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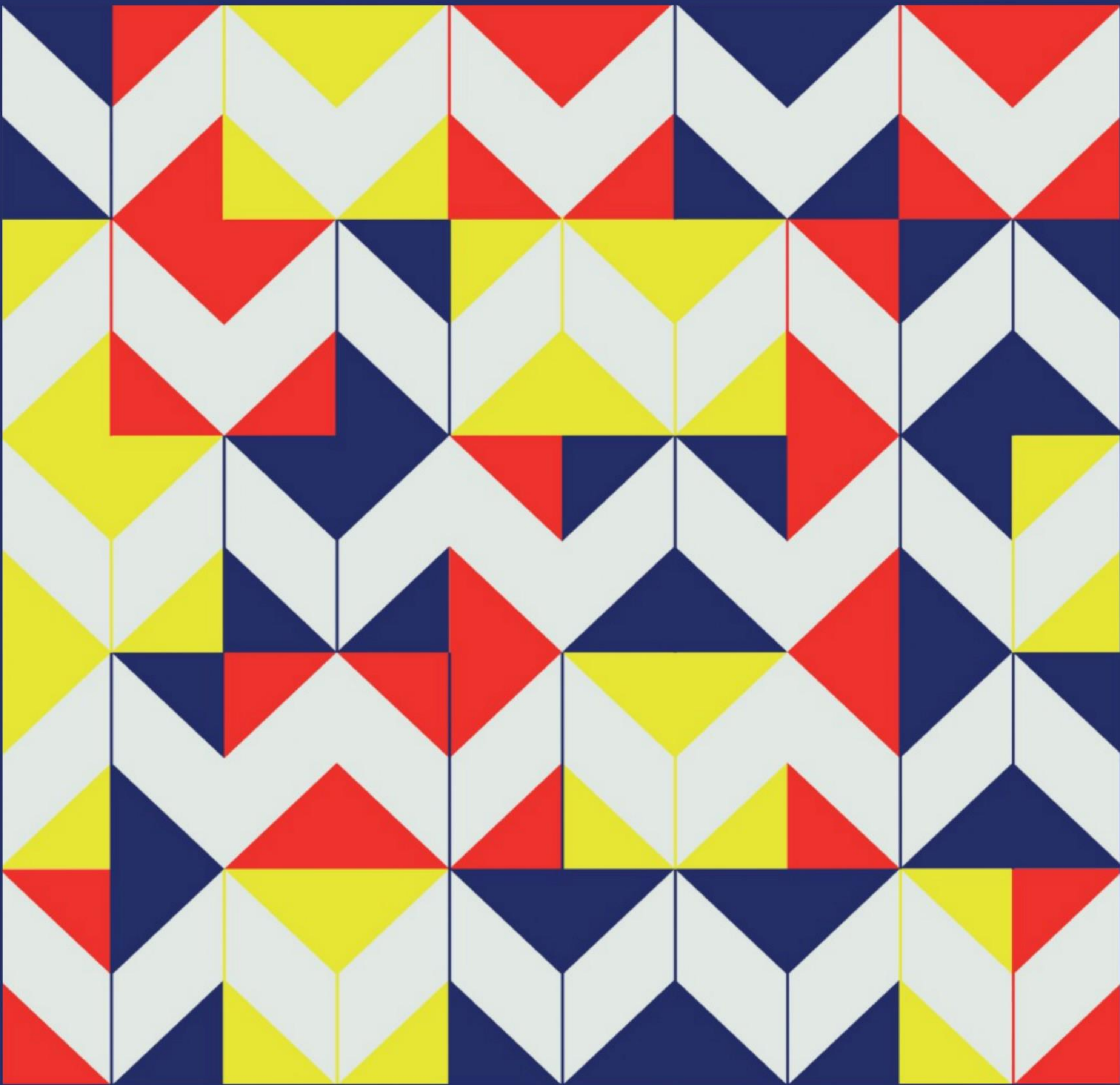

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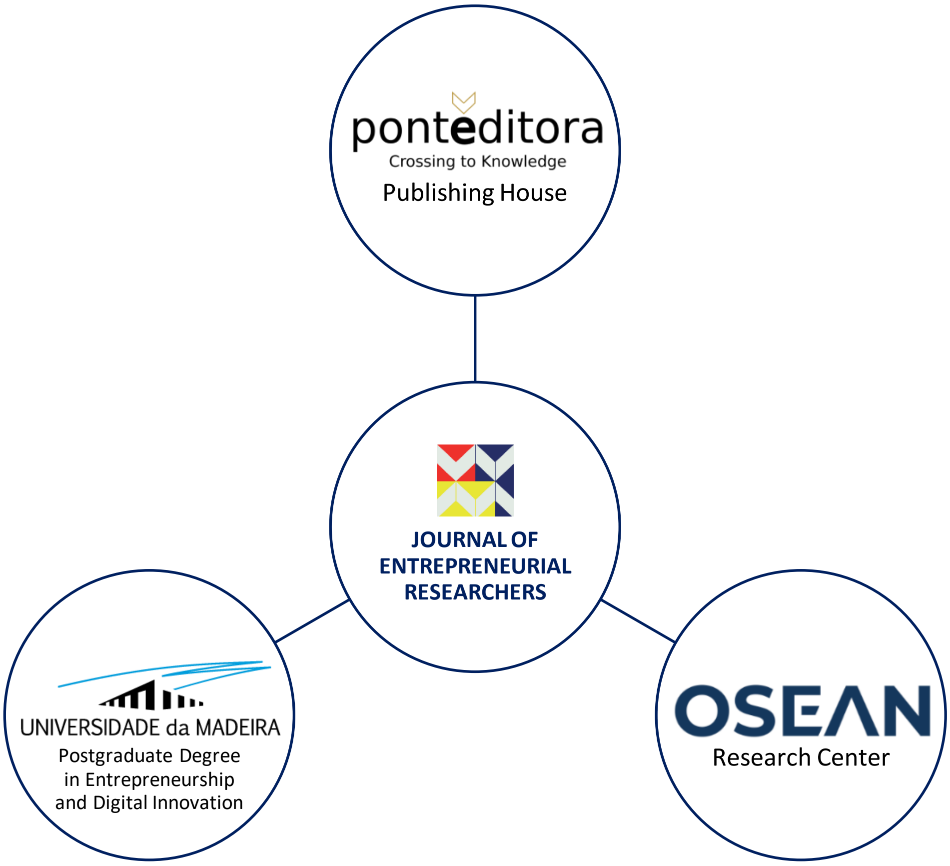

