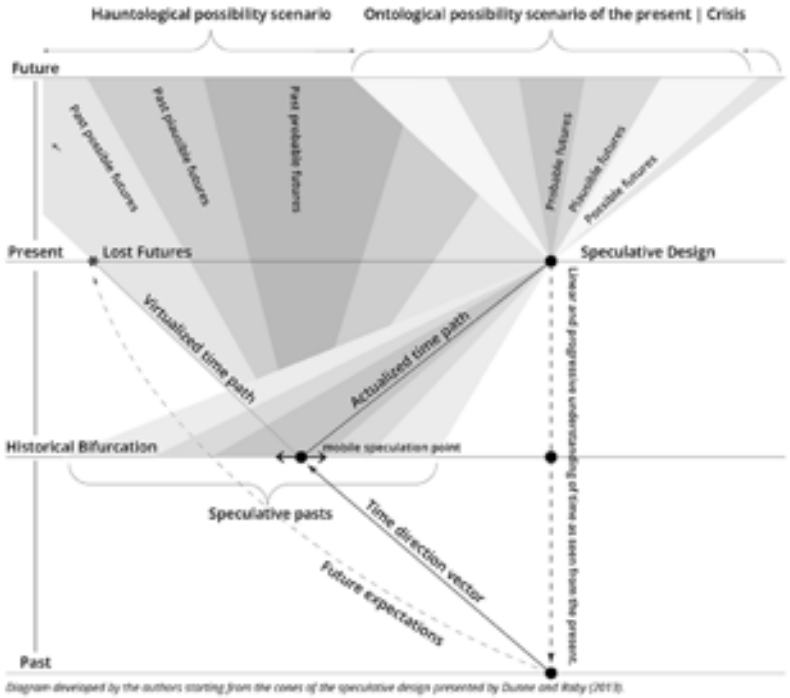

Figure 1. Hauntological Speculation Diagram, developed by the authors from the speculative design cones presented by Dunne & Raby (2013). It represents the contribution of the hauntological perspective to speculative design. It incorporates virtual (unrealised) trajectories, lost futures and the possibilities of speculating about the past.

For a second stage, we used the game cards for the Timeline board game (by Frédéric Henry, Zygomatic). All participants had to collectively define a historical event as a bifurcation point (see figure 1) from which to situate their speculation. The game cards were also a useful element to avoid a potential blank-page paralysis, as well as a bedrock from which to discuss and reach agreements among the group.

One of the interesting observations was how the activity eased the selection of certain technical objects, compared with processes or events. For instance, at the beginning one of the groups had selected the donation of Dolly the Sheep as a milestone. However, since it was not focused on a technical object, students expressed they had greater difficulty in their analysis and further alternative futures projections. When the team decided to opt for another technological moment (the first journey across the English Channel on an air balloon), the discussion was centered on the technical object, which led to a more fluid conversation and hauntological speculation. The group dialogue went toward the means of transportation, arriving at the following speculative question: What would have happened if hot air balloons would have been imposed as a main means of transportation? This set off an interest in establishing a difference with other predominant means of transportation, such as airplanes, cars, and subterrain trains. The hauntological speculation developed by the group to construct the speculative scenario, was guided by a baseline question: How would a city be articulated by hot air balloons as a dominant means of transportation? To address this question, we reflected on transportation services, architecture and infrastructures, social and class logics, acquired habits, energetic costs, among other factors (see figure 2). For students, one of the most useful notions to guide their speculations that derived from hauntological thinking, was that "for everything that exists or could exist, there is always something that seizes or will seize to exist". This is a simple yet considerable reflection at a formative level. A common guideline in the group was to comment on things that would not exist, therefore, speculative questions were oriented towards what would exist in their absence.

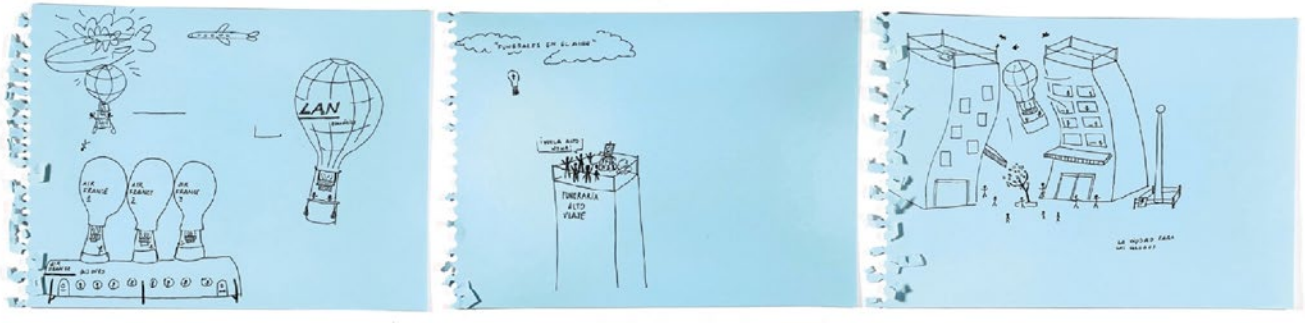

Figure 2. Drawings made by one of the participants in the exercise. It represents part of the group discussions about the socio-technical characteristics of the speculative lost future.

Figure 3. Images generated by OpenAI's artificial intelligence Dall-E. It visualizes some of the representative technical objects of The City of Balloons.

The activity encompassed a series of biases conditioned by the logics of present-day behaviors, which was noted by some of the participants. For instance, market logics or constant acceleration, which are implicitly rooted in our way of thinking. These arose more than once during the construction of the speculative scenario. A specific example comes to mind: one of the speculative technical objects projected by one of the students in the group was the installation of "giant fans" inside buildings to generate wind currents that would rapidly move the hot air balloons, as aerial roads. However, this was quickly questioned by another participant from the team who pointed out that this depended on a paradigm of acceleration which was not necessarily valid (or equally desirable) in a world that prioritizes hot air balloons as a means of transportation. This controversy was followed by a discussion about the relationship to time and technological advancements.

To visualize the results of this exercise, images were generated using artificial intelligence, of the most representative speculations of the scenario (see figure 3), taking as a reference some works that use these technologies to create "inexistent" past speculations (see: Un archivo queer inexistente by Felipe Rivas San Martín, 2023; Unsupervised by Refik Anadol, 2021; Terram in Aspectu by Liliana Farber, 2019). Consequently, employing artificial intelligence offered a series of opportunities (as well as challenges and ethical questions) for the application of this exercise in the context of a massive undergraduate Design module.

6. Lost Futures for Means of Transportation

Another version of the exercise "Designing Lost Futures: A Hauntological Speculation Exercise in Means of Transportation and Locomotion" was applied in another freshman year module of Design History and its Historical Contexts, within the class "Design, Rationalization and Fordist Consumption: Modern and International Design for the Masses". The objective of this variant of the exercise was to identify the designed and designable quality of the world, through a nonlinear perspective of history that would allow students to conceive of a possibility proposal, beyond the seeming inevitability brought by dominant technologies (Evans, 2018). Situated within a pre-Fordist period (limited between 1875 and 1905), students had to speculate about lost futures as alternatives to Fordism (see figure 4). The group dynamic started with a brief theoretical contextualization of the hauntological perspective, to then present some results from the previous versions of the exercise. To a concurred lecture class, students were given the following coordinates:

Analyzing the political, economic, technological, social, cultural, etc. conditions that allowed Fordism to become a possible future (which ultimately prevailed as a real and dominant production model), you are asked to imagine other futures for means of transportation and locomotion, alternative to Fordism, that, based on the same original conditions, could have been imagined as other possible futures for society at the time. The scenarios imagined by each group must be presented through an image that contains representative elements of the context.
The central piece of the image should be a technical object/artifact related to the means of transportation and locomotion that would characterize the alternative future as clearly as possible.

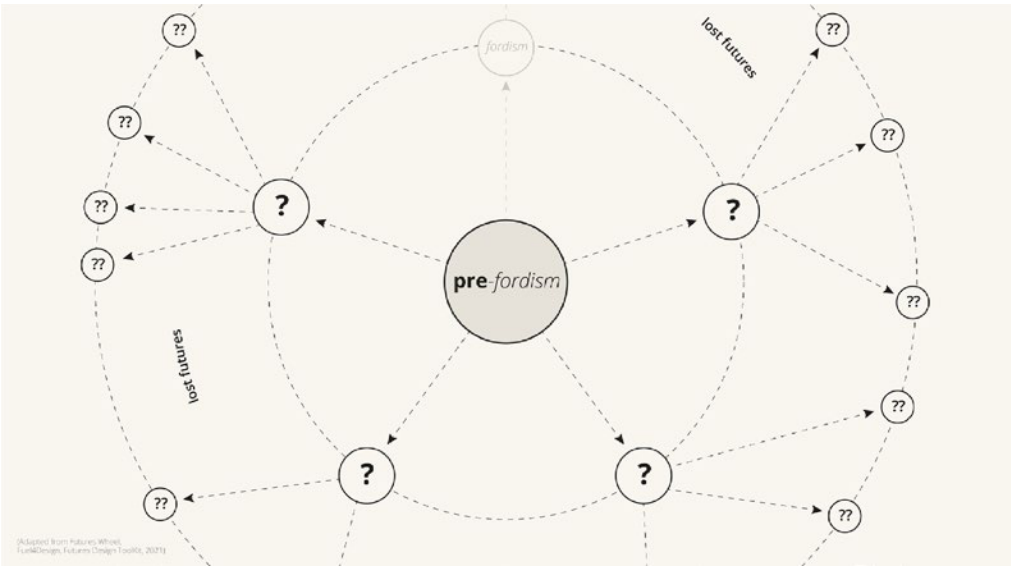

Figure 4. Diagram adapted by the authors from Fuel4Design's Futures Wheel, Futures Design ToolKit, 2021.
It represents the different possible trajectories that were in dispute in a pre-Fordist period.

For this, we asked each group to describe the scenario of that lost future and to identify a concrete situation that could represent the imagined context. After, they would digitally design the means of transportation and situate the technical object or artifact. The deliverable for this exercise comprised three parts:

1. A brief prompt of about 200 words, written for an image-generating artificial intelligence;
2. A generated image based on the prompt that represents the described scene, and;
3. A reflection text about the technical object and its context, without using artificial intelligence.

To illustrate the results, we present two examples. Firstly, the Hedósfera, which foments hedonism and "making yourself visible" through a translucid spherical means of transportation which is mobilized through rails (see figure 5). Its energetic matrix is electricity-based (no fossil fuels) and its main constructive material is tempered glass, plus metals in a lesser proportion. The artifact promotes sociability and routes that are predetermined by the railway system, which grants a relaxed travel experience and a 360-degree view. Instead of an accelerated and purely functionalist and linear movement, this lost future introduces the possibility of greater wellbeing and a deviation from a univocal concept of progress.

Figure 5. Image created with artificial intelligence by one of the highlighted groups. It visualizes the Hedósfera, an alternative means of transport to the automobile from a lost past alternative to Fordism.

Secondly, another proposal was ComuniCicleta (see figure 6), a collective bicycle structure. It is created using rather artisanal or semi-industrial manufacturing, tailor-made to the needs of each community, with varying styles, shapes, and colors.
For this means of transportation not all passengers would have to make a physical exertion, which would benefit senior citizens, children, and people with reduced mobility.

In this lost future the community drives progress. Solidarity is constantly articulated and inclusive, making it not only a means of transportation but also of human connection. Both examples speculate about different global perspectives (other horizons) by making design decisions when ideating means of transportation which reflects certain social expectations in the proposed scenario.

Figure 6. Image created with artificial intelligence by another of the highlighted groups. It visualizes the ComuniCicleta, another alternative means of transport to the automobile from a lost past alternative to Fordism.

7. Final Premises: On Hauntology and Artificial Intelligence

When developing this ongoing project, the (we could say spectral) apparitions that artificial intelligence has procured in other works with similar perspectives in the field of the arts (Felipe Rivas San Martín, Refik Anadol or Liliana Farber, previously mentioned), have caught our attention. While the decision of integrating these technologies can seem random, to our judgement, it is an attractive opportunity to explore scenarios and imaginaries with a certain degree of verisimilitude. This has been favorable to generate a feedback dynamic in the speculative use of artificial intelligence with Design students—not only through fast iterations to achieve a Design proposal, but also to discuss the fundamental Design categories of future scenarios: ranges of possibility, plausibility, and probability. However, we are aware that the latter results in more questions and controversies regarding the scope of this investigation.

To close, we identified some crossovers between the present proposal and critical studies on artificial intelligence, to sketch eventual frictions. Nick Couldry & Ulises Mejías (2023) have warned about the colonial-capitalist pre-configuration of future imaginaries. A "snatching" of the future by big corporations of technological irradiation, would have been possible, according to the authors, thanks to the implementation of a historical construction that is assumed as inevitable. In this sense, the increasing datafication and digitalization of the world has transformed practically everything that is social, seizing to be a space of dialogue and democratic debate, to become a "specter of propension and probability" (p. 290).

To our judgement, future investigations with hauntological speculation using artificial intelligence should consider an interrogation of the hegemonic and reproductive tendencies in present conditions, which are inscribed in the models of said artificial intelligence (Sartori & Theodorou, 2022; Suchman, 2023). Beyond forthright rejection, we consider that the application of artificial intelligence in the project-based method interrogates these technologies and emergent narratives (Ferguson, 1999) that explain problems in their origin, diffusion, assimilation, and use. For this reason, this reappropriation of Speculative Design (Prado & Oliveira, 2015), through the hauntological perspective, offers a tool to make the controversies related to these often "frozen" technologies (Dandurand, McKelvey, & Roberge, 2023) visible.

To this point, Fredrich Von Borries (2019) takes the two possibilities that social psychologist Harald Welzer brings up to escape the crisis: by disaster or by design. The first alludes to waiting until the system collapses before rebuilding over its ruins, while the second intends to "transform the existing into something new up-front, preventatively, through action that is oriented towards goals and planification" (p. 97).

It would then seem that, rather than expecting the world to collapse, for Design, it already has. Therefore, "designing" has to do with "how to live among the rubble" (Latour, 2016, p. 10). However, design also has to do with projecting, hence, with the possible, as well as having our gaze oriented toward the future, to avoid the paralyzing effect of a crisis of the future. This naturalization, partly ideological, needs to be addressed through a critical notion of what we understand for "crisis" (Mesa Moreno, 2011); otherwise, Design's practice and thinking risks being not as much projective than it is submissive (Von Borries, 2019), defuturising (Fry, 2009) or a mere ideological reproducer. Absences, specters or unimagined or interrupted designs reveal not only the designed and redesignable nature of the world, but also serve as a source of inspiration for the future, enlivening the utopic glimmers of pasts that deserve to be recovered (Žižek, 2004). Hauntological thought does not imply a literal return to the past, but rather, as Slavoj Žižek (2004) argues, a return to the field of possibilities that these pasts inaugurated. Therefore, it is not about replicating what has been done, it is about exploring what remained undefined; that is to say, an encounter with lost opportunities, beyond present ideological restrictions: hence Design's relationship with the new.

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DEPICTIONS OF SUSTAINABILITY AND UNSUSTAINABILITY: AI-GENERATED IMAGES AS PART OF OUR SEMIOSPHERE

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1. Introduction

Evidence shows that humans have been creating images for more than 50,000 years (Oktaviana et al., 2024), since that period, some of the major technological breakthroughs have been writing on clay, the development of paper, the creation of the printing press, photography, video, televisions, broadcasting, computers, the internet, mobile devices with screens, augmented reality (AR), virtual reality (VR), all up to images and video created by generative AI. Considering the previous statement, it can be argued that humanity has moved on from a spoken culture in which communication among communities relied mainly on verbal language, going through a stage that mainly used written forms for communicating and storing information. In this sense, humanity is now in a state that has been described as an image-saturated society (Jhally, 1990), a stage in which images are one of the main forms for communicating information, creating meaning, and seeking pleasure (Mirzoeff, 1998) thus, we are now part of a visual culture.

As part of our current global visual culture, images can be considered as texts that disseminate the meanings that hold the system together. In this sense, as Peter Torop states: "Lotman´s perspective enables one to combine the treatment of text as culture and the treatment of culture as text, which at the same time means a possibility to consider these simultaneously as wholes at different levels of the same system" (Lotman, 2009, forward by Torop, p. xxix). It can be argued that most of the media through which images are portrayed rely on advertising, for example, social media, news, search engines, and more recently streaming platforms, so many of the images can be considered advertisements. The meanings they convey are related to consumption. Thus, key characteristics of our current global culture are the visual (Mirzoeff, 1998; Mitchell, 2002; Sturken & Cartwright, 2018) and hyperconsumption (Bauman, 2007; Lipovetsky, 2007). In this cultural context, and from a semiotics of culture standpoint, AI-generated images can be considered texts that are now part of the global semiospehere.

It can be argued that the data collected and used to train AI can be considered as part of the nucleus of this global semioesphere and so the texts that it generates reaffirm itself. In the words of Massimo Leone: "The advent of sophisticated algorithms has ushered in an era where visual representations are not just mere reflections of reality but are charged with the power to influence, persuade, and even dictate societal norms and values" (Leone, 2024, p.2). As part of a larger study that takes into account the role of AI-generated images as part of the semiosphere a starting point of six images is considered. Based on the previous, this research uses a visual semiotic method to explore the meanings conveyed by AI-generated images when using prompts related to sustainability and unsustainability.

2. Generative AI and its impact on the biosphere and semiosphere

Intelligence is the ability to learn and put into practice what has been learned, thus Lavista Ferres and Weeks state: "Artificial intelligence is intelligence-the ability to learn and apply knowledge-that is conducted by machines" (Lavista Ferres & Weeks, 2024, p.5), they go on to clarify that the expression artificial intelligence was coined in the 1950s, but that machine learning is the specific term that exemplifies how algorithms are trained on data to create rules that can be put to practical means. Since this intelligence is based on the data with which it was trained, it is important to consider the quality of the information and the biases that it may possess.

Once an algorithm has been trained on data and created its own rules, it is considered a model that can interpret language and also generate it, hence the term, generative AI. The language generative AI can interpret varies from text, image, audio, video, and code, using this input, specifically in the visual domain it can generate video, 3D models, design, and images (Nvidia, 2024). This state of development of AI is possible due to the amount of computing power and data collection, requiring large quantities of energy.

Much has been written on how AI can contribute to achieving a more sustainable future, but it is also important to address the sustainability of AI. For van Wynsberghe, sustainable AI is: "focused on sustainable data sources, power supplies, and infrastructures as a way of measuring and reducing the carbon footprint from training and/or tuning an algorithm" (van Wynsberghe, 2021, p.214). The International Energy Agency (IEA, 2024) estimates that data centers, AI, and cryptocurrency could consume as much energy as the entire country of Japan by 2026. The report states that in 2023 NVIDIA with 95% of the AI server market share consumed an average of 7.3 TWh of electricity annually and could consume 10 times more by 2026. This amount of energy consumption has caused Google to increase its emissions by 48% since 2019 (Brandt & Gomes, 2024) and Microsoft by 29% since 2020 (Microsoft, 2024), so far from reducing their CO2 emissions and meeting their sustainability goals, these bring into question the sustainability of AI technology and its impact on the

environment, and therefore the biosphere. Taking this into account it is clear that AI impacts the environment. Still, to further explore the role that AI images can have in our everyday lives, it is useful to consider Juri Lotman´s theory that represents culture as a series of spheres. Hartley and colleagues identify 6 spheres to describe a complex system at a planetary level, starting with the geosphere, followed by the biosphere, noosphere, semiosphere, technosphere, and finally the futuresphere (Hartley et al., 2021). This work will focus on the semiosphere as the sphere where meaning is created, and culture resides.

For Lotman (1996) the semiotic space or semiosphere is not homogeneous and can have several sub frontiers within itself, mainly the center and its periphery. In the center one can find the dominant structures that give order and coherence to the semiosphere, it is mostly concerned with itself and reaffirming the texts created by its nucleus, putting almost no attention into deciphering external texts. In contrast, the periphery is laxer and more fragmented, thus interpreting the signs with less rigor, and when in contact with other semiospheres it looks forward to interpreting those foreign texts. Lotman goes on to explain that with every translation a new text is created, new information is developed and points out that there can be no exact translations between semiospheres, causing culture to be in a flux of constant change and never static. Without a semiosphere, language would not only not work, but it would not exist, and without language, there can be no culture. In similar terms, (Eco, 1986) goes on to state that the life of signs conforms to a fragile infrastructure that nonetheless influences all of our behavior.

As stated previously, one of the key characteristics of the current global culture is the use of images as a means of communication and the role they play in shaping and maintaining a semiosphere. Sturken and Cartwright (2018) consider photography, drawings, television, and digital media as representation systems that function similarly to language, and for that reason, semiotic and linguistic methods can be used to study them.

3. Method

Taking into account the foundations of the semiotic method, the founding fathers describe it as the life of signs in society in which a sign is divided into signifier, the sign in itself, and signified, the meaning it conveys. Pierce (1931) considers a sign as something used to represent something else, but further divides signs into three categories icon, index, and symbol. An Icon draws its significance by representing the main characteristics of an object, in this sense a road sign of a gas pump indicates that there is a gas pump; in contrast, an index is considered a sign that obtains its meaning in relationship to its proximity to what it represents, for example, a road sign with a fork and knife represents a restaurant. Finally, a symbol conveys its meaning due to cultural relations, for example, a solid yellow

line in the middle of the road indicates that cars on the other side of the line drive in the opposite direction, one must know the meaning attributed to the sign to understand it correctly.

Semiotics has been traditionally implemented in language and discourse analysis but since the use of images to convey information and meanings has become so prevalent, semiotic methods have been developed in order to study them. At the end of the 1960´s Roland Barthes was one of the first authors to create these methods, and since then many have been developed. Visual social semiotics (Kress & van Leeuwen, 2006) explore visual signs to decode the meanings present in the images through three meta-functions. The ideational meta-function allows the description of how the signs relate to each other. The interpersonal meta-function identifies how the sender interacts with the receiver through the images. Finally, the textual meta-function refers to how visual signs obtain their meaning based on their location and dimension within the composition. Next, the three meta-functions will be briefly described.

The ideational meta-function takes into account the represented participants, which can be objects or persons, and establishes if the composition is narrative or conceptual. A narrative composition is one in which a person or object has vectors emerging from it, in order to have contact with another person or object. Arrows, arms or fingers are examples of vectors, and the person or object from which the vectors emerge is considered de actor, and the person or object with whom the vectors have contact is named the goal. Thus, an ideational met-function with a narrative composition analyses the actor's characteristics in contrast to the goal. On the other hand, when a composition has no vectors, and therefore there is no interaction between the represented participants, it is considered a conceptual representation.

The interpersonal meta-function considers how the sender interacts with the viewer through camera shots and angles. The shot used to represent a person or object has a specific meaning and the viewer should decode it similarly. For each shot, Kress and van Leeuwen (2006) establish a personal, social, or public distance. The viewer also interprets an image based on established codes by the use of the camera angle. A high angle positions the viewer in a position of higher power to what is being represented, in contrast to a low angle which positions the viewer in a place of less power. Taking the previous into account, the use of a horizontal angle to portray a person or object establishes an equal level of power between the sender and viewer.

Finally, the textual meta-function explores the location, size and color of the different elements that make up the composition. Generally, the bottom part of the composition is associated with to earth, while the top part of the composition is considered as an ideal state. In a similar way, whatever is placed on the left side is interpreted as given information, and on the right part what can

be considered as new. Size and color are also important visual cues that highlight important aspects of the composition.

These three meta-functions facilitate a structured method for exploring the meanings coded in an image and also take into account common ways in which most people decode them. The images that make up the corpus of study were created with Stable Diffusion and MetaAI using the prompts related to sustainability, and unsustainability. A total of 6 images were generated by using the prompts unsustainable, unsustainable community, unsustainable city, sustainable, sustainable community, and sustainable city. Only the first image generated by each prompt was considered.

4. Results

This section explores the meanings conveyed by the six AI-generated images concerning unsustainability and sustainability, by implementing a visual semiotic analysis that relies on the three meta-functions previously described.

The first (Figure 1) of the six images was generated using Stable Diffusion by typing the prompt Unsustainable. Considering the ideational meta-function, this image can be identified as conceptual since it has no visual elements that look like vectors. The objects portrayed in the image represent decay and look like old car parts in a junkyard. Due to the distance from which the shot is taken, the interpersonal meta-function places the viewer at a far social distance, at a horizontal angle, and what seems a high modality because of the level of detail and texture in the image. This meta-function establishes that the viewer can be part of the image, with an equal level of power in relationship to what is being depicted as real. Finally, the textual met-function establishes no visual hierarchy within the image, there is nothing more important than the rest.

Figure 1. Unsustainability

The second image (Figure 2) was created using Stable Diffusion with the prompt unsustainable community. Using the ideational meta-function, it can be established that this is also a conceptual image in which each house represents poverty and low-income housing. Now, the interpersonal meta-function positions the viewer at a public distance and at a top-down angle, since this image also resembles the quality of a photograph it has high modality. In this case, the viewer is further away and has greater power in relation to what is being represented. The textual meta-function establishes that there is no visual hierarchy, no element is more important than the other.

Figure 2. Unsustainable community

Finally, the third prompt (Figure 3) related to unsustainability was an unsustainable city (Figure 3) it was generated using Meta AI on WhatsApp. Like the previous image, it is also a conceptual image in which each building represents decay. Most of the buildings look old, mostly unpainted, and with little or no maintenance, the plants growing on the roofs of the buildings seem like shrubs and weeds that are mostly unattended. Similar to the previous image, the interpersonal meta-function establishes that the viewer is at a public distance and with greater power over the city. In this case, the image generated with Meta AI has a more 3d feel to it and does not look as real as the images generated with Stable Diffusion. This not-so-real setting is considered a lower-level modality. As in the other two images, the textual meta-function allows to identify that there is no visual hierarchy.

Figure 3. Unsustainable City

Now, using the prompt Sustainable in Stable diffusion (Figure 4), like the other four images already studied, this is a conceptual image, there is no action occurring, so the ideational meta-function considers that a bird is used to represent nature. In contrast with the other images, the interpersonal meta-function identifies that it is a close personal distance, at a horizontal angle with a very high level of modality in which even the texture of the feathers can be appreciated, and a bokeh effect is simulated as if using a wide aperture. Thus, the meaning of this image can be interpreted as one in which the viewer can be very close to nature at an equal level of power. Finally, the textual meta-function establishes a strong visual hierarchy since there is only one element within the composition.

Figure 4. Sustainable

The fifth image (Figure 5) was created in Stable Diffusion using the prompt sustainable community, since this is an image in which there are arms, these are considered vectors and represent a narrative image in which the people are actors and the plants are the goal.

This image can be considered to portray a group of mostly women, working or having a walk among fruits or vegetables that they are growing. It is important to consider that this is the only narrative image that is part of the corpus. The study of the ideational meta-function in this image establishes that the viewer is at a far social distance at an equal power, within the context of a high mode of reality, this can be interpreted that the viewer is part of this community and is taking part in the activity being conducted. Exploring the textual metafunction it is possible to consider the person in blue in the middle as the main focal point, although this is not clear, and in that sense, it is not of great importance.

Figure 5. Sustainable community

The last image (Figure 6) was created in Meta AI using the prompt sustainable city and is very similar to the other image generated with the same app. This is a conceptual image used to represent what can be considered a green and sustainable city. This image also has plants on the rooftops but in this case, they look greener, and they have intentionally been grown there. It is interesting to consider how similar aspects of an image, as in this case plants growing on rooftops can be

interpreted with opposing meanings mainly due to color and other visual cues that make up the composition. Also similar to the image generated with the prompt unsustainable city, the interpersonal meta-function positions the viewer at a public distance with much more power, but a lower level of reality. Since this image was generated with Meta AI it is possible to establish that the default settings of this AI generate images with a lower mode of reality in contrast to Stable Diffusion, they have a more 3d render feel to them, while the images generated with Stable Diffusion emulate as if they are photographs.

Figure 6. Sustainable city

By conducting a visual semiotic analysis using the three meta-functions developed by Gunther Kress and Theo van Leeuwen (2006), it was possible to determine that sustainability is mainly depicted by the prevalence of plants, animals, and nature, while unsustainability is mostly represented by decayed buildings, low-income housing, and a junkyard. The ideational and interpersonal meta-functions provide a more in-depth analysis of what is portrayed in these six images generated with Stable Diffusion and Meta AI.

The study of these six images by using the ideational meta function allowed to identify that five of the six images are identified as conceptual images in which what is portrayed represents unsustainable or sustainable. It is interesting to point out that only Figure 5 is considered an image with a narrative structure in which the people sustainably interact with nature. Figures 1, 2, and 3 can be considered what Pierce (1931) called indexes, they show the consequences of unsustainability but they don´t show what causes it, a more appropriate result would be an iconic image, in which the viewer is presented with a representation of what can be considered to cause unsustainability. Also, Figures 2 and 3, resemble low-income housing, which can be considered social and economic unsustainability, but at the same time, these living conditions do not cause environmental unsustainability, posing further questions concerning the bias that relates poverty to environmental unsustainability.

In general, the interpersonal meta-functions allow to identify that the viewer is placed much closer to the compositions related to sustainability, in contrast to further away from those that represent unsustainable. Specifically, Figures 4 and 5 related to sustainability depict a personal distance and

a far social distance, while Figure 1 represents a far social distance while Figures 2 and 3 position the viewer further away at a public distance. The previous can be interpreted that the viewers are closer to sustainability and further away from unsustainability. The United Nations report (2022) at the Stockholm Summit states that humanity is becoming increasingly unsustainable due to humanity's environmental footprint. Considering this last statement, it would be more accurate if the AI-generated images placed the viewer at a more personal or social distance when using prompts related to unsustainability and further away from those related to sustainability. It would be more accurate for the images that represent unsustainable community and unsustainable city to place the viewer at a personal distance or social distance but not at a public distance as seen in Figures 2 and 3. Overall, the interpersonal meta-function distances the viewer from an unsustainable community and city but is very close to nature and feels like part of a sustainable community.

The textual meta-function is the last studied, it is important to point out that none of the six images that were analyzed used it as a compositional tool to convey specific meanings. It is somewhat common for conceptual images to also use hierarchy, color, and the positioning of visual elements to communicate specific meanings. It would be interesting to further study other AI-generated images to see if the textual meta-function is also lacking meaning and how it is being used.

In conclusion, the images generated by AI can be considered part of ongoing dialogue on the topics of sustainability and unsustainability, in this sense, the visual semiotic analysis has identified that the meanings portrayed in the AI-generated images contribute to keeping unclear the causes of unsustainability and position the viewer further away from an unsustainable community and city.

5. Discussion

This study mainly explores the meanings portrayed by AI-generated images related to sustainability and unsustainability but also has the purpose of further questioning how images generated by AI impact the semiosphere. Considering a complex system in which AI technology, specifically that required to generate images, is already having an impact on the biosphere, studying the impact of these images on the semiosphere would help to understand the role that generative AI is having in the development of culture since the current exposure to AI-generated images is ever-growing and it is even considered that by 2025 most of the internet content will be AI-generated (Constantino, 2024). Since images are the most common and extensive sign system through which meanings are disseminated along what can be considered a global semiosphere and taking into account that algorithms shape not just digital but also social realities (Leone, 2024) it is of vital importance to study the role of images generated by algorithms in the development

of human culture. Further research for a much larger data set by using content analysis from a quantitative studies standpoint should contribute to supporting or opposing the findings obtained by this study.

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REASSEMBLING RESILIENCE IN BREAKDOWN: HOW MEXICO CITY RECOVERED FOOD SECURITY THROUGH MICRO-INNOVATIONS DURING THE COVID-19 PANDEMIC.

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ABSTRACT | Mexico City is Latin America's and North America's most extensive urban system. Feeding this population efficiently and promptly is an enormous and complex challenge. Food supply logistics is one of the least understood aspects of food systems. Mexico City has the most extensive food wholesale market in the Western Hemisphere. The Central de Abasto opened in 1982 when the Mexican government was promoting the values and benefits of modernity across the country. A new infrastructure for food logistics in the capital was a priority, as the long-standing city food market was inadequate. For forty years, the Central de Abasto continued to grow and serve the city and central Mexican region. In 2020, the Covid-19 pandemic wreaked havoc on many labor-intensive facilities like Central. The shock of both the disease and distancing and mitigation measures surfaced patterns of institutional abandonment for 40 years – while the facility faced a simultaneous shock in supply and demand. Many bodegas (shops) closed as many owners died, and those that remained open had to lay off many of their employees to cut costs. This article explores how bodegas (shops) created survival strategies, gradually creating greater economic resilience after the pandemic. The crisis accelerated trends that already existed, but incipiently: from digitalization for sale to generational change to increasing the use of technology to seek to offer merchandise with more value. The Central de Abasto is an ensemble that is adapting to rapid change. The pandemic was just the catalyst, but it remains to be seen what the possible futures will be for Central and Mexico City's food system.

KEYWORDS | MEXICO CITY, COMPLEXITY, ASSEMBLAGES, MODERNITY, COVID-19, RESILIENCY.

1. Introduction

When a new visitor arrives at la Central de Abasto – the vast wholesale food market of Mexico City – they may experience chaos. Constant movement, shouting, fast-moving carts pushed by thousands of men, attending to thousands of customers shopping thousands of food stocks for schools, restaurants, hotels, and supermarkets. However, the perception of chaos is deceiving – the Central is a highly functioning complex system with intelligent, decentralized coordination. The Central de Abasto demonstrates the features of a complex, self-organizing system. It has been operating since 1982 in very challenging situations. Economic crises, earthquakes, and political changes have shocked Mexico's capital, along with the increasing presence of organized crime and different cycles of government corruption. However, nothing has prepared la Central for the 2020 pandemic. We explain how la Central adapted to this impact and how it may endure the ones that come in the future. Modernity has been a worldwide project of the dominance of rationality, moving societies into organized administrative structures and increasing order. It was primarily instigated by Western values of scientific control and progress through economic growth. Transmodernity philosopher Dussel (2008) shows that the "myth" of modernity is based on the idea of a European superiority held over other cultures and ways of being, originating from Spanish Occidentalism 500 years ago. Centralized food markets serving millions of people in a growing megacity can represent an epitome of Western modernism – an industrialized process of thousands of food providers and buyers operating within an enormous dedicated facility. However, the Mexico City market operates successfully as a uniquely Latin system, and our observations suggest that it does not follow the rational controls of modernist managerialism. Dussel's notion of trans modernity lends the insight that authentic cultural practices can build upon the "positive moments of Modernity" (Dussel, 2012, p. 43) toward a pluriversal, noncolonized social structure. These insights support the position that design interventions in such systems must account for the cultural ecosystem and paradoxical effectiveness of chaotic, localized practices.

This study observes whole system resilience facilitated by adaptations and interactions of the agency of its thousands of human parts. By April 2020, the COVID-19 pandemic spread its presence in Mexico City. The contagion seriously affected people in the bodegas (shops) at la Central de Abasto (CEDA), and many could not continue to work. The sales from daily operations declined by around 75 percent, creating a significant risk of collapse (Vela, 2020). A collapse of La Central would be uniquely devastating to the Mexican food supply because of its centrality to the state and its massive scale of operation, providing up to 80% of all food in the central Mexican valley.The design of the Mexican CEDA facility was adapted from the French wholesale system, the Rungis food market (Thiesset & Vlachos, 2022). Rungis, second in size only to CEDA, was also seriously affected by the pandemic. Mexico and France are highly organized around their capitals, so the food supply is centrally controlled from large terminals. Nevertheless, the operation of CEDA is very different from that of Rungis. US and European food supply centers are much more centralized by the administration. However, they then have potentially single points of failure due to the central decision-making, not the web of relations inherent in the CEDA system. The political economy of modern Mexican society changes many expected technological and urban parameters (Gallo, 2005). Mexico City is modern, but its food logistics must be digitized or technocratic. An underlying paradox becomes apparent, with the food logistics of a modern capital being tightly interconnected to Mexican politics (and crime).

1.1. Research motivation and hypothesis

The pandemic inflicted a simultaneous double shock in the food economic ecosystem at la Central – A demand and resource supply shock. The evidence from interviews shows that the pandemic management was weakly coordinated, supporting the rationale for the disappearance of probably hundreds of bodega workers – yet there is no official record of deaths. At the beginning of the pandemic, the CEDA administration decided to order people over 60 years old not to work. This prevention measure likely saved many lives, yet nevertheless, many died, even young men. Walking the aisles of la Central for two years, there was not a single bodega of roughly 2500 where nobody got sick from Covid-19. Many carretilleros (the dolly operators carrying the merchandise) disproportionately suffered, possibly because they circulated throughout all the aisles and had little ventilation.We suggest the hypothesis that the assemblage facilitating la Central management during the pandemic was like a double-edged sword. It was excruciating at the human level but also transforming for business. The story of Central de Abasto's siege and recovery during the pandemic shows the naturalistic social complexity inherent in massively decentralized self-organizing structures driven by social capital. The resilience and recovery

we observed show that people can and will adapt to the most extreme circumstances if they can sustain complex operations despite massive risks without ever observing how well the whole system was operating.

Methodology

Ethnographic field research was conducted from April 2020 through May 2022 at la Central de Abasto, periodically visiting over two years. Over 50 recorded interviews were conducted with different actors, from small bodegas owners to employees of major vendors, informal vendors, and government administrators. Digital ethnography included online and photographic journals. Bodegas were selected for observation for two distinct rationales: a) those with younger operators because it is difficult to interview owners (who fear discussing business with strangers for security reasons), and it was easier to interview sons and employees. This led to opportunistic sampling of others in (CEDA; b) Random, opportunistic availability and personal chemistry helped to facilitate conversations with different people. To conclude the data collection, a follow-up was held with five bodegas of various sizes, also extending the observation period and allowing observation of the changes in business in la Central over the period.

Data was analyzed by transcribing and recording interviews and conversations to examine for thematic analysis and indicative responses pertinent to the emerging study hypothesis. Both etic (responses to direct questions of interest) and emic (emergent and volunteered responses) were coded for the emerging theory. The theoretical perspective of the assemblage (DeLanda, 2006) was adopted as a highly pertinent explanation of the observations consistent with the study's hypothesis. The criteria of relationality, productivity, heterogeneity, desirability demand, and de/territorialization are evidenced across observations.
However, the study also covered a period of acknowledged crisis and organized responses to the unexpected, total changes to the work environment and the food industry. Latour's (2007) actor-network theory, consistent with assemblage theory, was helpful in the analysis of both the micro-organizations and relations of the bodegas in the cosmos of la Central, but especially in making sense of the many appropriations of technology, of the changes in products and materials, of prices and configurations as network relationships, and of power and familial networks within the contained work environment. In this paper, the analysis presents the crisis and the multi-network assemblage response to the massive changes imposed on the workplace and industry. These assemblages are always flexible and create different territories that have different temporalities. Distinct practices and languages codify these territories with their own pace or intensities. (DeLanda, 2006)

1. Findings

We present a series of field observations and analyses from the data, starting with ethnographic observations from a first-person narrative from the field study. The observations are followed by sociological analyses that describe resilient responses to the emergency situation, drawing on analysis of social capital (individual unit of analysis) and self-organizing of the whole system (organizational unit). The workers frequently said that la Central de Abasto (CEDA) was a city inside the city. Until I began to walk its aisles, it was impossible to conceive of its monstrous size. Kilometers of bodegas, shops that sell every kind of food commodity, from Mexican chiles to grapes from Chile to cinnamon from Sri Lanka, fill all the aisles. La Central revealed many paradoxes. We observed the crushing (and sometimes painful) weight of materiality, time, speed, order, and bureaucracy, as well as the leaks and escapes of humanity, even joys. In the end, in this sea of uncertainty, people balance daily between the brutal weight of material reality and the human (and non-human) capacities to persist. The distance between business success and tragedy was often very close. Moreover, there is no time for tragedy at CEDA. From an anthropological perspective, the show, the business, must continue (Hoffman et al., 2002).

We analyze two forces intertwined in the CEDA: the temporal and spatial. Time is an actant, vital, and invisible character in the investigation, and it is becoming increasingly present. Matter, space, and time have agency that becomes articulated in the assemblage. Several actors or characters in this research are non-human, including the building and facilities of la Central. The question arises about how we might "talk" with non-human actors. The assemblage methodology follows all the actors, even the non-human. Their actions create territories, which have their communication or language. If these territories persist, they can be observed in the general assemblage but may also be ephemeral. Talking with many bodegueros (shop owners) at la Central, I learned they are flexible with their relationships with the administration appointed by the government of Mexico City and have changed political parties several times in over 40 years. As political alliances change, the allegiance of organized crime also changes, pertinent to the connectivity of governance (Brondizio et al., 2009). Governance is also an assemblage with challenges "caused by the increasing connectivity of resource-use systems and the growing functional interdependencies of ecological and social systems" (2009, p. 253). The pandemic stretched that equation even more. Samuel (September 2021) has had lifelong experience as the son of one of the significant staples dynasties, whose family's staples bodega was at the downtown market of La Merced before arriving at CEDA in 1982. However, he had never seen such a sudden change as what happened.

"Yes, freight is costly. Boarding times are much slower, at least at the outlet. Before, it could take a month from Asia and two by boat. The shipments arrive in Manzanillo, Lázaro Cárdenas, and Veracruz, and the cost is four times higher.... My clients are people who sell to the industry. Some people prepare products for sale in restaurants, supermarkets, etc. Furthermore, they also buy from other supply centers in Mexico. Moreover, with the increase in prices, their purchasing tendencies have changed. There are products that they used to buy, and now they do not buy, and now they buy others that are cheaper, the basics, which are what have sold the most: beans, rice, lentils, chickpeas..."

Their customers buy only the basics because people sought necessities during the pandemic, not luxuries. Uncertainty dominated all decisions. Samuel is young, in his early 30s, and the heir to a generations-old family business, but now carries an enormous responsibility: to sustain that legacy successfully. He thinks carefully about his answers. He speaks slowly, but he is worried. His bodega, although successful with generations of experience, has never experienced anything like a simultaneous halt in supply and demand and only a trickle of activity. Orensanz (2022, p. 128) reported that the pandemic produced food shortages at la Central, but our in situ research never showed a shortage. The real problem was not supply but demand, yet the outcome appears the same. Commodity stocks were ready to be sold, but the buyers disappeared.

We cannot know what could happen if la Central closed because of the pandemic crisis, but Mexico City would certainly not starve. Wal-Mart is the dominant supermarket player in the country and has developed a robust supply chain connected to the US because of NAFTA. In every district of Mexico City, poor or rich, there are distinct types of Wal-Mart stores that could absorb much of the demand (Echeverría, 2024). After the US Civil War, a new economic institution was created to organize commodities trading, the futures market. In Chicago, it began with the wheat trade (CBOT), as Cronon (1994) notes, while in the South, the New Orleans Cotton Exchange (NOCE) was created. This matters today at the beginning of the 21st century for an important reason. The financial and technological infrastructure designed at the end of the 19th century created a lock-in phenomenon that persists, as David Pinzur (2021) describes, and these definitions of infrastructure produced ontological differences typical of the commodity market. Both markets had differences in infrastructure, but both agreed on something that persists to this day: commodities must be homogeneous to be marketed, and that is achieved with quality grading systems. Today, such grading can be seen at CEDA in the same boxes where the products are transported. Generally, the sizes differ in caliber. All this order was to control speculation as much as possible, but this was and continues to be a permanent element of the ontology of commodity markets.

Despite this, the intelligence of the market's assemblage is generally more significant than the speculators' perception. According to three young brothers (garlic sellers, who remain anonymous), an insightful account of the working experience of la Central, with a fragment of the exchange, is as follows.

I said to them that many older bodegueros wanted to refrain from talking. One of them, whom I will call José, told me:

"My brother was going to tell you to fuck off, but when you told him that you were an anthropologist, he changed his mind. However, for many people, even if you show them the university's credentials, they will not give you anything. Why? One, it is for security. The other reason is that many practices they use and will continue to use are illegal. Dumping is prohibited, but it is widely practiced here."

As I learned, the price is such a malleable actant at la Central that it may be considered fiction. The price is never fixed; it can always be negotiable, but it significantly contributes to one's agency in the assemblage. The numbers we see at the bodegas were primarily for government compliance. The price represents a field of power, a trading space to introduce or resolve conflict. The research has shown that in la Central, at least the big players play the price game.

1.1 Social Capital and Resilience

We make the case that the resilience of the succeeding bodegas resulted from the social capital of their owners and workers. Brondizio, Ostrom, and Young (2009) define the connectivity role of social capital as "the value of trust generated by social networks to facilitate individual and group cooperation on shared interests and the organization of social institutions at different scales" (p. 255). The general lack of social capital at la Central is not homogeneous, but it is not surprising either. Some studies have shown that Mexicans have deep trust problems. In 2010, the public opinion research agencies GAUS SC and LEXIA extensively studied Mexicans' aspirations, values, and dreams. In that study, the Mexican persona appeared surprisingly clear as an individualistic character concerned only with himself and his family. In November 2022, the study was repeated, and the results were similar. We see a citizen very poorly connected with other citizens – and even less with institutions.

Cruz-Torres and del Campo Ríos (2021) affirm that social capital moderated between uncertainty and cooperation during the pandemic. Their study analyzed whether Mexicans would tend to reduce their willingness to cooperate with others during the pandemic or not. In a confidential online survey, they evaluated willingness

to cooperate. The results indicated "that higher levels of uncertainty stemming from the COVID-19 sanitary contingency are associated with a greater disposition to harmful community effects, such as a lack of cooperation and a tendency to mistrust neighbors" (2021, p. 1055). Indeed, the concern for contagion, on top of the pre-existing suspicion accompanying high levels of competition, might have affected health and recovery in the vast CEDA facility.

Nevertheless, in a very Mexican paradox, the results support that social capital can protect against systemic distrust, but this "moderation effect" is not general. For instance, people who perceive their communities as high in social capital "suffer less uncertainty in the face of the pandemic." This was not the case at la Central de Abasto. We observed fear to be widespread everywhere during 2020 and 2021, especially in the first months of the crisis. In every bodega, small and big, there were sick people, and some closed because their owners died.

Even in this bleak moment, resiliency endured. Many got sick, but many recovered, and they needed to innovate so their business could survive this crisis. La Central's old business model was once centered on the family. However, the pandemic just accelerated underlying changes that were already beginning. The generational change was difficult because, even being older, the parents wanted to work to feel independent, and as some told me, they loved being in their bodegas more than in their homes. As a family business, the bodega was the center of social cohesion and the source of social capital of la Central for forty years. However, then the pandemic arrived.

A conversation with Israel (July 2021), an employee seller at a medium-size bodega, revealed how things changed with the crisis:

"These last two years, the Central has changed significantly; we have seen a tremendous change due to the digital issue. There are already many people doing home deliveries this way. They buy from us. They are clients who had food service but were diversified, and since they had nothing to do, they started that. Of my sales, food service is about 60-70%. They hardly pay attention to quality; what they want is price. However, if the product is very scarce, they do not care how much it is worth. Little by little, sales are recovering, but it will take time to return to 2019 levels."

Israel explained how the pandemic impacted business.

"We did not close during the pandemic. They have not come to vaccinate us; everyone has gone to get vaccinated on their own. What they have done is free tests, and the delegation sent them. However, in the bodegas, the majority are not vaccinated, not yet, because they are people under 40 years old, and they are just getting started."

It is important to note that the Mexican government did prioritize seniors for the vaccines. Younger people - the average age of people working at la Central at the time – were not selected to have vaccines until months later. That decision may have been consequential for many of the CEDA's workers.

The pandemic created conditions that constricted the flow of social capital to smaller social circles. The re-organization of employment, tasks, and roles in the bodegas, as well as supply arrangements, occurred in response to changes that, while collective, were responded to by small groups of the bodegas and their immediate buyers and suppliers. Nevertheless, while no overall directives shaped the decisions of the bodegas and no general plans were made, in this massively decentralized assemblage of actors, thousands of small organizations, few of them even coordinating with each other, sustained the entire Central operation. Like an ant colony, even if dozens of shops were affected or without products, others were sustaining or adapting their business with customers. The adequate potential capacity of the CEDA system still remained available to customers. However, demand had slowed significantly due to expectations not just of the market but of millions of people in the population, which affected the expectations of buyers and significant vendors.

1.2. Self-organizing as Resilience

We observed collective resilience as well as individual and social capital resilience. The assemblage process we hypothesize from these observations, as expressed in forming solidarities between bodegas and their immediate networks, demonstrates the resilience of large colocated networks. The CEDA facility has no top-down or managerial organization. The responsive recovery of many family bodegas following the rapid collapse of business conditions shows that selforganization of the parts results in restoring function, if not optimal, performance. Each bodega is a purposeful activity system seeking to restore its business in its supplier and sales ecosystem. The relations between bodegas were not coordinated but benefited from the propinquity of onsite communications. However, the effects of internal conditions did not seriously impede the whole operation. The most significant effects were the drop in external demand, creating problems for inventory planning and stocking supply.

One mode of self-organization was adopting technology to improve profits, even if average sales were lower. As with refrigerators provided by individual owners in the earlier era, new tools for production were adopted to restore business performance. The three brothers in garlic sales were one case where innovation was adopted to enhance product sales. The family owner (father) had sold only whole garlic for decades, but the pandemic

decimated demand. To recover the business, they innovated using technology investment to create more value. They bought an airpressure garlic-peeling machine and sold the peeled garlic at a much higher price.

"If we did not do it, we would fall to bankruptcy. We were buying each machine, whether the fridge or the peeling machine, and it was challenging to convince my dad. The purchase, sale, and resale model is already obsolete. It became a penny business. For resale to truly pay off, you must sell a truck daily. The problem is that there is you, and there are thirty others like you. We change the volume for the issue of added value since it becomes unsustainable to sell a very high volume."

The successful bodegas bet on technology. The garlic sellers analyzed the numbers (one of the brothers was an economist), and their risk paid off. Whole garlic sales are now just a fraction of sales. They survived, but not without costs. They fired some employees to buy the refrigerator and the peeling machines. However, in the end, they did not close like many others.

Most bodegas have no website or an online store, but that did not inhibit their adaptation. The ubiquitous smartphone and the apps used by customers and suppliers were the most helpful. As an everyday innovation, the adoption of the WhatsApp text app enabled many to leapfrog beyond their legacy practices. Many first used the WhatsApp smartphone app as an informal withinbusiness messaging intranet. The process quickly caught on to the whole system. Bodegueros, big and small, now use WhatsApp to receive commercial orders, send pictures of new merchandise, and chat with producers and clients everywhere in Mexico and abroad. WhatsApp has become the de facto critical social capital infrastructure at la Central. Moreover, with emoticons and voice mail, even the less literate can adopt its use for everyday work.

Mexico City's government is the de facto management of la Central, which provoked a persistent lack of accountability for its maintenance. When the CEDA opened in 1982, it lacked essential refrigeration, so the bodegas installed their own, especially those selling bananas, apples, garlic, and temperate fruits. Also, operational costs have been increasing due to precarious security from crime. La Central is one of the significant parts of the food value chain in Mexico, and organized crime has taken notice. The bodegueros have suffered continuous kidnapping threats for years. All these different costs compounded and resulted in social and material costs that incentivized change to the organization of la Central itself.

Smaller marginal gains indicated that bodegas had two options: to get bigger and trade higher volumes or increase their product's value, as the garlic brothers did. The family-centered bodegas are adapting, but not

all have, so some have sold their business to more prominent vendors. A market consolidation is happening. The brothers said some bodegas have bad reputations because "they kill the price for the producers, and they keep the product on their fridges and then sell it at the price they want when the season ends…." They say that la Central has five dominant actors for every product category. In groceries, it is clear because that sector is predominantly owned by descendants from Spain, called the Spanish "los españoles," perhaps the only group at la Central known for their ethnic origin. Furthermore, because they are some of the wealthiest bodegueros, trading especially in seeds and grains, they lend money to smaller ones.

As we returned to Samuel, the heir of a large grocery bodega, he complained about the high freight prices. Responding to the question of when the business will return to normal, he said:

"I do not think this business will ever return to what it was. It is cheaper for shipping companies to have fewer ships at sea, have them full, and charge four times more. Operationally, it is cheaper for them."

Do you think the storm will end in a year or two?

"I think it is going to take a while. The level at which it was in the logistics issue is years and years of economic growth, and right now, the growth…"

Two years after the field research, informants share that the CEDA is still recovering, but the demand has not returned to the level before the pandemic. Many restaurants closed, but food prices increased and were passed on to consumers. The open restaurants increased their menu prices, impacting traffic and becoming a circular problem.

2. Discussion

Institutions matter because they are formed with social capital. The one that has survived among all odds is the Mexican family because it is the first circle, the closest one. However, social trust has eroded over the decades. The long-standing hegemonic party, PRI, became authoritarian, commanding obedience by fear, not loyalty.

Thinking about what would have happened to la Central de Abasto in the worst of those pandemic days, we asked different bodegueros several times if Mexico City would suffer from hunger. The answer was a resounding no because of different reasons. The first and most common was the growth of Wal-Mart, especially in the past two decades, which has created its own logistics chain that supplies everything from popular neighborhoods with the Bodega Aurrera brand to higher-class neighborhoods with Wal-Mart Express. The largest CEDA warehouses also supply Wal-Mart since they earn a lot from volume.

In April 2021, I met Antonio Avila (his real name), the regulatory inspector in the "auctions" area, where the trade of vegetables on top of concrete slabs occurs, between the flowers area and the fruit and vegetable warehouses. He was on break due to the pandemic and being over 60 years old. He sadly passed away months after the conversation (it is unknown as to whether it was from complications of Covid-19 or not). Over breakfast, we talked for a long time, and in discussion, we walked through his domain, looking at the products and commodities in everyday work:

"The package of cactus (nopales) with 200 pieces was 60 pesos. Yesterday, it rose to 150 pesos, the first-rate, more than double. It is scarce; there is none due to the drought."