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Editorial—Digital Creativity for Developing Digital Maturity Future Skills

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In an era characterised by rapid technological advancements, the world is undergoing profound transformations (Teichert R., 2019). Klaus Schwab (2016) refers to these transformations not only as the Fourth Industrial Revolution but also as a sweeping "transformation of humankind". Indeed, the pervasive influence of digital technologies has permeated every aspect of people's lives, from the way we engage in sports and consume food to how we do business and interact with each other. The advent of new digital technologies carries the power to reshape behaviours, reinvent social relationships, and redefine the very fabric of humanity. These digital technologies have become integral to our human existence, yet a comprehensive understanding of their impact is missing and strategic guidance amidst this ongoing digital transformation is needed. Society as a whole should, indeed, adapt proactively to new digital technologies and learn how to take full advantage of their application. Schwab affirms that, in human history, there has never been "a time of greater promise or potential peril" (Schwab, p. 8, 2016) which implies that, in order to strategically drive change and leverage the digital transformation, it becomes paramount for change-makers and creators to acquire a new set of skills to master creatively the disruptive and innovative potential of new technologies (Schwab, 2016). Also, emerging technologies have far-reaching effects and implications, often exceeding the initial expectations. "We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run" (Amara,1980). The consequences of their application in different fields are still hardly foreseeable and thus manageable. Since the future is neither predictable nor predetermined (Voros, 2001), it is quite hard to imagine what is yet to come. However, being able to anticipate how technologies might evolve as well as to map their potential implications represents a fundamental asset for both organizations and individuals and an important step to reach Digital Maturity. To achieve these transformations, new strategies should be implemented, some of which include the need to rethink contemporary educational models.

The fast-paced evolution of the digital landscape requires preparing future young innovators, particularly designers, engineers and entrepreneurs, with new skills and competencies to navigate creatively and responsibly the ongoing digital transformation. Organisations such as small and medium enterprises, and business incubators must welcome and invest in digital talents capable of leading them towards digital maturity. In this context the overarching objective of the Erasmus+ funded project *Digital Creativity for Developing Digital Maturity Future Skills—DC4DM* (www.dc4dm.eu), has been to implement a human-centred educational model to empower individuals with Digital Creative Abilities (DCAs) and disseminate it within a European network of HEIs, SMEs and startups. The DC4DM project envisions the dissemination of a new culture on digital creativity with the purpose of fostering responsible use of new digital technologies and propelling organisations towards the design of more sustainable and just futures.

Digital creativity can be defined as the human ability to create innovative and original digital outcomes leveraging the opportunities presented by digital technologies in a strategic and responsible way (Bruno, 2020). Digital creativity is a multifaceted phenomenon that encompasses the cognitive, emotional, physical, and social dimensions of the human experience. This means that the essential skills, knowledge, and values which are required to activate and foster a creative process must be constantly updated and evolve at the speed of digital advancements too. To guarantee a thriving transition towards digital maturity, the next generation of innovators should be equipped with a mix of "hard" skills, such as technology design and data analysis, and "human-centric" skills, including cooperation, empathy, social awareness, and global citizenship, to empower them to shape a future characterised by inclusivity and equality (WEF, 2020). Higher Education Institutions (HEIs)—particularly those offering engineering, design and entrepreneurship curricula—have then the task of updating and re-thinking their traditional educational models acknowledging that digital technologies are becoming our next invisible and ubiquitous nature.

Adapting to digital transformation is not merely about acquiring new technological tools, but also about fostering a mindset that values creativity, collaboration, and ethical responsibility. In this context, higher education institutions play a crucial role in preparing the future innovators who will be at the forefront of these changes. By updating curricula and incorporating human-centred teaching methods, universities can ensure that their students not only keep pace with the rapid technological advancements but also lead the way toward a more inclusive and sustainable future. This alignment with the goal of the *Journal of Entrepreneurial Researchers* (*JER*) is crucial, as highlighted in the JER's founding editorial, which emphasizes the importance of transforming conventional universities into dynamic centres of research, innovation, and entrepreneurship. According to Leite (2023), true academic excellence arises from strategic governance, a high concentration of talent, and abundant resources, which together create a conducive environment for world-class learning and advanced research. With this vision, the JER seeks to promote a transnational network of advanced research with high social impact, contributing to more sustainable and equitable development. The Erasmus+ funded project, Digital Creativity for Developing Digital Maturity Future Skills (DC4DM), exemplifies this approach by offering a human-centred educational model that empowers individuals with creative digital skills. The DC4DM, demonstrates how education can be a transformative force in times of rapid technological evolution, inspiring Industry 5.0.

Through this *Journal of Entrepreneurial Researchers* issue we have invited the wide and multidisciplinary academic community to explore the following critical questions: *how is digital transformation not only altering mindsets, behaviours, and social attitudes but also revolutionising the processes of creation and innovation? How can small and medium scale enterprises keep up with the fast pace of digital technologies developments? How are work requirements and skill sets changing? How is higher education aligning with the needs and opportunities of the digital era? How can achieving digital maturity be an opportunity for sustainable transformation?*

The six articles included in this issue develop some of the proposed themes from different angles and research fields, such as:

- Higher education for the Fourth Industrial Revolution: preparing creatives and entrepreneurs to guide organisations towards digital maturity.
- Digital transformation and innovation for small and medium enterprises and organisations
- Tech-foresight and design futures methods and applications for digital transformation.
- Creativity and creative skills in the era of digital transformation.
- Ethical dilemmas while achieving digital maturity.
- Collaboration and communication strategies to envision sustainable and just future scenarios.