I asked if there is hoarding.

"There is some. Well, it is about 30% of the total trade, but before, there was more; now it is calmer. Most producers have their spaces, but those who do not come and kill their merchandise at a low price. I think 50% make an agreed harvest, half."

He has worked all his career at la Central; so how does he see the changes today?

"For a long time, it was only given minor maintenance. I have been here for 36 years; I saw the Central almost new. When I arrived, it was not even full. They have not paid the ejidatarios [farmers that share an ejido, a prevalent legal form communal land in Mexico] of the original chinampas. In December 2019 we counted 2,100 trailers, 1,600 two-ton trucks, and 59,000 cars and vans that entered daily. There are a total of 8,228 premises, including wineries and commercial premises. There are 981 wineries. There are many mafias here, many. The situation on the night shift is very different. In addition, there is sex work on the eastern road, along the aisles. That is the oldest job in the world."

If institutions fail to provide adequate support and maintenance, not only do the physical components fail, but the social capital, as human infrastructure, also erodes. Institutions are networks of civic participation, and when the civis, citizens feel disenfranchised to act, social inertia prevails. We agree with the study that concludes "there is a neutral quality of social capital because it can lead to both positive and negative outcomes of competing interests… like other forms of capital, social capital opens up some opportunities and closes down others" (Brondizio et al., 2021, p. 262).

Informants told us that some traditions are not upheld anymore, like the annual dinner celebration at the Central's anniversary. Bodegueros may care less, likely because older generations are retiring and new people do not share the history and social capital of the founders who began to work together in

1982. Some young generations are in charge, but some families have sold their rights altogether to newcomers. Moreover, this unraveling of the social fabric gives space now only to good actors.

"Social capital may also have a dark side. Gangs and mafia use social capital as the foundation of their organizational structures"

(BRONDIZIO ET AL., 2021, P. 262).

La Central moves hundreds of millions of dollars a day. It is a massive market, but only some trades are registered because many movements are in cash. Falko Ernst, an analyst for Crisis Group, explains what happens with just one case: the avocado trade. However, as with everything in Mexico, it is connected to the country's political economy.

"Until 2000, a single authoritarian party governed Mexico for an uninterrupted 71-year stretch. That party might have been a synonym for corruption, but it did manage to impose certain rules onto the narcos and keep violence in check. Then came democracy and former president Felipe Calderón's attempts to go after the cartels head-on. Regional governments became more autonomous, opening up new avenues for corruption without effective oversight."

(ERNST, 2020)

This new gray area opened new opportunities for criminal activities, and export products are very valuable and more straightforward to trade. Avocados were an obvious choice because of the high American demand and price spike. In a scenario this complex, we would not expect a rapid solution. Legal reforms of Mexican institutions will take years if there is the will to do so. Just as with the case of the avocado, that is perhaps only the signal of the problem, as repricing and tensions are already occurring with other commodities (Russell, 2022).

Finally, we might address the opportunities for meaningful design interventions in the CEDA system. From a systemic point of view, there is an initial dilemma between the realist and the constructivist formulation of the problem context. We are confronted with the realist perspective of the assemblage, that the CEDA operation is massively decentralized, and there is no management or desire for such over operations and practices. We consider the long history of the CEDA and its socio-historical practices, which are not "scalable" in the way systemic service design would seek to enhance and propagate as a new system.

Even if we could change practices, how would we do so, and how could improvements to business performance be promised? Individual outcomes are what the bodegas would care about most.

From the constructivist perspective, we might solicit interest from more prominent bodega owners who are interested in guiding a long-term vision and creating some form of coalition. Changes to practices and riskier technology experiments could be supported in a prototyping cocreation mode. However, these impacts might be limited to the participating organizations in a traditionalist environment. There are other possible design futures we have yet to explore, and so many structures and infrastructures have yet to be investigated in the ethnography. Such opportunities for intervention may be discovered with the participants themselves. The field research reported here was not an experiment but an inductive ethnomethodological study based on the opportunity to observe social and behavioral adaptations to a once-in-a-lifetime disruptive event. Our insights are drawn from focusing on the responses and recovery from the pandemic effects across multiple worker-participants and by analyzing la Central as an assemblage. Some of these could be managed with government support, such as investment in transportation hubs, docking and trucking improvements, and other infrastructure around the CEDA complex that could improve its sustainment over the longer term.

3. Conclusions

The "creative destruction" process in capitalism initially proposed by Joseph Schumpeter (1942) describes how innovations make obsolete the established practices of their times. The modernist imperative would be to control and monitor such large networks. A design approach might first trust that subsidiarity exists among stakeholders with real skin in the game to make the whole system work to fulfill their commitments. However, during the pandemic, controlling and monitoring the health of the workers at CEDA was impossible for Mexico City authorities and the federal Mexican government. Not because of a lack of resources but, as often found, due to a lack of political will. La Central has suffered from underinvestment for so long that the institution does not even register on the political radar of the Mexican political elite. The end of the PRI political era began in 1997 in the Mexican capital, and then PRI eroded nationally by 2000. The new democratic space was one of experimentation, where old forms died, and the new ones have not fully emerged. La Central has exhibited resilience, not because of management or the government, but despite its neglect. It has adapted even to survive the increasing presence of organized crime and survived the double shock in supply and demand of the pandemic.

Variables like generational change, the rapid use of WhatsApp and smartphones, and the always present soft dealing with the politics of changing Mexico City governments have enabled adaptation, especially in this crisis. Even during times of social capital degradation, CEDA has persisted. Will these practices suffuse the future crisis? Some bodegueros are already adapting to climate

change's impact, adapting to changes in their products' growing seasons - and perhaps technology will come to the rescue again, such as logistics apps for changing providers as they are available. However, there are new social requirements following innovations, like food on demand, where mobile food deliveries and digital commerce are growing. Moreover, while WhatsApp was widely adopted in the first iteration of smartphone use, some are already experimenting with new platforms and formats.

La Central will evolve not into a single future, only decentralizing the central market, as Orensanz (2022) suggests, but very different options, and we can see the signals of change happening now. Some bodegas have closed to the public but provide internal food service hubs. Some are more technology-oriented than pre-Covid, relying more on digital communications to manage smaller/faster inventories. Others are watching climate disruptions, as a worried mango bodegueros noted. He is investing in new suppliers to have more redundancy in supply. The new generations are excited about what is coming but also very anxious. Their parents gave them a legacy, and now they are in charge, with new thinking and new tools.

Assemblages are arranged between human and non-human actors. In the CEDA context, we saw the organic restructuring of work practices that seamlessly appropriated commodities and their logistics, technology and new machinery, forms of payment, and the people and roles they play. These assemblages create territories that can be more or less durable, sustained, sustainable, and interconnected. With all its codifications and intensities, this research has shown that the territory of CEDA continues a rapid transformation process. As Jessica (one of the few women bodega owners in the study) said:

"They (the government) did not just abandon la Central; they stole the money, that is different. From where do you think Morena (the present-in-power political party) got money for the campaigns?... Maybe we are at fault here because we have not demanded accountability, but a bodeguero once said no. What did the administration do? They closed this bodega for two weeks. It is hard, but we need to organize."

The old establishment of la Central is retiring or dying and leaving the reins to a new generation, but many traditions remain and will continue. However, the next generation of workers and owners are already within this assemblage, designing iterations with trials and failures, and shaping the future from their own choices.

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DESIGN-LED CIRCULARITY FOR FURNITURE MANUFACTURING. AN APPLICATION ON MONTESSORI KINDERGARTEN

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ABSTRACT | The increasing demand for sustainable production systems necessitates a reassessment of product design and lifecycle assessment methods, emphasizing socio-technical aspects. This contribution reflects on the results of a laboratory that addressed the needs to widen and identify possible new market areas for circular materials characterised by a marginal diversification of products in the furniture design industry. By collaborating with a local preschool to understand the pedagogical requirements and implications of design, and by creating synergies with recovered material suppliers, the Research investigates the potential of design to function as a mediating force between the inherent limitations of material solutions and their application context. The laboratory leverages technologically innovative recycled materials applied in the kindergarten furniture context, resulting in thought-provoking design proposals for identifying and developing viable design-led furniture production opportunities. Through a combination of design-led material assessment, user-centred approach and iterative experimentation, the Research seeks to provide insights into sustainable design approaches that align with environmental and pedagogical objectives while contributing to the advancement of sustainable design practices. The outcome of this experience is a strategic framework proposal, structured according to the laboratory experimentations, that aims to enhance design methods and process development, focusing on resource-efficient offerings. Ultimately, the Research hopes to contribute to transforming challenges associated with material constraints into opportunities for innovation and sustainable application through design.

KEYWORDS | DESIGN FOR SUSTAINABILITY, LIFE CYCLE DESIGN, MONTESSORI EDUCATION, FURNITURE DESIGN

1. Introduction

The growing demand for sustainable production systems has led to a revaluation of methods and tools for designing and assessing products throughout their lifecycle (Kardung et al., 2021). Sustainable design development becomes an increasingly urgent concern, as stressed by the European Union in its Circular Economy Action Plan (2020), and further reinforced by the new 2024 Ecodesign for Sustainable Products Regulation which calls for a shift towards more environmentally sustainable and circular products and claims the integration of environmental considerations into all stages of product development (EU Commission, 2024).

The evolution towards conscious design has broadened the level of innovation ensuring that products maximise efficiency, optimise resource use, and reduce waste, while being sustainable in terms of long-term satisfaction and usability for users (Bakker et al., 2014). Conversely, a material's sustainability is also perceived for its capability to integrate socio-technical aspects, such as user behaviour, consumption, disposal, maintenance, and recycling (Ceschin & Gaziulusoy, 2016). Exploring new materials and technologies to reduce environmental impact and open up new aesthetic and functional possibilities for designers has been acknowledged throughout the years (Roy, 2010). Controversially, the adoption of recovered material is often limited to specific application, hindering the broader potential these materials could offer (Vezzoli et al., 2015), with producers struggling to open new markets (Castell-Rudenhausen et al., 2022). Ecores et al. (2018) advocates that designing circular furniture products requires research and innovation as well as adopting, mastering, and implementing eco-design skills along with untapped material use. These factors are particularly relevant for the Made in Italy furniture manufacturing sector, which strives to meet rising demands for flexibility and adaptable solutions (Starkey et al., 2021). The goal is to contribute to the expansion of alternative recovered material application, by promoting conscious and sustainable practices, as well as involving stakeholders at various levels, while meeting environmental and societal challenges

(Vezzoli, 2003). In this regard a creation of a relevant value network of suppliers and the use of external expertise is essential to create an effective framework model (Moreno et al., 2016). This is enhanced by the involvement of Montessori kindergartens where the design of furniture will not only prioritise sustainability but also supports the context by promoting educational goals in early childhood education.

By considering the challenges posed to the furniture manufacturing, and the needs to widen and identify possible new market areas for semi-finished and circular materials, this contribution explores the integration of design for sustainability principles, circular economy, and Life Cycle Design (LCD) strategies, applied to a niche setting such as the Montessori educational environment, to bridge the inherent limitations of material solutions and their application context, enabling opportunities for sustainable production. Strategic partnerships and collaborations play a vital role in generating new resource streams, accessing additional skills and competences, and pooling resources to offer integrated solutions (Ecores et al., 2018).

The following sections present critical terms and definitions of the context, subsequently detailing the preliminary Research methodology and descriptive analysis applied in an experimentation lab, introducing the categorization of circular design, and LCD strategies. Section four presents a proposal framework, accrued from outcomes and strategies towards circular-effective production systems, which emphasise the key findings and contributions to both the academic and practical fields, followed by a conclusion and acknowledgment of the limitations and directions for future research.

2. Material sustainability matter

Insights into the circular economy and business transformation in the furniture industry shed light on the economic significance and environmental challenges faced by the European furniture sector (Farahmand & Rahimiaghdas, 2024). Despite a notable degree of knowledge and awareness of circular economy principles, the involvement of furniture companies in circular economy practices remains marginal, particularly concerning reuse and recycle actions, which comes along with a very limited use of process and product certifications.

According to European Federation of Furniture Manufacturers (UEA) statistics, furniture waste in the EU accounts for more than 4% of the total municipal solid waste stream. Of this 80% to 90% is incinerated or sent to landfill, with only ~10% recycled (Arditi, 2017).

While the traditional linear economy is frequently characterised by structural waste where components, products, or materials reach their end-of-use/life, research on the furniture sector has identified, at European level, potential opportunities within a circular economy framework (Pieroni et al., 2019) promising a wider range of efficiency and productivity strategies (Kirchherr & Piscicelli, 2019; Potting et al., 2017). Circular strategies

(i.e. Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacture, Repurpose, Recycle, and Recover) focus on a design approach that support manufacturing practices aimed to retain resources in use and minimise waste generation and destruction (Murray et al., 2023). This concept is reinforced by the establishment of programs such as the HORIZON "Innovative circular solutions for furniture" that specifically address to some extent circular design strategies, including safe and circular material choices, a shift from products to services, extended product life through design, increased material efficiency, and modular design.

2.1 Design as link for circular ecosystems

As awareness of the shift from a materials-focused to a more strategic level grows, waste materials are increasingly perceived as a valuable resource in supporting industrial prosperity, environmental sustainability as well as personal and societal fulfilment (Brown et al., 2019; Pearce & Ensley, 2004). The circular economy aims to enhance the lifetime of products, facilitate the repurpose of items, and divert waste materials from landfill back to production lines (Ellen MacArthur Foundation, 2015). Realising this requires advancement in methods (Bocken et al., 2016), metrics and assessment (Moraga et al., 2019), production systems (Bakker et al., 2014), products and services development tools (Moreno et al., 2016), and the creation of organisational capabilities such as experimentation, value chain innovation, and human factors (Nilsson-Lindén et al., 2019). In this sense, designers play a crucial role in moving through these dimensions (Santolaria et al., 2011) acting as a link between consumer's cultural sphere and the world of production (Mortati & Cruickshank, 2011).

Through a holistic approach and strategic partnerships, designers hold the possibilities to ultimately offer integrated solutions that could promote the birth of new resource streams and competences. Further, by adopting a circular design approach, the design process establishes specific data and informational hierarchies to prioritise waste prevention and production management.

Therefore, aligned with the European Commission's waste management directives (EU Commission, 2020), the Research provides alternative understandings on 'waste' by directly reintroducing it into the life cycle as a valuable 'resource'. By leveraging the recycling strategy, it aims to foster a new ecosystem, made of diverse levels of stakeholders able to create, maintain, and recover the value of resources in innovative ways. The Research identifies opportunities within the kindergarten context and envisions future possibilities for recovered material application, thereby contributing to circularity.

3. Creative educational context

Educators advocate for proactive measures to transform schools into hubs of innovation through interventions in designing educational environments that promote

spatial and didactic innovation (Edwards et al., 2014; Lorenzoni, 2014). Conversely, the design of furniture and the learning environment play a crucial role in supporting pedagogical practices and enhancing the learning experience for children (Antonacci et al., 2019) Child-centred philosophies, such as Montessori pedagogy, the Reggio Emilia Approach, and the Nordic European Model, are closely intertwined with design principles aiming to cultivate environments that foster independent thinking and self-directed learning (Montessori, 1781), and the child's intellectual expression (Fraser, 2011).

They facilitate the free development of children's activities, promoting autonomy, confidence, and the development of practical life skills, motor skills, and sensory training (Keskin, 2016; New, 2007).

Particularly, the Reggio Emilia approach considers the educational environment as a 'third teacher,' being significant as the teacher and peers (Cagliari et al., 2016). The careful selection and the design of furniture and materials in these classrooms serve not only as a functional object, but also a tool to nurture core skills (Murray et al., 2023).

Montessori (1978) emphasises furniture design that is proportionate to children's size, lightweight, and easily accessible to foster independence and practical skills development (Murray et al., 2022). Educational materials and furnishings support holistic learning, covering cognitive, sensory-perceptual, and practical development. Everyday activities like eating, washing, and dressing become learning opportunities, building children's confidence to function independently. Teachers guide students in exploring their environment, nurturing autonomy. Montessori materials are sensory-rich, engaging all senses to stimulate intellectual growth and focus on real-life skills. Tools from real life promote practical skills and fine motor development, with books and materials placed on child-sized trolleys and shelves for easy access. The environment features natural colours and materials to minimise distractions, creating a calming atmosphere for imaginative exploration (Lupi, 2018).

Furthermore, these educational models add values to the concept of 'all places are learning spaces' envisioning learning environments that serve multiple purposes (Stables, 2014). In the restroom, children learn basic life skills like using the toilet, washing hands and personal hygiene. Hallways become spaces for learning to walk, navigate, and greet others. Dining halls are where children enjoy meals, learn table manners, and develop healthy eating habits. Lasty, cultivating a sustainable way of living is one of the philosophies' cornerstones. To achieve this, these educational models include the outdoors as a conceptual learning space. Here, children have a chance to establish a strong relationship with nature and the earth.

Accordingly, research on the impact of furniture design on children's development and learning interest emphasises the role of

furniture in supporting and enhancing the learning experience within sustainability (Cole, 2014). Conversely, in the context of design research, studies on sustainable furniture design provide valuable insights into creating furniture that aligns with ecological needs and promote acceptance (Yang & Vezzoli, 2024).

3.1 Design for student and learning environment

The evolution of school furniture reflects a complex interplay between pedagogy, design, and societal values over time. Originally, school furniture borrowed elements from other institutions, with multi-seat desks resembling church pews and a linear arrangement facing the teacher. This setup emphasised the teacher's role in imparting "notions, principles, and interpretations of reality in accordance with unquestionable texts" (Lauria, 2002, p. 66).

Foucault (1975) further emphasised the rigid structure of the school, considering it as a 'machine for learning' and an 'organisation of a serial space' for surveillance, hierarchy, and reward. While pedagogy was still authoritarian, with children considered as passive recipients of knowledge, leading designers and pedagogues, throughout the 20th century, explored how design could enhance and transform teaching and learning experiences.

While pedagogy was still authoritarian, with children considered as passive recipients of knowledge, a paradigm shift emerged in the early 20th century, and leading designers and pedagogues started exploring how design could enhance and transform teaching and learning experiences.

The 1920s and 1930s marked the evolution towards more flexible and collaborative classroom setups. The teacher descended from the podium, and combined table-seat designs broke away from the traditional row, encouraging interaction. Figures like Prouvé introduced functional elements like sliding pencil holders and drawers that enhanced usability, while other designs fostered student engagement and collaboration, with students sharing the same desk.

During the mid-century, school furniture continued to evolve and designs such as the versatile stool by Bill and Gugelot or the Revolt chair by Kramer, exemplified a shift towards a more usercentred approach and student engagement. With the introduction of plastics in early '70s colourful and modular furniture designs appeared, especially for early childhood education, emphasising playfulness and multifunctionality (Harrod et al., 2012). This era marked a departure from traditional, monofunctional furniture towards more interactive and engaging pieces that supported diverse learning experiences and demonstrated a growing understanding of the impact of furniture in educational environments (De Gregori, 2011).

In parallel, research on the relationship between learning environment characteristics, educational quality and student behaviour gained traction, leading to the shift from

factory schools to open school models (Weinstein, 1979).). In response, school furniture continued to evolve nowadays, prioritising student-centred, collaborative, and ergonomic learning environments (Bøjer, 2019; OECD, 2013) and exploring alternatives to improve educational experiences.

4. The laboratory of ABCDesign. Furniture, Childrens and Circularity

To further enrich the discussions, the Research structured an experimental laboratory entitled "ABCDesign" in which participants have been invited to design furniture that could efficiently address the dual challenges of environmental sustainability and preschool education. For this purpose, the laboratory has benefited from the involvement of a set of specific key partners:

- (Omitted for blind-review), an international kindergarten management brand offering pedagogical practices grounded in creative and independent educational approach.
- (Omitted for blind-review), a consultancy agency with a strong expertise in supporting producers implementing the most effective and efficient strategy to reduce their environmental impact. They facilitated a network with the following producers:
    - (Omitted for blind-review), a company dedicated to the development of sustainable rubber flooring, that uses advanced technologies and the fundamental addition of specific skills and extensive experience to automatically recover the waste generated during production according to the principles of reduce-reuse-recycle.
    - (Omitted for blind-review), an eco-friendly plastic product producer with a strong asset on sustainability of its plastic products integrating design, research, and development of solutions that preserve integrity, protect the environment, and reduce resource consumption.

The laboratory integrates two lines of investigation: a qualitative field study to understand the context and gain insight into how users behave, interact, and perform activities in a specific setting; a holistic design approach to evaluate and determine the sustainability of predefined recycled materials, their properties, and potential applications. These two lines have been structured in the main 3 phases (Figure 1) of analysis, prototyping and scenario building.

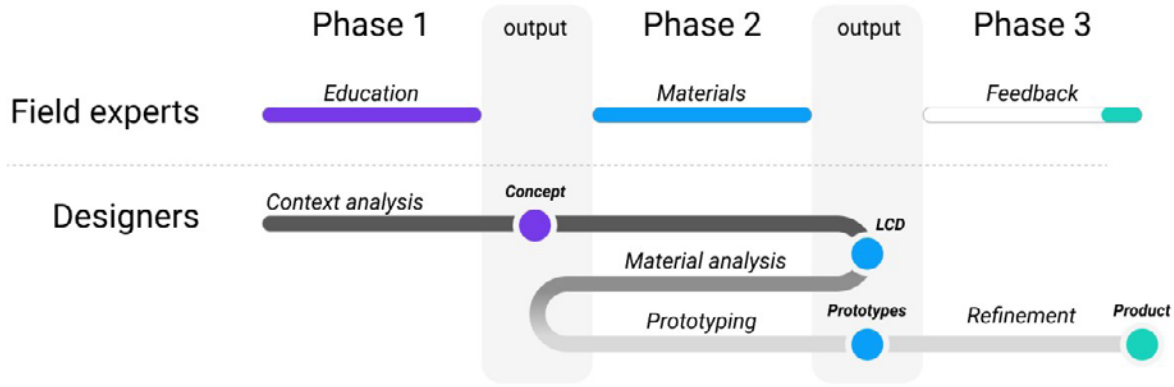

Figure 1. The stages of project development and the figures involved.

4.1 Analysis of spaces, products, users

The first phase encompasses contextual monitoring and analysis to establish a foundational understanding of the research environment and the target audience. The field study, (omitted for blind-review) Kindergarten, was enriched through expert consultation and an on-site observation (Figure 2), which facilitated an examination of pedagogical resources, physical infrastructure, products, and user dynamics.

Figure 2 The visit and observation of the context in the kindergarten.

The school environment is divided into different areas such as reception, play-educational activities, dining, changing and hygiene, sleeping, atelier room, outdoor area as well as being separated into three age sections: small (children 3-12 months), medium (children 13-24 months), and large (children 25-36 months). To enable close observation of the space, each working group, consisting of three designers, was allocated a specific area to focus on throughout the entire investigation and design process.

To facilitate contextual analysis, designers were supplied with a qualitative analysis tool based on the 5W, a method that provides an integral perspective for guiding design practices (Su, 2014) and to consider essential aspects such as stakeholders, product specifications, project timelines, project locations, and project justifications, thereby enhancing the clarity and effectiveness of the design process (Čančer, 2012), that is useful to define from the concept design and investigation stage.

The tool consists of structured tables designed to elicit data collection according to 5 predefined question sets:

- Who?

  Refers to anyone who attend the given investigation environment. Associated with this sheet are questions about who is being observed, such as how old they are, what their role is, what characteristics they have, how they relate to the space and how they interact to others. In the results (as in the example in Figure 3), not only types of users were collected but also the various connections between them according to their type of relationship.

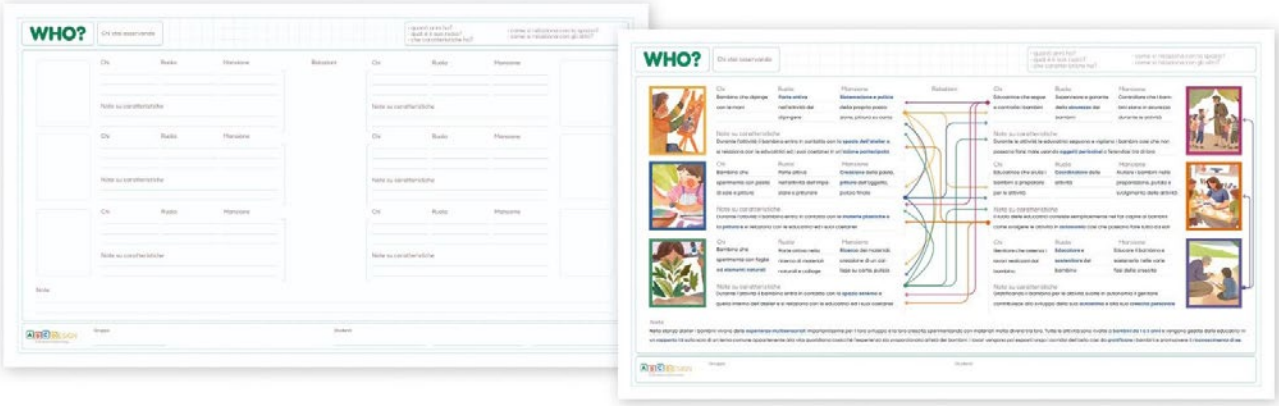

Figure 3 "Who" table, blank and filled by designers (Omitted for blind-review)

· What?

The template involves considerations about what activities are being performed, their nature (teaching, recreation, etc.), with what tools they are executed, the interactions they involve with the environment and whether they are individual or in group. The filled template (Figure 4) shows how the activities were undertaken through the analysis of children's interactions with existing products and teachers.

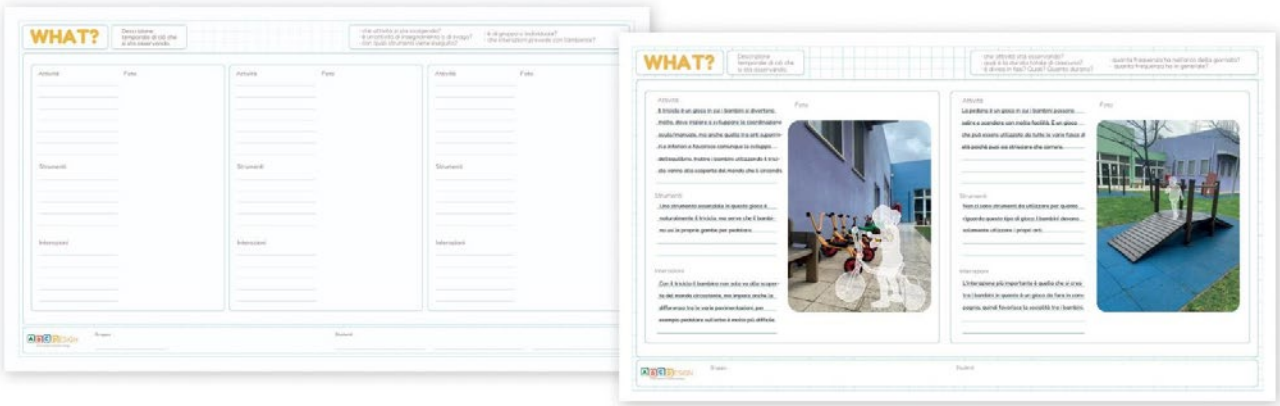

Figure 4 "What" table, blank and filled by designers (Omitted for blind-review)

· Where?

Requires the physical description of the place, not only with the mapping of the spaces but also considering how the space itself is characterised, how it is used, what objects define it and how it is exploited (also including the internal movements of people and objects). Here the designers mapped (Figure 5) the internal spaces and the movements patterns of users (parents, children, educators, and staff), identifying the areas of greatest flow and importance.

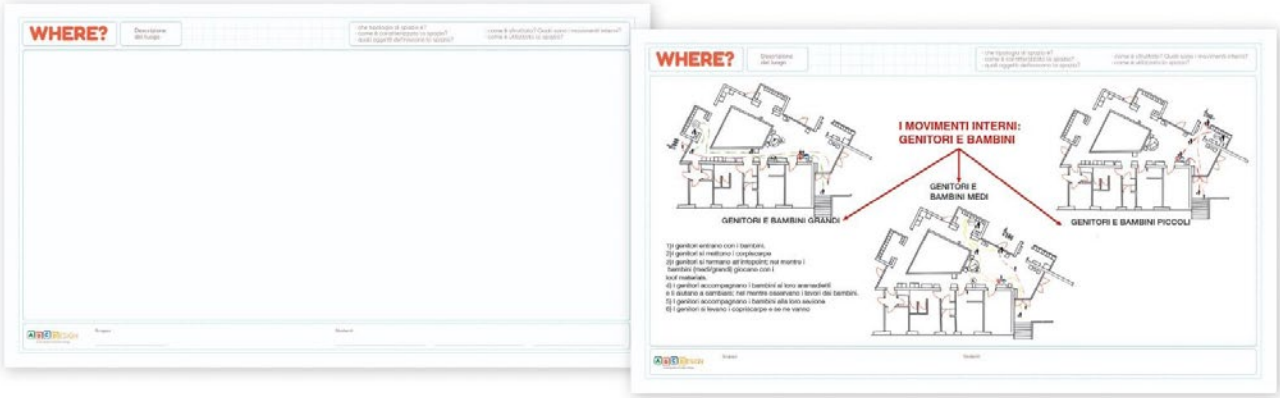

Figure 5 "Where" table, blank and filled by designer (Omitted for blind-review)

· When?

Provides a temporal description of what is being observed, defining the activities and their duration of each phase (if any) and total, and whether it is repeated (and if so, how often it occurs). The filled version (Figure 6) demonstrates not only the timing of observed activities, but the division into further temporal subgroups that define each activity overall, in order to understand intervals and internal organisational systems.

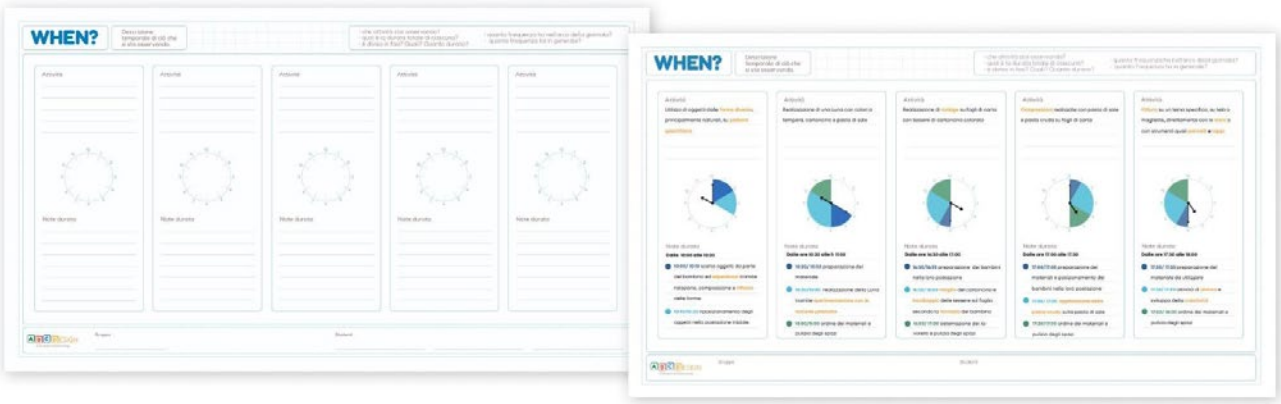

Figure 6 "When" table, blank and filled by designers (Omitted for blind-review)

· Why?

Concerns why what is being observed happens, such as the reason why an activity is performed and if it involves specific figures, why specific tools are used and in a specific space and way, and explanations as to why it happens at a specific time. In the finished exercise (Figure 7) not only the motivations for activities were noted down, but the scenes were represented by means of sketches as a way of in-depth observation of each detail.

Figure 7 "Why" table, blank and filled by designer (Omitted for blind-review)

4.2 Prototyping, experimentation, reiteration

As the context and concept clarified, recycled materials analysis shed the light on production and feasibility issues, enabling designers to progress through rough prototyping and deeper analysis to simulate, test and retrieve valuable data from their design proposals. Designers were provided with recycled rubber, supplied by (Omitted for blind-review) and recycled polyethylene sheets, supplied by (omitted for blind-review). This allowed them to deepen their initial ideas and implement new material knowledge to concepts and subsequent prototypes developments.

Following the presentations of the two materials by the supplier companies, participants were given data sheets regarding:

1. **supply:** the quantity of material available per group, and the types available according to colours and finishes;
2. **properties:** applications (whether indoor or outdoor), density, lifespan and toxicity information;
3. **production:** processes (moulding, pressing, etc.), machining (laser cutting, milling, etc.), post-production (painting, coating, etc.), finishes (colour, texture, etc.);
4. **resistance:** to external agents (climatic, electrical, etc.), to chemical agents (cleaning solvents, etc.), to heat (deformation, flammability), and breakage (impact, scratching, flexibility).

Further evaluation, focused on design proposals circularity, was guided through a LCD scheme (Figure 8). The evaluation was divided into 3 value clusters of strategies for optimising the use of resources, defining the consumption of the product and establishing its end-of-life for immediate systematisation of each part. Each cluster is then evaluated with a score from 1 to 3, generating a radar chart for comparing multiple concept proposals at time (in this specific case, there were three proposal each one), and with additional targets on the performance and properties of the given material.

Figure 8 LCD Strategies tool and filled sheet by designers (Omitted for blind-review)

In this case, adopting LCD meant not only to focus on the functions and structures of the product but also on planning the product's life cycle as a whole (Kawada et al., 2009), enabling the evaluation of individual solutions during the conceptual and preliminary design stages, and ensuring that design requirements are met across all stages of the product life cycle (Todić et al., 2017).

Enriched by a series of prototypes and reiteration processes (Figure 9), the selection of the concepts derived from a deeper elaboration of the considerations concerning as much its usability, and the potential new interaction scenarios, as design evolutions oriented towards the realisation of a product. The latter, and resulting concepts, were ideally designed to be made of only a single material or to have elements easily disassembled for disposal matter.

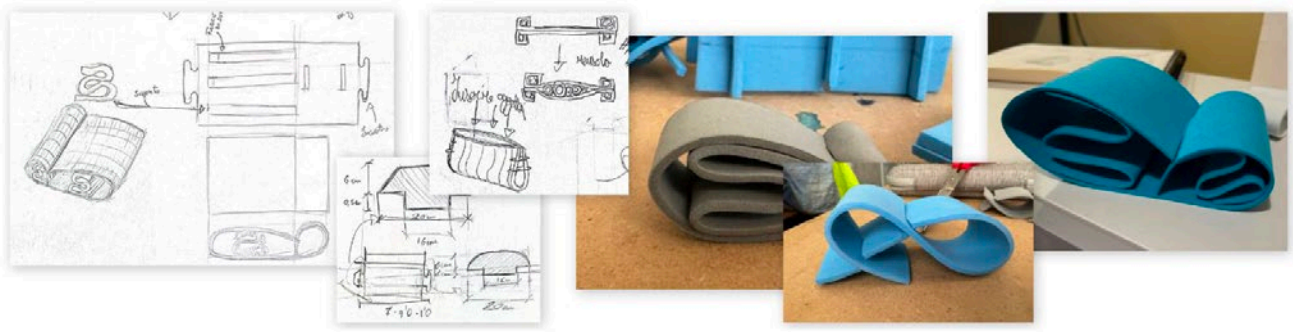

Figure 9 From sketch to rough prototype designed by (Omitted for blind-review)

4.3 Sustainable production and new interactions

The last phase encompasses prototyping and reiteration activities to achieve a final product based on design choices for sustainable production (e.g., design for disassembly and waste reduction from machining) and user interactions (such as use, ergonomics, and transportation). Each group faced challenges in aligning the design concept with the assigned material, both in terms of construction (as allowed by the material), use (comfort, uses, configurations, experiences), and handling (disassembly, shape change, disposal).

At the end of the process, each group successfully completed a furniture product that coherently integrated a series of information and inputs. As the project took shape, the system was able to automatically filter and select the most relevant information. From the analyses conducted, it emerged that each project managed to address two main challenges: the sustainability of the production processes and materials used, and the issue of preschool education, with particular attention to the cognitive processes of young learners and the needs of the adults in the considered ecosystem (operators and parents).

The research process underscored the significance of two interconnected design considerations that shaped the final outcomes:

a. The first focused on product sustainability, emphasising the specific characteristics of a predefined materials and their behaviours;

b. The second prioritised the creation of meaningful products that thrived to accommodate the children's need and their educational development, as well as facilitating the instructor while maintaining environmental responsibility.

Discovery Box (Figure 10) is an interactive and educational playground made of recycled rubber that fosters children's curiosity and discovery process, guiding them through a dynamic maze where each room facilitate motor and cognitive skills development.

Figure 10 Discovery Box prototype exhibition, designed by (Omitted for blind-review)

a. From a material perspective, the product is a self-standing structure that leverages on rubber's flexibility. Made from a single sheet of rubber, it underscores the need for an easily foldable solution that features additional and removable elements to facilitate disposal.

b. The playground is a learning environment designed as a dynamic maze in which the children can move through each room to develop different motor and cognitive skills such as concentration, coordination, colour spectrum recognition and tactile experience.

Playspace (Figure 11) is an interactive separator designed to support children's role-playing activities. The product hosts six handy shelves, a bench, and a sliding blackboard.

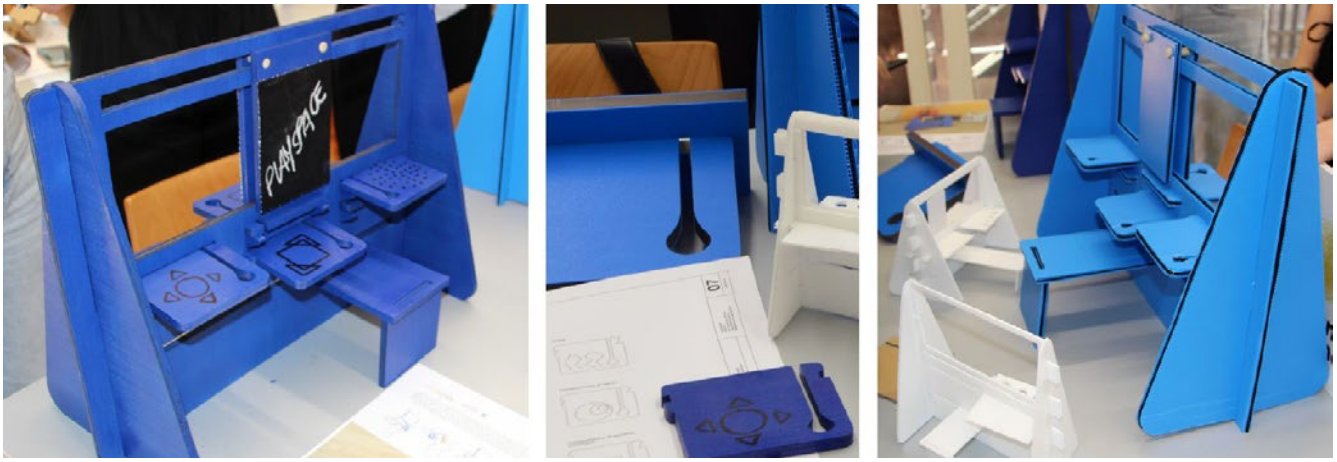

Figure 11 Exhibition of the final prototype and preliminary drafts of Playspace, designed by (Omitted for blindreview)

a. The material's resistance allows this solution to maintain its rigidity despite changing configurations. In addition, the material's degree of flexibility is exploited in the interlocking of the various pieces, which can be inserted, removed and interchanged by means of snap-in joints.

b. From an educational perspective, creating imaginary scenarios and narratives stemmed advanced understanding for the young participant in developing critical thinking on touching points of specific activities. In this sense, "crafting" their own narratives could ultimately help children to effectively communicate their understanding of real world and conveying them clearly to others participants.

Bouncy Bun (Fig.12) is a highchair designed for children aged 0 to 2 years, that accomplishes a double function turning itself into a rocker chair for two children.

a. The peculiarity of this stool are the joints characterised by a strong grip without the need of additional elements. Made entirely

Figure 12 Exhibition of the final prototype and preliminary drafts of Bouncy Bun, designed by (Omitted for blindreview)

from the same plastic panel, another feature that characterised this product is its reliability on material resistance and capability to be easily dismantled.

b. The use of this product by the child fosters creative development due to the change of activity defined by the position of the chair (which is done in total autonomy) and encourages sharing. Furthermore, the manipulation actions for changing orientation of the object (vertically for eating, and horizontally for playing) are formative for learning to distinguish the different phases of the day.

Tatami Kid (Fig.13) is a 'sensorial carpet' designed for children aged 03-12 months aimed to stimulate the child's motor skills, and to enhance tactile sensorial experience. This through an embossed surfaces and texturized weaves.

a. The flexibility of the material is fully exploited in this solution, where interlocking pieces are totally secured by passing bands into pre-cut carpet slots. The absence of fixed bands positions

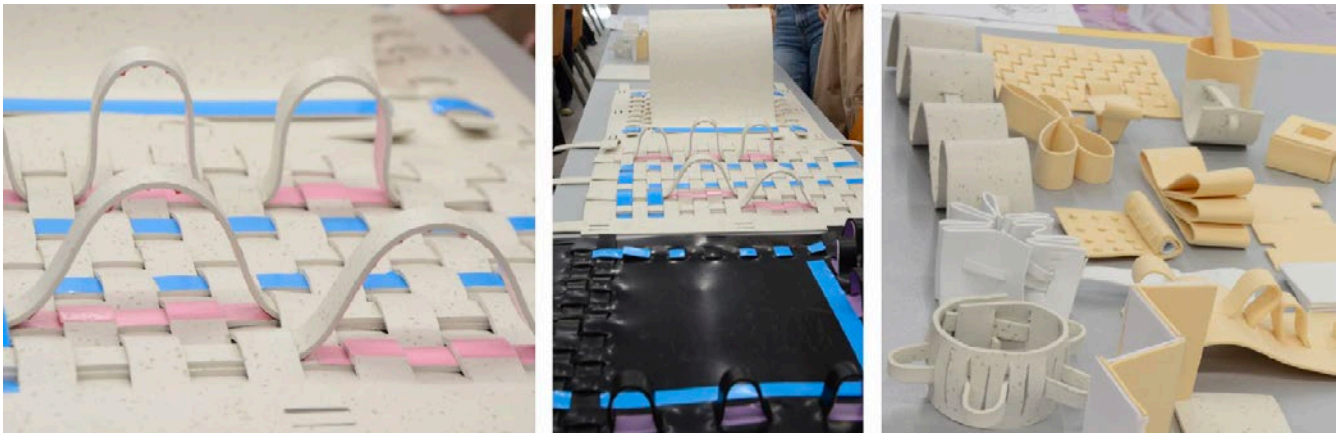

Figure 13 Exhibition of the final prototype and preliminary drafts of Tatami Kid, designed by (omitted for blindreview)

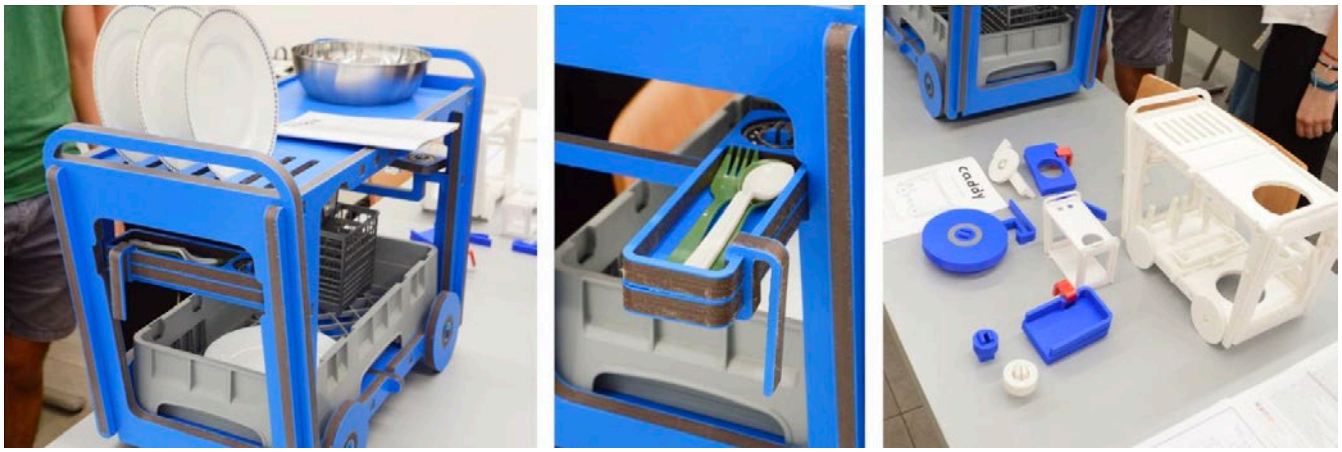

Figure 14 Exhibition of the final prototype and preliminary drafts of Caddy, designed by (Omitted for blindreview)

allows endless configurations and easy components replacement and disassembly.

b. The multiple support points support a child's weight, accompanying and not hindering natural development of fine and gross motor skills. In addition, the presence of different coloured areas encourages visual learning, creating a comprehensive sensory experience.

Caddy (Fig.14) is a multifunctional trolley intended for children from 24 to 36 months and designed according to the Montessori method, which aims at the child carrying out activities independently, in this case during mealtimes and their distribution.

a. This solution is ideated to be obtained from a single square metre of recycled polyethylene sheet. Each joint and mechanism have been designed to work without the need of additional glue or insert. The design is carefully studied to optimise material waste by strategically positioning the elements within the material, allowing for more than 4 trolleys to be placed in the same sheet (on the actual factory size of 150*300 cm).

b. The project aims to stimulate the child's autonomy by helping him or her to intuitively carry out activities related to the moments before and after meals. Moreover, each part of the trolley is designed to host specific elements and tools necessary for the activity (i.e. collecting dirty dishes at the end of meals, serving food, collecting stoves) while promoting the development of practical skills.

Sleepy Loop (Fig.15) is a foldable baby bed that takes full advantage of the flexibility characteristics of the rubber used: the lateral support curves keep the bed suspended, allowing for a peaceful rest in a comfortable position, the integrated cushion is positioned underneath the top band.

a. From a material and processing dimension, the bed structure is made from a single material, without any additional components, featuring a unique shaped hinge that securely locks the bed when place both in horizontally and vertically positions (preventing children to open it).

b. This project operates on a different level, considering both the child's need for safety and comfort during sleep and most importantly, considering the caregiver/ educator's need for flexible space to accommodate various activities according to schedules and guidelines.

Feo (Fig.16) is a folding cot designed to optimise space in nurseries. Each module can hold a standard-sized mattress (120*60*10 cm), allowing it to be used without the need to purchase custom-made mattresses.

a. From a material and processing dimension, the bed structure is made of a single material, without any additional insert, and hinges on a specifically shaped joint that ensure it when place both

Figure 15 Exhibition of the final prototype and preliminary drafts of Sleepy Loop, designed by (Omitted for blind-review)

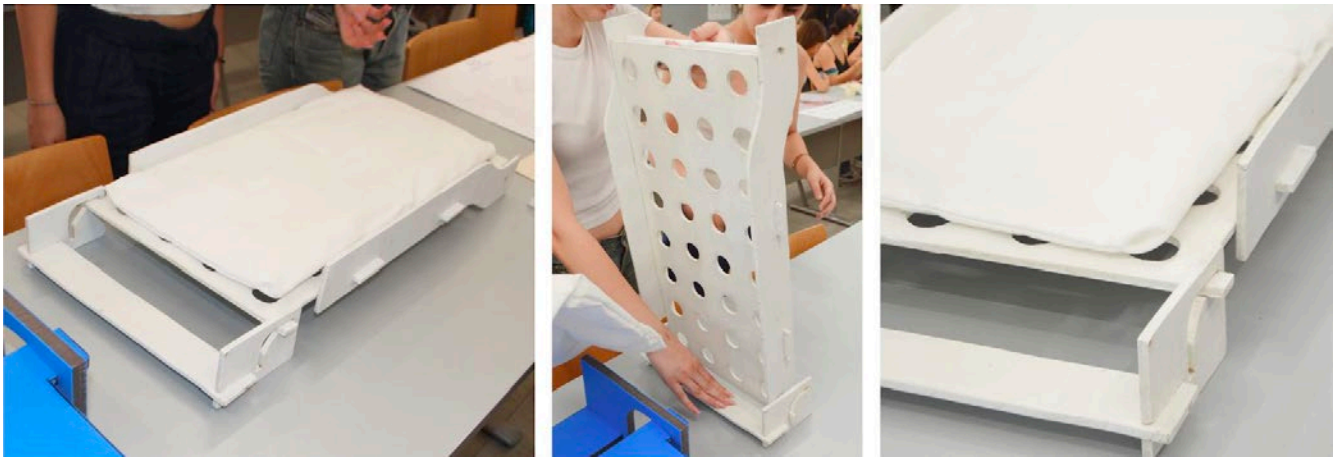

Figure 16 Exhibition of the final Feo prototype, designed by (Omitted for blind-review)

horizontally and vertically (hindering children to open it).

b. This project operates on a different level, considering both the perspective of the child user who sleeps on it and, most importantly, considering the needs of the caregiver/ educator who intervenes to ensure that the rest periods and activities are carried out according to schedule and guidelines.

Librello (Fig.17) is a book stool designed for the reception area of the kindergarten. The lower part serves as a bookcase, providing space for storing picture books, children's books and magazines, while the upper part consists of two seats at different heights to accommodate both child and adult.

a. The entire structure leverages on the material's tangential tension to create a selfsupporting, bended shape held in

Figure 17 Exhibition of the final Librello prototype and construction details, designed by (Omitted for blindreview)

position by a single rope. This design enables dual functionality: a multi-sized stool and a book holder thanks to flexible edge compartments.

b. The dual seating encourages shared reading experience between child and adult, while the shape stimulates the child's imagination and exploration. Through an easy access to books, possible thanks to the playful pick-up system, the visual stimulation and consecutive reasoning and action is further enhanced.

5. Assessing Design capabilities

From the analysis and the consideration stated so far, it is possible to retrieve a first picture of a potential trend of design outcomes when dealing with the two aforementioned dimensions of materiality and education. The insight gained throughout the design process has highlighted different design paths when designers are exposed to specific requirements. The findings suggest that sustainable design interventions can significantly impact sustainability outcomes, guiding designers towards more environmentally friendly solutions. Moreover, the research identifies different design dimensions, including educational and exploratory design for children, behavioural design, productive design, and efficient multi-user design. On the other hand, it is possible also to state that designers more readily identify peculiar insights on the behavioural level than on material one, demonstrating still a difficulty of design to overcome established production processes, if not by pushing it to a sort of limit for efficiency purposes.

These dimensions offer a comprehensive framework for analysing and implementing design solutions that cater diverse user needs and environmental aspects. The results and the process in-depths have revealed key considerations that the designer have embedded in their outcomes, leading to four distinct design approaches (Table 1):

· Design for educational and exploratory purposes, which also led the children to achieve and complete some activities independently (i.e., Discovery Box, Playspace)

· Design for behavioural development of user that learn and develop intellectual and sensorial skills (i.e., Bouncy Bun, Tatami Kid)

· Design for production that not only streamlines the process but also eliminates components that hinder disposal, like inserts or fittings: (i.e., Caddy, Sleepy Loop)

· Design for multi-user design that takes into strict account the different ergonomic scales of users in a context that brings together a diverse community: (i.e., Feo, Librello)

Project	RESULT	(a) Material		(b) Education	
Discovery Box	EDUCATION	Space saving	Tension structure	Exploring	Sensory training
Playspace		Tension structure	Easy disposal	Independence	Intellectual training
Bouncy Bun	BEHAVIOUR	Safe assembly	Single material	Sharing	Structured actions
Tatami Kid		Tension structure	Modular	Fine motor skill	Sensory training
Caddy	PRODUCTION	Production	Modular	Confidence	Structured actions
Sleepy Loop		Space saving	Single material	Autonomy	Sensory training
Feo	MULTIUSER	Space saving	Safe assembly	Multi-user	Structured actions
Librello		Tension structure	Easy disposal	Sharing	Structured actions

Table 1. The table shows the systematic analysis of the products resulting from the laboratory: each of them have been analysed by material and educational features. The results have highlighted four different design approaches that influenced their outcomes.

The laboratory structure provides valuable insights into what Design should consider when dealing with diverse stakeholders and the sustainability of a product. Firstly, designers must perceive the environment as a common ground for potential resources. Secondly, in the creative process, they should align the user's aims with the resource's capabilities to support the necessary activities and processes. This approach can reveal possible needs or future roles for users, allowing producers to anticipate applications for their solutions and explore new market opportunities. Additionally, the product should enable users to envision its future life, even when dismantled or repurposed.

These considerations help designers create an integrated set of actions aimed at achieving sustainable design. Throughout each phase of the process, diverse elements introduce valuable data, contributing to the practical application of materials in real-world contexts. To systematize this information, the following framework (Table 2) has been developed:

According to the laboratory results, the final stage of the Research in Design for sustainability involved a deeper analysis of the thematic patterns of the outcomes, as shown above. It has been recognized that the entire process, from the observation phase to the results, consistently reflected the needs and opportunities emerged, not only at first glance but also during subsequent experimentation phases. This approach provided valuable concepts, methods, and avenues for exploration within the study, guiding the initial direction for design experiments. While these insights significantly contribute to the Research, they are not the only factors influencing the design outcomes.

Indeed, the preliminary information obtained from interviews and on-site investigations was enhanced by detailed feedback and data collected during the testing phase. The involvement of the producer and the specific information explored by the design team highlighted potential alternative applications that could align with the concepts, even though the materials were not initially designed for those purposes. This ultimately confirmed the opportunities that Design could

Framework for Design' Sustainability	**ROLES**	**CONTEXT**	**PRODUCT**
ENVIRONMENT	*Objective*	*Need / potential*	*Envision*
RESOURCE	*Process*	*Application*	*Market*
DESIGN	Creative	Opportunity Making	**Integrated sustainability**

Table 2. Framework for Design' Sustainability

create new perspectives for all the main stakeholders involved. By the consideration outlined so far, the Research moved to a consolidation of a pattern of actions that has been structured as follows (Table 3):

Framework for Design' Sustainability	**ROLES**	**CONTEXT**	**PRODUCT**
EDUCATION	*Educational*	*Multi-stakeholder*	*Enhanced experience*
MATERIAL	*Productive*	*Decontextualized*	*New market opportunity*
DESIGN	Creative	Opportunity Making	**Integrated sustainability**

Table 3. Application of the Framework for Design' Sustainability to the results of the laboratory.

The project emphasised the integration of specific circular materials, highlighting tools and methods for sustainable product development. The research challenged designers to intervene in existing realities to benefit end-users, prioritising single material use, efficient production processes, and minimal material use while responding to the educational goals. Notably, a crucial factor was the constraints of the use of a sole provided material, recycled rubber or recycled polyethylene sheets, and embracing a circular design approach throughout the design process. Designers adhered strictly to single materiality, limiting components to those that demonstrably enhance sustainability. Additionally, they prioritised production efficiency and material use reduction, even by repurposing excess material into other product components. The findings highlight the design approach as an invaluable tool for understanding the direct and precise applicability of recycled material. Conversely, they also emphasise the necessity of the active and consistent stakeholders' involvement in the product's lifecycle to enhance sustainability. Users become the critical factor to assess a given material or product.

6. Conclusions

The Research presented in this paper offers a comprehensive exploration of the interplay between materials, education, and design within the context of sustainable product development. Design enables a holistic view of a process that involved stakeholders, service providers, and final users highlighting a pathway to bridge the gap between material limitations and application contexts through design. Through a process that strategically integrated diverse factors, from recycled materials to their application in a kindergarten setting, the study has identified key design dimensions and their impact on product sustainability offering viable integrated solutions.

The results highlight the importance of a holistic approach that considers both material properties and user needs. By aligning these factors, designers can create products that are not only environmentally friendly but also enhance, in this specific context, the learning and development of children.

The framework identified in this study offers a structured approach to integrating sustainability considerations throughout the entire design process. By understanding the complex interplay of roles, context, product, environment, and design, practitioners can make informed decisions to create more sustainable and user-aims products.

Further investigation is needed to explore the long-term impacts of these design approaches on both the environment and users. The framework proposed reveals some advancement in enhanced design methods, process development, and resource-efficient offerings, ultimately transforming material constraints into opportunities for innovation and sustainable design applications. Expanding the study to include a wider range of materials, product categories, and user groups would further enrich our understanding of sustainable design production. Ultimately, this Research contributes to the growing body of knowledge on sustainable product development by demonstrating the potential of design to drive positive change and the invaluable contribution the active involvement of different stakeholders plays in the construction of meaningful designs opportunities.

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TOWARDS A POST-ANTHROPOCENTRIC CREATIVE FRAMEWORK TO SUPPORT DESIGNERS IN ENVISIONING MORE-THAN-HUMAN FUTURES

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ABSTRACT | Climate change and rapid technological advancements are shaping an unstable and uncertain scenario, posing new questions for design (Mortati, 2022). These transformations challenge Western dualisms that separate humans from nature introducing the notion of nonhuman agency which fosters the development of new design frameworks (Forlano, 2017). Acknowledging human-nonhuman interdependencies (Quadflieg, 2021; Tironi et al., 2023) and a broader conception of life (zoe) that reconnects humans to nonhuman species (Braidotti, 2013) is crucial to make design the mediator between humans and nature. Post-anthropocentrism decenters the human subject to focus on ecologies and relationships (Yoo et al., 2023 as cited in Nicenboim et al., 2023), considers more-than-human perspectives to address planetary needs (Talgorn & Ullerup, 2023) and inevitably triggers reflections about designers' creativity. Creativity, a fluctuating concept shaped by the socio-cultural context (Runco, 2017; Bruno & Canina, 2019), is explored through a posthuman lens to identify the abilities that a new postanthropocentric type of creativity would entail (Roudavski & McCormack, 2016). Theoretical notions belonging to posthuman philosophy that intersect creativity research were critically reviewed and synthesized into the Post-anthropocentric Creative (PaC) Framework proposed in the paper. The PaC framework, indeed, systematizes existing knowledge, translating it into an actionable tool to help designers challenge the current anthropocentric paradigm by creating new narratives that promote careful action towards life on the planet. The framework will serve as a foundation for further research to investigate whether and how the employment of the PaC framework might enhance the design futures approach for envisioning preferable and morethan-human futures.

KEYWORDS | POST-ANTHROPOCENTRIC CREATIVITY, POSTHUMAN, MORE-THAN-HUMAN DESIGN, DESIGN FUTURES

1. Introduction

Amidst the ongoing climatic and technological transformations, an increasing degree of complexity and uncertainty is characterizing contemporaneity. On the one hand, digital technologies with their pervasive features have the potential to transform humankind (Schwab, 2017) and radically disrupt the competitive landscape (Zaki, 2019). On the other hand, and simultaneously, the climate crisis is rapidly becoming a global concern that raises important ethical questions regarding human exploitative behavior towards the planet. Anthropogenic transformations are indeed opening the way to dangerous modifications of the biosphere (Steffen et al., 2011) resulting in some of the so-called wicked problems (Rittel & Webber, 1973) namely biodiversity loss, water shortage, depletion of resources and climate change, which are worryingly threatening the ecosystem and endangering irreversibly life on the planet (Schmitz, 2015). Evidence suggests that, even though, throughout history, Earth has already witnessed drastic transformations that impacted the biosphere, human-induced effects are now putting at risk the planet's ability to sustain us and other species (Barnosky et al., 2012).

In this alarming scenario, mitigating measures are not sufficient anymore to deal with the contemporary climatic crisis. It is now evident that a prompt and collective response is necessary to shift from sustainability to regeneration and such a response needs to be supported by (i) new transformative strategies aimed at restoring social and ecological systems (Dolejšová et al., 2021); (ii) a radical shift in mindset to counteract the exploitative anthropocentric dominance (Camrass, 2020); and (iii) new frameworks to acknowledge humanenvironment interdependence (Camrass, 2020).

In this regard, through a design lens, the authors will retrace how Posthuman theories, a branch of contemporary philosophy, offer a valuable theoretical foundation to decenter the human subject in favor of a more ecological and relational understanding of

reality and humannonhuman entaglements. Posthuman theories frame a post-anthropocentric paradigm shift as the conditio sine qua non for the manifestation of our futures (Ferrando, 2016) highlighting the necessity to go beyond current human-centered perspectives to envision more-than-human futures. Within the design field, practitioners and researchers have been introducing posthuman principles through the emerging more-than-human approaches that account for the agencies of both living and technological nonhuman entities in shaping collective futures (Romani et al., 2022). Ultimately, discourses on post-anthropocentrism and posthuman theories fuel both new debates on creativity, contemplating a wider range of creative subjects and processes, as well as reflections on the abilities that a new post-anthropocentric type of design creative practice would entail (Canina et al., 2021; Roudavski & McCormack, 2016).

Building upon these considerations, the paper explores the key notions belonging to posthuman theories that could influence the design practice and integrates them into a framework to describe the features of a post-anthropocentric creative practice as well as the abilities necessary to envisioning more-than-human futures. The aim of the paper is to set the groundwork for further inquiry into the potential application and efficacy of such a Postanthropocentric Creative framework as a tool to anticipate future scenarios in which humans and nonhumans coexist and thrive.

2. From anthropocentrism to post-anthropocentrism. A posthuman theoretical groundwork

Extractive and destructive human interventions are rooted in anthropocentrism, a philosophical stance that advocates the intrinsic superiority of humans (Ferrando, 2016) with respect to other nonhuman species. Indeed, anthropocentrism considers humans as sole bearers of inherent value (Goralnik & Nelson, 2012) disregarding the nonhumans which can only be instrumentally worth to serve human needs (Ferrante & Sartori, 2016). Often, anthropocentric stances manifest in the ecological debate determining how humans should live in relation to the natural world (Goralnik & Nelson, 2012) in a utilitarian perspective. Anthropocentrism, in fact, emphasizes the "dualistic oppositions" that define what is human by what it is not (Braidotti, 2019b) and detaches nature from culture excluding interest for other species (Hayward, 1997). This binary conception of reality that overlooks the embeddedness of human beings within the ecosystem has now become anachronistic and risky for the sustainment of life on Earth.

Recently, several schools of thought and theories - among others Actor-Network Theory (Latour, 2004) and Object-Oriented Ontology (Morton, 2013) - have developed to criticize anthropocentrism and the deeply-rooted distinction between humans and nonhumans – which can include animals, plants, micro-organisms, climatic systems,

ecosystems, or technologies (Grusin, 2015, p. 7). The critique towards the central role of humans is laying the groundwork for a "post-anthropocentric turn" (Ferrando, 2016, p. 159) essential to modify the traditional humancentered conception of the world and enable humans to acknowledge their inherent entanglement with other nonhuman systems.

Within her Critical Posthumanities, Braidotti (2019a) frames the posthuman predicament at the convergence of posthumanism and post-anthropocentrism stressing that the former criticizes the humanistic ideal of the 'Man', while the latter questions human exceptionalism and species hierarchy (Braidotti, 2019a). Thus, the posthuman concept blurs the symbolic borders that traditionally define the notion of human by challenging dualisms such as human/animal, human/machine that separate humans from nonhumans (Ferrando, 2020).

In Braidotti's view, post-anthropocentrism calls for the redefinition of contemporary subjectivity as an assemblage of both human and nonhuman agents. Critical Posthumanities propose a new notion of the human subject as relationally constructed by many actors and agencies and that thus is inherently "decentered" (Nicenboim et al., 2023). In addition, Braidotti (2013) also introduces a wider conception of life (zoe) that she describes as "the transversal force that cuts across and reconnects previously segregated species, categories and domains" (p. 60). In her work, the notion of "zoe-centered egalitarianism" poses the idea that life - as a quality equally shared among humans and nonhumans - is the essential foundation for a radical new postanthropocentric meaning of reality. In fact, the nature-culture continuum is to be considered the starting point for a posthuman interpretation of reality (Braidotti, 2013). Furthermore, as Braidotti (2019) highlights, Critical Posthumanities offer a horizon of becoming, they reveal that "we" - as subjects structurally related to the human and non-human world around us – are in the process of becoming posthumanist and post-anthropocentric: we are in a transition moment. In this context, as Bridle (2023) notes, the concept of more-than-human world suggests that we, as humans, are only a small part of something that is vastly bigger that becomes and transforms with everything else that surrounds us.

"All human life and being is inextricably entangled with and suffused by everything else. This broad commonwealth includes every inhabitant of the biosphere: the animals, plants, fungi, bacteria and viruses. It includes the rivers, seas, winds, stones and clouds that support, shake and shadow us. These animate forces, these companions on the great adventure of time and becoming, have much to teach us and have already taught us a great deal. We are who we are because of them, and we cannot live without them."

(BRIDLE, 2023, P. 37)

This transition to become post-anthropocentric requires new ways of being, thus of thinking and doing. It is clear, therefore, that posthuman theories have an impact on the way we design. And since design is about imaginatively shaping the future (Taylor, 2019), these emergent theories might radically reframe the way in which designers employ creativity to envision and give shape possible futures for human-nonhuman thriving.

2.1 Post-anthropocentrism meets design: the question of creativity

Since they disruptively question traditional human-centered norms, posthuman theories and post-anthropocentric stances have a notable influence on the design field in which, indeed, they have been fostering the development of new design frameworks (Forlano, 2017) that account for human-nonhuman interdependencies (Quadflieg, 2021; Tironi et al., 2023). By decentering the subject and shifting the attention from being exclusively on humans to considering also other living species, posthumanism could turn design into the mediator between human and nonhuman worlds through the inclusion of more-than-human perspectives and the consideration of planetary needs (Talgorn & Ullerup, 2023).

As a matter of fact, alternative design approaches are now emerging to move beyond the dominant anthropocentric perspective and promote new forms of engagement with the otherthan-human world. These endeavors highlight a growing interest in understanding the relations between human and nonhuman agencies as well as the new possibilities that arise from human-nonhuman collaboration (Giaccardi & Redström, 2020). The nonhuman element in design can refer to either technology or the natural biological entities. On the one hand, for instance, more-than-human design gained momentum within the Human-Computer Interaction (HCI) field and calls for the involvement of the artificial world and new technologies as design partners (Giaccardi, 2020). On the other hand, other approaches to more-than-human design are focused on engaging the natural world and biological entities. They include - but are not limited to - multispecies design (Metcalfe, 2023; Roudavski, 2020), interspecies design (Parker et al., 2022; Roudavski, 2021) or life-centered design (Borthwick et al., 2022). Further collaborative approaches to design are either becoming popular or developing - such as speculative design and design futures – to explore the potential of future scenarios to enhance human-nonhuman coexistence (Romani et al., 2022). All these approaches are being theorized, studied, and applied in academic and professional settings. Some of them are more structured and have longer history while others have been sprouting as a response to theoretical discourses and gaining relevance in the last few years as experiments to practically apply post-anthropocentric tenets to design. These emerging approaches are surely valuable attempts to evolve design practice and enable it to tackle planetary challenges. Even though they all highlight the

necessity for designers to radically change their mindsets to achieve a post-anthropocentric paradigm turn in their practice, these approaches do not explore what such a new post-anthropocentric mindset might be and how it might be developed and nurtured. Today, the notion of human impact on the planet has soaked in discourses on design and designers are increasingly becoming more aware of the negative consequences their practice can generate. So, in this scenario, as Engholm (2023) writes:

"We do not need any more knowledge about the consequences of our actions – what we need is the new mindset that this knowledge ought to produce."

(ENGHOLM, 2023, P. 63)

But what is it that needs to change in the mindset of designers in order to disrupt their humancentered perspective and make them the enablers of preferable futures for both humans and nonhumans?

In this discourse, the question of creativity is relevant because post-anthropocentrism - besides providing a radically new theoretical groundwork to rethink design practice - inevitably triggers reflections about the creativity that designers employ as well as the agents, processes, and receivers that a new post-anthropocentric type of creativity would entail (Roudavski & McCormack, 2016).

To be creative is a necessity in contemporary ever-changing world (Glăveanu & Kaufman, 2019). As a matter of fact, creativity plays a major role not only for people to manage complexity and uncertainty but also for creators to face the multiplicity of futures (Canina et al., 2021). Indeed, humans are capable of exploring the realm of the possible through the act of creatively imagining and anticipating alternative futures and by doing so they become more resilient and prone to adapt to the ever-changing environment surrounding them (Glăveanu, 2018). Creativity itself is acknowledged to be a fluctuating concept that changes and adapts according to the socio-cultural context (Runco, 2017) and, therefore, as noted by Glăveanu and Kaufman (2019), it needs to be investigated historically, considering that the world's continuous process of transformation determines the evolution of its definition too (Bruno & Canina, 2019). However, albeit the latest diffusion of posthuman theories and new understandings of creativity that account for its dynamic, future-oriented (Corazza, 2016) and transformative (Sternberg, 2021) features, nonhuman agencies and multispecies interdependence are still little explored within the debates on creativity which represents a gap to be filled to tackle the contemporary complexities and acknowledge more-than-human ecologies (Rousell et al., 2022).

A post-humanizing creativity would give us the opportunity to creatively navigate current technological and environmental transformations and help us "become" in relation to those changes (Chappell, 2022).

Post-anthropocentrism, indeed, questions the traditional conception of creativity and lays the foundation for a new understanding of creative action. In a posthuman perspective, human and nonhuman entities are connected through a relational creative interdependence and creativity facilitates the understanding of such a relationality (Haraway, 2019 as cited by Harris & Holman Jones, 2022). Therefore, it can be stated that a posthuman conception of creativity would arguably enable radical changes in how humans acknowledge their embeddedness within the ecosystem and their entanglement with the nonhuman natural world. A post-anthropocentric understanding of creativity might provide designers with a new framework to account for human-environment interdependence, something that – as mentioned previously – would be necessary to tackle contemporary climatic emergency (Camrass, 2020).

Elaborating on this, therefore, the authors argue that defining a new post-anthropocentric framework for creative practice represents an essential building block to enable a radical shift in mindset urging designers to think out of traditional binaries separating nature from culture and envision potential trajectories for more-than-human futures.

3. Post-anthropocentric Creative Framework

As argued above, in a contemporary scenario marked by the unstoppable environmental crisis and in which posthuman theories are permeating, a new type of creative practice aimed at envisioning more-than-human futures would be key in leading us through the process of becoming posthumanist and post-anthropocentric. How can posthuman theories be used as a lens to interpret creativity and creative practice?

To date, desk research has been performed to uncover the overlaps between studies on creativity and posthuman theories and start outlining the features of a post-anthropocentric creative framework to empower designers' visioning activities.

In particular, to scrutinize existing research on creativity and post-anthropocentrism, critical literature review - as a method to identify the key concepts that underpin the theme under discussion on a theoretical standpoint (Garrod, 2023) - appeared to be suitable for the purpose. The Elsevier-based database Scopus as well as Mendeley and Web of Science were used to search for relevant articles through title and abstract screening. The search query included a fixed term (creativity) preceded by an interchangeable adjective, which could vary among post-anthropocentric, more-than-human, posthuman or post-human.

Interestingly, in most cases, a keyword or a set of keywords used on different platforms would provide as results the same publications. Eventually, thirteen articles from different disciplinary areas were selected and analyzed. Two Special Issues collect most of the articles, indicating that research on the topic is still little explored and conducted by few scholars but also highlighting its relevance. Ultimately, a book was included in the literature review (Bridle, 2023).

The richest body of literature that investigates posthumanism, post-anthropocentrism and creativity appears to belong to the field of Education. However, inquiry on posthuman creativity has gained momentum in art-based research (Harris & Rousell, 2022) and it is starting to be explored within design research (Canina et al, 2021; Roudavski, 2016; Roudavski & McCormack, 2016).
The grounding set of articles introduced above was essential to get acquainted with already ongoing research on the topic of post-anthropocentric creativity and identify the key notions that underpin the theory behind it as well as those abilities or attitudes that it would require. As a matter of fact, by comparing exemplars included in this initial body of literature, authors were able to extract the recurrent notions that almost every article reiterates as essential and pose them as building blocks for the development of the framework. For instance, most of the articles analyzed highlighted the centrality of nurturing feeling to establish a deeper connection with the nonhuman world.

Therefore, in the framework, the concept of understanding the nonhuman world through feeling to encourage a deep sentiment of care for it occupies a pivotal role for steering post-anthropocentric creative action.
Reflections conducted by the authors starting from the critical review of selected literature led to the synthesis of findings into the first theorization of the **Post-anthropocentric Creative (PaC) Framework** (fig. 1).

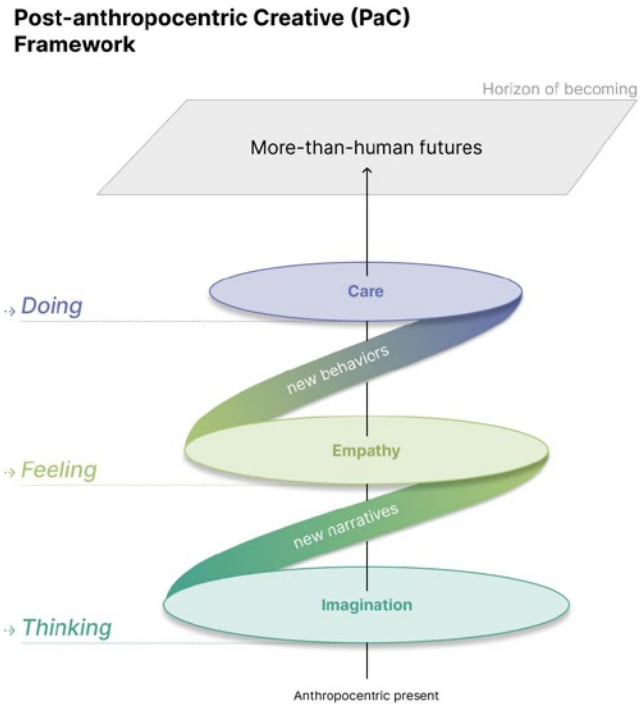

Figure 1. The Post-anthropocentric Creative (PaC) Framework. Visualization developed by the authors.

As anticipated, the framework seeks to systematize the main overlapping notions pertaining to post-anthropocentrism, the posthuman and creativity that emerged from the critical literature review. From the analysis of the literary corpus, indeed, it emerged that practices of thinkingfeeling-living in

relation with the more-than-human plurality might generate a new type of creativity that is posthuman and that has planetary scope (Harris & Rousell, 2022). The PaC framework, therefore, is grounded on a thinking-feeling-doing continuum that represents the three stages of a post-anthropocentric creative process. By delineating these stages, the framework traces a potential trajectory for the actualization of a post-anthropocentric paradigm shift, emphasizing the importance of imagination, empathy, and care as essential creative capabilities for envisioning more-than-human futures. Imagination (thinking), indeed, can facilitate the creation of new narratives that transcend anthropocentric perspectives, fostering empathy (feeling) towards the more-than-human world. Empathy is then consolidated into a deep sentiment of care, which informs responsible future-oriented actions (doing). Once the main concepts were uncovered and mapped, an additional literature review based on snowballing (Wohlin, 2014) was then conducted to expand the initial corpus with other resources to especially explore in depth imagination, empathy and care.

As emerged from the critical analysis of the literature, a posthuman perspective on creativity compels research to shift focus from what is created to how enmeshed actants create (Chappell, 2022) directing attention more towards the creative process rather than on its output. Indeed, to reframe creativity through a posthuman lens it is necessary to move away from the traditional use-value paradigm that privileges productivity over planetary wellbeing (Harris & Holman Jones, 2022; Rousell et al., 2022) and conceive it as a dispersed process that is not centralized on the human subject alone but that includes nonhumans - such as objects and environments - as embodied, agentic and enmeshed actants (Chappell, 2018, p. 14) which, together with humans, constitute creative ecologies (Harris & Holman Jones, 2022).

Therefore, the cognitive acknowledgement of human inherent interdependence with the morethan-human world and of the agency of nonhuman entities can be interpreted as the first stage of a post-anthropocentric creative process: thinking. In this stage of the process, **imagination** is perhaps the most relevant of creative abilities essential to challenge traditional dualisms and mobilize our binary thinking that frames humans as separated from nature. As a matter of fact, imagination allows us to construct mental images of what is not immediately present at our senses (Gotlieb et al., 2019; Milkoreit, 2017). Thus, it can become the connective, bordercrossing capacity to bridge the gap between the human and more-than-human worlds by enabling humans to cognitively perceive perspectives beyond themselves (Jensen, 2016) and reconsider their position with respect to other nonhuman entities.

Hence, in the discourse on reframing creativity through a post-anthropocentric lens, imagination should be seen as a boost for the creative process since it represents an essential ability for humans to mentally

embody the perspective of other beings. "Stepping into the shoes" of others could help us reduce the space that separate us from otherness and feel more connected to the more-than-human world.

As a matter of fact, as humans, we intra-act and relate with the nonhuman world (Chappell, 2018), we are deeply bounded to it. Relational encounters between humans and nonhumans are embodied and empathic felt experiences (Vagg, 2022). The state of being in-relation-with otherness - known as relationality (Haraway, 2019 as cited by Harris & Holman-Jones, 2022) - presupposes that we recognize to be affected by and connected to other nonhuman entities. What constitutes our relationality with otherness is, indeed, affect, namely our ability to transform and be transformed by what surrounds us (Massumi, 1987 as cited in Shouse, 2005). Therefore, to reconcile ourselves with the more-than-human world, to fully understand it and to feel responsible for its well-being, we need to embrace the notion that we are relationally and affectively interconnected and interdependent to it, we need to perceive our belonging to it and its power to shape us. When we open ourselves to understanding the more-than-human, we breach the established borders of thought and feeling which in turn allows us to perceive reality from another perspective (Bridle, 2023, p. 118). As a matter of fact, thinking and feeling are coconstituting, the former being imbued by affectivity that emerges from relational encounters with the more-than-human world (Rousell et al., 2022). Hence, feeling our connection to the more-than-human world, sensing our relationality with it, represents the second fundamental stage of a post-anthropocentric creative process. Such an understanding-through-feeling of the more-than-human world requires **empathy**, an act of imagination to come to know otherness and an emotive pathway towards a deeper understanding of our connection to it (Jensen, 2016). Empathy is stimulated by the perception, comprehension and attention for the experiences and perspectives of other living beings (Tam, 2013; Young et al., 2018). It is acknowledged to be an essential disposition to restore human-nature entanglement and drive transformation towards more equitable futures (Blythe et al., 2021). A post-anthropocentric conception of creativity, therefore, should leverage empathy as an ability to emotionally reconnect us to the more-thanhuman world helping us feel our strong ties to it.

As thinking and feeling are strongly linked and the boundaries between the two are blurred, so imagination and empathy – namely the main abilities that characterize the two initial stages of the post-anthropocentric creative process - are connected to one another.

Empathy is, indeed, enabled by imagination (Jensen, 2016) which, as mentioned, is the propelling force that initiates the post-anthropocentric creative process. Through imagination we can question current narratives, rooted in the binary worldview of humans-versus-nature, and build emotive pathways to understanding

otherness through stories (Jensen, 2016). As products of imagination, narratives mirror our interpretation of reality and have concrete implications on the world we build (Leitão, 2023). In fact, through stories and creative storytelling we can make and remake worlds (D. Harris & Holman Jones, 2022). With an acquired sensitivity towards the current climatic crisis and awareness regarding the posthuman condition, we could stimulate empathy towards the planet and its nonhuman inhabitants by employing imagination to rewrite anthropocentric narratives and chart a path towards morethan-human futures inspiring action to make them possible. Therefore, thinking and feeling, with their respective imaginative and empathic abilities, lead to the final stage of the post-anthropocentric creative process: doing. As noted by Milkoreit (2017), imagination – enabled by individual cognitive-emotional processes – allows us, first, to create mental images of the future and experience the emotions of the characters involved, and then, once some emotionally coherent future visions are created and collectively embraced, it has the power to impact the socio-political level, steer action in the present and modify existing norms of behavior (Camrass, 2020).

When new narratives are imagined and empathy for their "characters" is felt, **care** – the conscious sentiment of interest and concern for others – is likely to form. Care is vital for sustainable and flourishing relations with the more-than-human world because it requires us to do something, to act, to make it livable for all (Puig de la Bellacasa, 2017). Once the sentiment of care is consolidated, then designers are fully equipped to start engaging in visioning activities to anticipate more-than-human futures.

4. Conclusions

The paper aims at laying the theoretical foundations for a post-anthropocentric conception of creative practice that might enable designers in envisioning futures where humans and nonhumans coexist prosperously. Such a new type of creative practice is concretized in the making of stories depicting images of possible futures that disrupt the way in which we conceive our relations with the more-than-human world. The Post-anthropocentric Creative framework presented in this paper identifies imagination as the seed of the creative process. Imagination sparks in our flow of thinking when our previous way of relating to reality or others is questioned allowing us to move away from the here and now to explore alternative possible futures (Zittoun & Cerchia, 2013). Indeed, being a transformative capacity, imagination is key in crafting scenes of the future (Moore & Milkoreit, 2020). Leveraging on imagination, a post-anthropocentric creative practice is grounded in the creation of new narratives that could counteract traditional anthropocentric paradigms through the enhancement of feeling for the living nonhuman beings. Indeed, narratives have the power to strengthen our emotional

bond with nonhuman entities by fostering empathy, essential to reconnect humans and nature and promote pro-environmental action (Brown et al., 2019). In the design field, creative storytelling has proven to be key in enhancing our feeling of relatedness with what surrounds us and in stimulating future action (Talgorn & Ullerup, 2023). Hopefully, the alternative visions of future coexistence enabled by the PaC framework would make us feel entangled with the more-than-human world by fostering a feeling of care towards it which would steer our actions into making these futures possible. The framework will serve as a foundation for further research to investigate whether and how the employment of the PaC framework might enhance the design futures approach for envisioning preferable and more-than-human futures.

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A STUDY OF MULTISENSORY STRESS-RELIEVING PRODUCT DESIGN FOR FEMALE OFFICE WORKERS

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ABSTRACT | It analyzes the design of a stress-reducing product for female office workers, who are generally under too much stress. The study analyzes and translates user needs and design elements through questionnaires and user interviews, exploring the multisensory needs of female office workers to relieve stress. Based on the Analytic Hierarchy Process, the study prioritizes the design elements and derives the final design solution for office ladies' stressrelieving products, verifying the scientific feasibility and reference significance of the multisensory design based on AHP in the stress-relieving product design. Analytic Hierarchy Process application avoids the subjectivity and one-sidedness of the design process when considering the priority of the user's multi-sense experience, identifying the core design elements and design objectives of the stress-relieving products. The design of an intelligent stress-reducing luminaire is used as an example to test the applicability of this design method and strategy, and it also provides a reference for similar design studies.

KEYWORDS | ANALYTIC HIERARCHY PROCESS(AHP), STRESS-RELIEVING PRODUCTS, MULTISENSORY DESIGN; FEMALE OFFICE WORKER

1. Introduction

Office workers, as an essential part of the middle class, are the backbone of social development and the driving force behind economic growth. Therefore, their health conditions should receive more social attention. Research has shown that over 50% of office workers are in a state of depression, and 78% are in a sub-optimal health condition. Due to physiological factors, office ladies are more prone to emotional fluctuations when faced with pressure, leading to anxiety, worry, irritability, and other emotional reactions (Dennerstein, Smith & Morse, 1994). The severe stress issues among office ladies have become a significant hidden danger to the development of societal well-being. Assisting office ladies in relieving stress and maintaining physical and mental health is of significant practical value.

2. Research background

2.1 Nature and causes of stress

Stress is the cognitive and behavioral experience resulting from the interaction between stressors and stress responses. During the alert stage, external stressors trigger a series of physiological reactions within the body. Once these stimuli persist and enter the resistance stage, corresponding organs and systems are mobilized to cope with these stressors. If the stimuli continue to persist, the body eventually experiences exhaustion. Adaptation mechanisms that arise during the resistance stage face two possible outcomes: one is returning to the later stage of the alert stage, where other systems or organs are mobilized to cope with the stressors; the other is leading to the failure and exhaustion of the individual's bodily functions, ultimately resulting in death (see Figure 1).

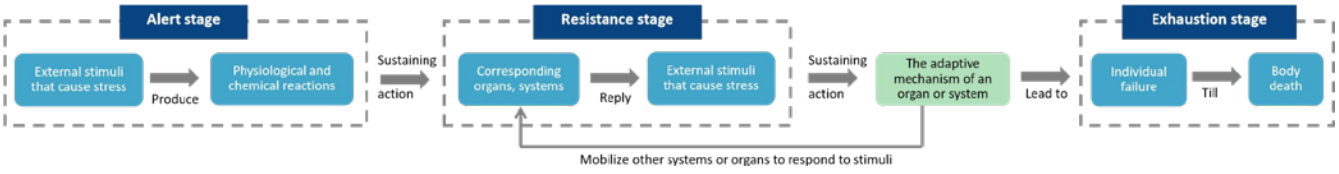

Figure 1. The diagram of the physiological response to stress.

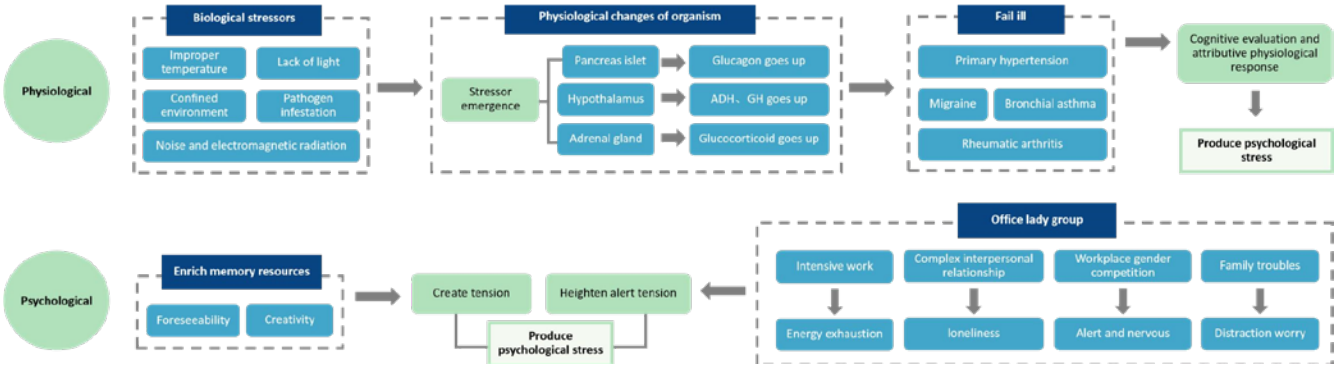

Figure 2. The flow chart of the physical and mental stress generation of female office workers.

2.2 Female office workers' stress and their stress characteristics

Intense stressors put office ladies in a prolonged state of high pressure, resulting in a significantly elevated psychological burden. The manifestations of stress and its effects on office ladies are primarily observed in physiological and psychological aspects (see Figure 2). Physiologically, stress is generated in unsuitable temperatures, enclosed environments, noise, and electromagnetic radiation. Biological stressors interact with the human body, leading to physiological changes. The appearance of stressors triggers an increase in hormones, causing conditions such as hypertension, migraines, arthritis, asthma, and other psychosomatic disorders, thus posing a threat to physical health and creating physiological stress. Simultaneously, individuals cognitively perceive and attribute the previous physiological reactions (Clougherty, Souza, K & Cullen, 2010) , forming psychological stress.

2.3 Current status of stress-relieving products

A comparative study of stress reduction products available on the market shows that there is currently a wide variety of stress reduction products (Jieling & Phungamdee, 2023), mainly categorized into three types: toy and puzzle-based products, training-based products, and impact and venting-based products. Most toy and puzzle-based stress reduction products combine elements such as Rubik's cubes and various hand movements to challenge users' cognitive abilities and achieve a calming effect (Clark , 2017). Examples include wireless fingertip-flipping cubes and puzzle gyro beans. Training-based stress reduction products often involve training specific bodily functions, such as ROM finger trainers and self-starting wrist power balls, which employ simple repetitive movements to reduce stress.

However, these products are generally only suitable for users during their leisure time and have limited long-term stress reduction effects. Impact and venting-based stress reduction products aim to outlet users' anger and frustration through squeezing and kneading actions, exemplified by products like screaming chickens. Although they offer a temporary release of stress through a direct and forceful approach, they do not address the underlying sources of stress. Overall, while stress reduction has gained broad attention in product design, there is still a research gap in the development of stress reduction products specifically tailored to the needs of women. Therefore, this study focuses on developing stress reduction designs specifically targeting office ladies

3. Research method and design process

3.1 Multisensory experiences and stress-relieving products

The 'multi-senses' typically refer to the human perception of the surrounding environment and objects through sight, hearing, smell, taste, and touch, consciously observing, analyzing, processing, and providing behavioral feedback through various senses (Mehraliyev, Kirilenko, & Choi, 2020). Excellent 'five senses' experience design, through information integration and processing, assists users in achieving a higher level of rational information construction in sensory experiences (Spence, C. 2011).

The multisensory experiences forms the foundation of a user-centric design mindset, with sensory experience at its core (AbuKhousa, El-Tahawy & Atif, 2023). It involves the dual perception of physiological and psychological senses, receiving, perceiving, and processing information. In the 1970s, Ayresa proposed the sensory integration theory, which elucidated the inseparable relationship between human sensory perception, brain function, and psychology.

As the fundamental means by which people capture, receive, and process information, applying the multisensory experiences to stress reduction product design can deeply satisfy users' sensory experiential needs and thereby achieve stress reduction effects (see Figure 3).

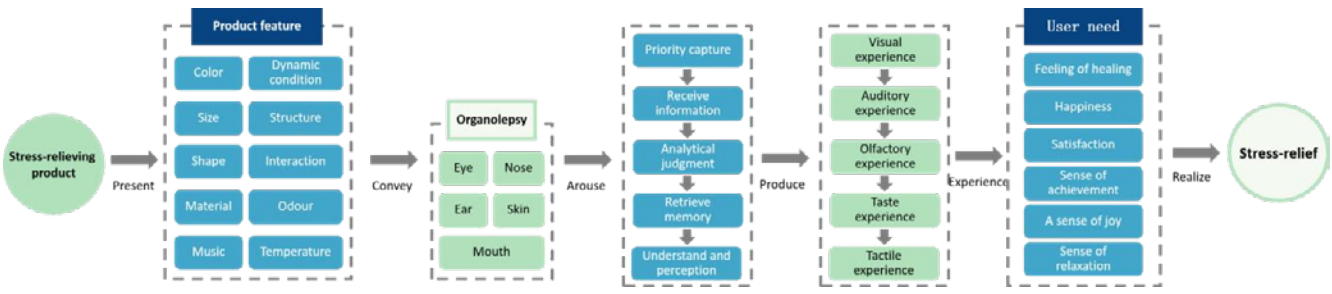

Figure3. The flow chart of multisensory experiences to achieve stress reduction effect.

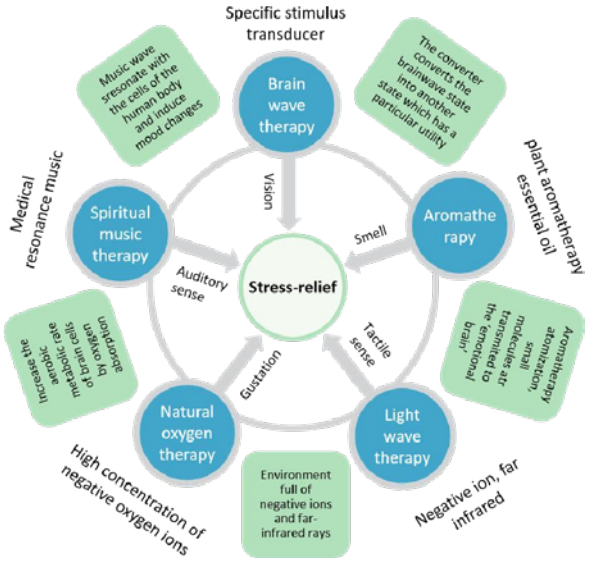

Figure4. The analysis of stress reduction therapy based on multisensory experiences.

By analyzing scientific therapies with stress-reducing effects, a series of scientifically based stress-reducing methods based on the five-sense experiences were compiled (see Figure 4). Key elements were identified, including specific stimulus converters, three-dimensional spatiotemporal dynamic structured medical resonance music, aromatherapy with plant essential oils, highconcentration negative oxygen ions, and far-infrared radiation(Didi & Yanmei, 2021). A critical behavioral analysis was also conducted to understand the realization of stress-reducing effects. These findings provide valuable inspiration and guidance for designing and researching stressreducing products.

3.2 Multisensory experiences and stress-relieving products

The Analytic Hierarchy Process (AHP) is a practical and effective multi-criteria decision-making method that quantifies and processes subjective judgments of individuals. By combining qualitative, subjective descriptions with quantitative objective comparisons, AHP systematically analyzes samples based on mathematical models. When analyzing and making decisions about complex problems, AHP can effectively avoid the subjective bias caused by changing demands.

The factors influencing the five-sense experiences are complex and diverse, making AHP suitable for comparative analysis of multiple factors under complex conditions (Horng & Hsu, 2020). To obtain precise user sensory needs, the five-sense experiences - AHP method (see Figure 5) is employed to qualitatively and quantitatively investigate and analyze the target group. This approach explores the core pain points and sensory needs of office ladies facing stress, analyzes important factors, calculates the weights of influencing factors, and presents scientific results in order of importance.

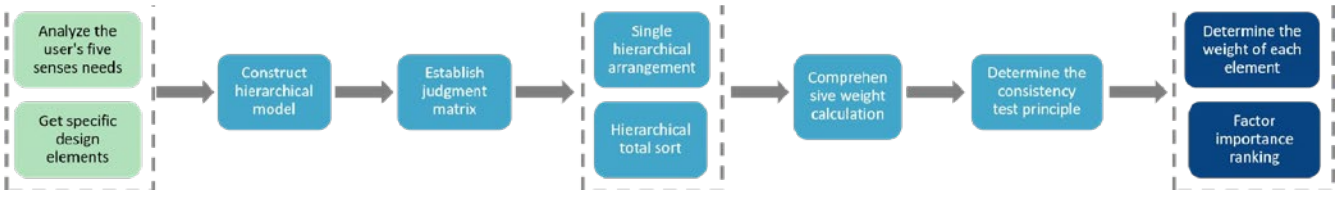

Figure5. The application process of multisensory experiences - AHP.

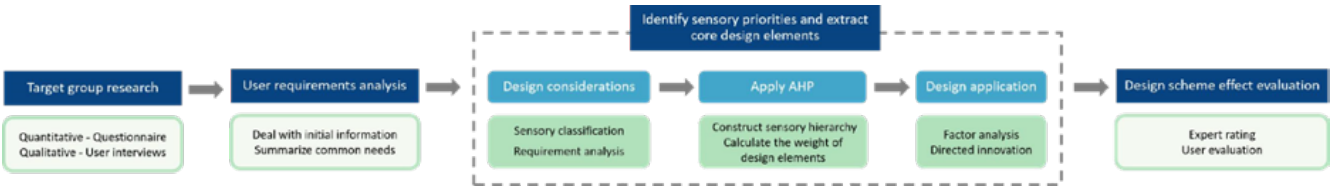

Figure6. The multisensory experiences design flowchart of female office worker' stress reduction products based on AHP.

3.3 Analysis of the design process of efficient and stress-relieving product design for female office workers

The design innovation of stress-reducing products targeting office women is achieved by introducing the Analytic Hierarchy Process (AHP) to determine sensory priorities and extract core design elements, thereby achieving the goal of stress reduction. Firstly, an analysis of the target users is conducted to understand office ladies' overall needs and design elements. This information is then combined with the AHP method to construct a hierarchical model and calculate the target weights of the design elements. Finally, the results are filtered, ranked, and analyzed to enhance design efficiency and user satisfaction. This process ensures that the design of stressreducing products for office ladies is focused on the most essential sensory aspects, providing an effective solution for stress reduction while improving (see Figure 6).

1. Through user interviews and surveys, a quantitative and qualitative investigation of the target group's sensory needs is conducted, summarizing the expected directions and attributes of stress-reducing products for office ladies;

2. In-depth analysis of the research results helps designers accurately capture the target group's implicit needs and underlying motivations, which are then transformed into design requirements;

3. The user needs are further categorized and summarized to perform a qualitative analysis of design requirements, determining the multisensory experience design elements and design directions;

4. Based on the AHP method, the sensory needs of the target group are transformed into a hierarchical structure model, and mathematical methods are used to quantify the design elements based on the established judgment matrix, further clarifying the design objectives;

5. The comprehensive weights of all design elements are ranked and selected, analyzing and understanding each element to derive and determine design solutions;

6. A professional assessment of the final design solutions is conducted. Objective quantitative data is obtained through relevant stress testing to assess the stressrelieving effectiveness of the product. Subjective qualitative evaluations are gathered through expert ratings and user feedback after using the product to validate the scientific effectiveness of the proposed solution;

4. Design process

4.1 User research

To obtain precise user sensory needs using the AHP method, the initial step involves analyzing and researching the target user group, which is achieved by combining quantitative research through questionnaire surveys with qualitative research through user interviews. The research aims to identify the core pain points associated with stress among office women, specifically focusing on the five-sense experiences. A detailed analysis is also conducted to determine the relatively important factors involved (see Figure 7).

To understand the market satisfaction of the target office women group regarding stress-relieving products, Net Promoter Score (NPS) and research questionnaires are used to explore their satisfaction levels with product types, styles, and performance. To ensure a higher level of accuracy, 100 questionnaires are distributed in office buildings, business district cafes, and residential areas. 72, 78, and 66 valid questionnaires were collected from these locations, respectively.

Thirty representative users were selected from the initial research participants, who are office ladies, for in-depth user interviews. The interviews aim to gather preliminary information about the target group's needs by recording the insights shared by the interviewees. This process helps designers identify unknown issues, capture implicit needs, and uncover underlying motivations. Similar or synonymous information is integrated and refined through categorization and stigmatization, leading to the analysis and transformation of these insights into design requirements.

4.2 Analysis of research results

The collected valid questionnaires are organized and analyzed. The Net Promoter Score indicates that the target group's satisfaction with stress-relief products in the market is relatively low. Over threequarters of the respondents have high expectations for stress-relief products, with 91.2% expressing anticipation for incorporating the five-sense experiences into stress-relief products. Through systematic analysis from a design

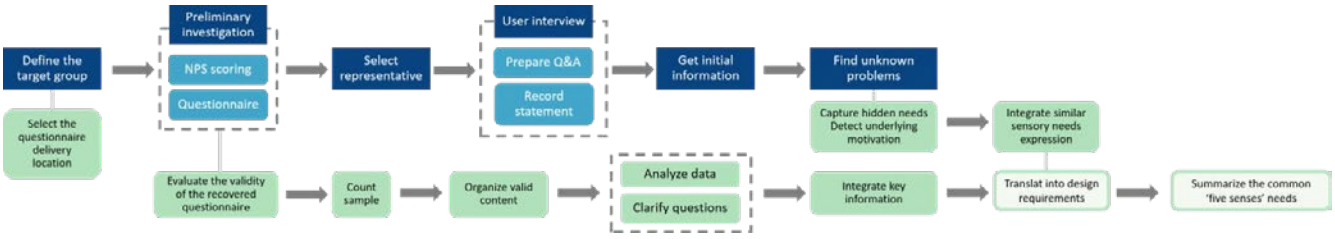

Figure7. The flow chart of the need analysis of user research and multisensory experiences design.

perspective, the valid information conveyed through questionnaire surveys and user interviews is classified, organized, and refined. The analysis identifies users' motivations and ambiguous needs by considering relevant design elements and transforming their language into a concrete overview of user requirements. The sensory factors that influence the stress-relief experience of office ladies are summarized and categorized based on the five-sense experiences. Additionally, the affinity diagram method is used to hierarchically classify the types of five-sense experiences needs and product attributes for office women, completing the qualitative analysis of their requirements.

4.3 Design evaluation grade index weight calculation

Based on the research results above, the leading indicators of the five-sense experiences include visual, auditory, olfactory, gustatory, and tactile experiences. According to the research findings, a set of criteria for ranking the importance of the five-sense experiences design is established, as shown in Table 1.

Table 1. Evaluation grade index of multisensory experiences design.

	Primary index	Secondary index		
The importance of multisensorydesign(U)	U1:Visual experience	U11: Color expression	U12: Dynamic characteristic	U13: Appearance and shape
	U2:Aural experience	U21: Timbre type	U22: Sound intensity	U23: Repetition Period
	U3:Olfactory experience	U31: Odor type	U32: Emotional symbol	U33: Distribution retention period
	U4:Taste experience	U41: Flavor type	U42: Cleanliness health	U43: Synaesthesia effect
	U5:Tactile experience	U51:Material hardness	U52: Windchill	U53: Assembling method

In the study, the weights of the aforementioned secondary indicators were calculated using the expert questionnaire method. Assuming there were L experts involved in the evaluation, a Delphi Technique-based questionnaire survey was conducted. Based on the statistical results, a ranking matrix was obtained and recorded as follows:

$$A = (a_{xi})_{L*M} (x = 1,2,\ldots,L, i = 1,2,\ldots,M)$$

After obtaining the scores from the experts, the entropy value is calculated using entropy theory. Based on the aforementioned theoretical support, the weights of each indicator are calculated to further clarify the weights of the secondary indicators in this study, as shown in Table 2.

Table 2. Secondary index weight.

Secondary index	U11: Color expression	U12: Dynamic characteristic	U13: Appearance and shape	U21: Timbre type	U22: Sound intensity
Weight	0.5	0.3	0.2	0.4	0.3
Secondary index	U23: Repetition Period	U31: Odor type	U32: Emotional symbol	U33: Distribution retention period	U41: Flavor type
Weight	0.3	0.5	0.3	0.2	0.4
Secondary index	U42: Cleanliness health	U43: Synaesthesia effect	U51: Material hardness	U52: Windchill	U53: Assembling method
Weight	0.3	0.3	0.5	0.3	0.2

Based on the weight distribution mentioned above, all secondary indicators are categorized into 'Major Impact', 'Moderate Impact', and 'Minor Impact' based on their importance. Then, the secondary indicators are scored according to their importance level, and the final scores of the primary indicators are calculated based on their respective weights, as shown in Table 3.

Table 3. Secondary index score.

Table Rows	**Secondary index**	Scoring interval	Final score for primary index
p1	U11: Color expression	[90,100]	p
p2	U12: Dynamic characteristic	[80,90]	
p3	U13: Appearance and shape	[0,80]	
w1	U21: Timbre type	[90,100]	W
w2	U22: Sound intensity	[80,90]	
w3	U23: Repetition Period	[0,80]	
c1	U31: Odor type	[90,100]	C
c2	U32: Emotional symbol	[80,90]	
c3	U33: Distribution retention period	[0,80]	
m1	U41: Flavor type	[90,100]	M
m2	U42: Cleanliness health	[80,90]	
m3	U43: Synaesthesia effect	[0,80]	
n1	U51: Material hardness	[90,100]	N
n2	U52: Temperature sensation	[80,90]	
n3	U53: Assembling mode	[0,80]	

4.4 Multisensory experiences elements priority analysis

Based on the calculated results, the design elements for this project are ranked in the following order of importance: Visual > Tactile > Auditory > Olfactory > Gustatory. It is crucial to strike a balance in the distribution of importance among the different senses in the subsequent design plans.

Considering the secondary weights, the following conclusions can be drawn:

1. Visual Experience: Color expression and dynamic features are the most critical factors, while the shape pf product is of secondary importance. Therefore, it is essential to focus on visually appealing effects by utilizing colors and shapes that resonate with the target users' psychology. Incorporating dynamic interactions can enhance both functionality and aesthetics (Cybulski, Keller, Nguyen & Saundage, 2015);

2. Tactile Experience: Material hardness and temperature perception are significant factors. The design plan should consider the varying impact of material softness or hardness and texture on the user experience. By testing the pressure feedback of the human body at different temperatures, the temperature of the contact surface can be optimized. The assembly method should facilitate convenience, amusement, and problem-solving during user interactions, thereby aiding stress relief;

3. Auditory Experience: Sound type and sound intensity are the most important factors. Given the wide range of music genres, the design plan should make the best choice based on the project's theme. Consider the users' common preferences for sound types and the experiential environment of the product. The playback mode should be determined according to the product's functionalities, with a focus on efficiency;

4. Olfactory Experience: Scent type and emotional representation are the most critical factors, considering their alignment with the product's visual theme. The concentration and diffusion period should be intelligently controllable, allowing for flexible and precise adjustments based on user perception;

5. Gustatory Experience: Taste type and cleanliness are important factors. It involves not only stimulating the taste buds but also incorporating green and healthy concepts.

5. Design implement

5.1 The design practice about Multisensory stress-relieving product for female office workers

The design requirements are prioritized based on the 'Multisensory-AHP' method. The final design solution is an intelligent stress-relief lamp called 'BREATH·BLOSSOM', which utilizes multisensory interaction to reduce stress (see Figure 8).

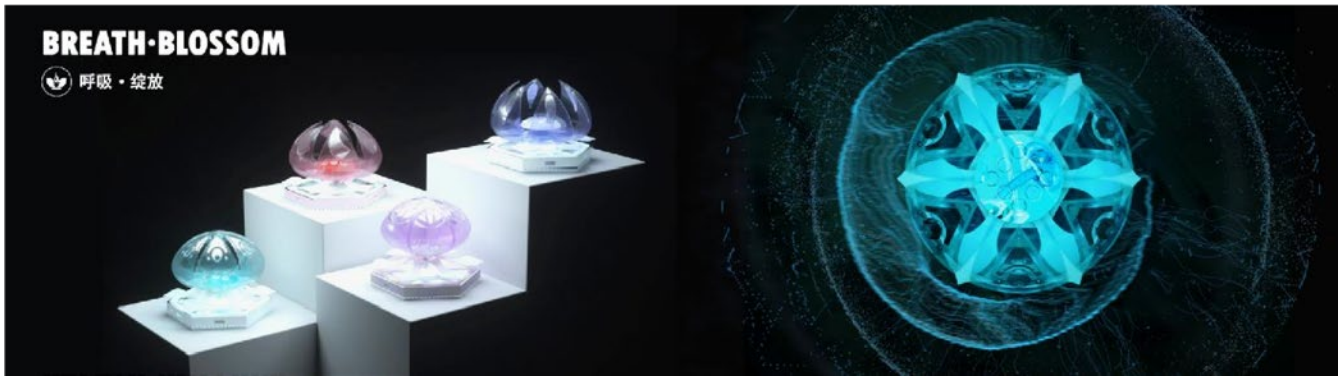

Figure8. The multisensory stress reduction product design for female office workers.

5.2 Visual experience

The color series draws inspiration from the natural world, selecting shades of cherry blossom pink, lilac purple, spring green, and icy blue, creating a dreamy style, as shown in Figure 9(a). Regarding petal shape, it takes cues from flowers in nature and applies digitally enhanced fiber textures (see Figure 9b) to mimic the illumination of light sources on the display screen. Distilling the features, corresponding simple geometric patterns are designed and applied to dynamic screen patterns, petal flat shapes (see Figure 9c), and mobile icons (see Figure 9d). The dynamic patterns displayed on the screen act as light sources regarding dynamic features and stress reduction functionality. Through a unique translucent lens, they form specific light trajectories through an opening and closing structure, serving as a stimulation converter that affects the user's brainwave state and achieves stress reduction, as shown in Figure 9(e). The opening and blooming of flower elements showcase the rhythm of life's breathing, echoing the action of taking a deep breath, helping users experience the magical beauty of life, find inner calmness, and alleviate stress.