Articles like "*Steering digital maturity: a design-based educational model for empowering digital creativity and future skills"* (Bruno C., Canina M.R., Monestier E.) and "*Preparing humane ML experts for a better future. Experiments with design and engineering students*" (Sciannammé, M.) highlight the need of educating future digital talents with new methods and tools which can prepare them to respond to the challenges of a world in constant transformation. Students from different disciplines should not just understand the technical aspects of emerging digital technologies but develop the skills and abilities for collaboration and cross-pollination. A strong sense of ethical responsibility should also guide future professionals when designing new digital applications and systems as suggested through the contribution "*Ethical navigation in the development of healthcare digital applications: a case study of the DC4DM Learning Lab on Madeira Island*" (Ferreira L., Vezzani V., Cerretti C.). Articles like "*Agile future creation methodology. Innovation method for startups to build future-proof solutions"* (Rana R.) and "*Psyment: advancing digital transformation in psychological assessments and diagnosis for healthcare facilities and organizations*" (Rodrigues B., Freitas E., Romão A., Ferreira L.) offer ideas for optimising workflow and inspire innovation within small and medium organisations where there is either a genuine need for digital transformation or thirst for digital creativity. Finally, *"Towards an analytical framework for AI-powered creative support systems in interactive digital narratives"* (Serbanescu A., Nack F.) brings to attention the need of understanding better new emerging technologies, such as AI systems, to not just use them at their best potential, but especially to enhance collaboration between different types of expertise who would surely unleash great levels of creativity, or better, digital creativity!

The DC4DM project officially concluded in August 2023, but many were the questions the researchers were left with. This issue includes six contributions from academics from the areas of design, engineering and entrepreneurial studies, but it aims to inspire further interdisciplinary conversations which may lead to new creative projects, research activities or simply collaborations in favour of the vast current debate on digital creativity and digital maturity.

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Steering digital maturity: a design-based educational model for empowering digital creativity and future skills

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Abstract

The demand for talents capable of navigating the complex digital landscape while aligning innovation with human needs is on the rise. Digital creativity, intended as the human ability to create innovative and original digital outcomes, stands as one of the main abilities that future leaders should master to guide enterprises towards digital maturity. As educators, how can we train digital creativity to achieve a digital maturity? The article introduces 4 main critical dimensions to empower students' digital creativity and retraces how these have guided the implementation of a design-oriented educational model to train digitally responsible future professionals. The DC4DM action model is presented as well as its application in a real-life educational setting: the Learning Lab. The educational experience is thoroughly described from the organizational perspective to demonstrate the effectiveness of a learning experience tailored for students to work closely with professional realities, tackle real-world challenges and co-create visions of digital futures.

Keywords: Competence-Based Model; Design Education; Design Futures; Digital Creativity; Future Skills.

1. Introduction

The degree of complexity and uncertainty that is characterizing the world we know is directly proportional to the speed of technological development (Sargut & McGrath, 2011). Digital transformation should be on the agenda in every sector and field, and society as a whole should, indeed, adapt proactively and learn how to take full advantage of new technologies, anticipating their impacts. Research (WEF, 2020) have demonstrated that the companies' inability to leverage technologies and take full advantage of their potential is mostly due to the expanding skills shortages that the workforce is manifesting. In human history, there has never been "a time of greater promise or potential peril" (Schwab, 2016, p. 8), which implies that, in order to strategically drive the change and leverage digital transformation, it becomes paramount for change-makers and creators to acquire a new set of skills to master creatively the disruptive and innovative potential of new technologies (Schwab, 2016). In the short-term future, there will be a growing need for the development of higher cognitive skills which include technological, social, and emotional capabilities considered as essential to adapt to digital working environments successfully, add value to what can be technologically automated and differentiate human and machine work (Dondi et al., 2021). Considering that creative thinking has been recognized to be one of the key factors that guarantee a beneficial cooperation between humans and technologies (Bruno & Canina, 2019a), the above-mentioned new set of skills should include creative competencies and abilities that would help people adapt and face proactively the ongoing radical changes brought and enabled by emerging digital technologies.

Today, designers and engineers have the main role and responsibility to integrate creativity and innovation to breakthroughs and solve some of the most complex problems facing society today, also taking advantage of the opportunities opened by emerging technologies (Meyer & Norman, 2019). Human creativity drives innovation, that is that spontaneous act pushed by intrinsic motivation, through which the individual can improve itself and his world. Innovation today does not solely rely on the technology itself, but mainly on how it interacts with humanity, solving their problems, needs or challenges. However, with the widespread diffusion of emerging technologies creativity has started to take a new shape—digital creativity (Lee & Chen, 2015) intended as the human ability to create an innovative and original digital outcome while taking advantage of the opportunity of digital technologies (Bruno, 2021). Being a human ability, digital creativity will require new abilities to manifest and to enable people to fully release their creative potential to create a new and innovative (digital) outcome (Amabile & Pratt, 2016; Amabile, 1996)

Training digital creativity has become therefore a requirement for design and engineer education that should rethink contemporary educational models and train the future generation of professionals to face the challenges of the digital era (DC4DM Consortium, 2023). New educational models should be devoted to developing digital creativity and the set of skills to activate it. The misalignment of the need to upskill people and the consequent urge to redesign the current educational models is easily observable (Lang & Triantoro, 2022; EU Commission, 2022), as there are no educational models in the literature that show educators how to train digital creativity from a design perspective.

The aim of the article is to present an action model, developed within the framework of the Digital Creativity for developing Digital Maturity future skills (DC4DM) EU project[1], that design and engineer educators could adopt to train digital creativity and prepare their students to become digital talent able to strategically apply digital technologies to create future solutions (Canina et al., 2023).

The human-centred educational model will provide young talents with the necessary abilities to leverage emerging digital technologies strategically and responsibly and thus become fully aware professionals. The first section of the article illustrates what digital creativity is from a design perspective and the effort done in identifying the crucial aspect that should be nurtured to empower it and move towards digital maturity. Those aspects have been used as a ground knowledge to build the DC4DM action model that has been reshaped and defined through several co-design sessions with experts from diverse disciplinary fields. The article continues presenting the action model composed by a methodology and a training format explained through its application in one of the Learning Labs organized within the EU project. A discussion will present the reflections emerged from the experience and some suggestions for future implementation.