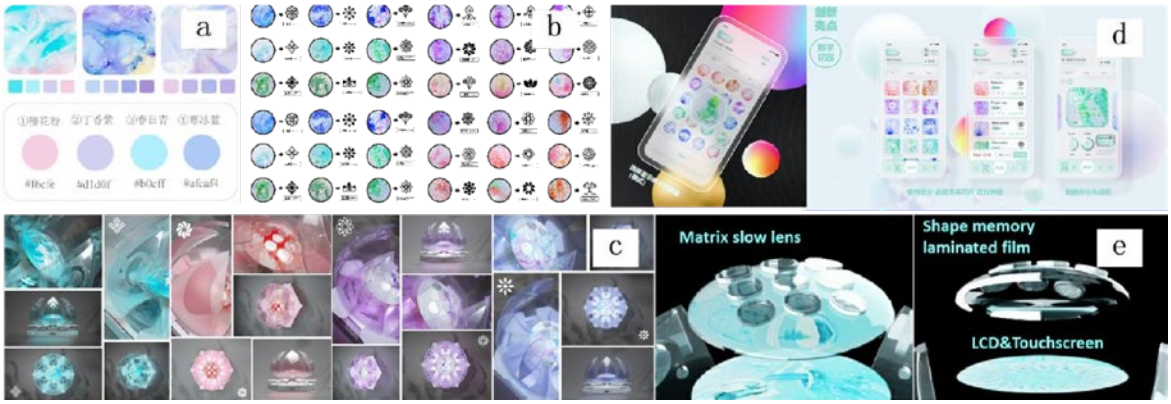

Figure9. The visual experience analysis of the design solution.

5.3 Tactile experience

The external main structure of the product is made of translucent gradient flexible plastics (PE, PP). The surface of this material has low hardness. It offers a soft and comfortable texture, making it easy for users to squeeze and adjust their emotions, providing a means to release and relieve stress. Additionally, it has excellent heat resistance and serves as a stable electrical insulating material, meeting the basic requirements for the primary material of the lamp. The internal functional carrier of the intelligent wall lamp adopts various metal and memory layer composite thin film materials. The bottom of the product contains sensors that automatically detect infrared signals using infrared reflection principles, enabling the lamp to be turned on and off with a swipe of the hand. It also allows for touch-sensitive dimming when the hand is held in place and can adjust the sensing temperature on the product's surface based on the user's mood, as shown in Figure 10(a). The hexagonal product units can be creatively assembled and DIY-ed for added fun and educational value(Cheng, 2019), reducing stress, as shown in Figure 10(b).

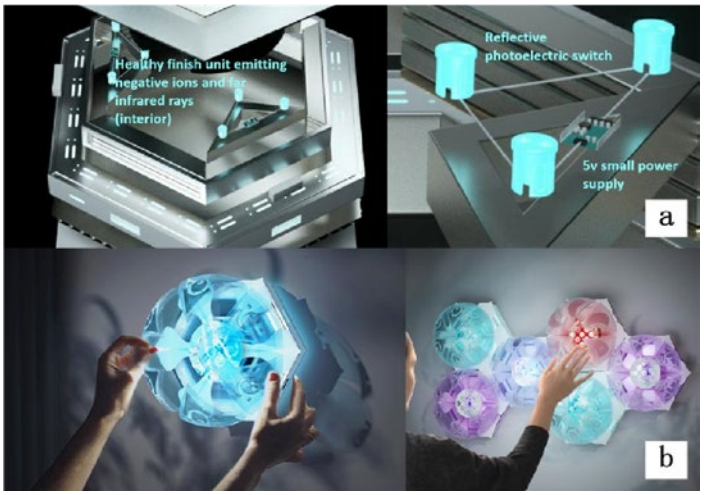

Figure10. The tactile experience analysis of the design solution.

5.4 Auditory experience

The sound profile selected for the product consists of specially designed medical resonance music with a fixed short cycle, accompanied by the rhythmic movement of opening and closing petals. The central axis asymmetric sound structure includes an internal magnetic full-range speaker (see Figure 11). The music vibrations of the medical resonance music harmonize with the body's cells, and the volume can be flexibly adjusted based on the user's experience, influencing emotional changes. The music complements the visual effects of the product, adding a dreamy atmosphere. Users can freely switch between different music tracks within the app interface and control the speakers' volume by dragging the sound axis, as shown in Figure 13(b).

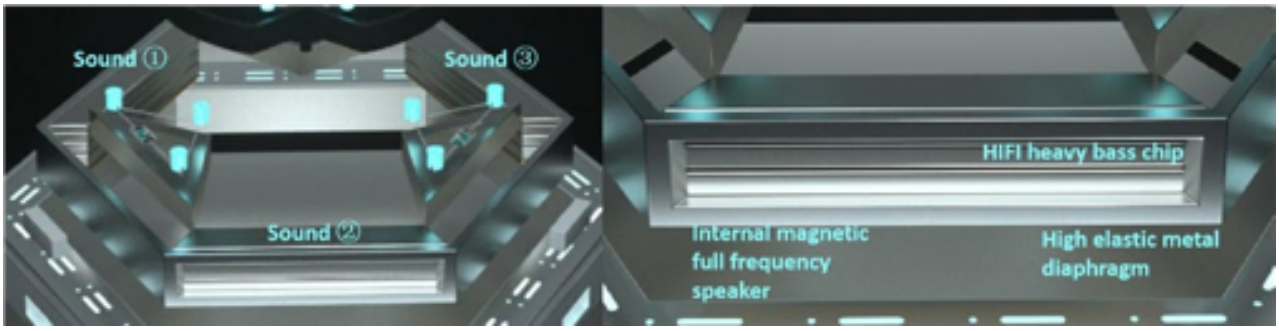

Figure11. The auditory experience analysis of the design solution.

5.5 Olfactory experience

The product features a built-in structure for placing plant essential oil aroma pads, which naturally diffuse through multiple diffusion holes. Different blooming modes correspond to different types of aromas, satisfying emotional symbolism. The base of the unit can be rotated and opened to replace the aroma pads (see Figure 12), and a rotary button can control the intensity of the fragrance. Additionally, the breath-ability film on top of the aroma box can be adjusted via the app to achieve more precise control of the aroma concentration, as shown in Figure 13(b).

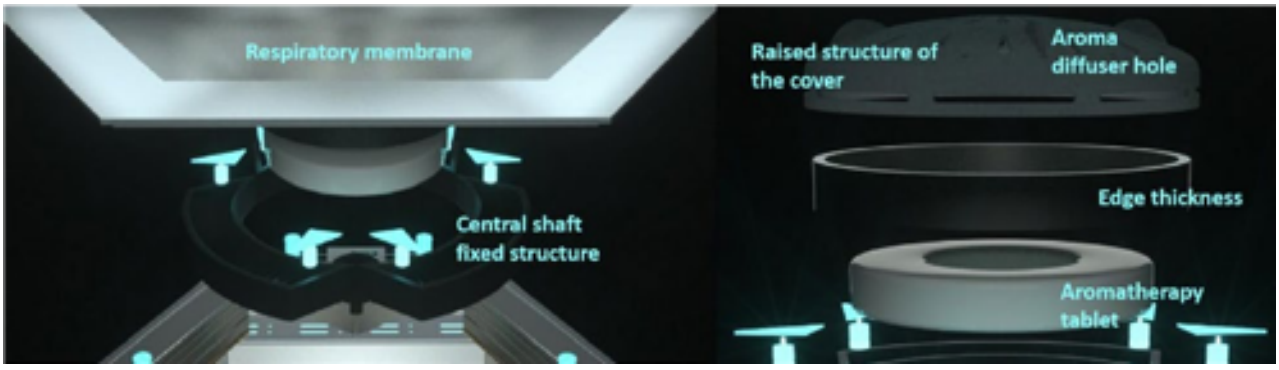

Figure12. The olfactory experience analysis of the design solution.

5.6 Gustatory experience

They were considering the type and cleanliness. The bottom of the product features a magnetic suction structure with an embedded fullerene release terminal that houses a negative ion generator capable of producing 450,000 ions per cubic centimeter per second. This aids in the efficient removal of dust and odor, reducing fatigue and increasing brain cells' aerobic metabolism rate, as shown in Figure 13(a). Users can feel as if they are immersed in nature, experiencing the breath of life and appreciating its rhythm. The app interface allows users to control the concentration of negative ions by dragging the concentration axis, which essentially adjusts the breath-ability film density of the lower gas release section, as shown in Figure 13(b).

Figure13. The gustatory experience analysis of the design solution.

6. Design evaluation

6.1 Expert evaluation

In order to achieve a comprehensive sensory experience design for stress-relieving products, it is necessary to conduct a professional evaluation and user feedback testing to assess the degree of target achievement in meeting the needs and elements of the target group. A group of 20 experts has been invited to evaluate the degree of requirement fulfillment in this research, using a sevenpoint scale as the rating standard. The horizontal axis represents the evaluation indicators, while the vertical axis represents the score points, which show a positive correlation with users' degree of requirement fulfillment (see Figure 14 a).

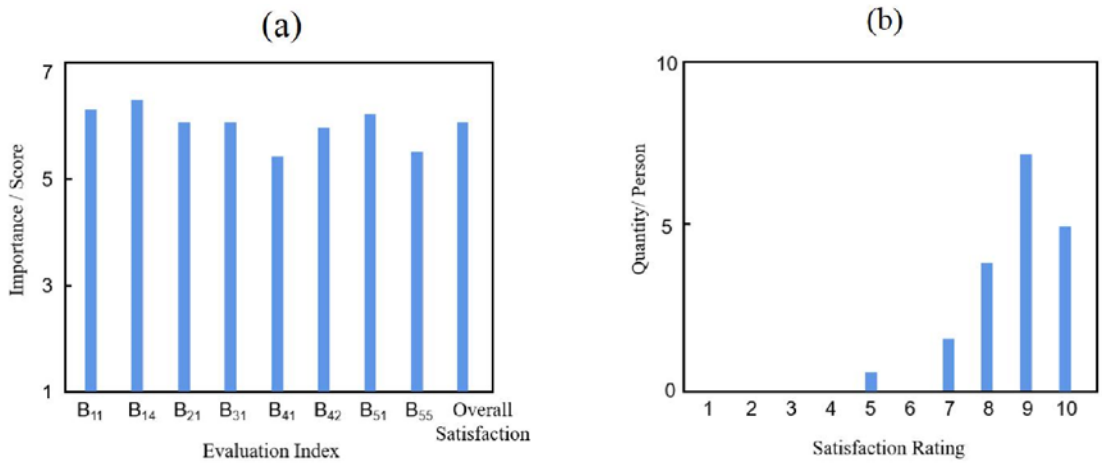

Figure14. The design evaluation results:(a)The evaluation result of the expert panel, (b)User NPS rating results.

6.2 User scoring

To assess the satisfaction level of the proposed product solution, 30 respondents who were interviewed previously were invited to participate in a Net Promoter Score (NPS) test. The NPS is used as the scoring criterion, with the score points represented on the horizontal axis and the number of respondents on the vertical axis. The respondents' recommendation scores are positively correlated with their satisfaction and loyalty towards the product (see Figure 14 b). The overall NPS score for the solution is 48.9, indicating that it meets the target users' requirements and is considered a relatively successful design solution.

7. Conclusion

This paper delves into the specific sensory requirements for stress relief, with a particular focus on office laddies. The Analytic Hierarchy Process is employed to explore these requirements. Through a series of processes including user research, requirement analysis, and weight calculation analysis, the paper effectively extracts, analyzes, transforms, integrates, and applies user requirements and design elements. This systematic approach mitigates subjective decision-making in the design process, culminating in a design that aims to help office laddies alleviate stress through the multiensory experience. The findings of this study provide scientific guidance for related design practices.

By prioritizing the sensory needs of target group, this study conducts a case study on the design of stress-relieving products. The AHP method is utilized to enhance design efficiency and user satisfaction, as well as validate the actual stress relief effects of the products. The research methodology and process are rooted in the issue of stress among female office workers and incorporate the practical application of stress relief through multisensory experiences. As a result, this study offers valuable insights and reference for future research on similar products.

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BRAND STRATEGY EMPOWERS THE REVITALIZATION OF RURAL AREAS AND SOCIAL INNOVATION IN CHINA

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ABSTRACT | Under the vigorous promotion of the rural revitalization strategy, China has witnessed a series of localized design explorations and practical applications deeply rooted in the development of rural areas. These practices usually focus on optimizing specific agricultural products, planning tourist routes, or exploring cultural resources. In order to systematically activate the rural economy, this study focuses on brand strategy as an important means to integrate and further advance rural resources, promote comprehensive and sustainable rural development, and drive social innovation. Taking the regional brand construction practice in Longshan County, Hunan Province, China as a typical case, it illustrates how to propose a vision and strategic model for regional brand construction driven by rural resources through the intervention of brand strategy. It emphasizes the organic integration of strategic analysis and evaluation stage, brand construction and execution stage, and sustainable development stage of rural revitalization. It proposes synergistic effects between small circulation dominated by three major industries and large circulation guided by brand strategy: primary and secondary industries provide raw materials for tertiary industry while tertiary industry promotes optimization and upgrading of primary and secondary industries to form a small circulation; under the guidance of brand strategy, various industries cluster for development which drives comprehensive improvement in regional brand public services to form a large circulation. Ensuring replicability of pathways and adaptability of models is also emphasized while providing a reference for future research on rural revitalization.

KEYWORDS | CHINA'S RURAL REVITALIZATION; BRAND STRATEGY; SOCIAL INNOVATION; SUSTAINABLE DEVELOPMENT

1. Introduction

1.1 Social Background: Current Situation of China's Rural Revitalization Strategy Development

With the process of modernization, the definition of rural areas has expanded beyond settlements primarily inhabited by agricultural populations engaged in farming activities. It has evolved into a comprehensive regional entity that encompasses natural, social, and economic characteristics. The special relationship between rural and urban areas emphasizes the importance of sustainable development in rural areas.

Since the 21st century, China has implemented several policy supplements and adjustments regarding rural issues. In 2012, a new wave of building beautiful countryside swept across the country, marking a new stage in China's rural construction. On October 18th, 2017, the report from the 19th National Congress pointed out that issues related to agriculture, rural areas and farmers are fundamental to national economy and people's livelihoods. It emphasized that solving these issues should always be given top priority by the entire Party and implementing the strategy for revitalizing rural areas (Xiang & Song, 2023).

Thus far, "rural revitalization strategy" has been officially proposed with multidimensional features emphasizing on enhancing the economic, social and cultural development levels of rural areas through leveraging their resources and potentialities to achieve coordinated urbanrural development as well as sustainable development.

1.2 Literature Review: Research Status of China's Rural Revitalization Strategy

The application of sustainable development theory to rural areas initially emphasized the importance of rational utilization of natural resources in achieving the goal of rural sustainable development. As understanding of rural areas deepens, attention and mobilization of resources for rural development gradually expand beyond natural resources to include cultural resources, human talent, tourism resources, and more. Sustainability concerns have

increasingly gained importance among organizations and their stakeholders around the world (Caiado et al., 2017).

However, achieving comprehensive mobilization of resources and collaborative cooperation among stakeholders is relatively challenging within such a complex system that encompasses various types of resources involving multiple stakeholders like those found in rural areas. The design discipline demonstrates unique advantages under these circumstances as it possesses strong interdisciplinary attributes.

The design discipline is undergoing a transition from “material design” to “strategic design”(Lou, 2010). In the past, design often relied on a point-to-point approach within individual disciplines to create added value or address immediate challenges. However, contemporary practice necessitates a consideration of how to confront complex issues through systematic integration (Papanek, 1985). This shift indicates that the manner in which design intervenes in “stuck” scenarios has evolved from early practices of “end-of-pipe solutions” towards more proactive “source interventions” (Liu et al., 2022).

This closely aligns with strategic brand building. As a core concept in enterprise management, brand strategy encompasses foundational theories such as brand positioning, brand value, and brand identity (Kapferer, 2008). It emphasizes the establishment of market position and enhancement of competitive advantage through clear brand positioning and systematic brand management. The introduction of brand strategy offers new perspectives and methodologies for rural revitalization. Chinese researchers have explored the theoretical implications and case analyses related to brand strategy, elucidating its specific application models and outcomes within various contexts of rural revitalization.

Numerous studies have analyzed the successful application of brand strategies in rural revitalization through specific case studies. The implementation of brand strategies in rural economies primarily manifests in the branding of agricultural products. Scholars have explored reasonable suggestions for enhancing the competitiveness and market influence of locally distinctive agricultural product brands from various perspectives, including brand value creation and promotional activities (Xiong et al., 2024). Additionally, some researchers have examined typical marketing cases of local specialty agricultural products to propose branding strategies within the context of rural revitalization (Tao & Tao, 2023). Furthermore, other scholars have approached the exploration of development paths for rural revitalization by focusing on rural culture. For instance, they constructed a model for cultural branding strategy based on design management experience across four dimensions: emotional service, strategic planning, organizational collaboration, and touchpoint experience (Liu & Du, 2024).

These research also address challenges and countermeasures related to the implementation of brand strategies (Deng, 2024). It discusses issues arising from advancements in digital information technology that complicate resource integration during brand strategy planning. These include a lack of diversity in brand communication models and insufficient collaboration among relevant stakeholders; corresponding response strategies are proposed to address these challenges.

In summary, various disciplines within design have made numerous attempts at academic research and project practices for rural development focusing on multiple aspects such as agricultural industry, cultural industry, and tourism industry which reflects scholars considerations for multidimensional needs in revitalizing rural areas. However, research examining the interlinkages between different industries from a macro-strategic perspective at the rural level remains relatively scarce. If rural development focuses solely on the isolated growth of a single industry, it may encounter limitations in economic diversification and potential for growth due to resource singularity. Additionally, this dependence and isolation make it difficult for rural areas to withstand constant external shocks in market competition. Furthermore, excessive exploitation and use of limited resources may cause irreversible damage to the rural ecological environment, affecting its ecological balance and capacity for sustainable development. This contradicts the requirements set forth by the sustainable development model - meeting human needs while ensuring social equity and respecting environmental limits (Holden et al., 2017).

1.3 Critical Path: The Importance of Regional Brand Development in Promoting Sustainable Rural Development

The key to achieving sustainable rural development lies in the implementation of national policies and fostering cooperation across sectors and localities, while also emphasizing citizens' self-reliance and self-organization. (Bock, 2015). In this context, rural resources in rural areas can serve as a stimulus for social innovation, leading to more comprehensive rural awareness, more proactive social innovation and more feasible sustainable development (Artur et al., 2023).

Combining the connotation of brand strategy and the research status of rural revitalization, this study will focus on the construction of rural regional brand. The construction of regional brands contributes to the formation of an industrial brand cluster with a certain regional characteristic of "Distinctive brand + Industry + Region", achieving the sustainable development of rural areas through "self-organization". Different from the previous brand strategy that only focuses on the development of a certain industrial chain when it intervenes in rural areas, regional brand is oftenbased on specific regional

history, culture, geography or industrial background and involve the competition and integration of local advantageous industries and leading industries (Ma, 2023). In the process of constructing rural regional brands, the countryside serves as the foundation, brand strategy serves as the path method, sustainable development concept serves as the guiding principle, and promoting social innovation and sustainable development in rural areas is our goal.

Therefore, Rural regional brand building from the perspective of brand strategy has unique advantages, which goes beyond pursuing single-industry development; instead, it starts from a macro-strategic level to implement specific strategies that emphasize horizontal connections between industries. It aims to construct a unique and comprehensive image for rural areas tailored to local conditions in order to promote comprehensive coordination and sustainable development across economic, social, and cultural aspects in rural areas.

1.4 Research Purpose and Significance

This article integrates brand strategy to consider the issue of "from line to surface" and explores how to effectively build and promote regional brands in the cause of rural revitalization for sustainable development. The aim is to provide a systematic approach for the rural revitalization cause in China, establish a resource-driven model for sustainable development based on the analysis of rural resources and geographical features, and support social innovation and rural sustainable development.

2. Research and Problem Definition

Longshan County is located in the hinterland of Wuling Mountains, Hunan Province, China. Due to its geographical location and the gathering place of Tujia ethnic culture, it has unique advantages in terms of natural resources and cultural resources. Despite being endowed with rich natural and cultural resources, Longshan County still faces significant economic challenges. As of 2022, the per capita GDP in this county reached 23,500 yuan per person. While this number indicates some momentum in economic growth, it only accounts for 27.4% compared to the national average level and 32.7% compared to the overall level in Hunan province, highlighting regional economic imbalances and pervasive poverty issues. In order to address this situation, Longshan County is actively seeking a path towards transformation and upgrading.

The project team first arrived at Longshan County in Hunan Province in November 2023. We visited natural scenic spots, industrial parks, and cultural museums with local government officials as guides to gain a preliminary understanding of existing resources in Longshan County.

Longshan County is rich in resources, with natural resources such as Wulong Mountain and Bamian Mountain, agricultural resources such as lilies, navel orange, cured meat, Tujia brocade, Rebala Tujia settlement, Qin Dynasty culture and other historical and cultural resources. However, under the appearance of rich resources and industries, the industrial development of Longshan County is facing challenges. The acidic soil and selenium content in the territory provide a high-quality soil environment for the growth of high-quality lily□but the lily industry in Longshan County presents a decentralized management model of small farmers and workshops, which reflects the diversity and flexibility of the local area, but also restricts the scale and branding process of the lily industry. In terms of brand development, although the navel orange fruit surface in Longshan County is orange-red, sweet and sour, and has distinct local characteristics, the existing navel orange brand has the problem of low brand recognition and limited market influence. In addition, while Longshan County possesses relatively abundant historical and cultural resources, its development process has been hindered by unclear positioning, a lack of focus, and insufficient resource integration. As a result, the development efforts have become fragmented, leading to suboptimal benefits.

In light of the existing challenges in the industrial development of Longshan County, the project team has gradually defined its design objectives for establishing a regional brand for Longshan County. The core mission of regional brand construction is to effectively balance between regional brands and various product brands within the region in order to stimulate maximum synergistic effects and maximize brand value release. This requires macro-level brand strategy guidance. From a high-level scrutiny perspective on rural revitalization underpinned by brand strategy, it is an integrated system engineering under a single vision spanning across multiple leading industries and auxiliary industries, achieving multi-dimensional and multi-level strategic combinations with characteristics such as locality stage connectivity replicability (Manzini, 2015), holding significant implications for social innovation and rural sustainable development.

3. Design Proposal Development

Therefore, in response to the issues of insufficient industrial scale, low brand recognition, and fragmented cultural resource development in Longshan County, the project team has structured the regional brand building for Longshan County into three stages (Figure 1). This approach is aligned with the principles of brand strategy synergy (Aaker, 1996).

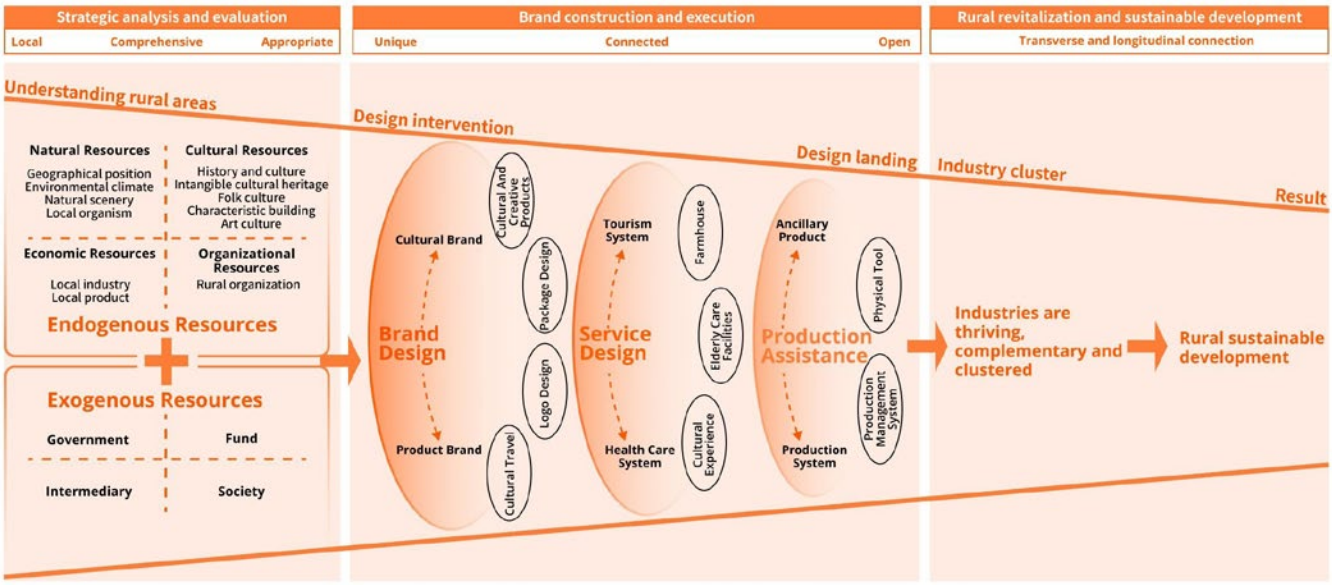

Figure 1. Vision and Strategy Model for the Revitalization of Rural China.

3.1 Strategic Analysis and Evaluation Stage

Strategic analysis and evaluation represent the initial phase of regional brand development, characterized by a local, comprehensive, and contextually appropriate vision. This stage seeks to leverage the synergy inherent in brand strategy to achieve effective complementarity and interconnection among various resources. By integrating both endogenous resources and exogenous resources within the region, it aims to ensure the coordinated advancement of diverse industries and brands under a unified strategic framework. Ultimately, this approach aspires to maximize overall value while fostering long-term sustainable development for regional brands.

Rural resources can be systematically categorized into three major groups: endogenous resources, exogenous resources, and restricted resources (Figure 2). This classification aids in accurately identifying the core competitive advantages and potential development space of rural areas.

Endogenous resources serve as the foundation for rural development, encompassing natural resources, organizational resources, cultural resources, and emerging economic resources. These resources constitute the unique competitive advantage of rural areas. The diversity of natural resources provides favorable conditions for rural development; the stability of organizational resources ensures internal cohesion and consistency in action within rural communities; the uniqueness of cultural resources becomes an important element in building regional brands for rural areas; while the initial accumulation of economic resource lays the groundwork for sustained growth in rural economies. Simultaneously, the introduction of exogenous resource injects new vitality into rural development. The influx of external funds

and advanced technology as well as expansion in market channels accelerates transformation and upgrading within rural industries. However, it is also crucial not to overlook restricted factors such as population age structure, transportation conditions, limited availability of certain resource types, and constraints on cultural dissemination—all these factors may pose challenges to rural development (Figure 2).

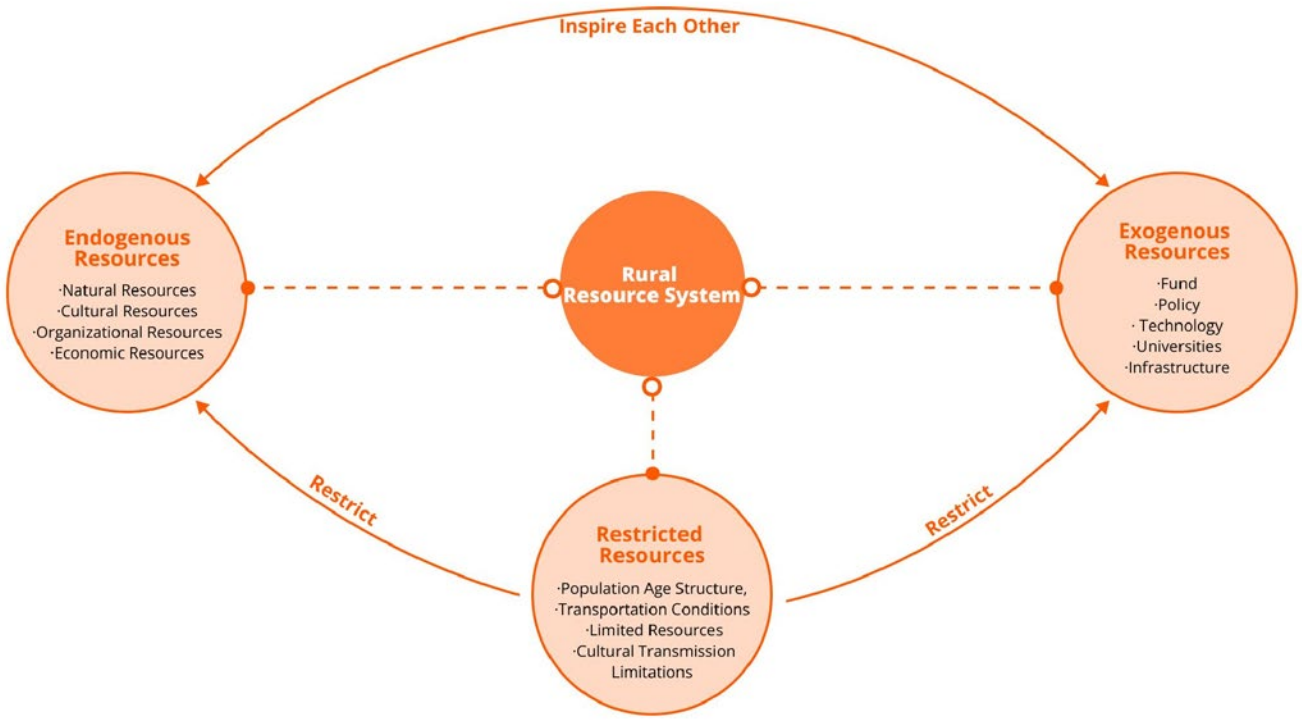

Figure 2. Rural Resource System.

Upon entering Longshan County for the first time, the project team meticulously focused on two key principles: “the uniqueness of resources” and “their potential for sustainable development”, and systematically classified, assessed, and screened both domestic and international resources within Longshan County. This process is a vital component of the development strategy for rural regional branding.

Firstly, the natural resources represented by Wulong Mountain and Bamian Mountain, the economic resources represented by agricultural products like lilies, navel orange and tea leaves, as well as cultural resources represented by Tujia brocade weaving and the settlement of the Rebala Tujia ethnic group are categorized as endogenous resources of Longshan County. Priority development will be accorded to those that demonstrate the greatest potential among them.

Secondly, considering the principles of localization and sustainable development, the project team chose the tea and lily industries as the first development anchor. Product line management was carried out for tea in accordance with varieties and price points, while proposing the integration and joint operation of scattered lily factories within Longshan County to promote their development towards large-scale, branding, and modernization through resource optimization. Additionally, the establishment of a navel orange brand and the enhancement of the brand influence of Longshan County's navel orange will stimulate increased income for farmers. At the same time, other industries represented by cured meat, camellia oil, rice and other products are sold as official gifts.

Simultaneously, the team recognized that cultural resources are a unique advantage for tourism development in Longshan County. Therefore it proposed to construct a comprehensive tourism service system centered on service design to promote effective utilization of Longshan county's resource locally.

At this stage, the team is required to define the advantages, potential, crisis and needs of the target audience of rural resources through comprehensive and accurate resource analysis, and form the core judgment and strategic objectives for the future development of Longshan County. Based on these analyses, a realistic and forward-looking strategic path is developed.

3.2 Brand Construction and Execution Stage

The second stage is a crucial transition from the strategic level to the practical level, which needs to pay attention to the synergy between the regional brand and the product brands in the region, which is embodied in sorting out the internal structure of the regional brand and shaping the regional brand positioning and brand image.

During this stage, the team upheld a unique, interconnected, and open vision to create the regional brand named "Xiangyue Longshan", leading the comprehensive construction of Longshan County's regional brand system. The "Xiang" in "Xiangyue" is derived from the abbreviation of Hunan Province. In Chinese, "Xiangyue" sounds like "meeting with each other", conveying the meaning of "Let's meet in Longshan County, Hunan Province". It is worth mentioning that under this regional brand, three branches were launched by project team: a regional public brand centered around agricultural products, a cultural tourism service brand focused on tourist experiences, and a brand marketing strategy centered around promoting the overall regional brand (Figure 3).

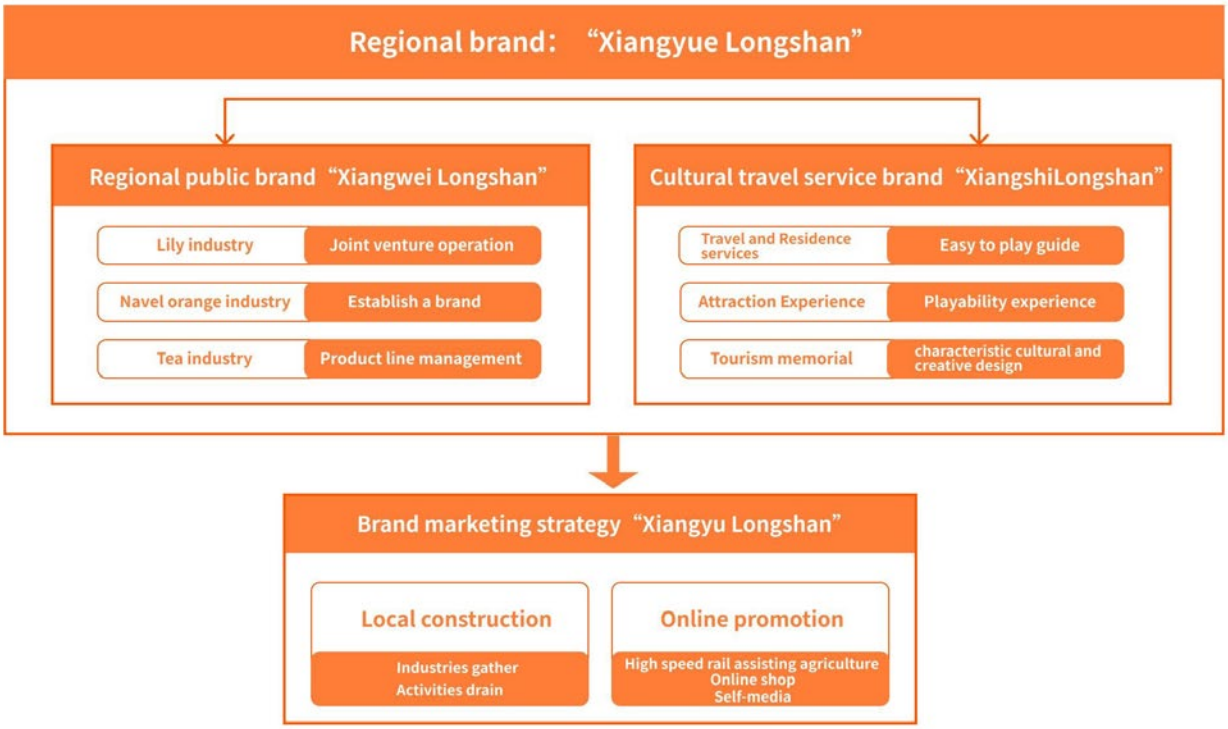

Figure 3. "Xiangyue Longshan" Regional Brand Building Work Plan.

Among them, for the agricultural products industry, the regional public brand "Xiangwei Longshan" is introduced. The term "Xiangwei" represents "Hunan cuisine" in Chinese, thus "Xiangwei Longshan" symbolizes an invitation to savor the delicacies of Longshan County. On the basis of the development strategy proposed in the previous stage, we began to promote the development of the four major agricultural products industries. It is mainly manifested in optimizing tea product line, establishing citrus brand, developing lily agricultural and sideline products, conducting one-to-one brand and product packaging optimization design for representative enterprises, establishing a cross-industry brand unified vision system, and ensuring the consistency and recognition of the region public brand of "Xiangwei Longshan".

In terms of cultural tourism services sector, "Xiangshi Longshan" brand was introduced aiming at addressing homogenization issues in rural tourism. Differentiated strategies including designing tourism service systems, planning distinctive travel routes and providing diverse tourist experiences were formulated to meet growing personalized needs of tourists. Leveraging rich local cultural resources in Longshan County, a series of tourist souvenirs were designed not only enriching shopping choices for tourists but also stimulating consumption growth in cultural creative products.

At the same time, along with the development of “Xiangwei Longshan” and “Xiangshi Longshan”, “Xiangyu Longshan” (In Chinese it means “Let’s have fun in Longshan County”) puts forward marketing strategies for regional brands from two dimensions of online publicity and local construction. Online publicity is carried out by short video publicity, Internet live broadcast and other ways to attract tourists to travel; Local construction collaborates with transportation, accommodation, tour services and cultural and creative product design to increase tourists’ local consumption, so as to achieve regional brand promotion.

To summarize, the focus of the second stage is primarily on the regional brand “Xiangyue Longshan.” Through a coordinated promotion of the regional public brand of agricultural products “Xiangwei Longshan” , the cultural and tourism service brand “Xiangshi Longshan” and the brand marketing strategy “Xiangyulongshan,” this initiative aims to inject new vitality and momentum into the rural revitalization efforts in Longshan County.

3.3 Rural Revitalization and Sustainable Development Stage

The vision of the third stage focuses on building a dual linkage system of horizontal expansion and vertical deepening among industries, promoting the synergy of resources and complementary advantages in various fields, and forming a sustained brand value-added effect. It marks that the development of industrial cluster has entered the core acceleration period.

During this stage, it is essential to strengthen, transform, and deeply develop the primary and secondary industries such as agriculture and manufacturing, while closely integrating with the tertiary industry (service industry), thus establishing a micro-to-macro interactive mechanism(Figure 4). Specifically, agriculture and manufacturing serve as the foundation by providing abundant raw materials and product support for the service industry; meanwhile, the service industry reciprocates and promotes the optimization and upgrading of the primary and secondary industries through its efficient public service functions, forming an internal efficient circulation system. This cycle not only significantly enhances synergies between industries but also lays a solid foundation for comprehensive sustainable development in rural economies.

Simultaneously, relying on brand strategy, various industries construct a closely interconnected network where each node complements each other in an orderly manner to promote regional brand public service development collectively forming a more extensive and far-reaching macro-circulation pattern. This process not only promotes optimal allocation and efficient utilization of resources but also enhances overall competitiveness and influence in rural economies. Enhance the competitiveness and

sustainable development of the overall industrial chain, and ensure that the regional brand of "Xiangyue Longshan" can achieve maximum synergies at various industrial levels.

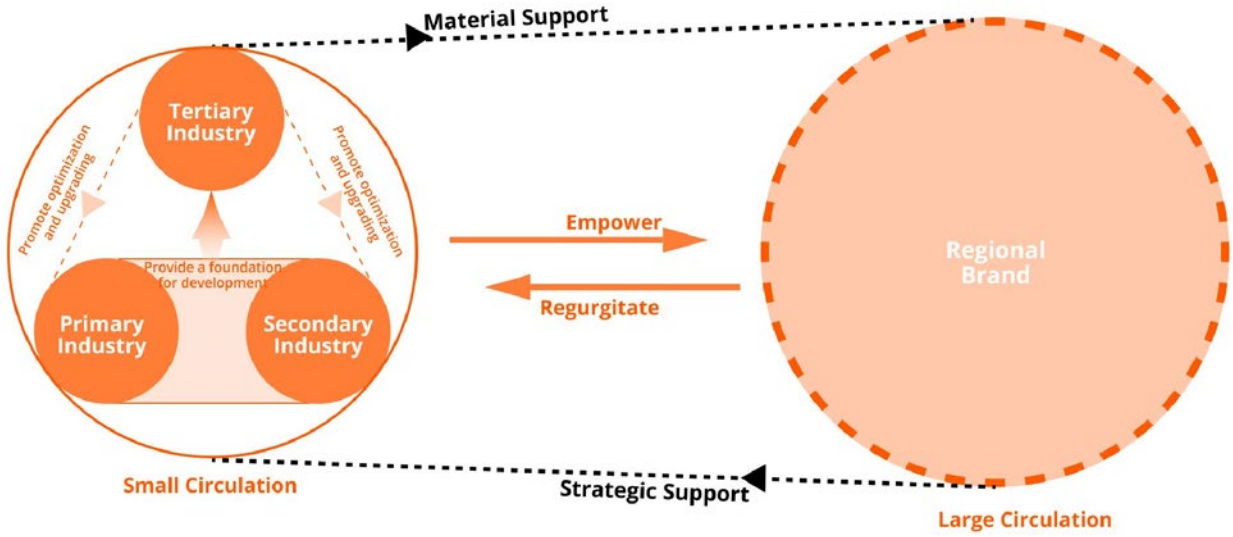

Figure 4. A Micro-to-macro Interactive Mechanism.

Ultimately, an autonomous, closed-loop yet vibrant benign circulation system is formed around rural areas. This system is centered on the interdependence of industries nourishing each other with public services as their support. Not only does this system provide sustainable development momentum for rural revitalization, but it also explores a replicable path for rural revitalization that demonstrates high adaptability and broad application prospects.

4. Project Summary and Conclusions

From the perspective of brand strategy, this study considers rural areas as a whole, emphasizing the importance of exploring and integrating rural resources. It also highlights the establishment of a linkage and circular system among industries in the process of rural revitalization. Through a systematic approach and strategy, the aim is to establish a comprehensive regional brand for rural areas by focusing on macro-level cognition. At the practical level, it has achieved comprehensive progress and sustainable development in terms of economy, society, culture, and ecology in rural areas; at the strategic level, it provides a sustainable, replicable, and scalable development path for rural revitalization in other regions. The innovation points of this study are mainly reflected in several aspects:

Integration of interdisciplinary perspectives: This study combines design disciplines with strategies for rural revitalization to propose an integrated brand construction approach. By incorporating aesthetic, cultural, and creative elements into regional brands from the unique

perspective of design disciplines to enhance their recognition and attractiveness.

Systematic method for resource exploration and integration: It proposes a systematic approach to explore and integrate rural resources that not only focuses on natural resource utilization but also delves into cultural heritage and social resources to form a solid foundation for constructing regional brands.

Development model driven by brand strategy and integration strategy: It proposes strategies that integrate diverse industrial resources through brand strategies to promote organic integration between three major industries within villages while fostering interaction to create synergistic effects at village level.

Exploration of sustainable development paths: The research not only focuses on short-term economic growth but also emphasizes long-term sustainable development in villages. By constructing an autonomous benign circulation system as well as providing new ideas for exploring paths towards village revitalization through sustainable developmental dynamics.

5. Further Research and Discussion

The relationship between design issues and solutions has always been a topic of discussion. In the field of design, the linear logic development of design problems and solutions is no longer seen as such, but rather as a simultaneous and iterative process of discourse exchange, emphasizing the dialogic nature of the design process (Ranulph, 1999). There is an iterative interaction between design problems and solutions. Therefore, seeking solutions to the "sticking" difficulties in the design scenario is not a one-time effort, but will be continuously iterated as people's understanding of the design scenario and problems deepens.

As rural revitalization is a complex issue rooted in different social backgrounds and involving interdisciplinary cross-cutting, with further understanding of this design scenario and new definitions for rural development issues, it remains necessary to pay attention to the adaptability of this model to other rural environments in the future. To address this issue, further research may include:

Firstly, validating, improving and iterating on the proposed strategic model through more case studies and empirical analysis.

Secondly, establishing a scientific assessment system for sustainable development to regularly evaluate and monitor rural area branding construction and the effectiveness of rural revitalization. Through feedback from evaluation results, timely adjustments to strategic plans can ensure sustainability and effectiveness in rural revitalization efforts.

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ARTIFICIAL INTELLIGENCE AS A CATALYST FOR INDIVIDUAL AND COLLABORATIVE CREATIVITY IN DESIGN CONCEPTUALIZATION

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ABSTRACT | Integration of Artificial Intelligence (AI) in the design process is a growing area of research interest. Less than two years after its public launch, AI has already established itself as the most disruptive tool revolutionizing how designers conceptualize, iterate and innovate. As AI technologies continue to evolve, it is pertinent that design students are acquainted with the potential of the technology and how it can be integrated in their professional practice. The objective of this paper is to explore the role of AI as a conceptualization and research tool in interior design. We aim to examine its effectiveness in enhancing the ideation process and facilitating collaboration and knowledge sharing in intercultural design teams. The case study presented is a collaborative online international learning project (COIL) with the participation of interior design students from Wayne State University (USA) and University of Monterrey (Mexico). Students were involved in experimentation with various AI tools and platforms in the early stage of designing children's spaces in commercial interiors. Through meticulous documentation and evaluation of all design variations generated, were gained valuable insights on the impact of AI on the evolution of the ideas. To collect research data on how students' creativity, idea exchange and decision-making were affected, surveys and reflection writings were distributed. The findings confirmed that students developed a greater understanding of AI as an essential tool in the design process. They acquired skills in utilizing it to aid the decision-making during the conceptualization phase. Furthermore, AI fostered their self-confidence in communicating within culturally diverse teams. The conclusion discusses the challenges encountered and lessons learned from the integration of AI technologies into the learning process.

KEYWORDS | ARTIFICIAL INTELLIGENCE, CREATIVITY IN DESIGN, DESIGN

1. The rise of AI and design education

Integration of Artificial Intelligence (AI) in the design process is a growing area of research interest. Less than two years after its public launch, AI has already established itself as the most disruptive tool revolutionizing how designers conceptualize, iterate and innovate.

The first industry-wide survey on the opinion of architects on AI, carried out by RIBA in November 2023, indicates that 41% of the architectural practices in the UK have adopted AI for occasional projects, while 2% use it for every project (RIBA AI Report, 2024). A more recent research on the use, types of applications and expectations for the future use of AI by Architizer and Chaos revealed that 46% of the respondents are currently using AI tools and 23 % are planning to use AI in the near future (Architizer, 2024). These findings confirm that AI has emerged as an indispensable digital tool in architects' and designers' workflows and that its transformative potential is yet to unfold. Though doubts were expressed that AI poses threats to the architectural and design profession, the majority believe it will play a significant role in the future. Those who have already implemented it in their practice report that it has improved the efficiency of their design process and has enhanced the accuracy of architectural modelling and simulations. Both studies confirm that the most common use, with greatest satisfaction of the quality of the AI-generated renderings is for the early stages of the project development. AI provides greater flexibility by enabling designers to rapidly generate innovative designs, which can later be explored, refined and optimized.

However, the majority of the professionals (60 %) have not received any formal training on how to use AI in their design projects, and 37 % indicate the lack of suitable training resources as a significant challenge faced in adopting AI tools. Consequently, designers mainly rely on self-learning and experimentation (Architizer, 2024). This gap underscores the need for design education to address AI training in its curriculum. As AI

technologies continue to evolve, it is pertinent that design students are acquainted with the potential of the technology and how it can be integrated in their future professional practice. Understanding AI and acquiring the knowledge and skills necessary to adequately assess, interpret and analyze AI-generated visuals according to the needs, context and specifics of use can ensure that students are more competitive and better prepared for the job market. Long and Magerko refer to these competencies required for the future as "AI literacy", which is defined as "a set of competencies that enables individuals to critically evaluate AI technologies; communicate and collaborate effectively with AI; and use AI as a tool online, at home, and in the workplace" (Long & Magerco, 2020).

Markauskaite et al. (2022) explored what kind of capabilities people need to interact with AI and how learners can develop them. Conceptualized from different perspectives these capabilities are grouped in three interrelated orientations: cognitive, humanistic and social. From a cognitive perspective, in the human-AI system, AI is viewed as a teammate that affects individual cognition, metacognition and behavior. Selfregulated learning and creativity exemplify key individual capabilities within this orientation. The humanistic perspective centers on human values and individual capabilities to use and shape AI to contribute to personal and collective well-being. The social perspective focuses on shared meaning-making and collective practices. In the context of design education, the development of these skills is henceforth to be researched. Vinchon et al. consider that the "human-AI collaboration can be extraordinarily productive" (Vinchon et al., 2023). AI can produce a large number of proposals quickly, thus providing a vast field for exploration of possibilities, but it is the human who plays a central role at the two critical phases of the creative process - at its beginning and end. Designers define the objectives and set the parameters of the AI-generated ideas and make decisions by evaluating, selecting and validating the output.

The objective of this paper is to explore the role of AI as a conceptualization and research tool in interior design. We aim to examine its effectiveness in enhancing the ideation process and facilitating collaboration and knowledge sharing in intercultural design teams.

2. AI-driven children's spaces design

The case study presented is a collaborative online international learning project (COIL) with the participation of interior design students from Wayne State University (USA) and University of Monterrey (Mexico). In this distinct educational approach, students and faculty from the two bordering countries were connected through online collaboration to develop a joint project on the design of a children's space.

Inherent characteristic of the format, "also referred to as globally networked learning and virtual exchange" (Rubin, 2022), is that

when exposed to diverse perspectives, students strengthen their skills to work in multicultural environments, broaden their global understanding, improve their critical thinking and adaptability. The project which was specifically designed to pair COIL with AI-driven design not only offered a memorable learning experience for our students but simulated a real-world, cross-cultural teamwork in a digital environment.

2.1 Participants

Fourteen fifth semester students from the University of Monterrey (UDEM) and fifteen students from Wayne State University participated in a four-week COIL project. The Mexican students were in their fifth semester of the interior design program in the Department of Art and Design at UDEM. The class in which the project was implemented was Institutional Spaces Studio. In this class, students experiment with various design strategies to create innovative and inspiring interiors addressing the physiological, psychological, social, cultural, and environmental needs of contemporary society. They explore the experiential aspects of the space and learn how to create a sense of place and memorable spatial experiences. The partnering students from the USA were junior students in the interior design program at Wayne State University. They were taking their second interior design studio course, which focuses primarily on experience design. In this class students explore the relationships between users and the space to create immersive spaces which are not only functional and aesthetically pleasing but deeply memorable and impactful.

2.2 Research method

The research method selected was grounded theory (Glaser and Strauss, 1967) since it allows the development of theories grounded in the data collected from the experience and interactions of the participants. We aimed to systematically gather and analyze qualitative data in order to identify patterns and gain insights that emerge organically from the research context. Grounded theory ensures that our findings are rooted in the actual experiences and perspectives of the students, which will aid us build a comprehensive framework explaining how the experiment influences the learning outcomes, competences and the collaborative process.

2.3 Project objectives

The "Children's spaces" project objective was to explore how the utilization of AI in the design of a children's interior space can enhance the efficiency, creativity and decision-making. The design brief gave students the freedom to select the context in which the project would be implemented - within any type of larger facility, such as a library, office building, community center, educational institution, etc., but delimited the target group - children aged 3 to 10 years and the designated area - 500 sq. m. The design should comply with safety regulations and guidelines for children's

spaces, and to consider the creation of an inclusive environment for children of diverse backgrounds, abilities and interests.

2.4 AI tools selection

The AI engines used in this collaboration can be categorized into two groups:

1. Conversational AI Models: These models are designed to engage in natural language conversations, answer questions, and provide information. They generate text-based responses in a dialogue format. Conversational AI models, such as OpenAI's ChatGPT, Google's Gemini, and FabriAI, assisted students in their primary and secondary research. These models supported tasks such as gathering information, analyzing data, creating mind maps, and discovering project opportunities.
2. Image AI Models: These models are designed to generate images based on text prompts or input images. They specialize in creating visual content through AI-driven artistic interpretations, translating textual descriptions or visual inputs into detailed and unique images. Image AI models, such as DALL-E 2, PlaygroundAI, and VizcomAI, enabled students to rapidly generate conceptual images of their design ideas. These tools facilitated an iterative process, allowing students to explore various design variations efficiently.

2.5 Cultural dimensions

One of the major benefits of the implementation of the COIL project is that it enriches the students' educational experience by providing opportunities to learn about other cultures, establish cross-border partnerships and exchange knowledge to achieve the project goals in a cross-cultural context. Students become familiar with diverse cultural perspectives, thereby fostering their identity as global citizens who are open-minded and respectful toward differences. This exposure broadens their understanding of the world and enhances their abilities to collaborate effectively in an increasingly interconnected and multicultural environment.

A particularly interesting challenge was addressing the diversity of cultural preferences among students and the inherent biases in AI models. Overcoming these biases and synthesizing new interpretations required careful consideration. AI models generate results based on the data on which they were trained. Students often draw inspiration from their own cultural backgrounds, which can influence their preferences. To address this, student groups were intentionally mixed to maximize the diversity of opinions. Additionally, they were encouraged to use multiple AI engines to explore the differences in the outputs and develop their individual proposals. Similar to human perspectives, AI engines can be directed to generate work based on specific inputs, such as reference images used as style guides. This approach facilitated a richer exploration of diverse interpretations and perspectives.

2.6 Project implementation

The dynamics of the collaboration began with an ice-breaker activity in which teams, composed of students from both universities, shared information about themselves. This is an important step in the formation of a friendly and inclusive environment. Through learning about each other's background, interests and motivations students build mutual trust which can further facilitate teamwork and enhance conflict resolution. To structure the course and foster collaboration, we employed modern presentation and discussion tools, which generated an accessible and productive class experience. We utilized MIRO as an online collaboration whiteboard platform, enabling students to upload their work, engage in discussions, and receive feedback from their peers. It allows users to create and share visual content such as diagrams, mind maps, and sticky notes, enabling teams to work together seamlessly from different locations. Using Discord, we facilitated a space for real-time meetings, chats, and discussions. Through the use of open groups and public discussion rooms, we created an inclusive environment where all students, rather than just individuals, could benefit from collective insights. This platform allowed faculty to address individual group questions and, if deemed valuable, share these responses with all students. Considering the time zone differences, Discord was an instrumental tool in ensuring effective and timely communication across the course. For the synchronous meetings we used Zoom. Zoom offers significant advantages, such as allowing participants to share their screens and granting faculty remote access to interact directly with software on students' computers. Additionally, Zoom enables the creation of online recordings of the meetings, which can be accessed for later review. Zoom was instrumental in enabling students to present their work, facilitate discussions, provide feedback, and receive training on the use of AI engines. Since all AI engines used were accessible online, students were introduced to AI as a research and design tool through live demonstrations during class. This approach allowed faculty to create a workshop-like environment and provided students with the opportunity to experiment with the tools. Based on students' questions communicated via Discord outside of class, additional video tutorials were recorded using Zoom and made available online to ensure students could review the material as needed.

The actual work on the project began with thorough research on the target users, their specific needs, interests and preferences. The analysis encompassed both the functional and emotional aspects of the space to ensure it will be interactive, inclusive and appealing. Key considerations included safety and ergonomic requirements, sustainability, technological integration, etc. To organize and visualize the research findings, students utilized ChatGPT within Fabri to make mind maps, which facilitated the comprehension of the various factors that impact the design of the children's space (figure 1). In the conceptualization phase, students began brainstorming ideas

about the functionality, interactivity and user experience of the space. They were encouraged to experiment with the various AI tools that had been introduced to them earlier to generate concept images. We required that they document meticulously each stage of the design process, including research findings, design iterations, AI tools used, and insights gained. Moreover, we asked students to reflect on the results obtained and note the benefits they observed, as well as the challenges and limitations they encountered in the AI-generated renders.

For the final presentation of the spatial concepts AI engines like VizcomAI were used to produce more accurate representation of the ideas. These AI-generated visualizations were combined with 3d models and other conventional techniques to create a more refined and comprehensive design. As a final deliverable each team submitted a visual diary showcasing all variations of the design developed throughout the process, including all the visual representations of the design concept and its iterations, as well as the prompts and the AI tool used (figure 2). Students provided descriptions explaining the rationale behind each design variation and the evolution of ideas leading to the outcome.

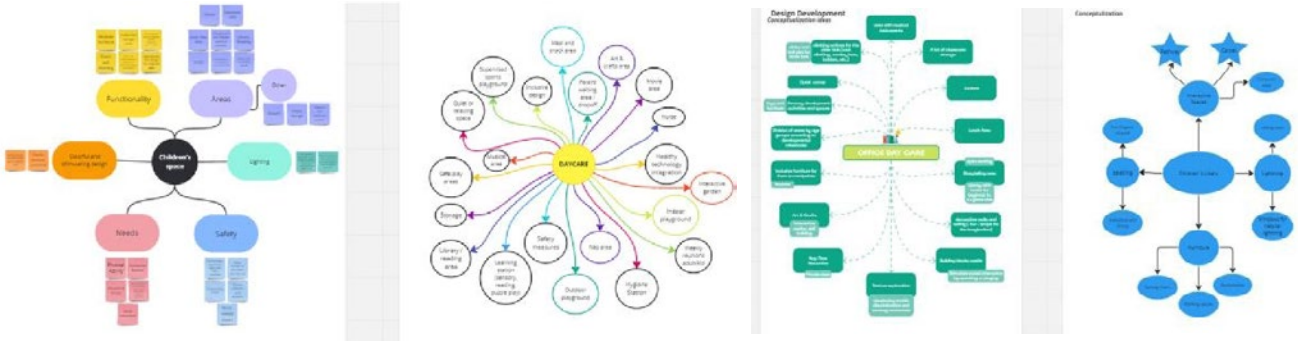

Figure 1. Mind-maps developed by students

Figure 2. Visual diaries documenting the design process

2.7 Results

Research data were collected during the project development using a multi-faceted approach. Through observations, we gained real-time insights into students' interactions, team dynamics

and behavior. The visual diaries prepared by the students offered a narrative record of their design process, while surveys and reflection writings done at the end of the collaboration provided an opportunity to obtain information on students' thoughts and learning outcomes expressed in a more personal and detailed manner.

The first interesting finding was that though the students were familiar with various AI tools, the majority of them have not used these technologies in an integral way for design projects. In that regard, the children's space project contributed significantly to their understanding of AI technologies in design and their potential application. This is evident from the following reflections written by students: "It [the project] helped me completely since I had never used those programs before, I learned from scratch and I think I did a good job," and "[w]e gained a deeper understanding of AI technologies in design. Previously, I was unsure of their practical applications, but now I realize how effortlessly they can be employed. It's remarkably convenient to generate quick, visual representations of projects, facilitating pre-visualization with ease."

In their evaluation of the overall experience of the COIL project, students shared the following opinions: "The AI generator was amazing, I had never done that, and I really enjoyed it," and "I liked it very much. It was a different approach to interior design, and I actually found it very helpful to use AI tools to my advantage to create a space in a more efficient and fast way."

Besides the speed at which AI produces images, among the AI features which students appreciated the most, were the ability to overcome brainstorming fatigue, AI capacity to generate unique images, the use of traditional image montage concepts to produce AI renderings, and its effectiveness as a research tool for data finding and analysis. The excitement with which students approached the project was evident in their enthusiastic participation, willingness to experiment with the different AI tools and their proactive engagement in the collaboration. Some unexpected results emerged such as a proposal for an AI-generated business model of an office daycare. This showcased student's ability to think creatively and their disposition to explore further the application of their design concept with the help of AI. When asked to describe the most engaging and enjoyable aspects of the project students indicated: "I really liked that we got to explore different types of AIs and working on the project with no expectations on the outcome helped me truly explore the different features of the AIs." However, the ability to write prompts to feed the AI engine was observed as a major obstacle in obtaining results relevant to the project specifics. Inappropriately written prompts led to inappropriate AIgenerated renders, so students revised them using ChatGPT to clarify and refine their requests. These iterations helped students learn how to better communicate their design intentions in a written form which subsequently improved

the quality and accuracy of the visualizations. Furthermore, students evaluated positively that we encouraged them to utilize the same prompts with various AI tools and to compare the outcomes: "Seeing the results of the prompts that we made were very interesting, and using that same prompt for other AI pages was very cool and pleasing to see how each of them managed to create different aesthetics and different proposals with the same text." Another student wrote: "I really liked that we got to explore different types of AIs and working on the project with no expectations on the outcome helped me truly explore the different features of the AIs."

Despite the overall positive opinion of the use of AI in design, students indicated some shortcomings such as limited options for floor plan generation, isometric drawings, furniture proposals, controlling the lighting of the scene, etc. However, the fact that they realize the constraints of AI tools, demonstrates their awareness of the importance of critical thinking and knowledge on design principles for decision making. "We looked for visual ways to reach the desired results and although the AI pages gave an approach, it could not give an exact representation of what we wanted for this space, but we really enjoyed being able to experiment and find these tools as a basis for brainstorming and moodboards". Another aspect which students disliked was that each AI engine has a different visual style which can be confusing and requires familiarization with the specific interface to fully utilize their potential.

In regard to their experience of working in intercultural teams, some students reported difficulties related to communication, especially outside class hours, as well as challenges stemming from the differing opinion of their partners. Nevertheless, they acknowledged the necessity of effective communication for the success of the project, as expressed in this student's reflection: "Collaborating as a team for this project was exciting as it highlighted the importance of communication and taking advantage of the strengths of each team member." In order to overcome the challenges of the collaboration students were actively engaged in discussions and critical reasoning to reach a consensus, which contributed to the development of communication skills and a deeper understanding of diverse perspectives in the design process.

Lastly, with this project students not only overcame their uneasiness to work remotely with designers from different countries, but also embraced the opportunity to experiment with new technologies. This experience helped them build confidence in integrating AI in their design process: "Before COIL I thought of AI as scary to some level because of how it's really becoming better and better every day. After COIL I feel at ease and happy to have learned a new area of design and acquired a new work tool."

3. Discussion

3.1 Project impact

The children's space design COIL project was our first attempt to implement AI in a structured way as a cocreation tool in the development of an educational design project. Motivated by the question whether our students are prepared for the new AI reality of the design profession, we designed a learning experience which encouraged them to experiment with various AI tools and explore their potential in transforming traditional design methods.

The results highlighted a positive impact on the design workflow and acquisition of AI literacy.

1. Impact on the design workflow and efficiency.

The impact of AI on modernizing the design workflow was significant. AI's ability to produce results in seconds enabled students to work more quickly and focus on creative aspects rather than labor-intensive tasks. Additionally, AI tools allowed students with less developed skills in manual sketching or 3D modelling to generate high-quality visual images. This is crucial because, as designers, our primary task is to produce effective solutions rather than art, and high-quality visuals are essential for successful project storytelling. To remain competitive, the field of design must continually innovate and adapt to new processes. Imagegenerating AI engines offer an attractive additional tool for designers, providing a workflow that can be significantly more efficient and effective at times. However, these engines still rely on the data provided. Thus, it is crucial to understand that AI does not replace the need for students to learn manual sketching and 3D modelling. For tasks such as 3D rendering and the development of conceptual images, which are very laborintensive, AI rendering now offers a workflow that is faster, more intuitive, and produces significantly better visual results.

To produce initial conceptual images as part of the initial project exploration, students utilized DALL-E 2 and PlaygroundAI. By using basic text prompts, students were able to contextualize their envisioned topics. The use of various AI models and style descriptions allowed them to explore different artistic interpretations and visual styles. This process was instrumental in understanding AI biases and overcoming inherent user preferences.

VizcomAI played a significant role in modernizing the workflow for developing and exploring specific design solutions. Students were able to combine basic hand sketches, 3D model screenshots, and traditional photo collage techniques to instruct the AI in producing high-quality architectural renderings. By using layers and quick sketches for furniture or human figures, students created realistic representations in seconds. The use of reference images helped maintain desired visual styles and address AI biases. This iterative process facilitated effective exploration of different design solutions. Notably, VizcomAI offered a very low learning

curve for students and significantly enhanced productivity compared to the traditional workflow of manually 3D modelling interior spaces and their assets. While manual 3D modelling remains essential for final project delivery, it is less efficient during the exploratory phase.

2. Acquisition of AI literacy.
Undoubtedly, AI augments the traditional design process by transforming how creativity emerges from text to generate a visual representation of design ideas. In this new AI-human collaboration, the competences of the designer to write prompts and to critically analyze the AI-generated renders are crucial. Our students discovered the importance of breaking down the design brief into distinct components that can be communicated to the AI in a concise, unambiguous and specific way to ensure the outcomes would closely align to their expectations. Through continuous experimentation and iteration, they refined their prompts to improve the quality and relevance of the AI-generated renders. The self-regulated learning process enhanced students' understanding of the capabilities of AI but also aided them in recognizing the value of the human perspective. Students acknowledged that creative criticism plays an important role in evaluating and analyzing whether the image proposed by AI aligns with the design brief and to what extent it corresponds to the designer's vision and the design goal.

Furthermore, in this collaborative endeavor it was important not only for the individual to appropriate knowledge on how to incorporate the use of AI in the design process, but also how the team is engaged with AI and what joint actions can be taken to achieve the desired results. Integrating the views of the others and exploring alternatives to respect the differences are some of the approaches towards enhancing teamwork.

3.2 Limitations, challenges and future work

From a pedagogical perspective, the systematic implementation of AI in the project development helped us analyze both its potential limitations and strengths in the preparation of our students. For example AI aided the exploration of unexpected concepts, color schemes, age-appropriate design elements but failed to optimize the spatial arrangement and comply with codes, ergonomic and safety requirements. In addition to functionality, aspects such as design's emotional impact and sustainability are considerations which rely mainly on human critical judgement and expertise. We obtained valuable insights on the capabilities of the students to interact with AI tools which gave us ideas about areas to focus on in future projects. A strategy to better support students in utilizing AI in their creative process is to include writing exercises to improve the accuracy and clarity of their prompts. This will ensure a more relevant and effective AI-generated output and will equip them with confidence in troubleshooting unexpected results. Additionally, the incorporation of

activities to evaluate AI-renders and compare them against design briefs and project goals, will further enhance students' critical thinking skills. While AI produces excellent renders, it falls short in developing traditionally needed media in interior design, such as plan views, sections and axonometric drawings, which demonstrates that AI cannot replace the work of the trained designer.

One of the challenges we encountered was determining how to evaluate whether the students have achieved AI literacy and the level of mastering the competencies required to work effectively with AI. We used traditional evaluation indicators such as depth and relevance of the research, creativity and originality of the design concept, functionality and aesthetics of the design, detail and accuracy of the design documentation. However, to ensure comprehensive evaluation of the AI-aided design process and outcomes, we consider that the assessment criteria need to be refined and updated. Providing a reliable method for the evaluation of the AI literacy of design students, including prompt formulation, critical evaluation of AI outputs, ethics and responsible use of AI, etc. could be the objective of future research. Though the ethical considerations of the utilisation of AI as a design tool were outside of the scope of the presented study, we recognize their importance. We plan to provide special guidance and recommendations for our students to address these issues in subsequent projects.

4. Conclusion

Contrary to the belief that AI might threaten creativity, with the implementation of the children's space project we demonstrated that it can foster both individual and collaborative creativity and can be successfully used as a research and conceptualization tool in design. AI tools offer numerous advantages that modernize the design process. However, it is important to note its drawbacks and limitations, which highlights the necessity of human criticism. We can conclude that students developed essential skills to interact effectively with AI, which respectfully had a positive impact on their design skills. We exposed them to a new environment where they had to solve problems in a new way which inherently requires a creative approach. Furthermore, student's unique skills and different cultural backgrounds contributed to the creation of a richer project. The overall positive evaluation we received as feedback from the participants emphasized that the project is timely and quite necessary. As one student shared: "AI is the future so it makes sense that we start learning about it in class, it was a good way to learn about actual things, not just a program." We will continue observing how AI technologies mature to explore further the opportunities it offers for design education and the design profession.

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“DESIGN FOR CHRONICITY: THE CASE OF PHARMACEUTICAL PACKAGING IN MEDICAL TREATMENT FOR ELDERLY”.

Mariel Domínguez Molina.

ABSTRACT | As the world’s population ages, people will tend to live longer but also face treatment for a series of chronic conditions for a longer time. In an era distinguished by rapid technological advancements and shifting demographics, the relationship between healthcare, empathy and design takes on a new significance level. In many cases, due to variable social dynamics, the youngest tend to grow further away from the elderly, making many young professionals unaware of the needs of elderly individuals, which reflects less empathy and understanding of the issues around the medical care of this demographic. In diverse contexts, design for the surroundings of the elderly patients is not as curated as the ones for children or younger population, leaving these group excluded from information exchange and participative research processes.

One relevant sector for elderly population is the pharmaceutical packaging design, that does not seem to keep up with the technical development in the field; its concepts have changed at slow pace in the last hundred years with punctual changes mainly around production efficiency and branding; leaving unattended issues such as physical and cognitive changes in elderly population, as well as the relevance of its inclusion on a long-term routine in the emotional states of patients with a chronic disease. In the same way, those few changes have not attended enough the cognitive ergonomics regarding the caregivers, even if an unclear communication could influence the mental effort and human error while handling these products. This stresses the need to reframe medical packaging considering a wider diversity of perspectives, and to boost the role of design as gatherer and intermediary between scientific improvements and the subjective experiences of individuals around the healthcare system for a more empathetic and user-centred approach.

In the present research, an explorative non-experimental transversal study was conducted, taking as case study a group of international design students at a master level to develop concepts of a variety of pharmaceutical packaging followed by the application of a questionnaire to register the possible barriers and opportunities young designers might have when approaching ageing and healthcare subjects, also to compare their insights from users and caregivers, in order to understand differences and common places that could later be useful for transgenerational inclusion.

By opening new research lines around the physical, cognitive, emotional, and social dimensions of users with chronic conditions, with better representation of user groups, we could improve the experience around medical treatment and possibly potentiate compliance. This can only be possible with the collaboration of different professionals in the related disciplines, such as gerontologists, healthcare professionals, users, and caregivers. Each stakeholder's unique perspective and expertise are crucial to ensure that medical packaging design meets the diverse requirements of each stage of the packaging's short life cycle.

KEYWORDS | CHRONICITY, GERONTODESIGN, DESIGN FOR AGEING, DESIGN FOR HEALTH, PHARMACEUTICAL PACKAGING

1. Introduction

This work was born from the observation of many barriers that elderly people need to face to go along with their routines, that younger groups take for granted; sometimes these users develop strategies or purchase a variety of tools to help them overcoming them. When observing the objects and services available for elderly individuals, particularly those who present one or more chronic conditions, it became clear that the options in the market are not thought to suit the diversity of this demographic, as it is for younger groups... many products were difficult to purchase and expensive, but also disruptive of the spaces of the users. Visiting an elderly person with various chronic conditions and facing also disabilities is an emotional demanding experience, not only for the shadow of sickness that all the aid objects bring into the space but because it is present in many moments of the daily routine, one example being all the strategies and devices made to help the user to manage their medical treatment routine. Hence the question of why are these objects like this? Who and how is designing them? Why aren't we as designers taking more steps to address it?

The second reflection came when observing young professional designers while projecting pharmaceutical packaging. It was quite evident that only a few of them were aware of the difficulties patients face when dealing with illness, and the lack of interest to project for elderly patients, even if they were the most common group of users also to their knowledge. Even the ones interested in common conditions present in elderly population, there was a big difficulty to understand their barriers, their expectations and perspectives, which brought the question of how can we learn to better design for this group, was it a matter of technical knowledge or was it a matter of empathy?

This work aims to explore the complexities of pharmaceutical packaging from a design perspective, considering the perspectives of multiple stakeholders, and most of all, boarding the issue of the users from a holistic perspective, considering the 3 mains spheres of the patient: physical, mental and emotional. The objective is to gather contextual knowledge that can inform the design field by incorporating insights from various

stakeholders and disciplines. By addressing issues such as non-adherence and combating ageism through empathetic and usercentric solutions, this research seeks to find what could be useful touchpoints between the various disciplines involved in safeguarding the well-being of seniors, particularly those in vulnerable situations. This holistic approach not only has the potential to reduce healthcare costs but also to significantly improve the quality of life for the elderly.

2. Ageing Population and Healthcare

Global demographic trends indicate a notable and sustained increase in the population aged 60 and older, which signals a significant shift in the worldwide population structure. This demographic shift, driven by advances in medical science and improved living conditions, is expected to result in the elderly constituting a growing percentage of the population in the coming decades.

Such changes have far-reaching implications across various sectors, including healthcare, social services, and consumer industries. There is an escalating demand for products, services, and infrastructure tailored specifically to meet the unique needs and preferences of the elderly. Addressing these challenges is crucial not only for promoting the well-being of seniors but also for economic sustainability related to their healthcare.

However, this increased longevity does not necessarily equate to better health or quality of life. In developed countries, while people live longer, they are not always healthier and may face physical or mental impairments over time. This scenario calls for better coordination across various sectors and the implementation of new systems that can provide an adequate response to the needs of elderly patients, that are not by any means a uniform group of users, only by age groups and situations of chronicity, there can be important differences in their needs and preferences, (eg) according to the ICH E7 guideline on clinical trials in the geriatric population, older people can be divided into three age ranges: 65- 74; 75-84 and 85+ years (EMA, 2010) but the condition of health or frailty will further create important differences between this groups.

By reducing the risks of errors and the progression of chronic conditions, we can help maintain functional abilities, empower individuals. A holistic approach would support healthier and more independent aging, ultimately reducing the burden on healthcare systems. Older patients are a sector particular concern due to some common deficits in physical or mental dexterity and memory, and the problem can be accentuated by a higher number of medications taken simultaneously (Cramer, 1998).

Inclusion of seniors is increasingly recognized as crucial for fostering a more equitable and compassionate community. As populations age, it's essential to value the contributions of older adults, recognizing their wealth of experience and knowledge. Efforts to

include the elderly often focus on improving accessibility in public spaces, and care facilities however, and ensuring that social services are responsive to their needs, but they should also include the representation of this population in research, particularly in the healthcare sector. Furthermore, policy frameworks and inclusive practices that accommodate aging populations can enhance their emotional state and quality of life, while also addressing the economic challenges associated with aging.

2.1 Design & Healthcare for elderly

Design is a dynamic discipline, characterized by a continuous cycle of evaluation and evolution, influenced by the interaction between products and users. The future of "patient centricity" that this industry is beginning to explore, needs a series of coordinated efforts and the progressive alignment of multiple stakeholders – from inside the healthcare system- but also outside of the traditional related fields, and this can only be achieved by collaborations and trans disciplinarity (DuPlessis et al. 2017). Product design must incorporate a synthesis of technical, scientific, and pragmatic knowledge to address various levels of interaction.
In recent years, there has been a growing emphasis on the non-physical dimensions, aiming not only at aesthetic appeal but also at addressing user needs and behaviours in the psychological sphere.

Improving ways to attend to the growing elderly population is a big concern for health systems and governments around the world, where that group is already reaching around 30% of the population in counties as Japan. As market size, seniors were already estimated to represent a global expense of US $1.4 trillion before 2025. (Majerol & Carroll, 2018). The pharmaceutical industry is particularly vital for this objective, since seniors are the principal consumers of medications.

It has been estimated that the majority (78%) of patients older than 65 years are on medications, and that 39% regularly take five or more prescribes drugs (Jörgensen, 2001) while up to 90% patients in this age group are reported to also take over-the-counter drugs. (Hanlon, 2001). Despite that, communication between pharmaceutical companies and elderly users often lacks a two-way exchange. This results in products, devices, and communication features influenced more by technical requirements, regulations, and economic drivers than by user-centric considerations. This gap is evident in pharmaceutical packaging, which should seamlessly integrate elements of graphic, industrial, and communication design but often fails to meet the specific needs of patients with chronic conditions, particularly in elderly age.

2.2 Chronicity

Chronicity is associated with declining aspects of life such as autonomy, mobility, functional capacity, and relationship life, resulting in increased psychological stress, hospitalisations, the use of resources

(healthcare, social, and welfare), and mortality.

Chronicity can be defined as the continuation of disabilities arising from an illness. (Strauss 1980) Many organisations have defined the duration of chronic conditions as at least 6 months, even if it has been contrasted by the opinion that no standard duration can be applied since each condition is unique, as well as the person experiencing it. (Clarke,1994). Generally, the onset of chronic conditions is related to terms such as insidious and gradual, having age as a relevant condition for risk, even if chronicity is not confined to older populations. (Hoffman, 1996).

It is estimated that approximately 70-80% of global healthcare economic resources are currently spent on managing chronic diseases; this becomes even more concerning the most recent epidemiological projections, according to which, by 2020, they will represent 80% of all diseases worldwide.

The care objectives for patients with chronic conditions, as they cannot be directed towards cure, are aimed at improving the clinical picture and functional status, minimising symptoms, preventing disability, and most of all, enhancing the quality of life, therefore design can contribute by paying attention to the factors that will improve different areas of their daily routine and contributing to a user-friendly and non-stressful environment.

2.3 Medicine intake as a daily ritual

Making an analogy between medicine intake -in which pharmaceutical packaging takes part- to other kind of holistic ritual would help considering other aspects of its significance. Just as rituals engage all the senses and affirm our connection to our surroundings and ourselves, so too does medication adherence engage a patient's trust and even faith -we could call it- in the prescribed medicines and the medical devices. Historically, sacred art and rituals served multiple purposes: for patrons, they displayed power; for priests, they symbolized authority; for the church, they educated the populace; and for the public, they provided means to understand and approach the divine, something they could not see. Similarly, the experience of taking medication is not just about the physical act but involves a kind of deeper, emotive engagement that influences body responses, hence the placebo effect. Chronic patients adhere to their medication regimens with a form of ritualistic devotion, hoping for positive outcomes despite uncertainties and any times without informed knowledge of the physical and chemical processes and reactions related to their treatments.

2.4 The Role of Cognitive Ergonomics, Information Design, and Neuroaesthetics

To address these dimensions, it would be important to incorporate principles from cognitive ergonomics, information design, and Neuroaesthetics into pharmaceutical packaging design. Cognitive ergonomics focuses on understanding human cognitive

processes and how they interact with the environment, which is crucial for designing packaging that is easy to use, especially for individuals with cognitive impairments common in the elderly. Information design plays a role in organizing and presenting information clearly and accessibly, which is vital for ensuring that medication instructions are easily understood and followed.

Neuroaesthetics, the study of the neural basis of aesthetic experience, suggests that design elements that are visually pleasing can enhance user engagement and satisfaction. This is particularly relevant for pharmaceutical packaging, where attractive design can improve the user experience, potentially enhancing medication adherence.

When considering the physical, mental, and spiritual dimensions in the context of handling medical packaging and taking medical treatment, each dimension offers a distinct perspective on the experience.

Physical Dimension:
Physically, this involves the practical aspects of managing medication, such as opening packaging, measuring dosages, and administering the treatment. It requires manual dexterity and may be influenced by the individual's physical condition, such as age, disability, or illness.

The physical effects of the treatment, such as its efficacy, side effects, and interactions with other medications, are key considerations. Maintaining a routine, managing symptoms, and adhering to prescribed doses are critical for physical health and recovery.

Mental Dimension:
The mental or cognitive dimension involves understanding instructions, remembering to take medication on time, and staying informed about the treatment regimen. It includes abilities like memory, comprehension, and decision-making skills. It overlaps with the emotional state that include coping with the stress, anxiety, or depression that may accompany illness or treatment. It also involves the mental discipline to adhere to treatment plans, understanding the significance of compliance, and being aware of potential side effects.

Emotional / Spiritual Dimension:
Handling medication can be linked to beliefs about health, healing, and well-being. It might involve rituals, prayers, or other practices that a person associates with their treatment. This dimension involves a person's sense of hope, faith, or purpose in facing health challenges. It might involve reflecting on the meaning of illness in their life, seeking comfort from spiritual beliefs, or engaging in practices that support emotional and spiritual well-being.

These dimensions are interconnected, influencing each other in complex ways. For instance, a positive mental attitude can improve adherence to treatment and potentially enhance physical recovery. Similarly, spiritual beliefs can provide comfort and reduce stress, impacting both mental and physical health. Understanding these

dimensions helps in providing holistic care that addresses not just the physical aspects of treatment but also the mental and spiritual well-being of the individual

3. Materials And Methods

This study was conducted in three distinct stages to explore pharmaceutical packaging design with a focus on elderly users. The stages were: (1) Qualitative Semi-Structured Interviews, (2) Observational Case Study, and (3) Quantitative Questionnaire. Each stage was designed to gather comprehensive insights from a range of stakeholders, including professionals, users, and designers.

Stage 1: Interviews

Qualitative Semi-Structured interviews with 10 open questions, that took place involving a total of 16 participants with the objective of obtain: first the perspectives of the users and their experience and to identify barriers and needs detected by them and their caregivers aimed to understand their experiences with pharmaceutical packaging, including challenges, barriers, and suggestions for improvement. Second, to understand the perspective of diverse actors involved in the pharmaceutical industry to gather insights on the current state of pharmaceutical packaging, focusing on their perspectives regarding design, functionality, and user needs. The participants were:

a. Professionals of the sector: 2 nurses, 2 doctors, 3 pharmaceutical industry professionals and 1 inclusivity expert.

b. Users and Caregivers: 5 elderly individuals over 60 years old with chronic conditions requiring daily medication, and 3 non-professional (familiar) caregivers assisting elderly individuals in home settings.

The interviews were conducted with both professionals and users by separate, in the case of group a, the by electronic means; the questions were sent one day in advance (by request of many of the professionals that wanted to prepare and read the questions in advance) and then, according to the schedule availability of the interviewees, the answers would be communicated by WhatsApp or Google Meet calls.

The interviews with users and caregivers took place mainly in person, since it was more comfortable for the users, and this environment allowed further observations or dialogue aimed to understand their experiences with pharmaceutical packaging, including challenges, barriers, and suggestions for improvement.

Stage 2: Observational Case Study

The study involved 60 international master's programs for postgraduate students with bachelor's degree on various fields of design. The participants, aged between 22 and 42 years old (with 90% between 22 and 30 years old), coming from 20 different countries. A mixed-methods approach was used to

observe the students' design processes and perspectives during one semester in order to gain insights into students' views, interests regarding packaging and the healthcare field.

a. Traditional Packaging. Students presented traditional packaging from their cultural backgrounds to provide insights into cultural values and perceptions to observe their familiarity with the packaging field and their take on local traditions and aesthetics.

b. User Research Approach: Students' methodologies for user research were observed to evaluate their interest and empathy levels towards different groups of users, as well as their research skills concerning the field of healthcare, users with brief or chronic conditions. Students' final design proposals were assessed for relevance to the target users and the technical depth of research into healthcare and production processes.

Stage 3: Quantitative Questionnaire

A 10-question questionnaire was distributed in both digital (Google Forms) and printed formats. This approach ensured accessibility for participants with varying technical capabilities. The questions addressed respondent demographics, perceptions about the elderly, and perceptions about pharmaceutical packaging. The questionnaire was first administered to the population involved in stage 2 (design students), with participation being voluntary. Subsequently, it was distributed to a similarly sized randomized sample to compare response trends across different professional fields and age groups. It was not applied to the same group of users of the interviews to not influence their point of view. A total of 120 individuals responded the survey.

Selection of Survey and Questionnaire Method

Since surveys are standardized tools for efficiently gathering large-scale data, they can offer insights into sample or population characteristics (Meneses & Rodríguez-Gómez, 2011). The questionnaire used in this study was designed to collect structured quantitative data, facilitating statistical comparisons of relevant variables, in this case, the Likert scale, a widely used instrument for measuring attitudes, was employed as inspiration. The scale involves presenting statements to which respondents indicate their level of agreement or disagreement, helping to assess beliefs, behaviours, values, and ideals. Reliability of the Likert scale improves with more response options, typically peaking around seven alternatives (Dillman, 2007).

- Design students
- Design professionals
- Healthcare professionals
- A randomized control group comprising individuals from various occupations and age groups

Methodology:

· Development of statements and response options

· Application of the scale

· Scoring and data entry

· Generation of a database

· Calculation of scores and frequencies

· Preparation of graphical representations

· Response alternatives were translated into numerical values for processing by software.

Data Analysis Process
Data entry, processing, and analysis were performed using Google Forms, Microsoft Excel, Google Sheets, and SPSS (version 10.0). These tools enabled systematic organization, analysis, and interpretation of the data, providing a comprehensive understanding of the research findings. The methodology integrated qualitative and quantitative approaches to comprehensively address the complexities of pharmaceutical packaging design for elderly users. By engaging with professionals, users, and design students, the study aimed to identify key areas for improvement and innovation, ultimately contributing to enhanced user experience and medication adherence.

4. RESULTS AND DISCUSSION

S1. INTERVIEWS

Pharmaceutical Industry Professionals

Not all pharmaceutical companies invest sufficiently in research and development focused on patient experience, particularly in packaging. Effective packaging design requires interdisciplinary collaboration, including engineering, physics, chemistry, and design. These disciplines ensure that the packaging protects the product and withstands external factors such as climate, humidity, and transportation conditions, ensuring the medication reaches patients safely and effectively.

Design has the potential to significantly enhance the patient experience. However, there are few designers specializing in the pharmaceutical industry. According to these experts, many designers lack knowledge of the technical processes in the Pharmaceutical Industry, but also sometimes of printing processes on specialised materials, which can result in impractical designs. Integrating design with other disciplines can create a cohesive and effective user experience, aligning aesthetic appeal with functionality and regulatory compliance. Some of them agreed in the fact that the patient profile is a critical factor in packaging design, but not all of them.

Patented medications, which are often more expensive, typically feature higher quality packaging materials and sophisticated designs aimed at wealthier consumers. In contrast,

generic medications tend to have simpler, less expensive packaging.

Children's medications were a critical factor for all of them, since everyone in the industry seems to have this factor imprinted on their policies, especially for OTC drugs, that often feature colourful and appealing designs to make the experience less daunting. According to these experts, designers should consider several key factors when creating pharmaceutical packaging, including ease of printing, simplicity, target user demographics, company branding, legibility of important information, and adherence to regulatory standards.

Users

Talking in an interview with older adults is complicated because, although they have no problem in sharing their opinions on various topics, they often provide little information about their own lives and view situations from a less fatalistic perspective than younger people, and they also will try not to speak ill of their family, possibly because previous generations were more protective of their privacy.

Therefore, most of what is learned comes more through observation and interaction than from questions expecting specific answers. Generally, the cognitive abilities of all the interviewees were optimal, with the only difference being noticeable after age 75. At this point, they tended to confirm details once or twice or felt overstimulated or pressured by their surroundings when they couldn't respond as quickly to demands that younger people handle more fluidly.

Regarding objects in their environment, older adults show a greater attachment to items than younger people. For instance, they might care for and "treasure" a stuffed animal that reminds them of their grandchildren, or a photo frame that holds a picture of a significant life event. Most of them steer away from minimalism, preferring to keep many objects organized and "in sight. Interestingly, professions do not seem to correlate with reported levels of empathy. Listening to their life stories or observing their actions, they did not appear particularly empathetic. It seems that in this survey, self-reported empathy is more about one's self-concept rather than age, gender, or occupation.

It is also noteworthy that those over 60 do not prefer to work for or with people their age. All mentioned the importance of being in a good mood, being calm and happy, and avoiding conflicts or thinking about things that make them sad. They seek to make their lives more pleasant with small things that do not involve much cost or effort. They find satisfaction in having an environment composed of pleasant things, either for their aesthetic qualities or the memories they evoke. An interesting position not shared by other age groups is that they believe their age group is essential due to their experience and wisdom. However, they think that economic status is more important than age regarding relevance. Most of them share issues with

understanding instructions and, secondly, with possible ergonomic problems because they find it harder to make some fine motor movements, sometimes due to less sensitive hands, large fingers, or arthritis issues (none had severe arthritis, but some atrophy in the distal phalanges was noticeable in those over 70). In other cases, it's a vision problem, making it difficult to handle objects requiring precision. Some of them believed that packaging was designed in some way due to the recommendations of doctors and physicians, making them suppose that "it has it's reasons to be as it is right now". Contrary to what might be expected, they rarely mention memory problems with medications at this stage. This is because, in many cases, the symptom or disease becomes part of a "new lifestyle" a term we use to describe the adjustments and coping mechanisms older adults develop to manage their health conditions, even if some of them even mentioned "a new identity" related to the diagnose. This 'new lifestyle' often involves incorporating medication routines into their daily planning and organization, making it a central part of their daily lives. They do not forget to take their medications, thanks to specific compensation strategies, but they do need to check several times if they are taking the correct medication and dosage.

Fig 1 y 2. Users and photographs of medication management they shared after the interviews

S2. Design Students Case Observation

In several instances, students who identified real user problems revealed that they had a family member who occasionally lived with them. This personal connection provided valuable insights, allowing them to focus on specific issues or needs. However, many other students conducted their searches randomly, selecting a medicinal product without familiarity with its primary users. some students aimed to raise awareness and destigmatize mental health conditions. However, their user research often oversimplified the patients' conditions and unintentionally reinforced the very stigmas they sought to eliminate. For instance, they portrayed depression patients as solely sitting or lying down, carrying antidepressants throughout the day while feeling ashamed to display the bottle. In other cases, teams struggled to deeply understand the user's condition. For example, they proposed a bracelet with small pills for Parkinson's patients to take orally, overlooking that this fine motor skill could be very challenging for these patients. Despite these challenges, some teams eventually developed better approaches for their final proposals. In contrast, projects that effectively addressed patients' needs, particularly in terms of ergonomics, showed more success. These solutions often focused on problems related to lack of sensitivity or dexterity, as well as visual decline. Such projects demonstrated a more straightforward and linear development process from start to finish. Overall, it was evident that most groups found it challenging to conduct interviews and maintain dialogues with much older individuals or those with health conditions. This difficulty suggests a need for new ways of learning how to approach more thorough research around healthcare issues and of transgenerational exchange and inclusion for creating effective and sensitive design solutions.

Figure 3. Collage of student works suitable for elderly patients with common chronic conditions. (Credits will be added after paper revision)

S3. Survey

Self-reported traits

Regarding empathy levels, we observe that non-student designers show the lowest empathy scores. However, this group does not show a significant deviation from the average empathy levels across different age groups. Specifically, individuals aged 18 to 24 exhibit lower empathy, whereas designers aged 25 to 30 demonstrate higher empathy, with some

of them being students as well suggesting a generational change on their perception. Notably, healthcare professionals rank highest in empathy, sensitivity, and empowerment, indicating their strong conviction on their capability to make a difference on their surroundings. Sensitivity scores vary less significantly, with design students showing the lowest sensitivity, contrary to expectations based on age or field. The findings suggest that healthcare professionals inherently possess more empathy, sensitivity, and a greater sense of empowerment compared to other professions.

Healthcare professionals or students demonstrated the highest empathy score (4.2058), reflecting the nature of their work. Design students and other fields reported similar levels of empathy (4.1969 and 4.1875 respectively). Design non-students had the lowest empathy score (3.9259) among the listed groups.

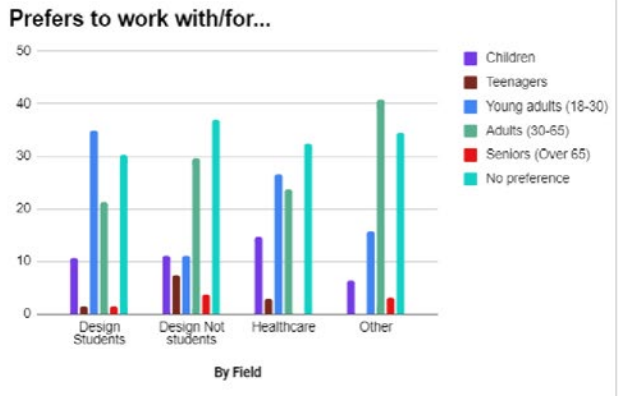
Perception towards elderly users

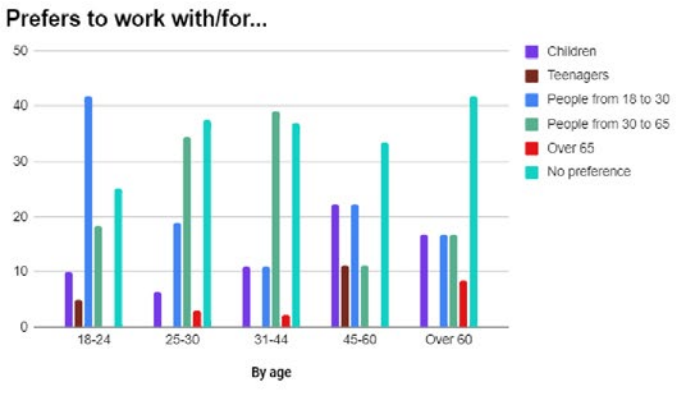
When assessing the perception of vulnerability in different age groups, designers believe that children are the most vulnerable. In contrast, healthcare professionals and others consider the elderly to be more vulnerable. Data segmented by age shows that the youngest individuals and those over 45 years old perceive children as the most vulnerable, while other age groups either see both as equally vulnerable and lean towards the elderly being more vulnerable.

Regarding cohabitation with elderly individuals, design students and people in their 30s are the least likely to have lived with an elderly person, correlating with their younger ages. There is no significant difference by profession in this aspect. Perceptions of when old age begins varying by field: design students typically believe old age starts between 60 and 70 years, whereas other groups, especially those aged 18 to 24, think it begins after 70 years.

In terms of attitudes towards working with different age groups, science students and younger individuals show a preference for working with young adults (18-30 years old). Adults aged 30-44 prefer working with their peers, but this preference diminishes for those aged 45 and older. Teenagers are the least favored group to work with across all ages, followed by individuals over 65, who also received low preference scores. Notably, a significant number of respondents expressed no preference, although their overall responses indicate a bias against working with people over 65. The importance of elderly individuals in society is perceived differently across groups. Non-students and healthcare professionals, along with people over 30, view the elderly as very important, while the youngest and design students tend to rate their importance lower. This discrepancy highlights differing perceptions based on age and professional background.

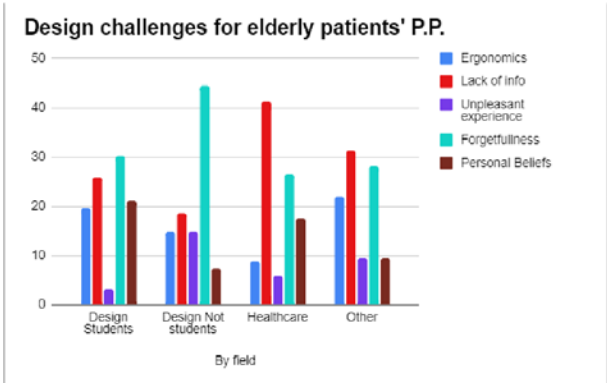
Perceptions on pharmaceutical packaging

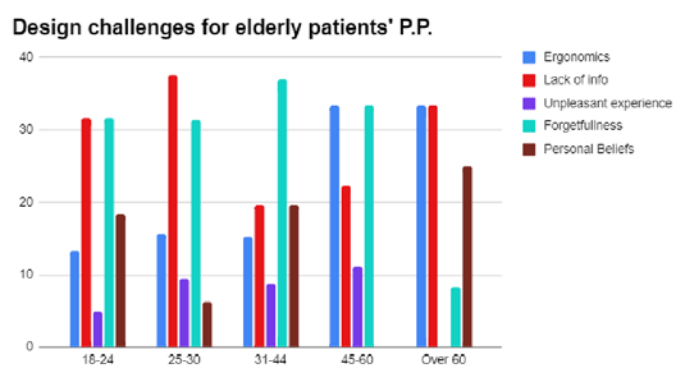


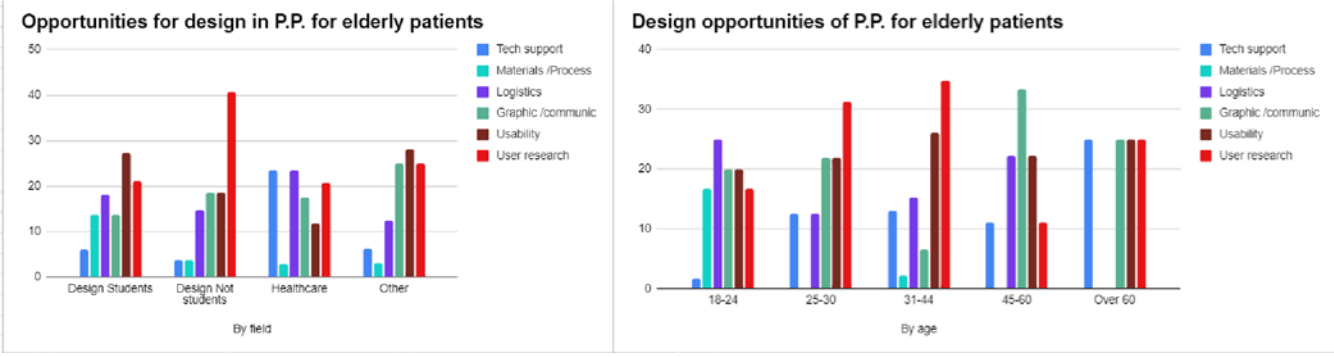


When addressing design challenges for elderly patients in pharmaceutical packaging, design students and non-student designers identify forgetfulness as the primary issue. This view is shared across almost all age groups. Conversely, healthcare professionals and elderly users emphasize the lack of information as the most critical issue, with ergonomics also being a significant concern for those aged 45 to 65. This divergence suggests that healthcare professionals and elderly users, who interact directly with medications, provide more accurate insights into these challenges compared to younger individuals and non-specialist professionals. In terms of opportunities for designing pharmaceutical packaging for the elderly, younger individuals and those aged 25-30 view logistics as a critical factor, while those aged 25-45, along with nonstudent designers, prioritize user research due to the insufficient understanding of this demographic's needs. Healthcare professionals and people over 60 show similar attitudes across all options, except for materials and processes, which they deem less important. This is likely due to the advanced state of the pharmaceutical industry in these areas. Technological support is also seen as a valuable opportunity by elderly users and healthcare professionals.

Notably, non-student designers and individuals aged 25-45 place significant importance on user research, while people aged 45-60 give higher importance to graphic communication, aligning it equally with other factors for elderly individuals.







Overall, these insights highlight the need for targeted user research and a focus on practical usability issues such as information clarity and ergonomic design to improve pharmaceutical packaging for the elderly.

5. Conclusions

Pharmaceutical packaging, though often perceived as a mundane element, takes on varied significance depending on the perspective of the stakeholder involved. For policymakers, it functions as a regulatory tool to ensure that the pharmaceutical industry adheres to standards and protects consumers. Pharmaceutical companies view it primarily as a protective casing that must meet regulatory requirements. For doctors, it serves as a reference for guiding patient care, while medical staff and nurses use it as an essential tool in their daily work. Caregivers see pharmaceutical packaging as a symbol of their dedication and attentiveness to their loved ones. For patients, it impacts their routines and environments and is integral to their self-care regimen. Despite its often-uninspiring appearance to designers, pharmaceutical packaging plays a crucial role that demands a deeper understanding and empathy towards medical personnel and patients. Medical professionals confront human fragility and health complexities daily, and even minor design flaws can have serious implications for patient health. This underscores the importance of studying how people interact with and perceive pharmaceutical packaging to improve its effectiveness.

The study highlights the multifaceted roles of pharmaceutical packaging, which vary significantly based on the stakeholder's perspective. For policymakers, it serves as a regulatory tool; for pharmaceutical companies, a protective casing; for healthcare professionals and medical staff, a daily work tool; for caregivers, a symbol of care; and for patients, a crucial aspect of self-care. This diversity underscores the necessity for designers to empathize with all stakeholders, particularly medical personnel who deal with the human aspects of healthcare.

Designers need to engage deeper on the research of the human and emotional dimensions of healthcare, collaborating with fields such as neuroscience to improve decision-making processes and simplify

visual communication. The analogy of pharmaceutical packaging to a "holistic ritual" akin to religious practices underscores its significance in patients' lives, suggesting that a more empathetic and multi-sensory design approach could enhance user experience and adherence. This research emphasizes the need for targeted user research and practical usability improvements, such as clearer information and better ergonomic design, to enhance pharmaceutical packaging for the elderly. It also calls for a more integrated, empathetic approach in design, acknowledging the diverse needs and perceptions of all stakeholders involved in the healthcare system. Packaging should be projected for two main fields of users boarding the three dimensions of their human experience, fostering decision-making, organisation and modularity for caregivers and the ritualistic experience on users. In order to do this, a wide range of experimentation is needed, to better settle the way in which packaging might unite ergonomics, cognitive ergonomics and Neuroaesthetics; focusing the experimentation in elderly, according to the physical and cognitive changes, that might have an effect on their perception of what "a good design of medical packaging is".

Limitations and Future Research

The study's limitations include the small sample size of international users and caregivers, which may not represent all cultural contexts; and constraints in resources and time affecting the comprehensiveness of the research. Another limitation on the research is the lack of possibilities to do longer-term research with users inside the same context and environmental conditions, and the explorative character of the research implies that for further research the methodologies should be developed in a more controlled environment, and with the participation of professional facilitators and co-researchers to follow a more restricted and replicable framework.

Future research should address these limitations and explore more diverse and extensive samples to validate and enhance the findings of this study according to methods developed by a multidisciplinary team.

By drawing on insights from neuroscience and incorporating more empathetic and user-centred design principles, we can enhance decision-making processes and develop pharmaceutical packaging that better resonates with its users. This approach can help move beyond a purely functional view of packaging, addressing both its practical and emotional dimensions, and ultimately improving patient experience and outcomes.

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ENHANCING PRO-SOCIAL EXPERIENCES THROUGH CROSS-CULTURAL INTERACTIONS FOR THE CAMPUS OF THE FUTURE.

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ABSTRACT | This study aims to present the design concepts and development of proposals for the "Campus of the Future," focusing on enhancing pro-social experiences through cross-cultural interactions. Highlighting the significance of cross-cultural communication and navigation in shaping future educational environments, this research integrates inclusive approaches and proposals with Crossed Reality (XR), Virtual Reality (VR), and Artificial Intelligence (AI) applications. It establishes possibilities for designing new types of experience-led services aimed at promoting pro-social interactions and inclusivity on campuses. Six different short projects were designed over the past two years through intensive workshops from the Post Urban Living Innovation Education and Research Program (PULI), each addressing various aspects of cross-cultural collaboration and communication. These projects were generated by students under the guidance of faculty members and researchers both Chiba University in Japan and Universidad de Monterrey in Mexico. They were assessed for their effectiveness in fostering understanding, empathy, and cooperation among students from diverse cultural backgrounds. The "Campus of the Future" projects explored challenges associated with implementing such services on university campuses, including technological barriers, cultural resistance, and the need for comprehensive training programs. By comparing and contrasting the outcomes of these six projects, the study provides insights into best practices for integrating technology into educational settings. In conclusion, this study offers a comprehensive overview of enhancing cross-cultural interactions through innovative technological applications in the "Campus of the Future." Addressing challenges and leveraging XR, VR, and AI technologies can create more inclusive and pro-social environments. Suggesting that careful application and continuous evaluation of these technologies can significantly shape the future of education, fostering greater understanding and collaboration.

KEYWORDS | EDUCATIONAL INNOVATION, INTERDISCIPLINARITY, GLOBAL COLLABORATIONS, DIGITAL TRANSFORMATION

1. Introduction

In recent years, the concept of the "Campus of the Future" has gained significant attention, emphasizing the need to enhance pro-social experiences through cross-cultural interactions that lead to next-generation experiences for students, faculty, and staff. This paper showcases a diverse exploration of design concepts and development proposals aimed at creating a responsive campus. These cross-cultural workshops and iterations focus on communication and the integration of inclusive approaches facilitated by advanced technologies such as Crossed Reality (XR), Virtual Reality (VR), and Artificial Intelligence (AI).

By sharing six short projects developed through the Post Urban Living Innovation Education and Research Program (PULI) at Chiba University and Universidad de Monterrey with undergraduate and graduate students, this research assesses the effectiveness of these projects in fostering understanding, empathy, and cooperation among students from diverse cultural backgrounds through cross-cultural experiences. Through a comprehensive analysis of these projects, the paper highlights the challenges and opportunities in implementing pro-social, technology-driven initiatives in educational environments. Additionally, it contrasts and considers which projects can be implemented in the short term and which will require a longer timeline.

2.Literature Review

2.1 Campus of the future

In our modern smart campus infrastructure, it's remarkable how students take charge of the conceptualization and design phases of smart campus ideas and projects from multi and interdisciplinary approaches directly to academic environments. This approach not only empowers students, it also provides a platform to participate in creating educational tools and making meaningful contributions to the academic community. Wang and Adil (2023) describe the "campus of the future" as a multifaceted concept that merges advanced technologies, innovative educational paradigms, and sustainable practices to meet the evolving needs of higher education. This

blend of elements highlights a vision for a highly adaptable, flexible, hybrid, sustainable, and technologically advanced learning environment, and deployment of AI-driven technologies (Kamalov et al., 2023), thoughtfully designed to meet the diverse academic needs and aspirations of all stakeholders.

One of the primary grand challenges is utilizing educational technology as the mechanism for fostering institutional development (Li, 2022), the vision of the "Campus of the Future" focuses on seamlessly integrating advanced technologies like the Internet of Things (IoT), Artificial Intelligence (AI), and Digital Twin into university settings as some of the tech trends. This integration enhances operational efficiency, user experience, and environmental sustainability (Pexyean et al., 2022). The integration of Augmented Reality (AR) and Virtual Reality (VR) in educational environment increases creativity and problem-solving skills, highlighting their possibility to transform education within learners from diverse cultural backgrounds. This leads to a better understanding of design processes and encourages collaboration through immersion and interaction (Pexyean et al., 2022, Dembe, 2022).

Thompson et al (2021) describe that despite the rapid emergence of new technologies, the methodological and pedagogical approaches in teaching practices remain relatively stable. This stability is viewed as a strength, enabling the educational technology community to reflect on and adapt its practices in response to new developments.

Yamao and Lescano (2020) explain that the smart campus concept also draws parallels with smart cities, on a smaller scale, with fewer devices and simpler networking complexities. Universities can enforce homogeneous technology use across the campus, turning it into easier management and deployment of IT infrastructures like IoT, cloud computing, and long-distance communication. Moreover, the smart campus serves as a learning platform for Industry 4.0, preparing students to develop and support IoT-based systems through project-based courses that encourage creative solutions to real-world scenarios in multidisciplinary contexts.

Culture and contexts play a crucial role in discovering a sense of unity and belonging among students, and the digitization of campus heritage through internet and virtual heritage which provides more accessible and engaging ways for students to connect with their university's history and culture. This digital cultural heritage augments the interaction between users and heritage, enhancing students' bonding with their universities and strengthening their individual identities (Gao et al., 2018). In summary, the Campus of the Future is efficient, advanced in technology and a culturally enriched environment that not only improves the quality of education and campus life but also prepares students for the demands of modern industries.

2.2 Cross-cultural experiences and pro-social interactions

A framework for designing cross-cultural education integrates multilingualism with interdisciplinary methods to establish inclusive educational settings which are tailored to students from varied cultural and linguistic backgrounds. Yassine (2006) characterizes intercultural competency as the achievement of understanding and appreciation for one's own cultural heritage along with the customs of diverse societies. The idea is to promote mutual respect and understanding among individuals on a global scale. Erlandson (2012) emphasizes the importance of considering cultural standards and core concepts like collectivism, power dynamics, and high-low context societies in developing intercultural awareness.

- Understanding cultural differences between cultures: Cross-cultural interactions enhance design education by exposing students to diverse perspectives. This leads to a richer learning experience, especially in a globalized world.
- Creating comfortable environments: Establishing inclusive and supportive settings, as open communication is crucial for fostering effective learning experiences for students from diverse backgrounds.
- Social barriers: Identifying and overcoming social obstacles that affect cross-cultural understanding and collaboration is essential for promoting an inclusive and respectful educational environment (Ma et al ,2024).

Zheng and Zhao (2012) describe that cross-cultural environments within the education context share detailed and multi-dimensional impact on the processes of learning and creativity, highligthing having cultural awareness and adaptability skills. The concept of cross-cultural experiences is outlined as engagements between people that encompass the comparison and contrast of diverse cultural components, which possess the capacity to a marked influence on belief systems, and patterns of conduct.