2. Literature Review

2.1. What is Digital Creativity?

Creativity is a fluctuating concept (Csikszentmihalyi, 1990; Runco et al., 2016b; Runco et al., 2010, as cited by Runco, 2017, p. 308), that is changing and evolving according to the sociocultural environment (Runco, 2017), the domain in which it is applied, and the perspective adopted for its study. The new digital domain, with its fast evolution, has contributed to expanding the way in which creativity manifests and the competences required for its successful application. The need to study and understand the digital impact on creativity has gained increased attention in the literature (Jackson et al., 2012; Schmitt et al., 2012; Zaman et al., 2010, as cited by Lee & Chen, 2015, p. 12), giving birth to a new wave of creativity studies where researchers from diverse disciplinary fields, are investigating how creativity is evolving and is influenced by the human, cultural, and technological evolution of the digital era (Bruno & Canina 2019a, 2019b). Conventional definitions of creativity have been questioned as they need to be redefined and reinterpreted from the perspective of digital technology (Williams et al., 2016)

"As digital innovation has permeated our daily lives, creativity has started to take a new shape: digital creativity" (Lee & Chen, 2015). Digital creativity is an evolving, growing phenomenon in rapid evolution and constant redefinition, where a dominant scientific thought has not yet been stratified and codified in theories and practices (Bruno & Canina, 2022). Exploring this phenomenon through the transdisciplinary lens of design, two main perspectives for understanding digital creativity clearly emerge (Bruno, 2021). The first perspective can be defined as digitally supported creativity that encompasses how human creative abilities can be enhanced and

[1] https://www.dc4dm.eu/

augmented by digital technologies to amplify creative achievement, and how creativity can be transformed and become yet more digital (Shneiderman, 2000, 2002, 2007; Shneiderman et al., 2005). The second perspective highlights the concept of human-centered creativity in the digital age that puts emphasis on the role of the new abilities and skills that creators should develop when creating and innovating with digital technologies. This perspective addresses the theme from a human point of view by observing the behavioural, social, and cultural changes related to the adoption of digital technologies (Zagalo & Branco, 2015; Literat & Glăveanu, 2016). The second perspective emphasizes the relevant role of digital creativity for innovation in the digital transition putting human creative abilities at the centre, as they are essential for our survival in this era especially in the necessary collaboration between humans and machines (Corazza, 2017).

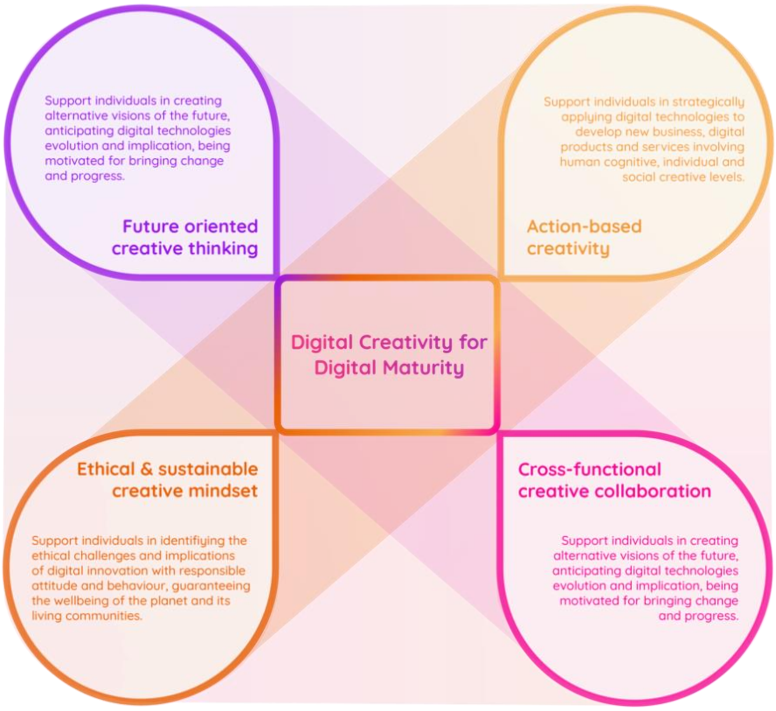
A design-oriented definition of digital creativity that merges both the above-mentioned perspectives state that "Digital Creativity is the ability to creatively and strategically apply digital technologies to innovate, thereby harnessing technological innovation to solve complex problems while keeping people at the centre. This ability requires humans to manage a creative design process, to develop new skills and to adopt digital technologies to enhance and augment our way of creating, i.e., our creative process, to increase human creativity" (Bruno & Canina, 2022)

2.2. Digital Creativity for Achieving a Digital Maturity

The DC4DM project demonstrated the crucial role of digital creativity as a fundamental ability that young professionals should develop for helping companies in achieving digital maturity (Canina & Bruno, 2021). Indeed, designers, who are called to solve wicked problems (Rittel & Webber, 1984) that are becoming more complex as the world evolves, are asked to develop digital creativity to guide companies in their transformations toward digital maturity. The main needs identified by digitally mature companies (Kane et al., 2018) are: i) to strategically apply digital technologies to develop new businesses, to digitalised operations and processes, ii) to face complex challenges that require the knowledge of employees with different functions that should work together also remotely on collaborative digital platforms, iii) to face future sustainable and social challenges, planning long term strategies to be competitive even in an uncertain future.

Empowering students' digital creativity to reach a digital maturity entails four critical dimensions, as showed in Fig. 1, that have been defined by intersecting the literature on creativity and digital creativity with the above-mentioned key practices that companies should implement to become digitally mature. Therefore, the dimensions explained in the following sub-sections constitute the ground on which the DC4DM training model has been built.

Figure 1: The four dimensions to empower students' digital creativity for achieving a Digital Maturity. Visualization created by the authors.