In the same investigation, according to scholarly investigations, the influence of cross-cultural highlights on the cultivation of creativity is dependent of an an individual's receptiveness towards unfamiliar cultural environments. Although it is considered that a certain degree of education might have a purpose and that such relations have the potential to augment levels of creativity, upon the open mindnessnes, (Zheng and Zhao, 2012).

Saulnier et al. (2014) demonstrate that in educational settings, successful cross-cultural learning environments are characterized by support systems that handle basic human needs, which makes the structure of the domain visible, prepares participants on this professional-level practice, and provides direct feedback.

Additionally, work on cultural studies in foreign language education emphasize the necessity of integrating language learning, language awareness, cultural awareness, and cultural experience to raise intercultural communication awareness. The use of network technology in cross-cultural education further supports these goals by providing innovative opportunities for cultural exchange and learning, which are essential in today's globalized world, (Shu & Xue, 2013).

Understanding cultural differences between cultures includes the cross-cultural interactions which might enhance design education by exposing students to diverse perspectives. This leads to a richer learning experience, especially in a globalized world. Creating comfortable environments, through the establishment of inclusive and supportive settings is crucial for assuring effective learning experiences for students from diverse backgrounds. And identifying and overcoming social barriers or tabus that might interfere between cross-cultural understanding and collaboration is essential for promoting an inclusive and respectful educational environment.

2.3 Technology at campus, trends and barriers

The decision to incorporate technological advancements in the field of education is difficult and influenced by a variety of environmental and individual elements. Significant obstacles include technological absence of integrated, precise, and timely data or information, predictive analytics, and bias. Additionally, tere might be a lack of incentives and support systems for the adoption of new technologies (Klein et al., 2019).

Despite these difficulties, the advancement of technology has brought a range of alternatives in the educational sector, such as big data, artificial intelligence (AI), cloud computing, and virtual reality (VR). These emerging technologies offer innovative tools for new pedagogical strategies (Jiugen et al., 2020; Klein et al., 2019). Information and communication technology (ICT) has revolutionized the learning process for students, enabling them to transition from conventional classrooms to virtual settings using internet-based technologies. Educational platforms now assist institutions in creating online courses and effectively monitoring student advancement (Jiugen et al, 2020).

Jiugen et al (2020) suggest that professionals engaging with these technologies, must have a profound comprehension and skills in the operational principles of virtual instruments are mandatory. This involves familiarizing themselves with the characteristics and functions of these tools to ensure the optimal utilization in virtual experiments. Through strategical planning of each stage of the design and execution, the procedure evolves into a methodical and well-organized effort. This method not only boosts the efficiency of the virtual experiences but also helps guarantee that the end product is both transcending and useful.

Well know technological innovations are also reshaping the educational landscape, Thompson et al (2021) from their research share that instructional design, learning engineering, and user experience (UX) design are becoming increasingly significant, along with extended reality (XR) technologies such as augmented reality (AR), virtual reality (VR), and mixed reality (MR). Combining these insights, it becomes clear that the thoughtful implementation of technology in education, supported by practices and collaborative efforts, can significantly improve the learning environment and outcomes for both students and faculty.

Project focus and objectives

Design initiatives for the Future Campus are purposed towards the empowerment of all users, which includes students and faculty members, who engage in a collaboration to develop innovative interactions that cultivate a forward-thinking perspectives and models that have an impact on learning outcomes and academic experiences that are characterized by excellence. The primary goal is to enhance the educational environment through the implementation of these initiatives.

The following table provides details on the six brief projects undertaken during the workshop sessions, including information on the iteration, location, year, and keywords associated with each project. This information serves as a comprehensive overview of the projects carried out within the workshop setting.

The projects were executed within interdisciplinary and collaborative settings at Chiba University in Japan and Universidad de Monterrey in Mexico. The workshops brought together groups of 3 to 7 undergraduate and graduate students from both institutions, fostering a rich exchange of ideas and perspectives among participants.

These intensive workshop sessions spanned a duration of approximately 5 to 10 days, during which the participants engaged in rigorous work and interactive sessions. Additionally, cultural visits were organized to facilitate the sharing of diverse cultural perspectives and ideas among the participants, further enriching the general experience of the workshops.

Table 1. Projects for the Future Campus

Project Title	Keywords	Year	Workshop Iteration and location
Neutral Network	Gender discrimination, Diversity	2022	1st iteration at Chiba University
Socioeconomic Integration Project	Integration, Collaboration	2022	1st iteration at Chiba University
Disability Equipment: Manjiro's Device	Community, Physical aid	2022	1st iteration at Chiba University
Tomomigos: Mental Health, Professional Development	Mental Health, Professional development	2022	1st iteration at Chiba University
Design Systems for next gen faculty and students	Design for the future, tech systems	2023	2nd iteration at Universidad de Monterrey
Empowering Cross-Cultural Collaboration	Project-Based Learning, Constructivism Theory	2023	3rd iteration at Chiba University

The primary focus of the project are the various challenges faced in different scenarios, especially within educational settings at campuses. The following bullets are the primary areas of focus from the past six mentioned projects:

1. Addressing gender bias: This initiative aims to mitigate gender bias within the university environment by developing a platform where users can create personalized avatars. By designing interactive virtual environments for social activities, the project seeks successful interaction between users.
2. Promoting empathy and collaboration: This project seeks to promote empathy,
3. collaboration, and economic growth for lower-class students. By implementing a program university students and conducting VR-based activities to enhance communication and teamwork, the project aspires to improve interactions and social dynamics free form socioeconomic status or bias.
4. Accessibility and inclusion: Challenges faced by individuals with motor or physical disabilities in various professional collaborations outside of campus and within educational institutions. It specifically focuses on schools where academic pursuits and practical research activities pose significant obstacles for these individuals.
5. Supporting mental health and professional growth: Development and support of diverse

conditions and needs of students, faculty and staff by creating virtual and physical activities designed to foster mental well-being and professional skills.

6. Innovating educational design systems: Innovate design systems for future technology use in education. It involves using advanced design tools and methodologies to implement educational programs that focus on future tech systems throughout the entire student journey, starting from early years.
7. Fostering cross-cultural collaboration: This initiative facilitates effective collaboration among learners from diverse cultural backgrounds by integrating AR and VR technologies into educational programs and encouraging cross-cultural interaction through collaborative projects.

The project is guided by a set of clearly defined and concise objectives that have been tailored with the intention of improving the overall well-being at universities implementing technology through design strategies and solutions. These objectives are comprehensive in nature, aiming to achieve the following:

- Creating Interactive and Adaptable Campuses: The primary objective is to develop campus environments that are not only interactive but also adaptable in order to effectively prevent and address mental health issues that may arise among students.
- Innovating Assistive Technologies: Another key goal of the project is to innovate and introduce new technologies that are designed to assist and promote interaction.
- Reducing Gender Bias: Furthermore, the project also has a significant focus on reducing gender bias within university settings, with the ultimate aim of cultivating a more inclusive and equitable environment that caters to the needs and rights of all students.
- Promoting Diversity and Inclusivity: The overarching vision of the project is to promote diversity and inclusivity by establishing strong connections among individuals from diverse backgrounds. This includes fostering a sense of community and collaboration within the campus and workplace.
- Expanding Program Accessibility: Lastly, there are strategic plans in place to expand the reach of the program to communities that may have limited access to the internet or smart devices. This expansion aims to ensure that individuals from all walks of life have the opportunity to benefit from the program, thereby promoting equal access to resources and opportunities for personal and professional growth.

Through these targeted efforts, the project aspires to cultivate a more inclusive, supportive, and engaging environment for individuals, fostering personal and professional development within university settings.

3.Methodology and tools

The project employs a diverse range of design methodologies, such as Design Thinking and Human-Centered Design strategies to tackle the diverse issues present within university environments, encompassing classism, gender bias, mental health concerns, and the integration of disabled individuals. These methodologies play a huge role in augmenting social cohesion among students from different backgrounds and ensuring an academic experience that is inclusive.

Some of the strategies implemented where:

In the process of survey construction was one of the primary objective of this approach was to gather first-hand data directly from the students for the purpose of the projects at hand. The acquisition of such data plays a pivotal role in fully considering the real areas of opportunity. The data obtained served as a foundation for deep analysis and the development of necessary interventions.

A considerable emphasis was placed on the identification of contributing factors and stakeholders creating archetypes and user journey maps, with a focus on the key elements that contribute to the specific project under consideration. Additionally, efforts were made to identify the strategies that were put in place to address, mitigate, or resolve the identified problem effectively.

An innovative approach involved the utilization of Artificial Intelligence (AI) for the generation of images and perspectives derived directly from the students themselves. This method aimed to find patterns and relationships within the project and gather information of the specific aspects that required attention and resolution.

Furthermore, benchmarking exercises were conducted, to understand similar project implementation processes. This analysis aimed to glean insights on how design solutions were executed in those projects and how similar approaches could be adapted for the current project.

Lastly, the utilization of software tools pertaining to graphic and video game design were integrated into the process. This was done to the effective design strategies for the utilization of the Oculus Quest platform, as well as for the use of diverse Artificial Intelligence (AI) training webpages.

Specifically for each project:

- Platform for Avatars: An integral component of the project involves the creation of a specialized platform tailored for avatars in software Blender, complete with predefined pronouns, alongside the curation of interactive virtual and AI assistance. This strategic initiative is to ensure seamless and successful interactions among users, thereby fostering an environment that is equitable and devoid of prejudices.

- Virtual and Physical Activities: At the core of the initiative lies the development of a comprehensive array of both virtual and physical activities designed to boost mental well-being and foster professional advancement among students. These interactive activities such ass piano lessons, chess and other, were thoughtfully curated with a specific emphasis placed on cultivating connections.
- Assistive Technology Development: A dedicated aspect of the project revolves around the innovation and deployment of sensor-based technologies that empower disabled individuals to perceive through sense as a multisensorial solution and engage with spaces that were inaccessible to them through the live streaming. This effort permits the mitigation accessibility challenges, generating tailored solutions aimed at improving solutions for the mobility and independence of individuals with disabilities.
- Creative Networks: By applying the power of creative networks, the project pursuits to enrich the diversity and authenticity of virtual representations by leveraging generative networks to generate outcomes that are distinct from real images. This deliberate strategy serves to enhance the overall user experience and promote active engagement.

In addition, these varied methods collectively strive the issues of classism, gender bias, mental health challenges, and accessibility barriers. These different approaches intend to tackle classism, gender bias, mental health issues, and accessibility problems in universities, creating a fair, friendly, and enriching experience for all students, faculty and staff.

4. Creative process and conceptualization

Crucial aspects in the development of innovative ideas and projects were explored by each group of students as they immersed in the journey of this workshop. Each team worked in a final presentation where all the details of the process, design ideas, conceptual framework were shown. Through the next summarized informative tables, serve as a comprehensive tool to summarize the essence of each project, providing a clear overall roadmap.

Table 2. Neural Network Project

Project Title	Objective	Key Activities	Outcomes	Future Plans
Neutral Network	Mitigate the gender bias in the university environment.	Creating a platform for avatars with specified pronouns. Designing interactive virtual environments for social activities.	Successful interaction among users. Positive reception from participants.	Further development of the platform. Implementation of "identical twins" for continuous activity.

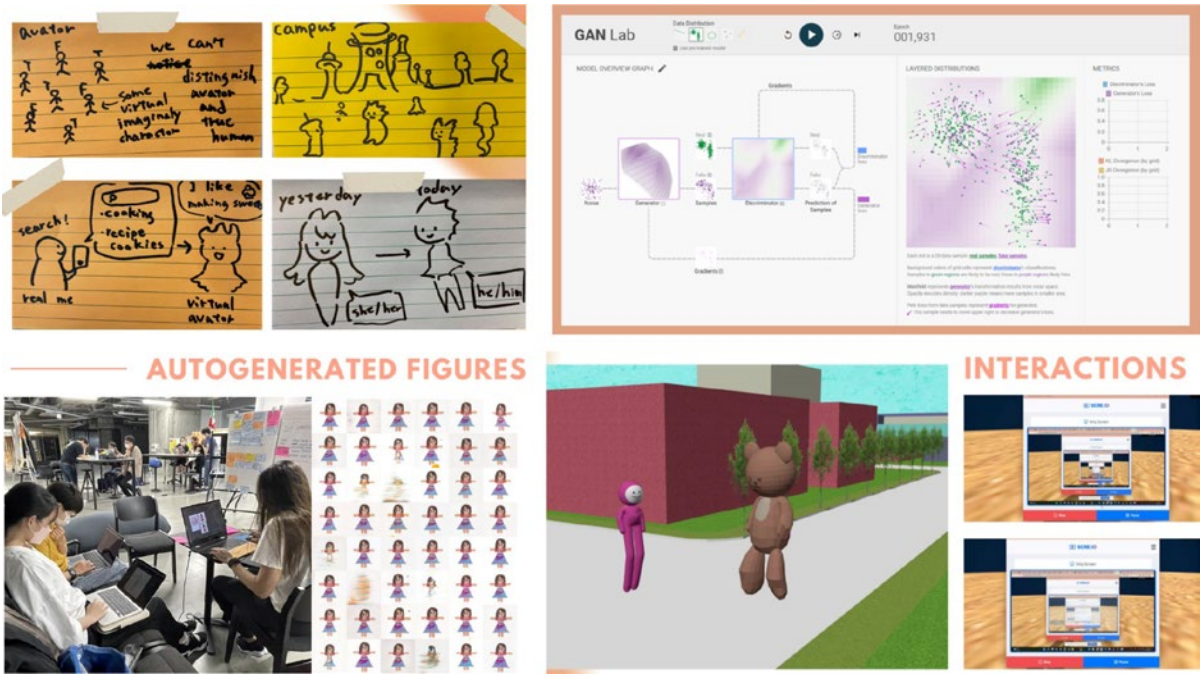

Figure 1. Neural Network project

Table 3. Socioeconomic Integration Project

Project Title	Objective	Key Activities	Outcomes	Future Plans
Socioeconomic Integration Project	Promote empathy, collaboration, and economic growth for lower-class citizens in their workplace.	Implementing a week-long program for freshman university students. Conducting VR-based activities to promote communication and teamwork.	Improved communication among students. Positive impact on student social interactions.	Development of both virtual and physical activities. Continued research to foster diverse workplace environments.

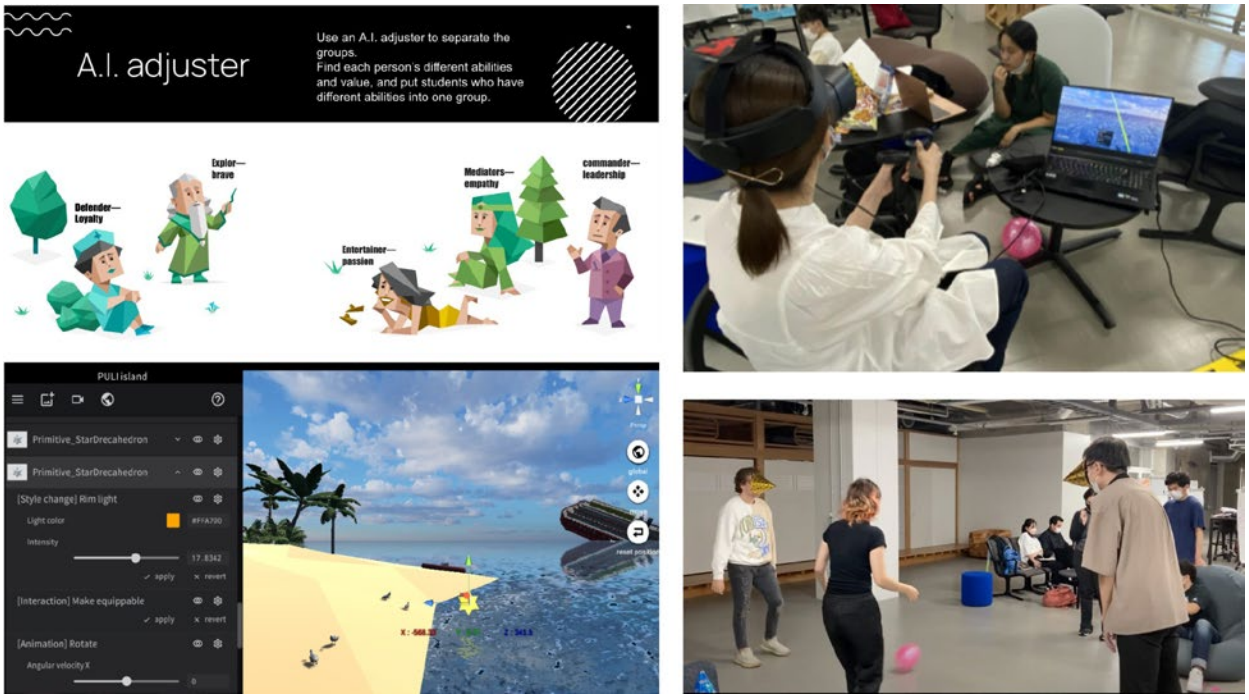

Figure 2. Socioeconomic Integration Project

Table 4. Disability Equipment: Manjiro's Device

Project Title	Objective	Key Activities	Outcomes	Future Plans
Disability Equipment: Manjiro's Device	Develop a device to help disabled individuals see and feel areas they cannot access.	Conducting field research to identify accessibility issues. Developing sensor-based technology to provide remote access experiences.	Identification of accessibility challenges. Successful development and testing of the device.	Enhanced integration of disabled students in university communities. Further development of the project in Mexico and Japan.

Figure 3. Disability Equipment: Manjiro's Device

Table 5. Tomomigos: Mental Health, Professional Development

Project Title	Objective	Key Activities	Outcomes	Future Plans
Tomomigos: Mental Health, Professional Development	Address mental health and professional development among students.	Developing virtual and physical activities to promote mental health and professional growth.	High interest and positive reception from participants. Significant personal and learning growth.	Further development of virtual activities. Implementation of physical activities on campus. Exploration of ways to create strong bonds in diverse workplaces.

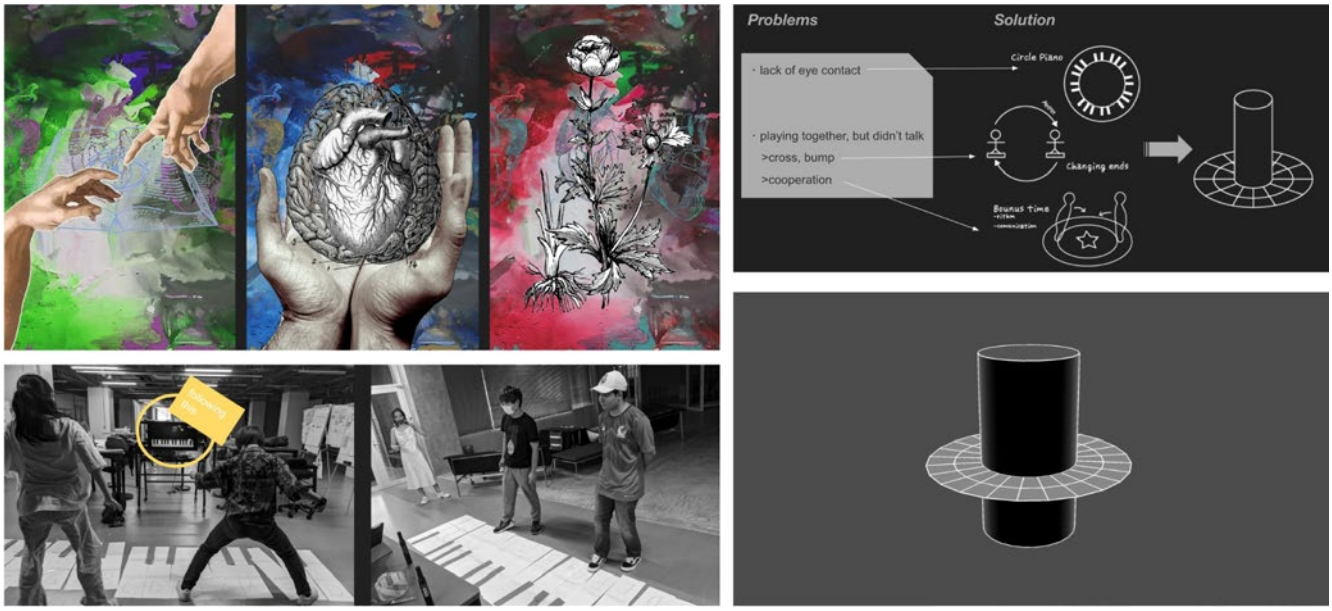

Figure 4. Tomomigos Mental Health, Professional Development

Table 6. Design Systems for Next Gen Faculty and Students

Project Title	Objective	Key Activities	Outcomes	Future Plans
Design Systems for Next Gen Faculty and Students	Innovate design systems for future technology use in education.	Utilizing advanced design tools and methodologies. Implementing educational programs focused on future tech systems.	Enhanced learning experiences. Improved integration of technology in education.	Continued innovation in educational design systems. Expansion to other educational institutions.

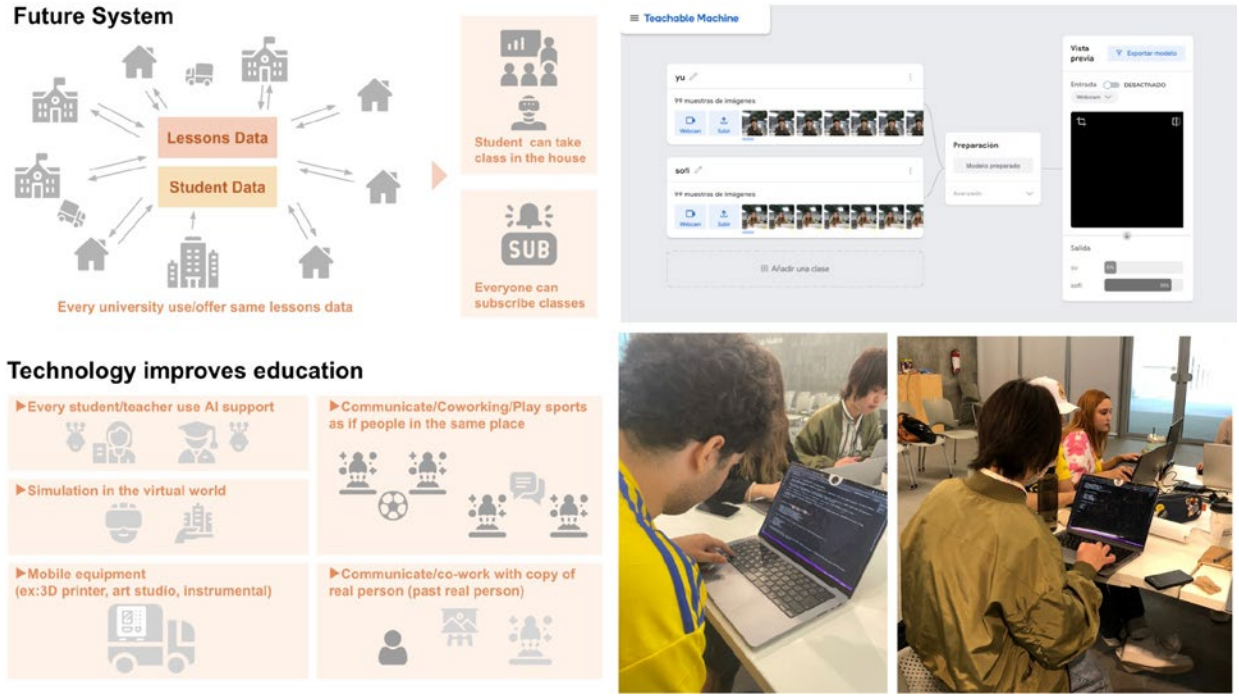

Figure 5. Design Systems for Next Gen Faculty and Students

Table 7. Empowering Cross-Cultural Collaboration

Project Title	Objective	Key Activities	Outcomes	Future Plans
Empowering Cross-Cultural Collaboration	Facilitate effective collaboration among learners from diverse cultural backgrounds.	Implementing AR and VR technologies in educational programs. Encouraging cross-cultural interaction through collaborative projects.	Improved cross-cultural communication. Enhanced creativity and problem-solving skills.	Further integration of AR and VR in education. Expansion of the program to include more diverse cultural backgrounds.

Figure 6. Empowering Cross-Cultural Collaboration

5.Integration and Transcendence

The integration and impact of the six projects focus on creating a strong and lasting effect on social dynamics and community bonding within a university setting. These projects aim to transform the university environment into a place where everyone feels included and valued. The main goal is to build a comprehensive support network that not only connects people but also helps form meaningful relationships across different age groups. This network is designed to encourage interactions that go beyond generational and social boundaries, promoting understanding and collaboration among students, faculty, and staff.

One key approach is fostering a deep sense of belonging and inclusivity within the community. This involves encouraging everyone to join in conversations without bias or prejudice, ensuring that all voices are heard and respected. By highlighting the importance of diversity, the project aims to create a welcoming space where physical attributes like appearance and age aren't the main focus, but rather the unique perspectives and experiences each person brings.

Using the latest technology, and thoughtful design, the project seek to build lasting connections that enrich everyone's lives. These cutting-edge tools help bridge gaps and make it easier for people to engage with each other in meaningful ways. The combination of these technologies and a strong community focus aims to create an environment where people feel supported, understood, and connected on a deeper level. In summary, these projects are all about making the university a better place for everyone. They strive to enhance social cohesion, break down barriers, and foster an inclusive atmosphere where everyone can thrive. By bringing people together and leveraging technology, the projects aim to leave a positive impact on the university community, making it a more harmonious and enriching place for all.

6. Conclusion and next steps

In conclusion, the design interactions have enhanced the knowledge and understanding of students and faculty by leveraging available opportunities without technologica or economic constraints. These constraints, however, do limit project implementation.

This approach ensures the educational experience transcends academic learning, fostering cross-cultural collaborations that develop both personal and professional skills. This transformative journey for Mexican students progresses through iterative processes, preparing them for a design-led educational experience that not only enhances conceptual capabilities but also transitions to practical, efficient methodologies. The evolving projects highlight the collaborative efforts of students, faculty, and staff from both academic institutions.

To conclude the following projects are considered as:

Implementable Now:

- Neutral Network: Quick to implement due to its reliance on existing digital technology.
- Tomomigos Mental Health, Professional Development : Virtual activities can be swiftly launched, with physical activities following shortly after.

Long-Term Projects:

- Socioeconomic Integration Project: Requires extensive planning and resource allocation.
- Disability Equipment: Manjiro's Device: Technological development and field research make this a long-term project.
- Design Systems for Next Gen Faculty and Students: Continuous innovation and technology integration necessitate a longer timeline.
- Removing the Limitations of Current Cross-Cultural Communication & Cooperation Course: Developing and maintaining AR and VR technologies requires a phased, long-term approach.

Limitations:

- Neutral Network: Needs continuous updates to maintain engagement.
- Tomomigos: Requires ongoing adaptation of interactive games or activities to remain effective.
- Socioeconomic Integration Project: High resource and time demands.
- Manjiro's Device: Cost and complexity of technology refinement and
- implementation.
- Design Systems: Continuous investment in new technologies and training.
- Cross-Cultural Communication Course: Extensive resources for AR/VR development and cultural adaptation.

In summary, while the Neutral Network and Tomomigos projects are ready for short-term implementation, the other four projects face significant technological and economical limitations that extend their timelines into the long term. Each project, however, holds the potential for substantial impact within its target area, given the necessary resources and time for development and integration. The next steps will involve team building and budget agreements to initiate the first stages of the selected project. Implementation will begin with minimum viable projects to validate impact and make the required changes. This is an iterative process, given the rapidly changing nature of technology.

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ACROSS BORDERS: A PILOT PHD PROGRAMME IN DESIGN, ART AND TECHNOLOGIES. OPEN QUESTIONS FOR A POST-DISCIPLINARY EDUCATION & RESEARCH MODEL.

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ABSTRACT | The multiple social, cultural, political and environmental challenges posed by the complexities and transformations of the contemporary world require a post-disciplinary education. In this complex scenario, design culture and artistic practice can provide an alternative model for thinking, planning and creating possible and desirable futures, and outline new models for research and education. The pioneering PhD programme in Experimental Research through Design, Art and Technologies, starting in the 2024-25 academic year at the [name of the university], Italy, proposes to shape new research profiles capable of integrating design and artistic, humanistic and social methods, knowledge and skills hybridised with scientific-technological ones. However, this raises a number of structural challenges.

The paper presents and critically discusses the open questions raised by the postdisciplinarity approach of the research doctorate. It aims to highlight the challenges and potentials of hybrid education in design and art at the convergence of technologies, humanities and socio-economic issues.

KEYWORDS | EDUCATION IN DESIGN AND ART, POST-DISCIPLINARY EDUCATION, HYBRID EDUCATION, POST-DISCIPLINARY PHD PROGRAMME, INNOVATION IN DESIGN AND ART EDUCATION

1. Introduction

The multiple social, cultural, political and environmental challenges posed by the complexities and transformations of the contemporary world require a multidimensional, cross- and transdisciplinary (Bernstein, 2015), or rather post-disciplinary (Pernecky, 2019), education (Morin, 2001). In this complex scenario, design culture and artistic practice can provide an alternative model for thinking, planning and creating possible and desirable futures and outline new transdisciplinary models for research and education. This concept is similar to what is currently called the Research through Design, one of three possible forms identified by Alain Findeli (2004). Zimmerman (2007) refers to RTD as "process of iteratively designing artefacts as a creative way of investigating what a potential future might be" emphasising the methodological possibilities of practice-based research and implicitly referring to the concept of the reflective practitioner, without which there could be no theoretical and conceptual reflection during or after practice, as Schön (2002) points out.

The pioneering PhD programme in Experimental Research through Design, Art and Technologies starting in 2024-25 academic year / XL cycle, according to Italian regulation, at the Frre University of Bozen-Bolzano, Italy proposes to shape new research profiles capable of integrating design and artistic, humanistic and social methods, knowledge and skills hybridised with scientific-technological ones. However, this programme, which addresses aspects of inter- and trans-disciplinarity, questions the very concept of discipline and opens a series of structural issues. The programme was initiated by the leadership of the Faculty of Design and Art, in collaboration with the Faculty of Engineering (and Computer Science), and with the participation of colleagues from the Faculties of Education, Economics and Management, as well as colleagues from other national universities and experts and fellow professors from foreign European universities. "The programme provides a space for speculative, critical and pragmatic reflection on problems, potential solutions and new conceptual perspectives inspired by design culture and artistic production. It integrates complex

design, scientific and social knowledge and requires the establishment of collaborative relationships with human, non-human and more than human actors through intercultural methods, learning from others, embracing cultural relativism and experimenting with new research tools and practices." as stated in the official description.

On the one hand it implies a pots-disciplinary reconfiguration of design identity, between practice-oriented research in which design choices are themselves strategic and theoretical moves (Anceschi, 1998) and a practice without theory (Bonsiepe, 2021), a science (Cross, 2001) or even a social skill facilitated by trained profiles (Manzini, 2015). On the other hand, it calls for a convergence of methods, perspectives and languages in a transdisciplinary effort (Rose, 2022), i.e. in the dialogue and cross-pollination of models and approaches from different research traditions and fields, focusing less on the process than on the project. And finally, it challenges the practices and paradigms of scientific dissemination, which often pit the most experimental and innovative modes against formalised processes, but which are sometimes too limited in terms of alternative formats and modes, especially when communication is not only aimed at researchers, but also at more public audiences, and becomes a transfer of knowledge, for stakeholders, policymakers and citizens.

The PhD programme in Experimental Research through Design, Art and Technologies is opening up a postdisciplinary vision, inaugurates a new approach that sees design and art as the driver of cultural innovation while at the same time shaping new models in design and art education through confluence with other research areas.

The paper presents and critically discusses the open questions raised from the post-disciplinarity approach of the research PhD programme. It aims to highlighting the challenges and the potentialities of hybrid education in Design and Art at the convergence of technologies, humanities and socio-economic topics.

2. Challenges for a post disciplinary education and research

1. The disciplinary dilemma (Challenge 1)

In the context of an evolving academic environment, the conventional boundaries between academic fields and research methodologies are undergoing a significant transformation. This reflects the broader societal shifts, challenges and crises that are occurring concurrently.

The initial challenge confronting the contemporary world of research and education, particularly within the domain of

design, is the fundamental redefinition of the concept of discipline and its interrelationship with other research environments, including endo- and exo-disciplines (Anceschi, Botta & Garito, 2006). In the first case, the other fields of knowledge share with it part of the theoretical, methodological and cultural macro-domain (see fig.1 the Map of the graphics field drawn by Giovanni Lussu in 1994). In the second, the contiguous areas of other areas of knowledge share elements to the point of blurring and overlapping the very boundaries between the various macro-domains.

In an increasingly complex academic ecosystem, the traditional and institutional boundaries between fields and modes of research are, however, undergoing profound transformation, reflecting the In the context of an evolving academic landscape, the conventional boundaries between academic fields and research methodologies are undergoing a significant transformation. This reflects the broader societal shifts, challenges and crises that are occurring concurrently. changes, challenges and crises that the world is also facing. The traditional model of education, which is highly specialised and vertical with respect to a particular knowledge domain, has been the subject of significant challenge in recent decades. This model, which has been described as an 'academic silo', is increasingly being questioned by a number of factors. On the one hand, the increasing complexity of research problems necessitates the consideration of diverse perspectives and competencies. On the other hand, the value of transversal and soft skills, such as collaborative capacity, has emerged as a key factor in bringing together differences in a synergistic manner, rather than viewing them as antithetical elements. Nevertheless, even the so-called T-shaped model now appears to be obsolete. This is an educational and knowledge system that assumes a transversal/horizontal competence encompassing several disciplines, followed by a vertical specialisation in a specific subject area (Barile et Al., 2012).

The disciplinary dimension of education is the primary focus of scrutiny, as articulated by Bourriaud in his Altermodern Manifesto. In this text, he delineates the

"The work of "artists (that) translate and transcode information from one format to another, and wander in geography as well as in history" (Bourriaud, 2009). Craig Bremner and Paul Rodgers take on Bourriaud's discourse and by questioning "the rupturing ad blurring of the design Disciplines" (Bremner & Rodgers, 2013) they argue for an "Alterplinarity" (Rodgers & Bremner, 2011) or "Alterdisciplinarity" (Bremner & Rodgers, 2013), which in a globalized context requires "an ability to make connections that generate new methods to identify 'other' dimensions of design activity and thought" (Bremner & Rodgers, 2013, p. 12). They further pick up Marshall and Bleecker's

concept of "Undisciplinarity" (Marshall & Bleecker, 2010; Bremner & Rodgers, 2013) where according to learning expert Stephen Heppell "design practice shifts from being 'discipline-based' to 'issue- or project-based' (Heppell, 2006)." (Eckert, 2017, p. 139).

It is Eckert himself, from whom this discussion is taken, who proposes as an alternative the Y-shaped model as a form of focusing and deepening those competences that are concentrated in that intersection between the transversality and verticality of the knowledge required or prefigured by the T-shaped model:

"Whether BA and MA programs represent complementary or consecutive studies, the missing link, which would facilitate a seamless transition from the depth of skill into the collaborative mode is a repertory of connective competences—competences enabling graduates to embed into an undisciplinary and collaborative working-context. For design education, we therefore "zoomed" into the junction between the vertical and the horizontal stroke (Figure 3) of the Tshape in order to define, what sort of skills might be needed for the transition from disciplinary towards cross-disciplinary working modes. Based upon this reflection, we propose a Y-shaped skill model (Figure 3), which focuses the junction between a disciplinary root and the collaboration across disciplines by shifting the attention towards the perceived role of the designer within the collaborative context (e.g., entrepreneur vs. consultant) as well as towards multimodal literacy (Kress et al., 2001; Kress, 2003; Jewitt, 2006, 2008) as key to transfer the depth of skill to processes of cross-media meaning-making. The Y-shaped skill model does not intend to replace the model of T-shaped personas. For design education, it rather works as a complementary and more detailed view on what sort of competences students need to acquire to embed their depth of skill into a collaborative and cross-disciplinary context." (Eckert, 2017, p. 140).

Figure 1. Giovanni Lussu, Mappa del campo della grafica / Map of the graphics field, 1994, published in The new Aiap configuration. Documents, interventions, a new statute, and regulations included in a supplement to issue no. 2 of Notizie Aiap published by Aiap Edizioni (p. 3) in1994. It was later re-proposed with a comment by Lussu himself in the Guida agli onorari in 2007, in support of a redefinition of the fields and meaning of graphic design.

The second aspect addressed by the issue of an education and research still based on a disciplinary perspective is the relationship between collaboration and interplay between the disciplines themselves and the adopted models of interaction. The paradigms of exchange and dialogue that have been consolidated over time ideally range from a situation of intra-disciplinarity, that is to say, cooperation of knowledge and methods within the same endo-disciplinary constellation to the concept of pluri-, cross-, multi-, inter-, and trans-disciplinarity (Stember, 1991; Jensenius, 2012; Rose, 2022).

In particular, the original definition proposed by Piaget places emphasis on the necessity for a holistic and collaborative approach. In particular, the original definition proposed by Piaget places emphasis on the necessity for a holistic and collaborative approach, as reported in Bernstein's review article (2015, p. 2): "The conclusion of Piaget's (1972) essay on various kinds of interaction between the disciplines mentions transdisciplinarity offhand, as a kind of an aside, as a "higher stage succeeding interdisciplinary relationships […] which would not only cover interactions or reciprocities between specialised research projects, but would place these relationships within a total system without any firm boundaries between disciplines" (Piaget, 1972, p. 138)."

This original and primordial definition already contains the root of a further evolution of the relations between disciplines, their relationships and, above all, their boundaries, leading to a perspective that is no longer whatever-disciplinary, but rather post-disciplinary, in which the very concept of disciplines is questioned and gradually replaced. Paradoxically, many disciplines are beginning to move towards postdisciplinary approaches that involve their cross-fertilisation with other research methodologies and practices, embracing other intellectual traditions in order to better understand their own domain of knowledge and respond to the categorical crises they face. This reflection is well outlined in the conclusions of the article by Jessop and Sum, who, by comparing aspects of pre- and post-disciplinarity, focus on three main critical issues - in their case related to the field of political economy, but conceptually extendable to other fields of knowledge:

"First, the most exciting developments in the study of contemporary political economy involve the revival of pre-disciplinary approaches […] and the rise of post-disciplinary approaches such as 'cultural studies', which, when applied to political economy, opens a space for 'cultural political economy'. Second, the study of political economy became a disciplinary venture in the course of the consolidation of the institutional separation of the market economy, the national state based on the rule of law, and the emergence of civil society and the public sphere. The limitations of

these fetishised distinctions always made the most provocative work in political economy interdisciplinary in the sense of drawing on the best work from different disciplines […]. But we are now witnessing the emergence of a post-disciplinary approach that respects the crisis in the received categories of analysis and the disciplines that correspond to them. Third, the intellectual tradition […] can be made even more fruitful through its creative synthesis with other pre- or post-disciplinary traditions such as political ecology and feminism (or 'queer theory')" (Jessop & Sum, 2001; p. 90)

As Pernecky notes in the liminal book Postdisciplinary knowledge (2019), the concept of post-disciplinarity emerges from the convergence and participation of diverse cultural backgrounds and contexts, as well as from a commitment to openness and freedom of inquiry that prioritizes the object of research over its disciplinary affiliation. This trajectory can be observed in various forms of cognitive practice, including "painting, sculpture, poetry, performance and literary works", which often precede the establishment of disciplinary structures.

"A story of postdisciplinarity can be aligned with different figures, movements and problems, and it can also be told through a technical, philosophical, methodological, political or artistic narrative. Where it begins depends on whether we trace postdisciplinarity to the word itself; to articulations of what it ought to do or not do; to concepts such as 'freedom' and 'openness'; to ideals about learning; or, more broadly, to the creative and imaginative capacity of the human being. […] The story of postdisciplinarity thus becomes many, with each adding a layer of richness and complexity." (Pernecky 2019, p. 64).

Postdisciplinarity represents the conceptual and epistemological framework within which novel, open and hybrid models of research and education in the field of art, design and technology find their natural dimension, potential and expression.

2. Design practice as theoretical speculation (Challenge 2)

One of the most challenging issues in design research and education is the question of methodologies that are proper to the field or borrowed from other fields. This is particularly the case with regard to the more speculative dimension of research typical of the theoretical component of a field of knowledge. As Gui Bonsiepe has observed, design has long suffered from this one-dimensionality of being a practice without theory:

"Judging from design publications and media representations, it can be argued that design is currently being carried by a long wave. […]. However, at the same time, a contradiction emerges between the widespread use of the term design and the limitations in the theorisation of the phenomenon. Design is today a theoretically unexplored phenomenon, despite its

widespread presence in everyday life and the economy. How can this lack of theory be explained? Avoiding a simplistic answer, it can be argued that there is a trade-off between the fragility of design discourse and the lack of a convincing design theory. Design is so far a baseless domain. In order to open up a new perspective, a reinterpretation of design outside the frame of reference of gute Forme or good design with its associated sociopedagogical aspirations may be useful. This reinterpretation is formulated here in the form of seven characteristics or theses on design: 1) it is a domain that can be manifested in all spheres of human practice; 2) it is future-oriented; 3) it refers to innovation. The act of design brings something new into the world; 4) it refers to the body and space, especially to the retinal space; 5) it aims at effective action; 6) linguistically it is anchored in the domain of judgements; 7) it addresses the interaction between user and artefact. The domain of design is the domain of the interface." (Bonsiepe, 1995, p.24)

In this debate, which commenced prior to the 1990s but achieved significant dissemination and discussion during this period, Anceschi (1993) coined the concept of theoretical move, whereby he referred to the conceptual contribution that some projects introduce through professional practice. Similarly, Anceschi identifies a field of knowledge and experience that designers draw upon to contribute to design research. This is not limited to a pure formalism, but rather encompasses theoretical, semiotic and perceptive issues that are explored and confirmed by design practice.

This position can be likened to what is currently referred to as Research through Design, which is one of the three possible forms identified and formalised by Alain Findeli (2004).

- The objective of research for design is to facilitate the advancement of design practice by meticulously documenting the processes and concerns of practitioners, with the designers and their practice regarded as the primary subjects of study.
- Research into design is primarily conducted in universities and research centres that contribute to the scientific discipline of design studies. This involves the documentation of objects, phenomena and design history.
- Research through design (RTD) is the most closely aligned with actual practice, which serves as a research tool. Designers and researchers who utilise this approach are able to create new products through experimentation with novel materials and processes.

While the first two can be considered analogous to traditional research fields and approaches, the third raises a series of questions regarding the potential contributions of designers to the design, research, and knowledge fields. In this regard, Zimmerman et al. (2007) make reference to HCI in order to define RTD as a "process of iteratively

designing artefacts as a creative way of investigating what a potential future might be". This contribution serves to further identify possibilities and methodologies of research through practice. Indeed, it is a vision that can be likened to the scientific process, based on experiments and iterations, with the aim of progressively improving the design. It is also important to note that RTD implicitly builds on the concept of the reflective practitioner, without which there could be no reflection during or after practice, as Schön (2002) indicates. While definitions of RTD vary, the question that remains open is how, at the end of the research process, the knowledge acquired through the project and reflection can be evaluated, criticised, and transmitted so that a wider field of researchers and designers can draw on and build upon the results.

The intrinsic nature of research conducted within the domain of design introduces a distinctive quality, particularly when situated within the conceptual framework of postdisciplinarity. On the one hand, it is characterised by a distinctive practice- and action-oriented dimension, encompassing practice-based research and action-based research. In these approaches, the design is not merely a meta-product employed as a stimulus in the experimental process of verifying recurrences and correlations. Instead, it is the primary objective, enabling the abstraction and inference of conceptual models, theoretical speculations, and the systematisation of frameworks. Conversely, his own methodological and conceptual approach and contribution become a model for enquiry and speculation in other fields. The Design Thinking approach, which involves adopting design as a 'platform' for exploration, conceptualisation and understanding of complex phenomena, is a key example of how design can offer a valuable contribution to other traditions of investigation.

3. Design/er identity in education and research (Challenge 3)

However, the pooling of practices and the borrowing of methods, theories and practices from other fields raises an important question about the identity of design itself and the role of the designer within the cultural and professional landscape in relation to other fields of knowledge.

The design is primarily configured as a generative and effective practice and is still in the process of developing a theoretical framework or an organic definition that would allow for the organisation of a cultural overall vision (Bollini, 2011; 2016a; 2016b). The definition of a disciplinary context and practice serves to define the professional and, as a result, the tools and training practices. If, as Potter (2002) asserts, every human being is a designer, defined as the capacity to conceptualise and create ideas and objects, what is the specific role of the professional designer?

A designer may be defined as a Gestalter, a professional whose role and purpose is to give form, order, pleasure and comfort (to products, places and circumstances). In

the context of visual design, the object to be shaped according to the triad of things, places and messages is the message itself.

Conversely, the designer is a technically proficient individual with functional expertise, operating within a range of functional objects that can be identified, and which may be situated in contexts of free and ephemeral design, or in highly specific and concrete circumstances.

In the field of visual design, two antithetical approaches and paradigms can be identified in Italian culture, represented by two charismatic figures: A. G. Fronzoni and Bruno Munari.

The initial case study exhibited a notably personal poetic expression and composition, suggesting that the subject may still embody the figure of the teacher, who communicates and teaches using a personalised language. However, Munari eschews any consideration of his personal design thinking and creativity, attempting instead to describe and generalise his experience into a methodology, as a series of operations that are necessary and arranged in logical order (Munari, 1981).

The duality of approach, which encompasses a range of nuances and intermediate positions, is founded upon the concept of visual design culture. This concept is currently viewed as both an artistic creation and a pursuit of objective values. Consequently, the manner in which teaching and the transmission of values are conducted, whether aesthetic, functional, formal, or objective, varies. However, despite this variability, certain issues remain constant in the transmission of design ideas. The focus then shifted to the modelling and narration of a project, that is, the methods of communication employed. The code of representation selected, the use of three-dimensional modelling systems, the description of projective planes, or the expression of theoretical assumptions, are examples of ways to display and, simultaneously, to design the project. Consequently, these methods are inextricably linked to the teaching process.

However, in more recent times, the concept of the designer, their role and the formation of a designer has been subject to significant scrutiny. This is particularly evident in light of the increasing prevalence of design practices, the accessibility of technical production tools and the dissemination of cultural knowledge. This has led to the emergence of alternative models that challenge the traditional boundaries of the designer's role and profile.

In many instances, it is possible to identify nascent models that view design as a pervasive and crossdisciplinary competence, approaching the status of a soft skill. On the one hand, there are positions such as Manzini's (2015) with respect to a facilitating role in which the designer makes their knowledge and expertise available to a community, facilitating design processes. This is the position, above all, of participatory design processes and co-designing bottom-up construction, which finds its contiguity

especially in the world of human-centred design, user experience research and design practices. This contiguity thus interfaces and dialogues with the realms of cognitive and human sciences, as well as digital technologies, encompassing a continuum of approaches, methods, and core values.

This is the design of when everyone designs, which represents a radical transformation in the role of the designer. The other, even more radical position is represented by Mike Monteiro, who, in his pamphlet Ruined by Design (2019), takes the issue even further, arguing that a designer is not someone who is trained in the culture and practice of design. Rather, the designer is someone who makes political, social, and ethical decisions, thereby assuming a significant role that has repercussions and impacts in the real world, in people's lives, and in the transformation of the world. The training of the designer has evolved beyond a focus on creativity, portfolio development, and an immersion in artistic culture. Contemporary designers must possess a range of skills that extend beyond these traditional domains. These include an understanding of business models, the capacity to conduct research, the ability to measure and analyse data, the capability to write professional emails, contracts, and invoices, and the capacity to present and discuss one's work. These skills are not adequately addressed in current training programmes, yet they are essential for effective professional practice.

"Creativity can't be the cornerstone a design foundation anymore. We need to teach students responsibilities of their craft, and it needs to be done at the foundational level. We need to value the consequences of our actions more than the cleverness of our ideas. Design is not about expressing yourself. Design is not about following your dream. Design is not about becoming creative. Design is about keeping people from doing terrible things to other people. [Monteiro, 2019; pp. 61, 63]

For Potter, the role of the designer is an intrinsic aspect of humanity, as each individual possesses an inherent creativity and capacity for ideation that naturally leads them to approach the world in design terms. Conversely, for Monteiro, the role of the design dimension is that of ethical and social responsibility, which is a shared responsibility among all individuals, given their capacity to impact the world and others.

4. Diversity in academic dissemination (Challenge 4)

In the academic context, design research often finds itself in a complex and ambivalent position. It is often located within the human and social sciences, or the humanities more broadly, while being aligned with more 'scientific' disciplines that seek to match the processes and methods of design with those of the hard sciences or engineering.

The homologation of design to science in academia has very definite implications. This affiliation implies the adoption of experimental and verifiable research methods, the replicability of the experiments themselves, and a reduction in the role of design to the sole dimension of problem solving in a sort of procedurality that implicitly suggests a mechanicity of the act and practice of design in the broadest sense. In light of the aforementioned assumptions and hypotheses, the outcome of the process is a result, a successful project insofar as it is consistent with the initial assumptions and the process itself. The temptation to adopt a 'mechanical' and functionalist view of design, which continues to elude reduction despite the liberation from total artistic practices, is often misplaced. This is despite the fact that the design process is not solely driven by 'creativity', which has often perceived as the main driver of design, on the other hand. If, as Cross (2001) points out, the assimilation of design to science in terms of both design research and theoretical culture has seen this relationship change, re-emerge and transform itself at certain critical junctures in the history of design itself, this relationship when the inauguration of master's and bachelor's degree courses introduced design into university education brings with it further food for thought.

"These concerns [with respect to the relationship between design and science] emerged strongly at two important periods in the modern history of design: in the 1920s, with a search for scientific design products, and in the 1960s, with a concern for scientific design process. The 40-year cycle in these concerns appears to be coming around again, and we might expect to see the reemergence of design-science concerns in the 2000s." (Cross, 2001; p. 49)

The issue at hand is of vital and critical importance, particularly when design is required to adopt processes of scientific production and dissemination that challenge the conventional wisdom of academia and, moreover, of the hard sciences, among possible models.

If the dissemination models are indeed those of the paper-based text, which is characterised by an extremely rigid organisational structure (IMRaD: Introduction, Methods, Results, and Discussion), reflecting research practices, there is a risk of losing part of the specificity and richness of the project culture. This is particularly pertinent when one considers that a significant proportion of research in/on/through design incorporates visual, spatial and multimodal communication tools (Bollini, 2012; 2022), which are not fully utilised in the verbal component of the textual format alone, i.e. literacy and numeracy.

It is therefore evident that a postdisciplinary discourse requires the implementation of innovative dissemination models (Bollini & Moretti, 2024) that are capable of including, integrating, and enhancing existing modes of dissemination and project narratives, while simultaneously incorporating diverse methodological approaches to research. The

debate on this specific topic is becoming increasingly pervasive, particularly in an environment such as Italy, where the dissemination and scientific publications have a significant impact on academic career progression and evaluation and assessment systems. These issues are being discussed in a number of contexts, including the CRUI (Conference of Italian University Rectors), the SID, the Scientific Society of Design, as well as individual research and opinion groups (Lupo, 2022) with the objective of identifying new methods, formats and platforms for sharing the knowledge produced within Italian universities, both among peers and in a way that is accessible to a wider audience. Such possibilities include the production and evaluation of visual essays, where the graphicacy element assumes greater prominence than the other communicative assets, as well as the use of interactive and multimedia tools. Additionally, the research may result in a range of outputs, including exhibitions, systems, services, products and artefacts of various kinds.

5. Cross-pollination and social responsibility (Challenge 5)

The opening up of dissemination practices to a wider audience than the scientific community of reference, now made up of personalities from different backgrounds converging on design and its practices, transcending niches, rituals and jargon, represents the moment of synthesis between the many possibilities offered by a post-disciplinary approach to design research and education. This change strongly emphasises the increasingly strategic and important role that design practices also play in other fields, in terms of sharing and transferring knowledge, not only to internal stakeholders, but above all to external stakeholders, decision-makers, policy-makers and citizens, stimulating their participation and forming conceptual and methodological tools, as well as data and results, to build informed participation and decision-making processes. The mix and convergence of different contributions, as in the case of the proposed new doctoral programme, ranging from design to art, from human sciences to technologies, can therefore contribute to the formation of a new generation of hybrid, "contaminated" researchers, open to dialogue, capable of generating new models of research and education, as well as conscious, meaningful, ethical and sustainable innovation and transformation in the world and in the complexity of its systemic challenges, crises and opportunities.

3. Conclusions

The implications of this challenge for both research models and educational practice can only be drawn from the experience of at least the first cohort of researchers over the next three years and the subsequent development of this pioneering proposal. For the moment, however, the five challenges outlined and discussed are a first result, at least speculative, of the introduction of the new doctoral programme

in Experimental research through Design, Art and Technologies and the involvement of different faculties, universities and international experts who have taken up the challenge of a hybrid, open and postdisciplinary proposal.

Among the concrete challenges facing the first year of the XL cycle, which also seem to suggest criteria for evaluating and reflecting on the proposal itself, is the ability to transform the potential frictions between different cultural, disciplinary and methodological systems into opportunities for innovation and growth in a post-disciplinary perspective that goes beyond specific definitions and converges on common ground with different perspectives. A second aspect will be the ability of lecturers and doctoral students, scholars and researchers to dialogue, collaborate and cooperate on individual topics in an integrated, interconnected and transversal way, enhancing and multiplying individual research with synergetic effects. Finally, the ability to negotiate, agree and inhabit shared epistemologies, terminologies that create a common ground for conversation and growth.

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DESIGN IN THE MULTIDISCIPLINARY ERA: COLLABORATIVE APPROACHES TO CULTURAL AND TERRITORIAL REACTIVATION.

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ABSTRACT | The new methodological approaches that have developed over the past decades have led to an ever-increasing rapprochement with communities as they can reactivate processes of re-appropriation of territorial identity. The use of similar terms referring to inclusive practices, often used as synonyms, such as co-design, co-creation, participatory design, and open design, immediately highlights some points to ponder.
This paper aims to shed light on how design can build relationships by analyzing these contemporary methodologies, and through the comparison of three Italian cases of community involvement in the cultural and territorial reactivation processes. The best practices are selected based on the impact generated on the territory and communities, the size of the intervention - small, medium, and large - and the "competitive advantage" (Cangiano, 2019) that they created on the social substructure - an approach that ensures social resilience and is not built around profit.
The comparison involved Torino City Lab, a Living Lab in northern Italy, and two cases from the south, namely Farm Cultural Park in Favara, Sicily, and Noi Ortadini in Matera, Basilicata.
The purpose of the analysis is to synthesize territorial examples and models supporting regenerative visions in socio-cultural terms, comparing the various collaborative approaches in support of site-specific expressions of design.

KEYWORDS | MULTIDISCIPLINARITY, DESIGN METHODOLOGIES, CO-DESIGN, TERRITORIAL REACTIVATION, SOCIO-CULTURAL REGENERATION

1. Introduction

In recent decades, there has been a progressive rapprochement between design and community thanks to collaborative methodologies. An ever-increasing sense of responsibility, whether ethical, cultural or political, has led designers to imagine broader and multifaceted methodological visions, capable of giving rise to practices of re-appropriation of territorial identity. As a result, notions such as co-design, open-design, participatory design, and cocreation practices were born.

In Lévy (2002) and De Kerckhove's (1998) theories on collective and connective intelligence, multidisciplinary approaches combine different areas of expertise to tackle complex problems. According to Lévy, Collective Intelligence would be the product of memory and collective imagination, capable of bringing out the skills; Connective Intelligence, according to De Kerckhove, is located in connections and networks and characterizes the way we reflect and process knowledge. Connective intelligence represents the most dynamic and practical part. In this scenario, where more and more actors interact and contribute by exchanging experiences, interests and needs, the concept of community emerges: inclusive, able to experiment with open forms of action and widespread creativity (Manzini, 2018). Paraphrasing Ferreri's concept of 'consciousness of place' (2018), we can delineate community as a manifestation of widespread awareness, imbued with values, visions, and representations, which reacts more or less openly to the development conditions set by society. Using collaborative methodologies makes it possible to reinforce the sense of belonging and responsibility towards one's territory, facilitating the assumption of initiatives by citizens and their active participation. Focusing on communities means analyzing the capacity of local actors to operate as a territorial collective actor (Dematteis et al., 2003). Collaboration practices can reactivate places and foster a shared identity of belonging beyond geographic boundaries. As Ferreri (2018) noted, Italy's small towns and villages are repositories of cultural heritage essential to national identity.

In response to the lack of systematic understanding of collaborative methodologies and the ambiguity of methods for assessing quality, effectiveness and value (Wang et al., 2022), this study proposes a comparative approach to analyzing contemporary practices and addresses the following research questions:

RQ1: How can design build relationships through collaborative methodologies to reactivate territory and community?

RQ2: How do methodologies of participatory design, co-design, open design and co-creation differ?

RQ3: What is the impact of these methodologies on cultural and territorial reactivation?

RQ4: Can we identify methodologies that are inherently more effective?

The study shows that different collaborative methodologies produce different results in terms of community involvement and territorial reactivation. The comparison across three scales of intervention - small, medium, and large - allows the identification of key factors common to the different cases. Moreover, they use different degrees of participation and different actors: large scale - involvement of institutions and authorities (top-down approach); medium scale - bottom-up process starting from citizenship and territories; small scale - prevalent involvement of associations and specific groups. All methodologies emerge as effective tools for territorial reactivation and building more openness and resilient communities. Design, thanks to its disruptive capacity to trigger development and design transformation (Ferretti et al., 2022) plays a crucial role in this process, facilitating dialogue and the creation of trusting relationships.

The structure of this document is as follows. Section 2 gives an overview of the different approaches mentioned. Section 3 and 4 analyses methodologies used within these collaborative networks. Section 5 presents and examines three different Italian case studies and Section 6 presents some final considerations about the comparison and concludes the study.

2. Different approaches

In order to adequately understand the topics discussed, this article proposes a summary and definition of the following terms, highlighting their facets and the difficulties in reaching a universal definition; however, it does not aim to define a state of the art. To achieve this, the most reputable definitions from literature reviews and studies by experts in the field were collected and summarized.

2.1 Participatory Design

This term, introduced from Scandinavia around the 1970s (Cross, 1972), describes an approach that actively involves end users in the design process. It focuses on using tools to facilitate communication between

stakeholders with different backgrounds. Simple tools that invite nonexperts to participate actively in the process.

Participatory design is characterized by its commitment to a democratic approach, aiming to simplify and make the design process accessible by enabling end users to understand and tailor it to their needs. Thus, this practice fosters empowerment and mutual learning by using tools and methods that promote transparency and understandability in the design process.

The strength of the collaboration between the roles of the designer and the end user in this participation is well expressed in the words of Simonsen and Robertson (2012): "The participants typically undertake the two principal roles of users and designers where the designers strive to learn the realities of the users' situation while the users strive to articulate their desired aims and learn appropriate technological means to obtain them".

In recent years, participatory design has evolved to include different variations, which change the definition based on the hierarchy and intensity of the interaction between the designer and other participants.

2.2 Co-design

The authors Sanders and Stappers (2008), explain how the designer and "people not trained in design" collaborate, just as suggested by the prefix "co" indicating cooperation or collaboration. Moreover, in their definition of this term, they admit that the user who participates in design is not only involved in some steps but also collaborates in the design itself, depending on his experience, skills, and sensibility to play an equal role to that of the designer.

In the co-design process, all actors are involved and play a fundamental role by contributing their everyday experiences, participating as "diffuse designers" (Manzini, 2015). In fact co-design is starting to be defined as "collaboration between stakeholders in designing solutions to a prespecified problem" (Vargas et al, 2022).

Contrary to Sanders and Stappers' definition, Simon (1988) explains that in co-design, design professionals work alongside individuals without specific training, emphasizing the designer's role as a process facilitator. In this sense, the designer interrogates users by exploiting and enhancing the input received in the final design but without making them participants in the design itself.

In this view, the designer has the opportunity to leverage his design skills based on problems identified not by the individual but by the experience of a multitude, allowing him to expand and embrace a broader spectrum of problems to be solved.

A recent study by Avila-Garzon and Bacca-Acosta (2024) notes how this term is associated with fields such as machine learning, optimization, hardware/software co-design, and health issues.

2.3 Open Design

The concept of open design appeared in the scientific literature around the 2000s (Vallance, Kiani and Nayfeh, 2001). The most common interpretation refers to a project that follows the open-source model by sharing all information under a Creative Commons license (Balka, Raasch and Herstatt, 2010; Ciuccarelli, 2008; Van Abel et al, 2011). Through these agreements, all design information can be used, modified, and produced by anyone (Menichinelli, 2014). Therefore, open design is based on the concepts of openness and transparency in the design process. It must be accessible and reusable by anyone and for any purpose (Van Abel et al, 2011), and promotes the sharing of knowledge, tools and results within broad communities. This approach allows anyone to contribute to the design, regardless of specific expertise, facilitating large-scale collaboration because its focus is not on the final product but on "its recipe" that is, the sources and method of creation. Open-design can thus be clearly defined as "the state of a design project where both the process and the sources of its output are accessible and (re)usable, by anyone and for any purpose" (Boisseau et al, 2017).

From state of the art by Boisseau, Omhover, and Carole Bouchard (2017), it is also evident that the main areas of use of this term are: the do-it-yourself, which involves end-users capable of creating and modifying designs on their own, using publicly available resources and guides; the meta-design, which includes projects where end-users are integrated and actively contribute in the design process; the industrial ecosystem, which concerns the exchange of knowledge and resources between companies in the context of technological development aiming to shorten development cycles and leverage open innovation.

2.4 Co-creation

This term is often used in a generic and all-encompassing way of collaborative approaches (De Koning et al., 2016; Sanders & Stappers, 2008), and as such has many variations related to different fields of study that have adopted it.

In the business field, introduced by Prahalad and Ramaswamy (2004), the term is associated with the word "value" because it refers to the creation of new value that is generated by the collaboration between user and consumer through interaction with the service, allowing value to be not "delivered" but "co-created."

In the design field, this term identifies design processes where various figures actively participate, from stakeholders to end users, as well as representatives of other disciplines. With this meaning, Ind and Coates (2013) suggest co-creation is understood as creating collaboratively but without outlining specific methodologies or practices.

Looking at more recent theories of more-than-human, the meaning of this term expands to emphasize the coexistence and co-creation of all life forms to address complex ecological challenges, creating bonds and building symbiotic relationships not only among humans (Haraway, 2016). Therefore, in recent years the term has begun to shift to "design-with" (Wakkary, 2021), an approach which recognizes humans as not the only actors in the design process. Instead, they must collaborate and coexist with non-human elements, thus rethinking design as a shared and co-constructed activity by all actors involved, requiring collaboration and interdisciplinarity.

Moreover, the study by Avila-Garzon and Bacca-Acosta (2024) reveals how this term is associated with areas such as product/service/brand co-creation, social media, customers, innovation, value co-creation, knowledge generation, artificial intelligence, living labs, and virtual reality.

2.5 The different roles of the designer

Participatory design, co-design, open design, and co-creation are approaches that actively involve users in the design process. They present more or less significant differences, especially the role of the designer and the way collaboration is structured.

Participatory design focuses on a democratic process in which the designer facilitates the understanding and expressing user needs, ensuring an output that can be considered predictable and controllable.

Co-design extends this collaboration by involving users as co-designers along the process. In this case, the designer acts as project manager, coordinating the interaction between practitioners and users for an equally predictable and controllable outcome.

Open design adopts an open-source model, sharing information under Creative Commons licenses. This approach promotes transparency and large-scale collaboration, making the designer one of many actors in a horizontal process that produces a predictable but not completely controllable result.

Finally, co-creation places all stakeholders, including users and designers, on an equal footing. In this case, the designer integrates as an equal among the other participants, contributing to a predictable but co-created outcome.

3. Methodologies

Getting into the specifics of the methods, participatory design, co-design, open design, and cocreation develop in similar phases but differ in structure and key participants. As for the definitions discussed in the previous section, literature presents many interpretations also in the methodological field. Given the consistent heterogeneity

of design projects, a corresponding variety of methods has been observed depending on the application fields (Jones, 2018), and, often, varying according to the subjective interpretation of the researcher. Since the analysis in this contribution aims to understand the structures of the processes for interpreting three collaborative project cases, it was decided to provide an example of the methodologies selected from extensive literature reviews and based on their relevance to the contextualization of our case studies.

The case of co-creation has not been addressed from a methodological perspective; its definition, in most of the analyzed cases, encompasses many other approaches. Furthermore, according to Avila-Garzon & Bacca-Acosta (2024), many contributions do not clearly define the methodology, and those that do present no specific consensus, even if there are some touchpoints and common frameworks. Messiha et al. (2023) state that "scholars have not consistently and efficiently contributed to the construction of co-creation theory," attributing this to inconsistencies and confusion in the way these terms are used, and possibly a potential fragmentation of knowledge due to the multidisciplinary approach.

Moreover, according to the study by Peter Jones (2018), co-creation methodologies are not formally documented or developed and frequently are branded or proprietary craft practices, making them difficult to validate or compare. These aspects, according to the scholar, contribute to a multifaceted scenario in which we find minimal peer critique of methods.

3.1 Participatory Design

The procedure of participatory design involves the collaboration of end-users with the designer in all phases of the design process. In the Scandinavian approach, active user participation is required, whereas in the U.S. there is a tendency to adopt less intrusive methods such as observation and artifact analysis (Spinuzzi, 2005). According to an in-depth literature analysis by Clay Spinuzzi, there are typically three phases: Initial exploration of work, Discovery processes, and Prototyping.

The first phase involves familiarization between users and designers and the introduction of work tools. The second phase consists of the initial dialogue about the product or system to be designed, leading to the definition of specific objectives. The third phase involves the creation of the prototype. All phases can be repeated multiple times until the process is fully concluded.

3.2 Co-design

In the co-design process, besides designers and users, various other professionals from different fields are also involved, allowing for potentially more functional results from

multiple perspectives. Within this approach, numerous methodologies exist, often with significant differences. Following, we will report the version from Mulvale et al. (2016) developed in the field of health system, which shows a particular adaptability when abstracted from the specific area for which it is conceived.

The system consists of four phases: diagnostic, intervention, implementation and evaluation.

Designers, various professionals and users are always all involved in every phase. The first phase, Diagnostic, is aimed at elicit experiencing data; the authors propose some methods as individual interviews, use of visual representation media, focus groups and ethnographic observation. The second, Intervention, is the proper design phase, in which to highlight the problems to solve through the design, or the issues in the system they are evaluating or testing. Following, Implementation develops the considerations done so far in smaller co-design groups, and finally, Evaluation is aimed to make improvements to the hypothesized solutions.

3.3 Open Design

As represented by Silvia Gasparotto in her literature review (2019), the methodological structure can be exemplified in a three-phase scheme, not dissimilar to that of Participatory Design. The three phases are: Conceptualization, Refinement, and Production.

In the first phase, a person or group, which does not necessarily include a designer, structures the "source project," to which other people, not necessarily part of this initial group, will contribute in the subsequent phases. The peculiarity of the method is its horizontal peer-topeer structure, which does not allow any degree of control over subsequent versions of the project.

Indeed, after the launch of the source file released as open source, the subsequent phases involve the interaction of other users for the reworking of the content, which reaches its prototyping through the phase of "open manufacturing," whether manual or digital.

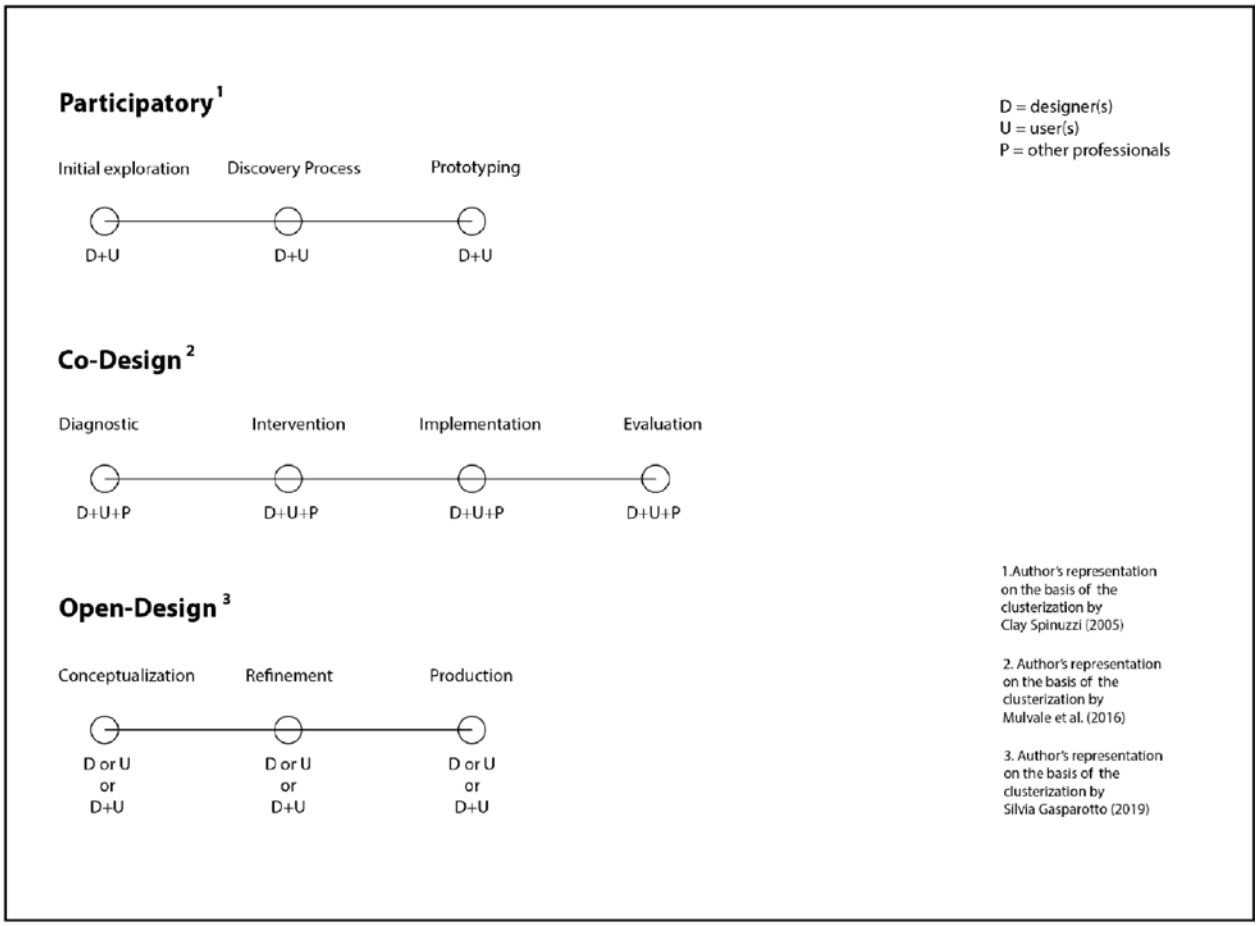

Figure 1. Participatory, Co-Design and Open Design methodology representation.

4. Case studies' methodologies

4.1 Torino City Lab - Living Lab

The first of the three chosen case studies is a Living Lab (LL) situated in Turin. According to the definition of ENoLL (European Network of Living Labs), LLs "are real-life test and experimentation environments that foster co-creation and open innovation among the main actors of the Quadruple Helix Model, namely: Citizens, Government, Industry, and Academia" (What is ENoLL?, s.d.).

Trying to insert LLs to one of the collaborative categories explained above, we immediately encounter some difficulties. Based on our analysis, they could correspond to the co-design definition, which involves designers, users and other professionals; also Scott, Quist and Bakker (2009), among others, attribute LLs to co-design, whereas Dell'Era & Landoni (2014) locates them between user-centered design and participatory design.

Schuurman et al. (2015) point out an interesting gap in methodology in the literature: "[the literature] positions Living Labs too much as an "everything is possible" concept that resembles an empty box, in the sense that you can put whatever methodology or research approach inside."

Nevertheless, some authors, such as Vicini et al. (2012), Esashika et al. (2023), tried to exemplify specific methodological processes that could be applied to different Living Labs. That proposed by Vicini et al. is particularly clear and develops in four phases: Co-Creation - which includes analysis of the scenario, ideation and co-design, - Exploration - consisting in the set up of the testing platforms, the execution of the tests and the exploration of the results, - Experimentation - therefore, more tests and data collections, - and finally Evaluation - which consists in data analysis and conclusions. Analyzing this method, it is possible to find a general coherence and some specific touch-points with the method by Mulvale et al. explained before in the co-design section.

In the specific case of Torino City Lab, it is interesting to highlight the process of creation of the networks: after the first contacts of the Utilizers with the LL net, the Utilizers prepare a testing proposal and send the application via the official website (Torino City Lab Website, s.d.). This open process allows anyone to propose its collaboration, and highlights a bottom-up approach to the creation of the final network, in a pre-set top-down methodology.

4.2 Farm Cultural Park - Urban Regeneration

Farm Cultural Park is situated in the south of Italy, in Sicily, in the municipality of Favara. This urban regeneration project started from a couple living in Favara and willing to trigger a recovery process of the historic center (Faraci, 2017).

Since the literature on this case study deepens mostly the architectural interventions, but does not focus on collaborative approaches to the project, we interviewed one of the two founders, Florinda Saieva, who gave us the following information.

At first the project did not involve the community, as the opening was scheduled for two years later, therefore there would have been more time to co-design. Though, after the collapse of two buildings in the historical center of Favara, the Municipality had decided to demolish the neighborhood and the project had to be pushed to immediate execution in order to avoid the procedure and save the area from obliteration.

Community involvement occurred later; the method adopted was to create distinct projects with different objectives. These were conducted through the involvement of entities, such as schools, and communities using surveys, focus groups, and workshops. The work ultimately culminates in the actual co-design of the space in question. This methodology was repeated with different targets and for designing different

specific areas. Also interviews were used to collect other design stimuli from other targets; the local community is encouraged to provide feedback and suggestions on future exhibitions, events and projects. Public institutions were also involved in the processes of discussion of the projects; specifically neighboring municipalities and mostly local Universities (F. Saieva, personal communication, July 24, 2024). Even though this project does not start from designers per se, the emerging methodology is aligned with shared co-design methodologies and evaluation methods reported by scholars (Want et al., 2022). It is relevant to notice that the approach adopted in this case is significantly more flexible and less structured than the Living Lab.

4.3 Noi Ortadini - Social Regeneration

Noi Ortadini (translatable as "Us Gardeners") (Jones & Pappas, 2023), is the smallest among the compared cases; it consists of a project started from a single person and developed because of the creation of a community of friends with similar passions and values.

Also in this case, we collected the following information by speaking directly with members of the organization (S. Simeone, personal communication, July 15, 2024). The project took place in Matera, a south-Italian city, where a group of friends, professionals in different fields and not coming from design, created a regenerative project around a vegetable garden they cultivated together.

The collaborative aspect in this case is relative to the participants of this open small community of citizens, which collaborate to the growth of the garden and the development of a series of social activities involving local citizens, and authorities; we could define the process as codesign within the association. In this case, no strict methodology can be found; in fact, the aleatory nature of the gathering is the key to its development.

As stated in some witnesses collected by Kuthz et al. (2023), the success of a participatory project often passes through an informal methodology untied from surveys and pre-structured settings, but from active collaboration based on listening to the needs of the place intended as territory and inhabitants.

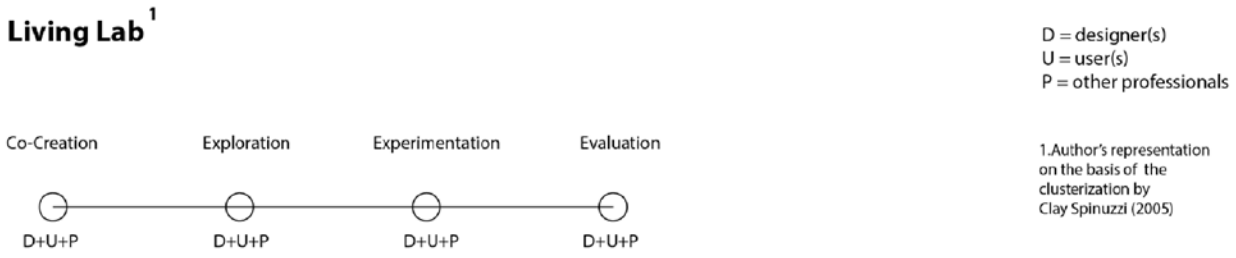

Figure 2. Living Lab methodology representation

5. Case studies

5.1 Torino City Lab

The section was developed based on the study by Cillo V., Del Giudice M. et al. (2020) and the consultation of the websites of Torino City Lab, Casa delle Tecnologie Emergenti, Comune di Torino, and Torino Social Impact.

Torino City Lab is an initiative promoted by the City of Turin with the goal of transforming the city into an open-air laboratory for experimenting with innovative urban solutions. Launched in 2018, the project offers companies, start-ups, universities, and research centers the opportunity to test new technologies and pilot projects in real-world contexts, facilitating public-private collaboration to develop solutions that improve citizens' quality of life and address concrete challenges and needs of the area.

In 2016, Turin inaugurated the first Living Lab in the Campidoglio district, with 29 experiments on environment, mobility, and tourism. In 2018, the focus shifted to a circular and collaborative economy. In 2021, The City promoted the application for the establishment of the Casa delle Tecnologie Emergenti (CTE NEXT) in close collaboration with the universities of Turin and other strategic partners. In 2022, the City was included among the 100 European cities committed to reducing emissions by 2030, becoming a "Mission City" and a hub of climate innovation and experimentation. In 2023, the City established the Living Lab ToMove, which builds upon and expands the goals and facilities of Torino City Lab and CTE NEXT, also pursuing energy and environmental sustainability objectives across the board.

Main actions:

- Collaborations and partnership networks to foster innovation through events and workshops;
- Field experimentation and testing of new urban technologies;
- Support for tech start-ups (incubation and acceleration);
- Smart mobility projects and IoT (Internet of Things) infrastructures;
- Initiatives for sustainable energy production and consumption;
- Digital education projects in schools and accessibility to digital technologies and development of innovative services for the community;
- Professional training programs and workshops for students, entrepreneurs, and professionals;
- Community participation through their involvement in the experiments of new technologies and the implementation of participation and public consultation platforms;
- Promotion of sustainable lifestyles, such as the use of renewable energies, sustainable mobility, and intelligent resource management, as well as urban redevelopment projects to improve public spaces.

Economic impacts:

- Increase in investments by tech companies and start-ups looking to test and develop their products;
- Growth in employment both in companies and related services (consulting, maintenance, technical services);
- Growth of the entrepreneurial ecosystem through support for local start-ups and Small and Medium Enterprises;
- Increased collaboration between universities, research centers, and companies, fostering the development of advanced skills in technology and innovation;
- Greater efficiency and productivity in traditional sectors through the adoption of new technologies.

Socio-cultural impacts:

- Reduction of the digital divide (greater access to technology for all segments of the population);
- Greater support for artistic and cultural initiatives that use technology for new forms of expression and audience engagement;
- Increased collaboration with local cultural institutions and with non-profit organizations and volunteer associations to develop projects with a strong social impact.

5.2 Farm Cultural Park

This section aims to describe the process of sustainable design, social innovation, and inclusion, triggered by the Farm Cultural Park in the historical center of Favara. It was developed based on the reading of several articles and contributions, including Faraci G. (2017), Tesoriere Z. (2023), Occhipinti F. (2017), and Mariani M. (2020), from the Farm Cultural Park website and related projects, listening to interviews available on the web, some direct experiences within its spaces, and, finally, a personal interview with one of the founders.

Farm Cultural Park is an independent cultural center located in Favara, a small town in the province of Agrigento (Sicily), which, since 2022, also has a location in Mazzarino (CL). It was founded in 2010 by the private initiative of notary Andrea Bartoli and lawyer Florinda Saieva, a couple of art collectors with a great passion for contemporary culture who dreamed of raising new generations - including their two daughters - in a socially and culturally stimulating environment.

The regeneration initially involved the area of Sette Cortili, a neighborhood in the historic center of Favara that, due to the collapse of some buildings and the death of two girls, was at risk of being demolished. The couple, returned from Paris, decided to take action to stop the neglect and marginalization of their city, accelerating the project's start and acquiring the area. With the involvement of artists, architects, and designers, both national and international, renowned and emerging, they transformed the disused spaces into places for the community with the intent to preserve the town's culture and identity. In addition to exhibitions and

installations, workshops, meetings, conferences, and festivals are organized. The place soon became a cultural reference point both locally and nationally and beyond, proposing itself as a replicable model in different contexts.

Figure 3. Farm Cultural Park's entrance, Sette Cortili, Favara (AG)

Over the years, Farm has expanded its exhibition spaces and participated in important international events, including the Venice Architecture Biennale. It established SOU, the School of Architecture for Children - focusing on educating young generations to create responsible and aware citizens - and Prime Minister, School of Politics for Young Women - to train and inspire them to become leaders and change agents in their communities - now spread throughout Italy.

Another significant moment was the inauguration in 2019 of Countless Cities, the Biennial of the Cities of the World, which aimed to shift the focus from the State to the Cities, emphasizing their growing importance concerning a country's economic, political, cultural, and social life. This event led to the reopening of Palazzo Micciché, a 19th-century noble palace, set up with the intention of redefining the meaning of a historical-monumental building, aspiring to become something else: "Human Forest" project, a place for meeting and bringing people closer to nature.

Andrea and Florinda, through the work of Farm, demonstrate that culture, art, the meeting of people, and the love for a place can be powerful catalysts for transformation and rebirth.

Figure 4. Human Forest, Palazzo Miccichè, Favara (AG)

Main actions:

- Cultural and artistic redevelopment;
- Promotion of cultural events;
- Education and training through workshops, labs;
- Educational programs for all ages on art, design, sustainability, and gender equality;
- Community involvement.

Economic impacts:

- Increase in employment, not only in quantitative terms but also qualitative, and reduced brain drain;
- Updating and professional qualification of local human resources;
- Growth of new entrepreneurship (start-ups);
- Investment in the historic center/culture combination by SMEs;
- Increase in tourism and opening of new businesses by the local population.

Socio-economic impacts:

- Increased social cohesion, sense of belonging, and collective responsibility;
- Positive and proactive attitude of the community;
- Increased cultural and artistic prestige of Favara;
- Greater attention to the maintenance and care of public spaces, the urban context, and the community's needs;
- Inclusion of vulnerable or marginalized individuals;
- Increased self-esteem and aspirations of the local population;
- Improved image of the territories and reduced antisocial behaviors;
- Perception of a greater sense of security by women.

5.3 Noi Ortadini

The section was developed based on the study of the Noi Ortadini website and related projects, listening to interviews available online, and a personal interview with Sara Simeone. Noi Ortadini APS is an Association for Social Promotion that manages a green space in the "Serra Venerdì" neighborhood of Matera. The idea originated in 2020, during the lockdown, from the private initiative of Andrea Grieco, a biologist and aspiring natural farmer, who started a horticulture project on land near his home in Matera. During the summer, he participated with his colleague Sara Simeone in a synergistic and regenerative agriculture course at the Serra Venerdì garden, and in the following months, new members joined, and activities began to expand.

In December 2020, Noi Ortadini formalized its structure as an APS. With the support of the community and institutions, it participated in strategic meetings to define guidelines for urban gardens and established collaborations with Basilicata Link, a local cultural association, as well as with young artists, architects, and both local and non-local networks. Over the years, it has proposed entrepreneurial initiatives and engaged in educational and cultural activities; it collaborates with national organizations and social cooperatives and amplifies the group's engagement within the community, aiming to regenerate the area and create a gathering space.

In June 2021, it joined the participatory discussions organized by Coalizione Civica Matera, involving various Third Sector Organizations around the theme of common goods, and it was recognized as a catalyst for urban regeneration, social inclusion, and sustainability, emerging as a virtuous example of community participation and sustainable development.

Figure 5. Noi Ortadini in the vegetable garden, Matera (MT)

Main actions:

- Urban agriculture and environmental sustainability through the creation of urban and shared gardens and the promotion of recycling and composting;
- Promotion of agricultural education through outdoor workshops and seminars on sustainable cultivation techniques;
- Community involvement in the design and management of urban gardens, community events, and farmers' markets;
- Collaborations with entities, associations, and local interest groups;
- Enhancement of the territory through the recovery of abandoned areas (about
- 4000 sqm) and the promotion of local heritage;
- Awareness programs related to the 2030 Agenda to inform the community on sustainable development issues.

Economic impacts:

- Training and acquisition of skills related to European project design, including participation in calls for proposals;
- Job opportunities for local youth;
- Interest and support from local institutions.

Socio-cultural impacts:

- Greater sense of community and solidarity and active participation of people;
- Increased connection of "ortadini" citizens with nature;
- Transformation of an abandoned space into a place accessible and open to the entire community;
- Greater involvement of both local and non-local youth;
- Increase in activities and services that promote intergenerational and intercultural relationships, with particular attention to migrants and people with disabilities.

6. Conclusion

The research questions brought to light different interpretations. As the case studies analyzed show, design can and does build collaborative relationships in the contemporary age. In Celaschi's essay, design acts as a bridge capable of connecting and integrating different areas of knowledge (Germak, 2008), metabolizing and synthesizing certain design practices and creating a "conscious collage" and a continuous reshaping of knowledge. Like an enzyme that sets in motion a process of (re) interpretation capable of generating new matter (Tufarelli, 2022). As can be seen from the collection and synthesis of the most widely accepted definitions, the different methodologies differ in definition but not always in methodology. Trying to categorize the case studies examined, the situation blurs to the point of asking a further question: how important is it to define a preset methodology, rather than to focus on creating a cohesive and adaptable approach? In a small scale and small community context, cohesion appears crucial, obsessing over the division of approaches and attempting to use the perfect methodology may not be the key to project success. The question also prompts reflection on further aspects such as the importance of context, creating a sense of unity and shared goals, the type of project or initiative, and the skills and experience of those involved. Prioritizing valorization, cohesion, community involvement and flexible approaches is key to succeeding in social and territorial regeneration. "Accepting the fact that non-experts also make critical contributions and should work alongside experts is a sign of progressiveness and maturity in the discipline of design" (Muratovski, 2022) and is reflected in the possibility that an approach works even without a clear and defined method, but, more precisely, despite having one. This hypothesis highlights the need for further research.

The comparison of the three cases highlighted the similarities and differences between the different methodologies. All three projects emphasize the active involvement of the local community, with a particular focus on education and training, and engage in territorial enhancement. Specifically, Farm Cultural Park and Noi Ortadini implement participatory projects and community activities. They offer educational and training programs on specific topics such as art, agriculture and sustainability. They are involved in the regeneration of abandoned spaces and the promotion of local heritage. Torino City Lab includes community participation in the experimentation of new technologies and organizes events and workshops to foster innovation and collaboration.

The differences between the different cases concern thematic focus, scale and impact, and types of intervention: Farm Cultural Park focuses mainly on art and culture as tools for urban regeneration, Noi Ortadini focuses on urban agriculture and environmental sustainability, and Torino City Lab is oriented towards technological experimentation and urban innovation. While the first two operate in more localized contexts (Favara and Matera respectively), with a strong community and territorial impact, Torino City Lab operates on a broader urban scale, aiming to make Turin an intelligent and innovative city. Finally, Farm Cultural Park and Noi Ortadini, carry out physical and tangible interventions (transformation of urban spaces, creation of vegetable gardens), and Torino City Lab focuses on technological and digital interventions (testing new technologies, smart city).

In conclusion, Torino City Lab, Farm Cultural Park, and Noi Ortadini represent three distinct models of urban regeneration and social innovation. Each of them has a specific focus and the common goal is the improvement of the quality of life of citizens and the promotion of sustainability and inclusion. Torino City Lab is the one with more industrial objectives and initiatives. For example, in collaboration with the company ABzero, urban trials are underway to develop innovative technological solutions and social acceptance for a drone-based autonomous transport system (Smart Capsule) designed to transport medical equipment in urban areas.

Assuming that the scale of the project influences the need for structuring, following rigid standardized methodologies is seemingly negligible. Flexibility and adaptation to individual needs, through the combination of different strategies, appears to be a strength that can transform and innovate cities and communities. For this reason, we cannot at present identify methodologies that are inherently more effective.

Design thinking emerges as a concept to support the theme in light of the above. In the context of social innovation, design thinking is particularly valuable because it allows for a humancentered approach to problem-solving (Kazuhiko, 2014). All those involved, whether designers or non-experts, employ their design skills during a project. They first identify and understand the problem, then they imagine a better solution. Finally, they translate those ideas into practical actions. Non-experts offer pervasive design skills through life experience and creativity. Design experts contribute by utilization of design tools and the capacity to facilitate co-design activities. Today, it is easy to find clear examples of these two groups working side by side in any design activity. Co-existence is accentuated when dealing with issues of social innovation (Muratovski, 2022).

In conclusion, despite the multiplicity of existing terms and methodologies, it is clear from this paper that these should not be considered static and rigid elements. On the contrary, their primary function is to facilitate the initiation of a process of collaboration and sharing of a common vision. In this sense, they can be understood as guidelines, to be used flexibly and adaptable to specific needs. To grasp the complexity of the phenomenon, it is necessary to continue the comparative analysis of further case studies.

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HOSPITALS OR HOMES: WHERE WILL WE BE CURED IN THE FUTURE? DESIGN CHALLENGES AND VISIONS IN THE RAPIDLY EVOLVING HOME CARE SECTOR.

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ABSTRACT | The healthcare sector, independent of national and international political organizations, allows people to receive medical care and assistance in specialized healthcare facilities, such as hospitals and clinics, or directly in patients' homes.

The degree of adoption of these places for care provision has proven to be unstable throughout history, being dependent on technological and societal conditions, as well as users' needs. Globally, home care services are becoming increasingly popular due to the global pandemic experience and the rapid technological advancements, that allow home-use medical devices (HUMD) to become increasingly usable by unprofessionalized users and capable of solving progressively complex medical needs. The home care industry is evolving at a steady pace and has great potential for growth in the coming decade due to the benefits and opportunities for the users introduced by its solutions (Precedence Research, 2024).

This phenomenon makes it necessary to investigate the potential of future scenarios in which home care services, such as telehealth and in-home medical assistance, could supplant other forms of care, particularly in economically and socially mature contexts.

In this evolving situation, designers and decision-makers should be aware of the emerging challenges that need to be addressed to meet market requirements.
This study is one of the ongoing results of a PhD research, whose main objective is to understand

the role and contribution that the design discipline can bring to medical device R&D, and the recognition of its most effective approaches to achieve this purpose. The objective of the initial phase of this research was to map the principal contexts of medical device utilization. Desk research was conducted to investigate two key issues: firstly, the longevity of sanitary structure and home contexts over the long term concerning their adoption as places of care, and secondly, whether the design of medical devices for different contexts necessitates the input of different design expertise.

The paper presents the findings of the first aim of this desk research, indicating that the relationship between care in healthcare facilities and home care is likely to maintain a sort of equilibrium in the long term, particularly in economically and socially mature contexts.

KEYWORDS | HOME CARE, HEALTHCARE DESIGN, MEDICAL DEVICE, DIGITAL TECHNOLOGY, SPECULATIVE DESIGN

1. Introduction: Hospitals and Homes as Places of Care

Healthcare services lay the foundation for the correct functioning of any modern society. In the current landscape, they are mostly delivered through a variety of healthcare facilities scattered throughout the territory such as hospitals, clinics, nursing homes, and ambulatories.

However, the position of these facilities, often heterogeneous between different areas, at least within the Italian territory (Bucci et al., 2021), poses accessibility problems to certain patients' limited range of motion.

Accessibility is here intended as "the characteristic of a device, service, resource or environment to be usable with ease by any type of user" (Bertini, 2003).

Physical and cognitive impairments can indeed transform reaching any place outside the home into an extremely complex task.

Home care services demonstrate their effectiveness in providing medical assistance to users with these difficulties. They are healthcare services provided within patients' homes: examples include caregiving, health data monitoring, and medical treatments (Bawa and Sinha, 2022). They can be divided into two main categories: those that can be provided remotely using telecommunication technologies, defined as telehealth or telemedicine services, and those that require the physical presence of dedicated professionals. The latter can be further divided into two sub-categories: doctor-on-call services, where the patient receives assistance at home at need, and nursing services, where a patient is not independent and needs constant assistance to perform daily tasks.

With the rapid technological development and due to the COVID-19 pandemic global experience, home care services have become a viable alternative to other forms of care for an increasing number of patients (Stepick and Tran, 2022). Indeed, benefits like fewer hospital readmissions, minor exposure to infectious diseases, minor health costs, more

accurate patient assessment, and higher patient autonomy (Stapleton and Bossie, 2024) are meaningful benefits for most typologies of patients.

For instance, telehealth services make it possible to receive increasingly complex medical care services without the patient having to reach dedicated healthcare facilities.

The potential of the home care sector to serve an increasingly larger audience has been outlined in a report published by Precedence Research (2024), in which it is stated that "the global home healthcare market size was valued at USD 373.56 billion in 2023 and is expected to reach around USD 1,469.92 billion by 2033 and is poised to grow at a CAGR of 14.81% during the forecast period from 2024 to 2033".

This consistent trend may prompt speculation as to whether the home care sector could potentially supplant the sanitary structure-based sector in the long term.

The recent history of the medical services sector in the USA provides a case study that demonstrates the degree of adoption of sanitary structures and patients' homes as places of care to be unstable and susceptible to societal changes (Bowman et al., 2017).

In this dynamic scenario, designers and decision-makers should be aware of the emerging design challenges that must be addressed to satisfy the market requirements, considering its expected growth in the following years.

2. Methodology: Desk Research and Contextual Mapping

The PhD research this study is part of has the general objective of understanding the role and contribution that the design discipline can bring to medical device R&D, and the recognition of its most effective approaches to achieve this purpose. To reach this goal, the research has been divided into four subsequent phases: (1) a map of the principal contexts of medical device utilization; (2) a review of methodologies currently adopted in medical device research and development; (3) the definition of the competences of the various professional profiles involved in the development of medical devices and comparison with those proper to the design discipline; (4) possible rethinking of project teams that include designers. This doctoral research is expected to lead to the following expected results: (1) a mapping of professional profiles, skills, and tasks in medical device design, along with their correlations, and (2) guidelines that help medical device manufacturers to purposefully integrate designers into their R&D teams. The present study is part of the first phase. The mapping process perpetrated by examining the MDR 745:2017 revealed the possibility of clustering medical devices into two principal categories: those intended for exclusive use by qualified personnel within controlled settings, such as healthcare facilities, and those designed to be used by unprofessionalized individuals, including patients and caregivers, in uncontrolled environments. Home Use Medical Devices

(HUMD) belong to this second category as they are mostly used by laypersons within patients' homes.

In light of this distinction, desk research was conducted to investigate the present and potential future design challenges associated with these two contexts of medical device use. This was done to investigate two key issues: firstly, the longevity of sanitary structure and home contexts over the long term concerning their adoption as places of care, and secondly, whether the design of medical devices for different contexts necessitates the input of different design expertise.

The paper presents the findings of the first aim of this desk research, indicating that the relationship between care in healthcare facilities and home care is likely to maintain a sort of equilibrium in the long term, particularly in economically and socially mature contexts.

3. Design Challenges for a Home-Based Sanitary System

Medical services and products are an integral part of people's lives, whether it's the case of wearing glasses for myopia or undergoing periodical dialysis due to renal failure. The definition of medical device provided in the MDR 745:2017 is broad and encompasses a diverse range of devices, many of which are significantly different from one another. Given these differences, primarily concerning factors such as associated risks during usage and contexts of use, envisioning home care as a comprehensive healthcare delivery model is ambitious and presents a multitude of design challenges.

This is because it is of the utmost importance to prioritize user safety and clinical effectiveness when designing and deploying any kind of medical device or service. In the current regulatory environment, these requirements are met through a combination of regulations, technical standards, clinical testing, and certifications. However, it is possible that future solutions may not yet be covered by such measures. To identify these challenges, many aspects of medical product and service development have been analyzed.

3.1 Users

Within the home care contexts, six major categories of users have been identified: people who are ill or convalescent, or who have to manage complex illnesses; people with disabilities; partially self-sufficient elderly persons; family members or persons related to the patient; formal caregivers (professionals); informal caregivers (laypersons) (Tosi and Rinaldi, 2015).

One of the most pertinent factors differentiating these users is their level of health literacy. The term involves many aspects of health understanding, including comprehending health information, navigating the healthcare system, and communicating healthcare needs (Simonds, 1974). Health literacy influences the appropriate use of medical devices, and

low health literacy is linked to the misuse of such products, possibly leading to extremely severe consequences (Kolnik, 2020). This factor determines the two main categories of users within the sector: laypersons and professionals. Laypersons are people who do not have specialized knowledge about healthcare disciplines, while professionals are those who do (Tosi and Rinaldi, 2015).

This differentiation is linked to medical devices' usability, learnability, and understandability, factors that determine a certain user's ability to use them safely while carrying out their intended purpose. Another factor to consider is the role of the users during medical device usage. It is important to note that some medical devices are intended for the self-administration of care, while others are designed to administer care to another person. While user-related design issues may arise in both cases, the first one may pose a greater design challenge. Indeed, the patient's ability to successfully use the product may be hindered by momentary or permanent physical or cognitive impairment (Collingsworth et al., 1997).

Traditional medical devices can be inaccessible to people with disabilities and, thanks to the purposeful design of medical devices, barriers for these users can be alleviated (Lemke and Winters, 2008).

Such disabilities would cause a patient to rely on caregivers to assist with self-care devices, possibly introducing unanticipated users into the product usage scenario.

This is of utmost importance in that home care services and devices should enhance patient autonomy, i.e. the patients' independence and right to make decisions regarding their treatment and medical attention (Atrak and Khoshdel, 2015). It is recognized as a modern principle in bioethics that respects personal freedom and the free choice of the patient in any degree of illness (Visbal, 2007).

A major user-related design challenge would be to enable stakeholders to use an increasing number of HUMDs while ensuring that limited health literacy has little negative impact on the clinical outcomes and safety of the product use.

Additionally, designers should find ways to successfully adopt the design-for-all paradigm into medical devices for self-care HUMDs, also due to patients' specific cognitive and physical abilities. It should be noted that eventual impairments can also be caused by diseases other than those treated with a certain medical device. The fact that many clinical conditions can coexist within a patient (Stapleton and Bossie, 2024) increases the possibility that some critical characteristics of target patients may not be considered during medical device development. The problem arises if these unforeseen characteristics hinder the usability of the designed medical device. Attention should also be paid to unforeseen users (e.g. caregivers giving support with self-care devices with insufficient patients), who could assist a patient using a self-care device.

Additionally, designers should also innovate techniques for remote interaction between users, allowing professionals to have more ways to intervene in situations where the presence of laypersons is not sufficient.

Considering the reported user differences, other design challenges involve social, communicational, and organizational phenomena (Di Fiore and Ceschel, 2017). Indeed, miscommunication between caregivers, physicians, and patients, also determined by cultural differences, poses a dangerous threat to patients' safety (Stapleton and Bossie, 2024).

Solutions should be implemented to reduce miscommunication to the minimum at various levels, whether cultural or health literacy-related, for example through the mediation of artificial intelligence.

3.2 Product characteristics

Designing medical devices for home use presents unique challenges. While developing solutions for healthcare facilities allows designers to work on known contextual data, home environments are unique and differ greatly from one another. Aspects related to the users and their activities, the physical and social environments, and other devices available can be highly unpredictable and not standardized as in hospitals. It is therefore essential that designers develop HUMDs that are capable of functioning effectively in a wide range of environmental conditions. General product requirements should include durability features, such as resistance to elements like dust, moisture, and mechanical shock, along with usability features, such as clear and illustrated instructions for use, understandable and comfortable morphologies, function names on buttons, and simple feedback systems to help users interact with the product as seamlessly as possible. One recommended approach to addressing this uncertainty would be to design devices with the assumption that they will be used in the most challenging conditions. Furthermore, certain medical devices, such as TAC machines, appear to be incompatible with the home setting due to their operational complexity and their physical dimensions, which can be contingent upon the dimensions of the human body.

These larger and less accessible instruments would be impractical for home care applications also due to their frequency of use. A significant number of medical devices are used to diagnose or treat conditions that a patient may never encounter during their lifetime. To address the reported issues, it would be necessary to determine the criteria according to which HUMDs would be provided, whether proactively in a standardized manner or when specifically needed. Connected to this, effective in-home medical device delivery methods would need to be established. While improved compactness of the devices would facilitate this aspect, many of them would be constrained by technological limitations and the physical ergonomics of the human body.

3.3 Technological aspects

In addition to the experience gained during the COVID-19 pandemic and the benefits it brought to the development of home care solutions, this sector has also seen rapid expansion due to technological advancements (Stepick and Tran, 2022). In the context of the pandemic, a range of medical services, including medical counseling and monitoring, were remotely delivered with effectiveness thanks to the use of digital tools that enabled seamless communication between patients and physicians. Telehealth services rely on telecommunications to establish meaningful interfaces between relevant stakeholders.

However, low technology acceptance among distrustful users (Park et al., 2021) may be another obstacle to the development of the home care sector, where device failures or misinterpretations can lead to serious consequences. Moreover, technological innovations in the healthcare domain can be rejected by different types of stakeholders also due to factors like their perceived ease of use and their perceived usefulness (AlQudah et al., 2021).

The issue of low technology adoption represents a significant obstacle to the evolution of the home care sector, slowing down its transition towards a paradigm shift. To facilitate the rapid development of the sector, it is imperative to identify innovative solutions to address this challenge.

Another challenge associated with technological advancements is to ensure that designers are adequately prepared to develop new solutions with emerging technologies. When properly implemented, novel hardware and software can facilitate novel solutions to existing problems. However, it is also necessary to consider the willingness of people to eventually entrust their lives to products with which they are unfamiliar. Furthermore, these technologies must guarantee user safety in addition to their usability. It is therefore essential that regulatory mechanisms evolve in parallel with the market's technological implementation requirements to provide guidance on emerging issues related to the implementation of these technologies.

3.4 Infrastructural and Economic Aspects

In order to gain insight into the practical implications of organizing a home-based healthcare system, it is beneficial to systemically compare the two models of healthcare provision under investigation in this study. Sanitary structures, such as hospitals and clinics, can be viewed as centralized nodes for the delivery of healthcare services. In these places, a large number of people can access a large number of treatments. In contrast, in a system exclusively established on home-based services, houses would function as decentralized nodes for service provision, which could result in increased logistical complexity. If a substantial quantity of

resources can be transported to a single, centralized location for the treatment of a large number of patients, a decentralized system would require the development of a complex capillary distribution system to treat the same number of individuals.

This would not only impact single-use items such as batteries, test strips, and medications, often essential for many medical devices to function properly, but it would also necessitate the availability of physicians to deliver the necessary equipment to patients' homes when required. This increase in complexity would have a considerable impact on the economies of countries, especially for those with public welfare systems, which would be required to make significant investments to construct a comprehensive infrastructure capable of reaching every residence within the nation.

Moreover, a decentralized model would also have a deleterious effect on the complex processes of medical device cleaning and maintenance. A hypothetical house equipped to provide a comprehensive set of home care services would likely include a rich array of HUMDs. As the variability in maintenance schedules is dependent on the specific device type and its frequency of use (Dabadi et al., 2023), it follows that each reusable medical device would need a distinct maintenance frequency and methodology. This suggests that individuals would be expected to perform these tasks independently. The challenge thus arises in designing effective methods for assisting laypersons, who typically possess lower health literacy than professionals trained in these processes, to successfully navigate the complexity introduced by HUMD maintenance. An alternative approach would be to develop a service to carry out these processes for users. However, this solution would be more complex due to the decentralized nature of this hypothetical healthcare model.

An additional area of concern regards the domain of emergency management. While hospitals can have trained personnel and a vast array of resources that can be rapidly deployed to manage crises and other unexpected threats to health, such interventions would not be as efficient within the home setting. Indeed, trained personnel would still have to reach the location via ambulance or other vehicles equipped to deal with emergencies, leading to an increased impact on infrastructure.

In addition to the identified challenges, there are other contextual barriers that hinder the innovation of the sector. There is an asymmetry between the development of innovations and their adoption in healthcare facilities, as these structures may not be ready for such changes without proper assessment and preparation (Leonard et al., 2019).

The rapid development of innovative medical devices and services is driven by the assumption that related infrastructures and resources are sufficient for these products to be implemented on a large and capillary scale. However, this favorable setting often

proves to be utopian, and interventions designed in this manner are unlikely to reach the implementation phase. In light of these limitations, designers must contextualize their work as much as possible, taking into account the constraints that determine the feasibility of new solutions.

3.5 The Potential of the Home Care Sector

The complexities introduced by the considerations made above indicate that the immediate availability of sophisticated medical devices and highly trained personnel provide healthcare facilities with a distinct advantage over home care settings in terms of clinical effectiveness and efficiency of the healthcare services provided. It seems unlikely that these characteristics are going to be replaced by HUMDs, despite how advanced they could become in the future thanks to technological advancements. Nevertheless, their potential for future improvements and the advantages they offer to every kind of patient will likely cause home care to remain a significant sector over the long term. From the aforementioned considerations, it could be hypothesized that these devices will progressively increase the number of clinical conditions that can be effectively treated at home and their efficiency in achieving their objective.

This will depend on the successful implementation into HUMDs of evolving technologies such as artificial intelligence and more capable sensors and actuators. At the same time, an increasing number of medical devices will likely become more usable by laypersons.

These facts would enhance all three main home care service typologies.

Telehealth services would increase the variety of health services that can be performed remotely. Nursing services will likely evolve in response to an increase in the usability of medical devices for laypersons. This would, in conjunction with the integration of new technologies, facilitate the treatment of a greater number of clinical conditions with a reduced reliance on specialized personnel.

With regard to the doctor-on-call service, the introduction of more compact and technologically capable medical devices would result in an upgrade of the doctor's equipment. This would increase the likelihood of successfully treating a wider range of conditions at the patients' homes, thereby reducing the necessity for their hospitalization in more serious cases.

Downstream of these hypotheses, it could be stated that home care objectively possesses a great margin for growth and improvement, but it will likely not have the potential to establish itself as the only type of care.

This relation between these two methods of healthcare provision will, however, work synergically and benefit each other.

The enhancement of home care in terms of usability and the range of services offered will firstly increase the benefits introduced by this sector, and secondly, facilitate the management and allow a more efficient optimization of healthcare facilities. The reduction of individuals receiving care within these structures and of the services they provide would allow optimization processes in terms of timing and quality of these services. Moreover, their structures would likely become less complex and spatially better organized.

Nevertheless, the acceptance of technology, the complexity of regulatory pathways, which can take anywhere from a few years to over a decade, and other factors mentioned above indicate that this scenario will only be achievable gradually in the future.

4. Conclusions: A Beneficial Coexistence

The complexity of the healthcare services domain is attributable to their objective of guaranteeing better health conditions to patients while also ensuring all the involved users' safety. As a result, the evolution of the healthcare sector has led to the development of various channels for delivering its services, as every context of care has its specific requirements. History demonstrates that the degree to which these types of care are adopted is susceptible to a multitude of factors, including technological and societal phenomena.