2.2.1. Future Oriented Creative Thinking

Digitally mature organizations need to plan a long-term strategy to face the changes brought by the emerging digital landscape and be competitive even in an uncertain future, looking out five years or more (Kane, 2017). This entails an ability to apply creative thinking that will help in envisioning future scenarios. Imagining a future different from the present requires creativity and the ability to stretch one's imagination beyond what is immediately visible and the courage to think otherwise (Rubin, 1998; Glenn, 2009; Sarpong & Maclean, 2016, as cited by Hiltunen, 2021 p. 44). Creativity is essential in the search for signals and directions of change (Schwarz et al., 2014), and the future is understood as the result of ongoing acts of creation (Lombardo, 2011). Creative thinking has been therefore considered as a component of futures thinking (Lombardo, 2017; Pouru & Wilenius 2018, as cited by Hiltunen, 2021 p. 44), but futures thinking, in turn, is a component of creativity (Hiltunen, 2021). Futures thinking can liberate people from pre-existing ideas and boost creativity in many ways (Koh & Leung, 2019). Imagining an unexpected future can help us take leaps forward, and imagining multiple alternative futures can liberate our thinking and inspire us to try something new. Individuals who are in a "future-oriented condition" produce more novel ideas in tasks requiring creative insight (Koh & Leung, 2019), and according to Chiu's (2012) findings, the more distant the imagined futures are in tasks requiring creative imagery, the more creative the results will be.

Future-oriented thinking produces unconventional thoughts that are more motivationally relevant that have a greater impact on people's subsequent behaviour (Koh & Leung, 2019). Indeed, people project higher change and progress in the future (e.g., technological, scientific, and societal progress) and these visions of future change could drive pro-environmental and political behaviours in the present (Bain et al., 2013, 2016).

Thinking of the future activates a growth and progress mindset as well as thoughts about potential problems and dysfunctions (Bain et al., 2013, 2016; Kashima et al., 2009) which are relevant when thinking about the future strategy of an organization. Thinking in a future-orientation will bring these unconventional schemas to the fore and benefit creative idea generations.

We can therefore state that Digital Creativity for achieving Digital Maturity requires kindling a future oriented creative thinking, which could support individuals in defining alternative visions of the future (Russell & Buck, 2020), being motivated for bringing change and progress. Also, being able to anticipate how technologies might evolve as well as to map their potential implications represents a fundamental asset for both organizations and individuals and an important step to reach Digital Maturity. Since the role of designers is to ideate solutions for latent or future needs, it is important to recognize thinking of the future "as an intrinsic part of the design process" (Evans & Somerville, 2007, p. 1) that therefore requires to embed new future-oriented approaches within the design curriculum.

2.2.2. Action-Based Creativity

As stated in its definition, digital creativity requires people to manage a creative design process to strategically apply digital technologies to develop new business, to digitalise operation and processes. This would help organizations in scaling small, practice based, iterative digital tech experiments into enterprise-wide initiatives that have greater impact (Kane et al., 2017).

The creative process can be defined as "the succession of thoughts and actions that lead to original and adapted ideas" (Lubart et al., 2004, p. 85). It unfolds through a chain of events characterized by steps or phases or activities, with a beginning and, potentially, an end. The creative process may be nonlinear, takes place over time and it requires both thinking and action to produce a tangible or intangible creative outcome. Most creative ideas indeed occur while acting and doing the work (Sawyer, 2012).

The creative process can therefore be considered simultaneously a mental cognitive process happening in the mind of the creator and an action practice happening in the material world through a series of individual and/or social activities. It has both a psychological and a behavioural manifestation, as it is the design process which constitutes the approach and the process that the designer used to come up with solutions that are both new, original, and adapted to future users and usages (Bonnardel, 2012). Creativity in design is an action-based practice that requires:

- On a cognitive level both a divergent mode defined as the enlargement of the search area for creative ideas and a convergent mode that supports the definition of a focus (Bonnardel, 2000; Bonnardel et al., 2018).
- On an individual level the activation of knowledge, skills, and values that empower individuals to harness their creative potential (Amabile, 1996) who creates new solutions through a creative process.
- On a social level the interaction with the real-world environment and society related to the problem under scrutiny (Csikszentmihalyi, 1988; Lubart et al., 2004).

Therefore, training digital creativity for achieving digital maturity requires nurturing an action-based creativity considering all these multiple levels.

2.2.3. Ethical and Sustainable Creative Mindset

Emerging technologies open multiple possibilities to innovate and improve the quality of human life, but at the same time, they generate new ethical issues that need to be carefully addressed (Green, 2017). If, on the one hand, technological power makes humanity evolve, on the other hand it also carries with it brand-new concerns related to sustainability in its broader sense. Sustainability, indeed, does not only pertain to environmentalism, but it also embeds the concepts of social equity and economic development (Johnston et al., 2007). Designing, working, and managing digital technologies means balancing and pondering environmental, societal, and economic essential factors in the perspective of medium- or long-term futures (McGill Sustainability, n.d.). Therefore, when innovating through digital technologies harnessing their potential to solve complex problems, it is relevant to develop a creative mindset that is ethical and oriented toward sustainability. The development of this mindset turns out to be essential when creating with digital technologies to steer the ongoing digital transformation and achieve maturity. Digital creativity for achieving digital maturity requires developing new skills and a newly implemented creative mindset that leads to a greater awareness of the actions performed as well as their implications for others.

This new creative mindset facilitates the identification and understanding of ethical challenges and implications of digital innovation. This also means being able to drive a digital strategy by adopting an ethical attitude and behaviour during the design and implementation process. It also enables the responsibility of improving and guaranteeing the wellbeing of the planet and its human and non-human communities while designing with technologies. This implies learning to: (i) see and think from the perspective of other organisms, beyond the human needs; (ii) analyse and tackle challenges by balancing the environmental, economic, technological, socio-cultural, and political perspectives.

Training digital creativity for achieving a digital maturity means nurturing an ethical and sustainable mindset that will enable learners to use creatively, efficiently, and responsibly emerging technologies to become “drivers” of change (DC4DM Consortium, 2022; Canina et al., 2023) and make them fully aware professionals (WEF, 2020).

2.2.4. Cross-Functional Creative Collaboration

Breaking down silos, encouraging collaboration within cross-functional teams is an important requirement for organizations aiming at becoming digitally mature. The problems of our century are becoming more complex, asking for cross-disciplinary collaboration with multiple knowledge and skills, for the accomplishment of the creative activity (Micheli et. al, 2019). This requires implementing systemic changes within the organization itself to form a new cross-disciplinary and cross-functional workforce able to collaborate and lead towards innovative and future-oriented solutions. Cross functional teams encourage people to think differently. As they can have a holistic view on the issue at hand from diverse perspective (Kane & Phillips, 2017). Moreover, exposure to multiple cultures and backgrounds can inspire creativity because it encourages people to adhere less firmly to the common schemas prevalent in their own culture and to adopt new schemas (Leung et al., 2008). Therefore, fostering collaborative interdisciplinary work and idea generation with others, harmonizing diverse backgrounds to yield creative outcomes (Amabile & Pratt, 2016; Osborn, 1963; Csikszentmihalyi, 1988), is essential for digital creativity.

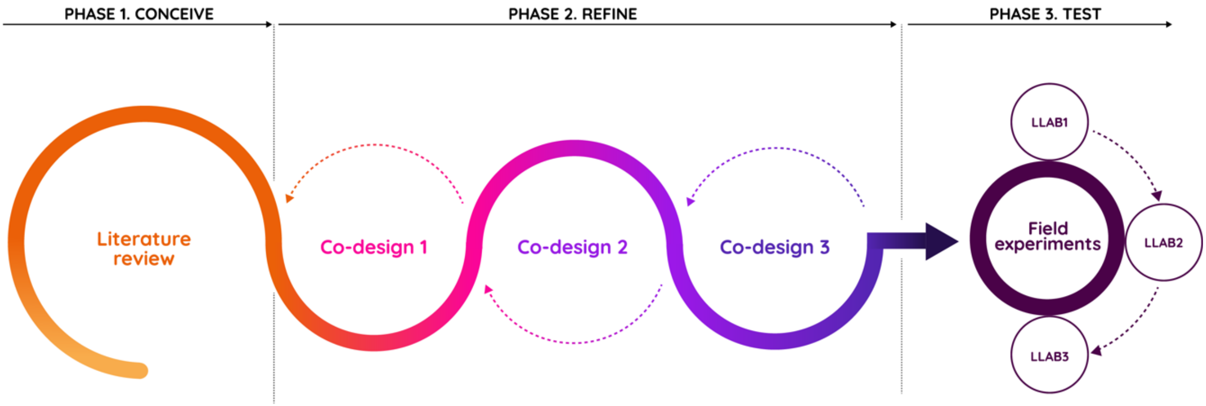
Team creativity is more than just the combined creativity of the individual team participants. There are factors that influence the contribution of the participants and their interactions. One of these is trust, which lies at the heart of teamwork and, since it influences how knowledge is shared, interpreted, and integrated by team members, it also represents the groundwork of cross-functional collaboration (Mooradian et al., 2006). Other important aspects for activating a successful cross-functional creative collaboration are to develop the propensity and willingness to be vulnerable to others’ actions and ideas, to care for each team member, as well as developing a cooperative behaviour intended as the ability to build bonds with other members, acquire awareness of interpersonal differences and commonalities, be open to others’ personality and ideas (Reiter-Palmon et al., 2012). It is clear that in order to enhance team creativity it is necessary to act in both the individual and social areas, nurturing and reinforcing the relationship between collaborating individuals.

3. Building the DC4DM Action Model

The expertise of the authors—who have been working at the intersection of design methods, futures thinking and (digital) creativity for a long time—set the groundwork of the DC4DM model by providing a design-oriented approach to education offering learners the possibility to actively exploring real-world challenges and issues through a project-based learning. Central to the DC4DM model indeed is a design futures process, conceived by the authors, which encourages learners to envision and create future scenarios and solutions through a learning-by-doing approach.

The methodology adopted to build the model is summarized in Fig. 2 and consist of three main steps each one using a specific method such as literature review to conceive the model, participatory co-design activities to refine the model with experts, and field experiments to test it in real world scenarios.

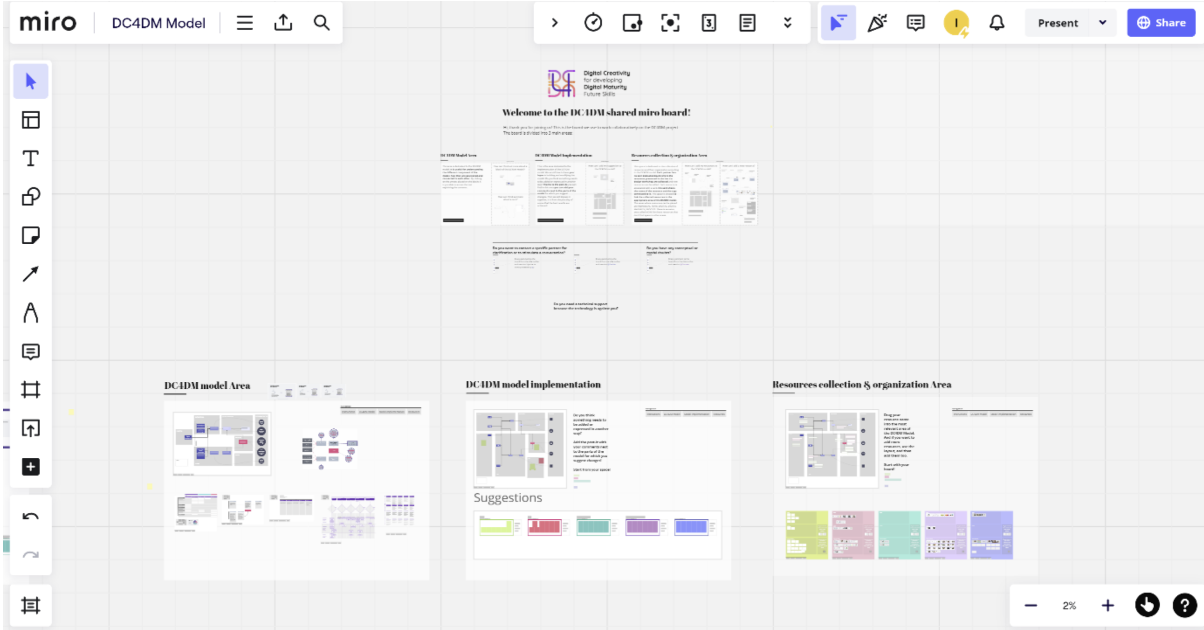
Figure 2: Schema of the employed methodology. Visualization created by the authors.