In this dynamic scenario, designers and decision-makers should be aware of these changes to identify emerging design challenges that must be addressed to satisfy market requirements. It is plausible that none of the types of care examined in this study can be wholly supplanted, as each possesses distinctive potentialities that align with particular contextual necessities and prerequisites.

In synthesis, an increasing number of therapies currently provided in healthcare facilities will be offered as home care services.

This is due to the fact that the technologies incorporated into HUMDs will diminish the need for professionals during their utilization.

However, there are limitations that will impede a complete transition toward home care services, even in the long term.

In fact, many characteristics of the healthcare facilities seem to make them valuable also in the long term.

Although the number of services offered in healthcare facilities may decrease due to the expansion of the home care sector, the quality of these services within these structures is also likely to improve.

Consequently, it can be hypothesized that the two types of care analyzed will likely continue coexisting in the long term.

The identified design challenges and the other findings align with the objectives of the study, which was to provide an overview of potential future developments in the various contexts of care. They are valuable for the doctoral research project as they provide a foundation for the second phase of the desk research, which aims at understanding whether the design of medical devices for different contexts necessitates the involvement of different design expertise. Moreover, they encourage the distribution of research efforts across all care contexts, as no area of application is likely to become dominant in the long term.

Nevertheless, existing and forthcoming regulatory and safety issues pertaining to HUMDs must be subject to continuous review in order to ensure the practical relevance of the research project. Subsequent to the findings of this study, further research could also be conducted to investigate appropriate methodologies through which designers could align the development of sophisticated medical devices and their application in diverse home environments as real-world contexts of use, with the aim of enhancing the likelihood of these devices to be adopted.

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“DESIGN TO CREATE VALUE: *MADE IN*... PARAGUAY FOR TRANSITION”

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ABSTRACT | The profound digital transformation currently underway, in every field and across the globe, undoubtedly leads to the creation of new forms of value (Roco & Bainbridge, 2013; Helmer et al., 2021). In this highly dynamic world, characterized by continuous global evolution and a high level of competitiveness, keeping pace is not merely a goal but a necessity. The enhancement of a country requires an integrated and systemic approach: design and its transdisciplinary nature play a crucial role as a strategic lever and driver of innovation, capable of creating short, medium, and long-term scenarios for value creation, thus initiating a real cultural, economic, and social transition (Tromp & Vial, 2022).

This contribution, which presents part of a project by the EDME research group at Politecnico di Milano, aims to identify opportunities and possible development paths for the state of Paraguay, a country chosen for its strong growth potential (Cepal, 2022) and its emerging digital transition as a driver of innovation not only in the South American context but also internationally (Cepal, coordinator Oviedo E., 2021).

Starting from the analysis of the current state of the art and trends in macro-identified areas, a comprehensive vision is presented from which to derive objectives for initiating and guiding the future development of the country while fully respecting and enhancing its indigenous culture and history.

Through case histories (smart mobility, smart cities, Healthcare 4.0, digital experience retail, smart agriculture, smart industries, smart tourism, smart services, etc.), the evolutionary trends of various sectors are presented to identify possible opportunities and strategic action lines. The key points of analysis for each area will be digitalization and perceived values (social/communicative values and economic/productive values).

Moreover, the common denominator, also at the methodological level, is "Design for the Common Good," which encourages the development of cross-cutting innovations that transcend the limits of specific interventions to create new value on a systemic scale (Botta & Junginger, 2021).

The necessity of operating on a large scale places the concept of "infrastructure" at the center, conceived as the architecture and platform for managing the evolution that must permeate every aspect of the country's social, cultural, and economic life, also involving the activation of networks among diverse stakeholders who are engaging in new relationships for the first time (Träskman, 2022).

The objective is to define representative scenarios of possible guidelines to be developed into targeted design activities aimed at positioning and enhancing the country's image, expanding economic integration, and stimulating the activation of new relationships that contribute to the cross-fertilization of technology and knowledge.

A secondary but equally important objective is to raise awareness that guiding industrial choices within cultural pathways, behavioral trends and tastes, and lifestyle and consumption patterns in a turbulent and rapidly changing landscape requires transdisciplinarity, meaning the innovative transfer of skills across different fields and sectors.

KEYWORDS | DESIGN FOR COMMON GOOD, THINKING INFRASTRUCTURE, SMART CITY, INTERNET OF THINGS (IOT), SMARTNESS

1. Introduction

Latin America is developing solid growth in the digital ecosystem. With increasingly widespread 5G connections and a growing number of Internet users, the digital economy has become critical to the region's sustainable development. The rapid adoption of digital commerce and consumption of digital goods and services is becoming a key issue. This offers various stakeholders the opportunity to take part in an ecosystem that will foster digital transactions.In the research we present, which is still ongoing, we shine the spotlight on Paraguay to analyze the country's specificities and its digitization.

In line with the strong digitization process in Latin America, Paraguay is experiencing significant growth in mobile connectivity and network infrastructure. It has a population of more than 6.8 million and only 3% of the adult population in the country has a credit card, while 72% of adults have Internet access and 89% own a cell phone.

These figures indicate the country's evolution toward a more digital society: as a global trend, consumption of digital goods and services has grown substantially in recent years. Increased by the lockdown due to the pandemic, but consolidated in these very last few years, with a considerably young population (42.9 % between the ages of 18 and 44), Paraguay is well positioned to see digital consumption grow in the coming years. (Statista Market Insights, 2023)

From a methodological point of view, the EDME[1] research team mapped the state of the art in Paraguay through a critical analysis of the context according to different layers: geographic-political, socio-cultural, economic-productive, and technical-technological. Each layer represents a specific dimension of the Paraguayan context, offering a comprehensive and integrated view of the country's current conditions and future potential.

[1] EDME (Environmental Design Multisensory Experience) Interdepartmental Laboratory at Milan Polytechnic University. EDME Lab. offers a physical space where experiences of digital, multimedia and multisensory worlds can be developed and experienced; a space where a relationship can be created between virtual and physical, material and sensorized objects and visualized and created experiences that are not only visual, but also auditory, tactile, olfactory and synaesthetic.

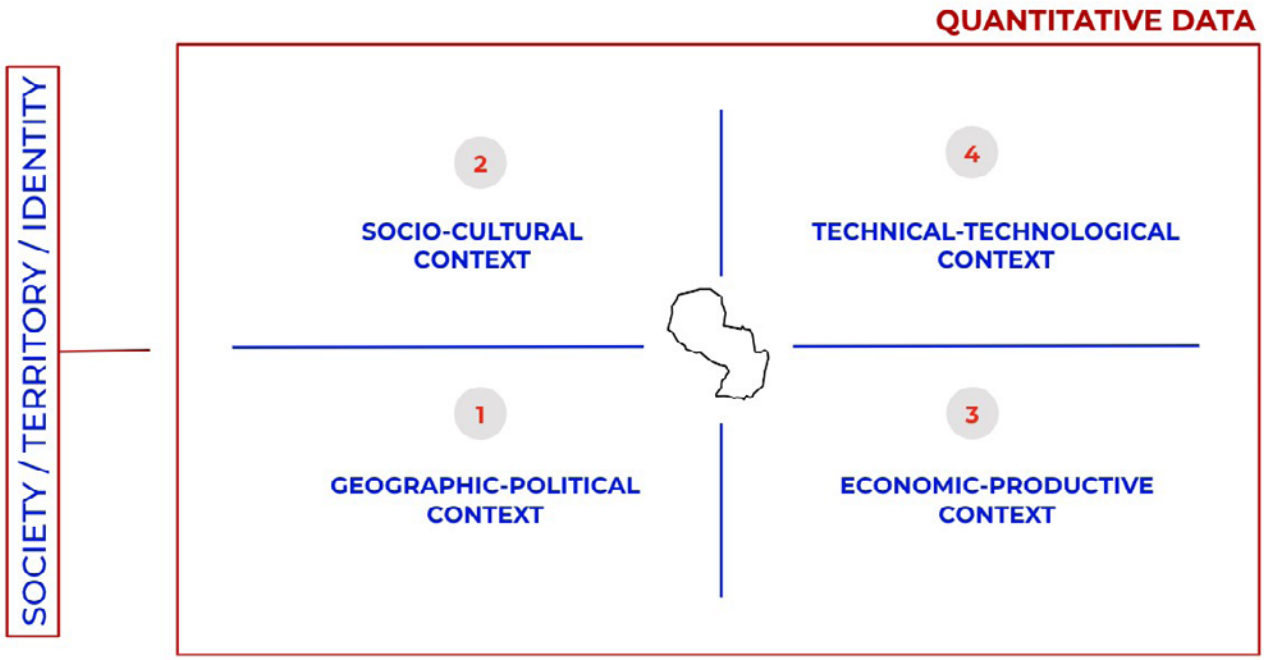

Figure 1: Multilayer mapping of Paraguay by EDME Lab.: geographic-political, socio-cultural, economic-productive and technical-technological analysis for sustainable and digital development strategies.

The methodology according to a multilayer approach has enabled the identification of both the strengths and weaknesses of the system, highlighting targeted strategies for digital transition and sustainable development.

The subsequent identification of case histories, selected based on specific parameters and keywords, enabled to bridge the gap between the current state of the art and emerging trends. This evolving scenario forms the foundation for constructing the theoretical framework outlining development lines and business opportunities for the country's system. The common denominator essential to the methodology used is "Design for the Common Good." This systemic approach aims to maximize results by focusing on the "Third Sector" related to social purposes. It emphasizes designing high-quality relational spaces and environments where these relationships occur, introducing the concept of "infrastructure" as both a structural and managerial element.

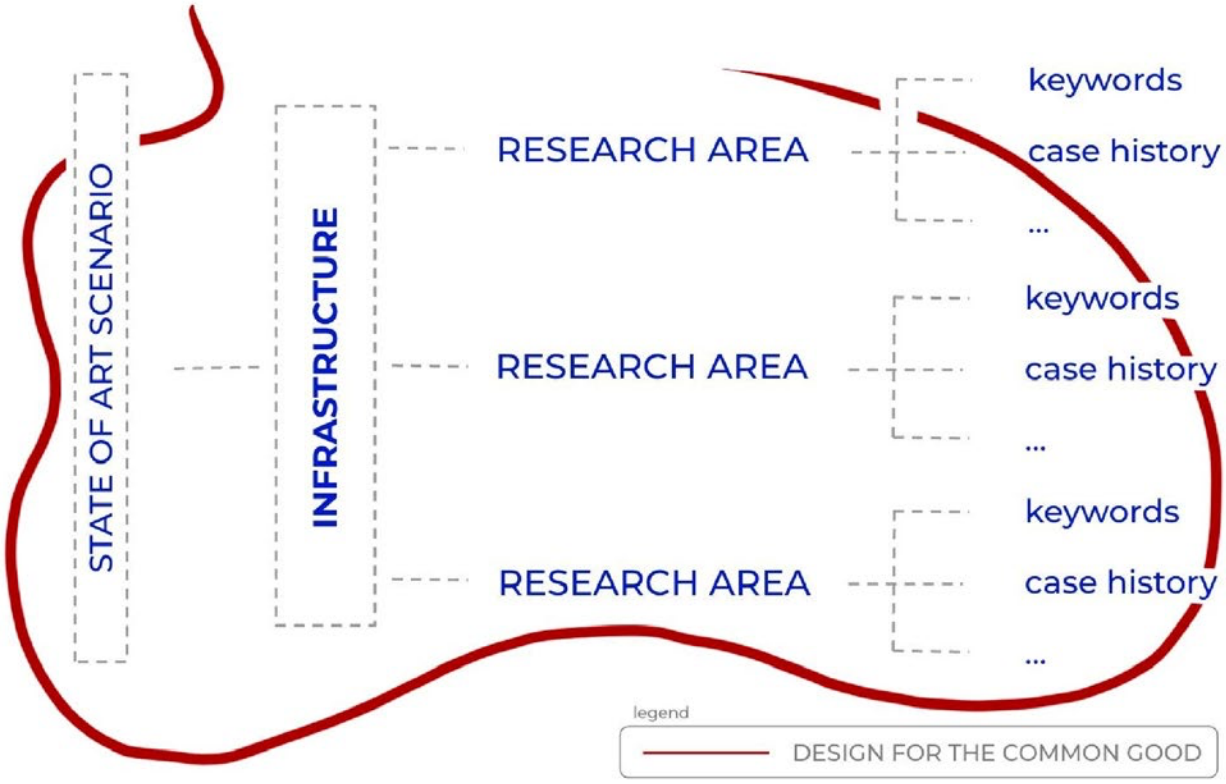

Figure 2 : Research methodology that from the reference scenario uses keywords and case histories to identify the gap between the state of the art and evolutionary trends. The expected result is the theoretical framework of guidelines for the development of the country system.

2. The South American context: trade and international relations

South America is a region characterized by considerable cultural, historical and geographical diversity. In recent decades, this area has seen a growing commitment to international cooperation and economic integration, with numerous bilateral and multilateral agreements aimed at strengthening ties among member countries (Oviedo, 2021). Major organizations promoting regional integration include the Common Market of the South (MERCOSUR), the Andean Community (CAN), and the Pacific Alliance. These bodies have been instrumental in facilitating trade and economic cooperation, enabling greater interconnection among the region's economies (Cepal, 2022).

Cooperation among South American countries from trade relations extends to areas such as education, health, security, and the environment. This fabric of relations provides a solid platform for the introduction and scaling of technological innovation processes. Indeed, digitization is recognized as a key factor for economic and social development, capable of profoundly transforming productive structures and improving quality of life (Roco & Bainbridge, 2013).

In this context, Paraguay emerges as an example of a country that can leverage

regional cooperation to advance its digital transition. As shown in the document prepared by Cepal (Oviedo, 2021): "Assessment of South-South Cooperation in Six Selected Latin American and Caribbean Countries-Shared Challenges in the Implementation of the 2030 Agenda for Sustainable Development", despite challenges such as the still-developing technological infrastructure and socioeconomic inequalities, Paraguay has shown a strong commitment to innovation and digitization. This is reflected in government policies and international collaborations that aim to promote the use of technology for sustainable development by laying the foundation for inclusive and resilient growth.

3. Development goals and cooperative actions

Paraguay's development goals align with global goals, such as the United Nations Sustainable Development Goals (SDGs). The country's strategy focuses on various aspects, including education, health, infrastructure, renewable energy, and digital transition. International cooperation plays a crucial role in achieving these goals, with the country benefiting from both regional and global aid and collaboration.

Openness and close relations among South American states provide a favorable environment for the implementation of scalable innovations. Digitization, as the central theme of this research, presents itself not only as a necessity to modernize local economies, but also as an opportunity to add value (social, cultural and economic) and improve competitiveness internationally.

And not only that. If competitiveness also means the ability to govern the economic dialectics of markets, then design culture is certainly one of the strategic resources for competing in the global market: it is an engine capable of orienting industrial choices within cultural itineraries, behavioral and taste trends, lifestyles and consumption styles, in a turbulent and rapidly changing landscape. A strong point is transdisciplinarity, that is, the transfer of expertise in an innovative way between different fields and sectors. In this context, the Politecnico di Milano in its own right can apply to be a partner in the development process precisely within the framework of the need for interconnection and exchange of knowledge, aiming to develop strategies to apply digital solutions that can be adopted and adapted in various contexts.

4. Paraguay: geopolitical context and development goals

Paraguay is a landlocked country characterized by contrasts between its development potential and the challenges it faces. Its geographical location and natural resources offer many opportunities for economic growth and the well-being of its people. In particular, it is rich in water resources, such as the Guaraní aquifer and the binational Itaipú and Yacyretá dams, which provide abundant water supply and clean, renewable energy production. The Itaipú dam, one of the most powerful in the

world (Pope, 1995), meets the entire domestic energy needs and supplies power to cities such as Rio de Janeiro and São Paulo (Mander, 2017).

With a population of about 6.8 million and an area of 406,750 km^2, Paraguay has one of the lowest population densities in South America. However, population distribution is unbalanced, with 60% of the territory, the Gran Chaco, inhabited by only about 2% of the population (INE, 2023). The largely informal economy is dominated by the agricultural sector, while the industrial sector is relatively small. The socioeconomic structure is characterized by the predominance of the latifundium, with 86% of land owned by 2% of the population (Ezquerro-Cañete, 2020), creating significant disparities in the distribution of wealth.

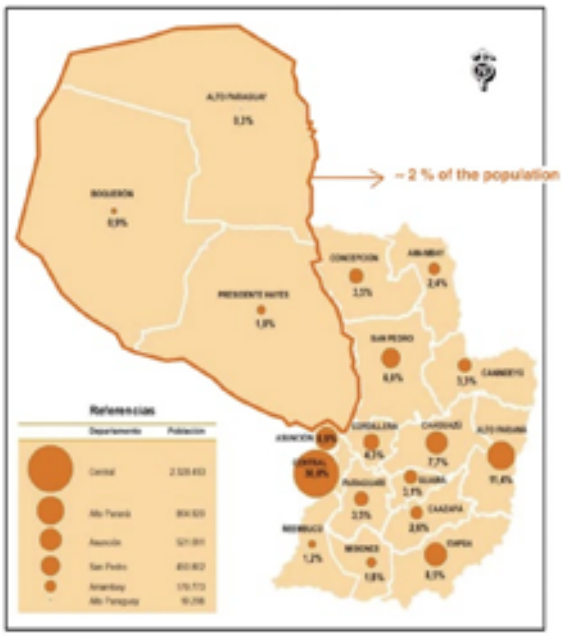

Figure 3 : Paraguay: population distribution by department. Year 2023. Paraguay's low population density and unbalanced distribution with 60% of the territory inhabited by only about 2% of the population. (Instituto Nacional de Estadística Paraguay, 2023). Image reprocessed.

Despite being a large producer of hydropower, most of its energy is exported at low prices to neighboring countries, contributing little to the national economy. In addition to these economic challenges, Paraguay's digital transformation is also hindered by a significant digital divide. While mobile connectivity has grown, many citizens, particularly in rural areas, lack the digital literacy skills necessary to fully participate in the digital economy. Addressing this digital literacy gap is crucial for ensuring equitable access to the opportunities offered by digitalization and fostering inclusive growth. Furthermore, targeted digital education programs could play a vital role in enabling the population to leverage digital tools more effectively and contribute to the country's sustainable development.

The political and institutional environment has seen modernization and transparency efforts, such as the System for Monitoring Recommendations (SIMORE), which has improved human rights management and international cooperation. However, Paraguay is ranked as poorly competitive in the World Competitiveness Index, highlighting structural and institutional difficulties that hold back the full exploitation of its resources (World Economic Forum, 2019).

Despite these difficulties, Paraguay has shown signs of economic and social progress. International cooperation, particularly in the context of the aforementioned MERCOSUR, has contributed to the consolidation of the democratic process and the strengthening

of productive competitiveness. Paraguay, located in the heart of Latin America, is a natural bridge between the region's emerging markets, with abundant natural resources and a tax policy characterized by low taxation, all factors that incentivize international investors.

The Paraguay 2030 Strategic Plan reflects the country's ambition to upgrade its infrastructure, not only internally but also to the global market. Targeted investments in roads, ports, and other physical connections are an integral part of this strategy, which aims to position Paraguay as a major trade and logistics hub in the region (Ministry of Foreign Affairs and International Cooperation Italy, 2019). Priority development goals include improving infrastructure, promoting education and health, and adopting sustainable technologies. Digitization is seen as a key tool for achieving these goals, with the Paraguayan government launching several initiatives to promote the use of technology in various sectors (digital documents, with related data protection issues, creation of digital/internet centers to ensure widespread access, the transnational smart road, etc.).

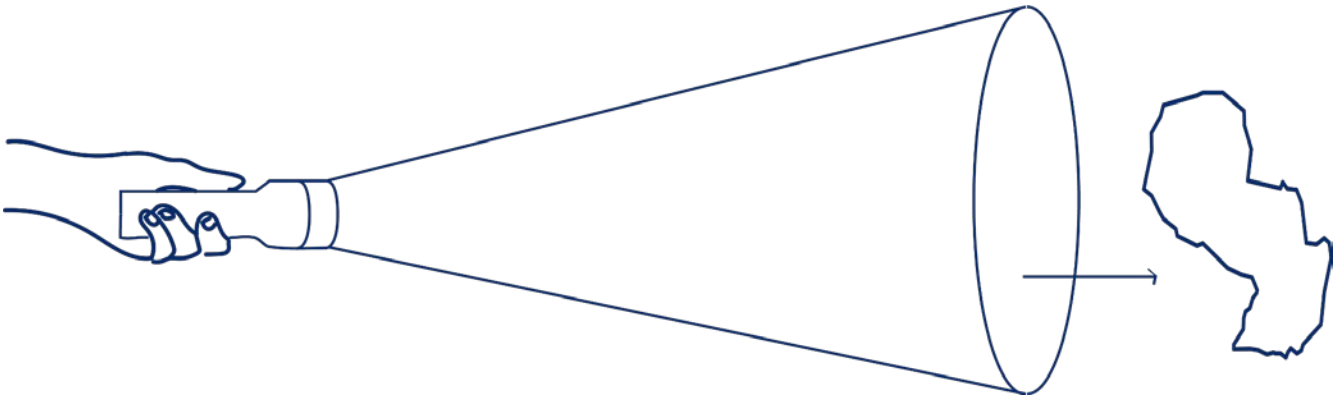

Figure 4 : The Paraguay 2030 Strategic Plan sheds light on infrastructure, education, health, and digitization, among others, positioning the country as a regional business hub.

The goal is to develop models of digital solutions, embedded in a strategy involving the various levels of public and private administration, that can foster Paraguay's transition to a more innovative and sustainable economy.

Creating synergies, with the goal of creating development and shared value, is an effective way to foster and incentivize international cooperation for innovation and sustainable development. The adoption of advanced digital technologies will not only improve the efficiency and competitiveness of Paraguay's country system, but will also help strengthen relations among the various actors involved, promoting an integrated and systemic approach to economic and social development.

The research of the EDME laboratory of the Politecnico di Milano fits precisely into this climate of great ferment that Paraguay is experiencing and promotes precisely the activation of knowledge and development "networks" in the context of international cooperation, encouraging a relationship with the economic and productive reality through experimental research and technology transfer.

5. Research introduction and objectives

The contribution aims to create a theoretical framework that suggests a set of guidelines for the development of practices toward digital transition by organizations of different entities. The application case used is Paraguay, for which strategies are identified to make innovation and foster the development of digital services and processes. Emphasis is placed on a systemic vision-the approach is posited as the foundation of the framework itself-with the aim of creating transdisciplinary projects that bring different stakeholders together to foster the sharing of experience and knowledge toward a paradigm shift in everyday life, laying the foundation for subsequent strategic development.
The framework is characterized by the construction of scenarios representative of actionable guidelines, flanked and supported by different types of case studies: these cases, mapped and analyzed with critical reading, were identified from well-known and widespread examples, thus already verified, and other more disruptive but still experimental projects under development, such as startups. This mix is crucial for a good reading of market trends: on the one hand, one looks at what is present and what is used most, and on the other hand, one looks at where interest is placed and which directions are preferred for future developments. The application of the framework, to enable a successful transition to digital, will need to be contextualized with respect to the area in which it is going to be designed, involving communities of place to create projects that are actually meaningful and shared.

A key element to the success of this framework is addressing the infrastructural and educational challenges faced by Paraguay. It is essential to ensure that the necessary technological infrastructure, such as high-speed internet and access to digital tools, is available across the country. In addition, increasing digital literacy through targeted education programs, particularly in rural and disadvantaged areas, will empower citizens to effectively engage with and benefit from digital services. Without these foundational steps, the digital transition risks leaving segments of the population behind, widening existing inequalities.

6. Digital transformation and the possibilities offered by Design

The digital revolution and the unprecedented acceleration of technological development, globally, have caused a real change of scenarios in all fields, from social and cultural to scientific and productive. The way of strategizing and innovation has changed.

Widespread digitization permeates profound changes in activities, processes and organizational capabilities, seizing and reconfiguring digital technological challenges into opportunities to create new value. To achieve this, however, it is necessary to implement a systemic approach that promotes a view of the whole and coordinates stakeholders in proactive and effective processes. In fact, digital transformation is defined as a process that aims to improve an entity by triggering significant changes through information, computing, communication, and connectivity technologies (Vial, 2019).

Consequently, digital transformation strongly engages organizations to remain attuned to technological turbulence that comes in the form of new possibilities, continuously evolving industries and customer expectations (Viaene, 2020).

While a systemic and transdisciplinary approach is crucial for digital transformation, practical implementation requires the creation of collaborative platforms that bring together stakeholders from various fields—government, education, technology, and civil society. These platforms will facilitate the exchange of knowledge, support the development of tailored digital solutions, and allow for testing in localized contexts. Additionally, involving local communities through participatory design processes ensures that the solutions created are aligned with their cultural and social needs, fostering both technological and social inclusion.

We can, therefore, say that, in contemporary global society, digital advances offer several opportunities to push the transformation of operating models concerning many different contexts. In this sense, governing a digital transformation process is a complex task, as it means guiding the process from exploring the broad spectrum of opportunities that digital technologies offer, to reducing this complexity to a final set of actions to be designed and executed.

In turbulent contexts, organizations face contradictory challenges that give rise to management tensions and paradoxes and require radical responses. (Vendraminelli, 2023).

Precisely by addressing organizational paradoxes-which consist of a persistent contradiction between interdependent elements (Schad et al., 2016) - Danneels & Viaene (2022) identify certain decision-making processes capable of making dynamic processes of formulating innovative proposals that are accepted and used by all.

This kind of process can be pursued through Design's own methodologies. In fact, there is no denying the central role of Design as a strategic lever in complex scenarios, an engine of innovation to drive even digital transformations. Design, as a new "connector," becomes the managerial and organizational paradigm to make innovation, and then to train new professional profiles adapted to the new context: director of knowledge and skills essential to make worlds not always connected (industries, institutions,

research centers, universities, territory) collaborate and contaminate.

Magistretti et. al (2020) propose five approaches typical of Design that prove essential to bring innovation to the systemic level. The first approach is "extending," that is, amplifying the shared knowledge base through transdisciplinary collaboration of different stakeholders. Indeed, the complexity of the process must be addressed by considering the specific problem, but also by looking at how that problem is affected by and interacts with the organizational context, the market environment, and the stakeholder system (Dunne & Martin, 2006). Then we move to the dynamic approach of "debating" to promote, through debate, digital transformation processes by juxtaposing technological and human perspectives. Designers, able to understand the different perspectives of internal and external stakeholders, are able to build a constructive debate that allows the digital solution to be grounded in more robust insights. Next, "reframing" is identified as a dynamic approach that guides the selection of technology requirements based on users. The ability to empathize with users is at the heart of the discipline of Design and is fundamental to interpreting the amount of information that digital processes can create. The designer challenges the status quo with challenging questions, steering the innovation process toward experimentation and adoption of truly innovative directions (Verganti, 2016). The fourth dynamic capacity of design thinking is "interpreting" and is based on designers' ability to predict future scenarios (Dunne & Raby, 2013), adopting different frames of perception to investigate different facets of the technological challenge. The last dynamic capacity of design thinking is that of "recombining," combining technological and human knowledge within a holistic framework. Starting with sociocultural trends and narratives, creating future scenarios as starting points for the development of digital design solutions, it is critical to synthesize ideas pragmatically, creating concrete action plans for final design implementation.

7. Design for Common Good

Design for the Common Good is a design approach aimed at enhancing community quality of life through sustainable, inclusive, and ethical solutions. Evolving from Design for All, it is grounded in the concept of the common good (Hussain, 2018), focusing on the benefit of communities and public spaces at a broad scale, such as accessible healthcare and effective public safety systems. This approach emphasizes active end-user participation and interdisciplinary collaboration, promoting a positive and lasting societal impact. Design thus becomes a tool and facilitator of complex realities, activating innovative processes that trigger social and behavioral transformations. The goal is to create collective benefits by overcoming isolated interventions with an integrated systemic vision, in which the total is greater than the sum of its parts, quoting Aristotle. (Botta M., Junginger S.,2021)

In the case of Paraguay, a country that faces significant challenges in terms of economic development, infrastructure, and social inclusiveness, adopting a systemic approach can be an effective response to the state's current needs by proposing virtuous models to address social, economic, and environmental challenges in an integrated and collaborative manner, seeking solutions that generate collective and lasting benefits.

A systemic view implies recognizing that each intervention has ripple effects on other aspects of the system. For example, improving transportation infrastructure not only facilitates mobility and trade, but also has positive impacts on quality of life, access to education and health services. In addition, creating sustainable transportation networks can reduce environmental impacts, contributing to greater sustainability of the system as a whole. This type of approach recognizes that investment in one area can enhance capacity and opportunities in others, creating a virtuous cycle of development.

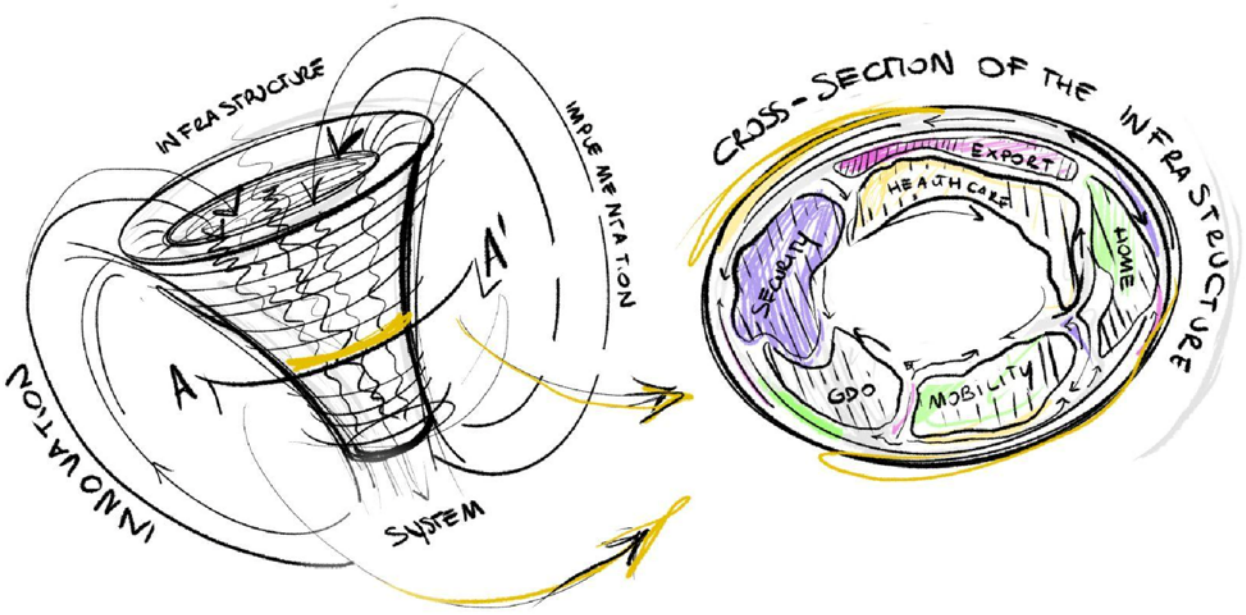

Figure 5: Virtuous cycles of approach applied to cross-cutting innovation approach, by EDME Lab.

Design for the Common Good also promotes social inclusion. Designing accessible and safe public spaces and infrastructure for all, including people with disabilities and disadvantaged communities, promotes equity, social inclusion, and common good. This approach not only improves the quality of life for all citizens, but also strengthens the social fabric, creating more cohesive and resilient communities.

For Paraguay, the enhancement of country-system infrastructure must include the development of smart and sustainable road

networks, the promotion of smart agriculture, and the integrated management of water resources. These interventions not only address immediate economic development needs to be translated into value, but also help create a more stable and secure environment for future generations.

Another crucial aspect of the systemic vision is the involvement of a wide range of stakeholders, including citizens, nongovernmental organizations, businesses, and government. This collaborative approach ensures that solutions are well integrated and truly meet the needs of the population. The active participation of diverse stakeholders facilitates the creation of more creative and relevant solutions, promoting a sense of shared responsibility and ownership.

8. The framework and objectives of the research

The authors' objective theoretical framework started from a state-of-the-art mapping aimed at identifying trends, lifestyle habits in different areas and some quantitative data. By means of a macro-scale filter, it was then possible to visualize a systemic image, returning an articulated vision and a general snapshot on which to subsequently go vertical in a specific and localized way, identifying the goals to aim for in order to initiate and guide the future development of the country, in full respect and enhancement of indigenous culture and history.

This need to operate on a broad scale has led to the focus on the concept of "infrastructure" as the architecture and platform for managing the evolution that permeates every sphere of the country's social, cultural

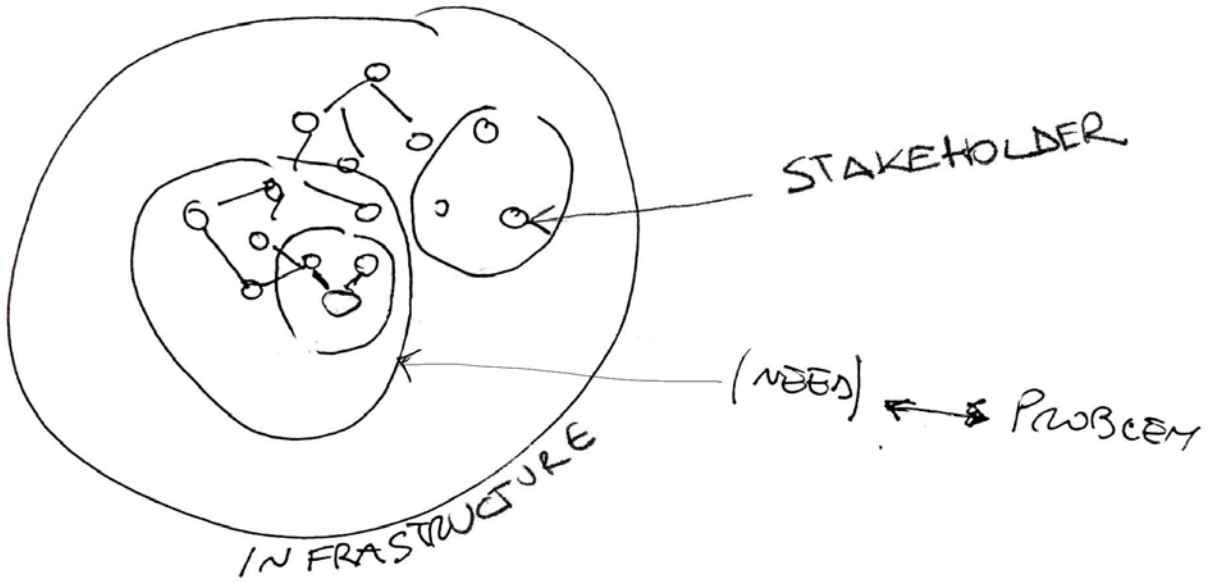

Figure 6 : systemic vision applied to the concept of infrastructure, by EDME Lab.

and economic life, including the activation of networks among different stakeholders called for new relationships for the first time. (Träskman T., 2022).

The goal is to define futuristic (future + possible) scenarios that can create suggestions and bring back best practices for the development of targeted design activities, positioning and improving the country's image, expanding economic integration and stimulating the activation of new relationships that contribute to the contamination of technology and knowledge.

In addition, in parallel, through training activities, including professional training, it is possible to increase awareness that guides industrial choices within cultural itineraries, behavioral and taste trends, lifestyles and consumption styles. (Mathis et al, 2019) This system is crucial in a turbulent and rapidly changing landscape, which, through transdisciplinarity, transfers skills between different fields and sectors in innovative and effective ways.

Paraguay's context, as reported earlier, is one of strong growth. Policies foster international cooperative relations-especially in the South American area-putting the country at the center of debates for social, economic and digital development and growth across the continent. In fact, increasing urbanization is observed in the country, with the construction of new residential neighborhoods and the development of urban infrastructure to support population growth. In terms of technological development, Paraguay faces the challenge of accelerating the country's digital transformation and continuing with the policies that have allowed the ICT sector to grow in recent years. Economic literature points to a country with a good business climate, where the public and private sectors have a good dialogue. It has a newly created digital agenda for the period up to 2025 that outlines specific goals for the sector and a telecommunications development plan that aims, among other things, to expand broadband coverage to 80% of the population by 2030.

In this context of great ferment and a strong propensity for societal development, aiming for a digitization of processes is intended to bring a number of extremely significant benefits to make services and infrastructure shareable and accessible to a large segment of the population. In order to achieve significant results, it is necessary to take a systems approach that encourages the design of strategies focused on the creation of community value. Through the discipline of Design, and embracing the theories of Design for the Common Good, we aim for a paradigm shift in design that is no longer for people, but for the land and all the actors who live in it. In this sense, the economic value generated by a person is not sufficient to represent that person's index of well-being; in fact, as enunciated earlier, it is calculated with respect to a series of broader factors, considering his psyche, his relationships with people and with Nature, etc. (Manzini, 2020).

In this sense, in order to actively engage communities, understanding their needs and proposing projects that are actually meaningful, it is crucial to preserve and enhance indigenous culture and history as much as possible, ensuring that development is respectful and beneficial to the local context.

According to McKinsey's (2019) "Tech for Good" report, "Technology can play a key role in reducing inequality and promoting social well-being". With this in mind, it identifies six main areas where technology can have a positive impact:

- improving job security
- raising living standards
- foster health
- innovate in education
- promoting environmental sustainability
- ensure equal opportunity

However, for these benefits to be fully realized, it is crucial to adopt a collaborative approach involving government, civil society and business in order to maximize the effectiveness of technology and efficiently manage labor market transformations.

To strengthen these relationships, it is essential to conduct careful mapping of society, identifying contexts and clustering stakeholders and related needs. Figure 7 shows a diagram, elaborated by the authors, of the connections between society, infrastructure and services, expanding the scope of research more and more while verticalizing each solution in a practical and concrete way, reporting comprehensible and easily implementable examples from which design processes can be activated.

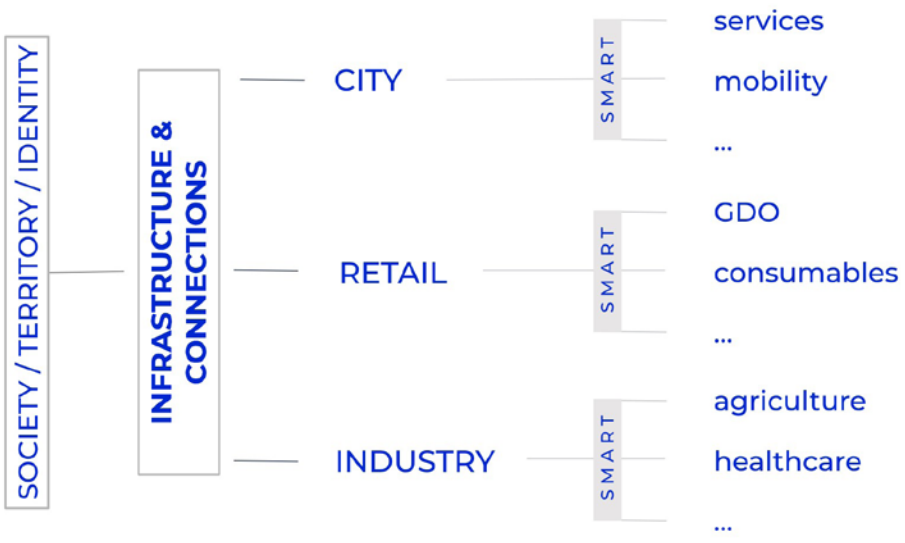

Figure 7 : The smart connections of society: a systemic look

The tree structure - which, however, does not start from a single resource, but from a cloud of contexts and elements related to the territory - helps define a "smart" society in relation to the systemic approach it takes in proposing design and development solutions, addressing problems of a complex nature in their totality and seeking vertically oriented solution activities from a local perspective. In addition - according to common and widespread thinking - the concept of "smart" refers to the intelligent and innovative use of technologies to solve problems, optimize processes and create solutions that improve the quality of individual and collective life by connecting functions

Combining these definitions constructs the "smart" approach as a process that, from societal issues in various contexts, takes the form of integrating data, sensors, algorithms and interconnected devices to make cities, infrastructure, services and products more efficient, sustainable and accessible.

9. Smart integration, case studies and possible interventions

Smart integration involves different scales of interaction between user and technology and is almost always mediated by a digital interface identified by a screen.

Starting from a broad scale, we can identify infrastructure systems designed to reinforce existing infrastructure, integrating with it and enhancing it for broader, faster, more effective and widespread operation. Some examples that can be reported in this regard are the digitization of identity and citizenship documents, or the creation of satellite networks capable of connecting every corner of the planet (Figure 8).

Figure 8 : Smart integration - Examples of large-scale applications.

Moving down to an intermediate scale we find experiences integrated with the user's environment, offering products that place themselves at the user's service to simplify everyone's daily actions.

At this scale we find online commercial infrastructures such as e-commerce, or quick access infrastructure services to regulate flows and facilitate fruition. (Figure 9)

Figure 9 : Smart integration - Examples of application at the intermediate scale.

Finally, we can find the close scale, the one closely related to the user, in which advanced and personalized experiences are offered, working carefully on how the device is used. Here we can identify - as examples - automated home automation systems, wearable devices etc. (Figure 10)

Figure 10 : Smart integration - Examples of close-scale applications.

So, smart integration refers to the ability to connect and synchronize different devices or systems to create a unified and enhanced experience for users. In a product-systems design context, this approach could lead to new city dynamics, also revolutionizing the way we think about and enjoy public spaces.

These product-systems find their greatest application of use in Smart Cities, a city model that gets this name because it aims to optimize urban resources and processes through the use of digital technologies, with the goal of improving residents' quality of life, promoting social inclusion and strengthening communities. These smart cities use information and communication technologies (ICTs) to create more livable and sustainable urban spaces where citizens are at the center of policy and decision-making. Through the use of IoT (Internet of Things) sensors and digital platforms, smart cities monitor various aspects of urban life, such as public transportation, waste management and energy use, in real time, making services more efficient and accessible (Batty et al., 2012).

One of the most significant aspects of smart cities is the ability to actively involve citizens in decision-making processes. Digital platforms allow two-way communication between government and residents, facilitating civic participation and promoting transparent and collaborative governance. This participatory

approach helps create a sense of belonging and community, as citizens can directly contribute to the improvement of their urban environment (Nam & Pardo, 2011).

Smart cities also offer opportunities to address social inequalities and improve access to essential services. Technological solutions such as shared mobility apps, smart lighting systems, and connected healthcare networks help create more inclusive cities where all citizens, regardless of socioeconomic background, can benefit from a better quality of life (Allam & Newman, 2018).

However, the transition to a smart city is not without its challenges. Ensuring that technology implementation respects the privacy and security of citizens' data is essential (Kitchin, 2014). In addition, continued efforts are needed to ensure that all segments of the population can access and benefit from technological innovations, thus avoiding the risk of further widening the digital divide (Van Dijk, 2020).

In recent years, several cities have moved toward creating processes and infrastructure typical of a smart city. Singapore, for example, represents a successful model in implementing smart solutions to improve citizens' lives and optimize public services. Using technologies such as IoT and AI, it has created an interconnected and sustainable urban ecosystem with an efficient and integrated public transportation system, smart mobility solutions, and an advanced sensor network to manage public services efficiently. In addition, the digitization of government services has simplified interactions with citizens, improving public safety and demonstrating how the adoption of smart technologies can transform a city into a global hub for innovation.

A further virtuous example is Shanghai. Indeed, the Chinese metropolis has developed a highly efficient mobility system with integrated public transport and self-driving vehicles; in addition, citizens benefit from a digital platform that provides more than 1,000 services, from utility management to access to information and events. Smart street lighting and efficient buildings reduce environmental impact, while the creation of a digital twin of the city allows innovative solutions to be tested in a virtual environment.

In summary, smart cities represent an urban development model that aims to create more equitable, inclusive and sustainable environments, where technology is used not only to improve the efficiency of services, but more importantly to put people at the center of urban transformation.

From the research and themes identified, three significant macro-areas were highlighted that filter the development of possible pathways that are fundamental to the creation of futuristic scenarios. These themes represent the infrastructures of society and involve, on multiple scales and from a systemic perspective, various everyday dynamics for social, productive and economic development.

The macro-areas are identified as city, retail and industry and are positioned within the pathways to futures characterized by varying degrees of plausibility. Each pathway, depending on the macro-theme it encounters and the historical moment, develops distinct vertical actions that are implemented in delineated contexts. The work of the research team lies in being able to predict directions and project strategies that aim to achieve this prediction (Figure 11).

Actions that project into the future can be exploded into subtopics from the 3 identified filters: figure 12 shows all the possibilities that the research team has defined with the aim of opening up a wide range of opportunities for the development of practical actions.

The clustering of the sub-categories expanded several possibilities that emerged in the search for case studies and concrete best practices that would bring clear and concise examples of virtuous applications in the sector.

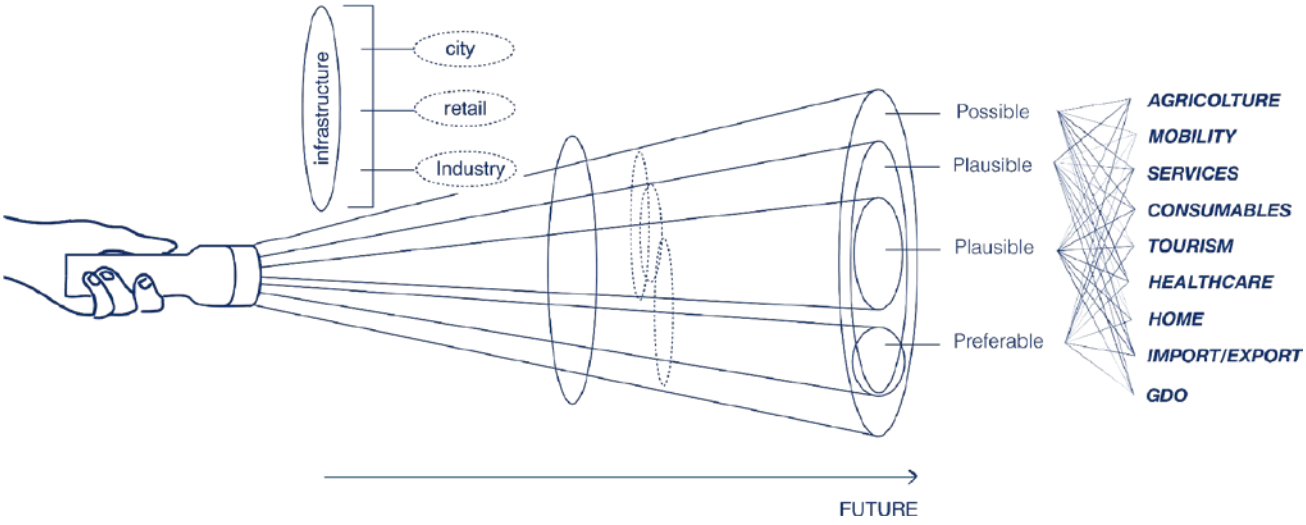

Figure 11 : Cone of futures applied to macro-areas for outlining futuristic scenarios (futures + possible) and development strategies.

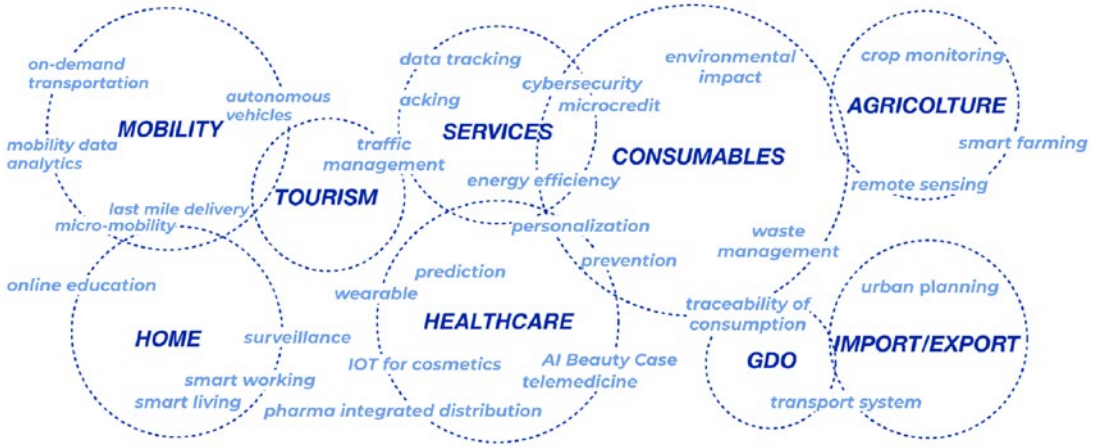

Figure 12: Macro-areas of intervention in outlining futuristic scenarios with sub-categories by subject area.

The first category identified is that of Mobility, in which sustainable on-demand transport services were identified that favor the transport of more people by reducing the flow of cars and energy consumption. In addition, focus was placed on micro-mobility initiatives to encourage the use of electric scooters and bicycles for travel and delivery services. Focusing on an infrastructural discourse, mobility data analytics systems are considered useful for monitoring consumption and developing strategies and policies favorable to the development of sustainable practices.

Another key category is Services, where data on microcredit and microfinance services are collected to help small entrepreneurs develop their businesses independently. In addition, several online education programmes are reported, useful for providing training or university courses and disseminating knowledge in a relatively direct way.

With regard to the country's economic development, the primary sector is identified as the founding and still dominant category throughout the country. Aiming at the digitisation of processes, there is great scope for economic and environmental development. In fact, some smart farming practices, which adopt sensors to monitor and maintain the land, can greatly improve the harvest, allowing for more constant control and savings in time and costs.

Telemedicine control practices have also been found in the Healthcare category. Telemedicine, in fact, is used to maintain direct contact between doctors and patients, allowing them to have a direct channel in case of need. Through the use of interconnected devices and smart sensors, it is possible to directly and remotely monitor a patient's condition, offering consultations based on real data and read out in real time.

The Home category, on the other hand, aims to implement smart processes to strengthen home automation control and improve people's everyday life, enhancing the security of their places and creating a concept of home that can converge well-being, family, but also sociality and work.

These are some of the main categories identified during the research and proposal mapping process. The case studies identified in relation to Paraguay have been contextualized so as to be able to better dialogue with the communities of place, without expecting users to adapt to the technology, but trying to respond to the needs that have emerged, raising awareness of the use of devices and smart objects.

10. Discussion: the limitations of the project

From the research presented in this study, there are a number of crucial challenges and potential obstacles that could hinder the implementation of digital transformation strategies in Paraguay. One of the main challenges is digital literacy, which must necessarily be implemented in order to bring an adequate level of digital competence

among the population, enabling technologies to be used in a consonant manner, making the most of the possibilities they offer. Therefore, it is crucial to implement digital education programmes that not only provide technical skills, but also a critical understanding of the use of digital technologies (Van Deursen et. al, 2020).

Another significant challenge is infrastructure development. Many areas of Paraguay, particularly rural areas, lack the necessary infrastructure to support full digitisation. Targeted investments in network infrastructure, such as high-speed internet access and the availability of digital devices, are essential to ensure that all citizens can benefit from the opportunities offered by digital transformation. These interventions are currently underway in the country, especially in terms of building communication channels to easily connect territories. With this in mind, it is of great importance to implement strategies that envisage the implementation of digital connections so as to further strengthen and facilitate physical ones.

In this context, socio-economic disparities represent a major obstacle for the implementation of interventions towards digitisation. Differences in income and access to resources between different regions and social groups can widen the digital divide, creating a society in which only part of the population can benefit from digitized services and processes. It is imperative, therefore, that digital transformation policies are designed with a focus on social inclusion, to ensure that no one is left behind. For this reason, a holistic approach is adopted, based on design for the common good, which can pursue - in the futuristic scenarios to come collaborative practices, designing for the community and the territory while respecting local identity and traditions.

In this approach there is a strong emphasis on transdisciplinarity, emphasizing how in a context of transition to digital is necessary to enable the applicability of transformation processes. It is useful to provide some practical insights into how these initiatives can be implemented effectively. For instance, the creation of collaborative platforms bringing together experts from various fields (technology, education, business, etc.) can foster the development of innovative and integrated solutions. Such platforms can facilitate the exchange of knowledge and resources, fostering a culture of continuous learning and change.

In summary, while the digital transformation strategies presented offer a promising framework for Paraguay's future, it is crucial to address social and structural challenges to enable the successful implementation of innovative practices and processes.
In this sense, the design discipline can effectively manage the complexity of the project, through an inclusive approach and transdisciplinary coordination: only in this way will it be possible to realize the full potential of digitisation and promote sustainable and equitable development that is respectful of the context in which it operates.

11. Conclusion

The theoretical framework presented in this study offers guidelines for creating a strategy towards digital transition in Paraguay. Its systemic and universal applicability makes it suitable for application in other developing countries as it addresses the specific challenges of developing shared and easily implemented strategies. In particular, the adoption of a systemic approach, characterized by a transdisciplinary component, makes it possible to develop innovative and integrated solutions that can be applied in different territorial and social contexts.

A crucial aspect of the framework is its focus on value, with particular emphasis on economic and social value. Digital transformation, if well implemented, can generate significant increases in productivity and business competitiveness, as well as create new job opportunities and economic growth. However, it is important to recognise that value is not limited to the economy. A Design for the Common Good approach also involves considering social and environmental value, promoting sustainable development that benefits the entire community.

The infrastructure of the country-system plays a key role in applying strategic investments to improve accessibility to digital technologies and to create a favorable environment for innovation and sustainable growth.

In conclusion, the exportability of the framework to other contexts lies in its flexibility and adaptability. The outlined strategies can be modified to meet specific local needs, taking into account different socio-economic and infrastructural conditions. The transdisciplinary approach facilitates collaboration between various actors, allowing synergies between different sectors to be exploited and solutions to be adapted to specific local realities. This framework can thus serve as a model for other countries, offering a solid framework on which to build digital transformation strategies that are sustainable, inclusive and capable of generating long-term value.

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