A first version of the action model has been proposed by the authors after an intensive literature analysis building on the identified dimension of digital creativity relevant to achieve digital maturity. Indeed, literature review is acknowledged to be a useful method for organizing insights and spot knowledge gaps to build theoretical frameworks and new conceptual models (Snyder, 2019). The initial version of the action model has been consequently implemented and refined through a series of three participatory co-design sessions organized between October 2020 and April 2021 and led by design researchers belonging to the Design Department of Politecnico di Milano either virtually through web-based tools (Microsoft Teams) and or physically. Co-design methodology has been adopted as it allows for the creative cooperation of designers, researchers, and experts in the field under investigation (Steen et al., 2011) that share their knowledge, skills, and resources to conceptually create something new (Zamenopoulos & Alexiou, 2018). Co-design, therefore, represented a great opportunity to gather experts from various fields of expertise to refine and implement the first draft of the model. Indeed, the overall aims of the sessions were to refine conceptually the model, select and design activities and methods to put the DC4DM model in action to train students, integrating insights of experts from different fields. Indeed, the co-design involved the participation of a diverse team of educators and researchers from universities, a business incubator, and SMEs from three different countries—France, Italy, and Portugal—ensuring multidisciplinary skills in design, engineering, and business.

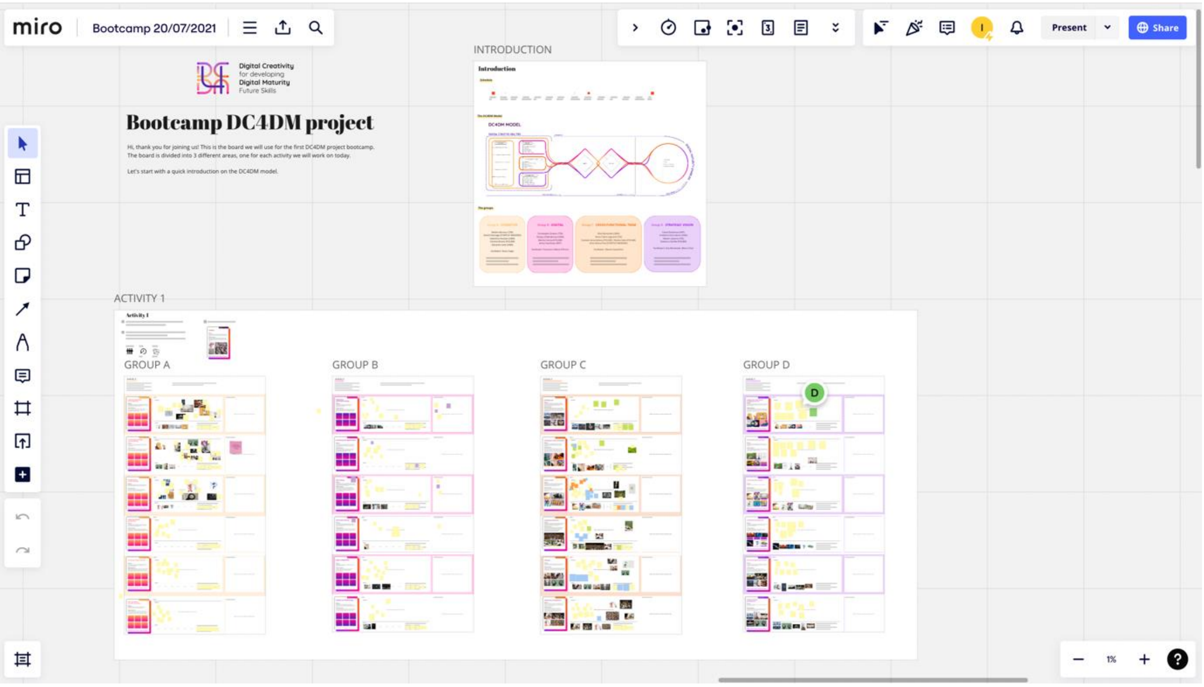
Each co-design session had specific objectives and the team of experts attended all three sessions. The first co-design session (Fig. 3) was dedicated to model refinement. Participants were asked to engage in brainstorming activities to provide critical feedback to improve and enrich the initial draft of the action model proposed by the authors. The session was held online using Miro as a platform for remote collaboration. The suggestions collected were implemented in a new and definitive version of the model.

Figure 3: First co-design. Screenshot of the Miro board used to conduct the activities.



The second co-design session (Fig. 4) required participants to reflect on their educational expertise to train the skills and competences included in the model in order to provide educational resources, tools and methods that could be used to put the model in action. Reflections focused on the selection of existing tools and/or the implementation of *ad hoc* resources to populate and sustain the action model. The collected resources have been then analysed by the authors, selected, and structured within a design toolkit that is an actionable resource that could be used by educators in their classes. A visualization of the action model has been developed to facilitate its understanding and adoption.

Figure 4: Second co-design session. Screenshot of the Miro board used to conduct the activities.



The last co-design session (Fig. 5) has been dedicated to validating the action model and the resources selected as well as the definition of the training format to apply the model.

Figure 5: Third co-design session held in person at Politecnico di Milano.

The implementation process that led to the final version of the model was iterative and required a multi-layered approach. The final version of the DC4DM action model was finally tested through field experimentation (Scandura & Williams, 2000) that enable us to deliver the actionable model and tools to practitioners (Eden, 2017). Three multidisciplinary workshops, called Learning Labs, were organized involving master's students from the design, engineering, and business courses. The aim of Learning Labs was both to train students with digital creativity abilities for digital maturity and to test the resources included in the model directly with educators and students, which were indeed further improved to define a DC4DM Toolkit and a Learning Lab Training format.

4. The DC4DM Action Model

The DC4DM action model allows educators to train their students—mainly in the fields of design, management and engineering—with digital creativity making them Digital Maturity Enablers, namely digital talents capable of identifying opportunities for innovation and growth within the digital scenario, designing human-centric strategies and solutions through the principles of ethics and sustainability (DC4DM Consortium, 2023).

This tool for action is composed by two main parts:

- a DC4DM methodology based on i) a Design Futures process that stimulates a future oriented creative process to envision future technological solutions ii) a series of preparatory activities that enable learners to activate a sustainable, ethical, and future mindset when designing with digital technologies. The methodology can be founded in the DC4DM toolkit that is now published openly on a Miroverse platform.[2]
- a Training format that guides educators in the application of this methodology to nurture digital creativity. The format can be consulted on the DC4DM website.[3]

[2] https://miro.com/miroverse/dc4dm-toolkit/
[3] https://www.dc4dm.eu/format/

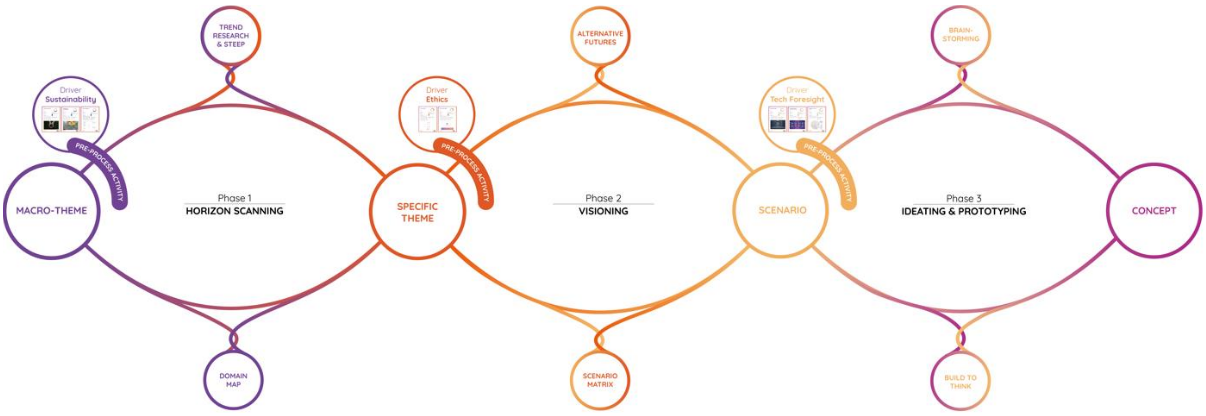
4.1. DC4DM Methodology

The DC4DM methodology (Fig. 6) is based on Design Futures process that merge Design Thinking and Futures Thinking approaches (Canina et al., 2021) which, through a series of steps and tools, activates a *future oriented creative thinking*.

The process, based on successive divergent and convergent phases, is deconstructed into three steps:

- *Horizon Scanning*. It concerns exploring a topic from a macro perspective, analysing social, technological, economic, environmental, and political trends and signals. Horizon scanning allows to uncover the landscape of possibilities that could potentially influence the future of that specific domain, leading to a future domain map that is truly comprehensive.
- *Visioning*. It concerns identifying patterns and constructing maps of the future where to undertake an immersive journey. It is the phase in which you can immerse yourself in the journey of envisioning alternative futures starting from the divergent Horizon Scanning. Through Visioning it is possible to construct alternative futures which would lead you to four captivating future scenarios.
- *Ideating & Prototyping*. Once the preferred scenario is selected it starts a new step where creativity can flow to generate innovative and technological ideas which align with the needs and characteristics of the future scenario of reference. In this step a cycle of divergent and convergent thinking is employed, many and different concepts can take shape and come to life. At the beginning of the Ideation phase, through iterative brainstorming and prototyping the most suitable and effective solution (product, service, strategy) is developed.

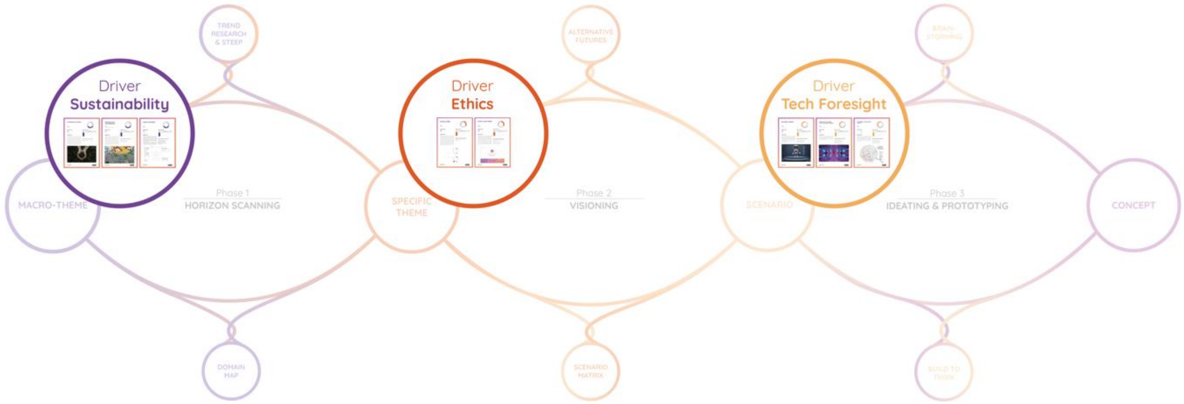
Figure 6: DC4DM Methodology. Visualization developed by the DC4DM project consortium.



Each step is applied through 2 methods and related tools which have been developed and implemented by the authors throughout the length of the project. The methods, and the presentation integrated to support educators in applying it, can be consulted in the DC4DM toolkit.

The DC4DM methodology identifies three main drivers for achieving Digital Maturity and to design responsibly for a digital future—Sustainability, Ethics and Tech Foresight (Canina et. al, 2023). These represent pillars to the thinking and design process; therefore, the methodology includes some preparatory activities (Fig. 7) to the process that encourage critical reflection on personal abilities and knowledge that activate and strengthen *a sustainable, ethical and foresight mindset.*

Figure 7: Pre-Process activities within the DC4DM Methodology. Visualization developed by the DC4DM project consortium.



Each driver's activities guide the sequential phases of the design futures process as here explained:

- *Sustainability*—Before stepping into the Horizon Scanning phase, it is fundamental to analyse the macro-theme of reference by thinking through both the opportunities for and obstacles to sustainable development. Students must learn to address any inspiring case study or critical question by considering their own responsibility in designing sustainable futures. Improving and guaranteeing the well-being of the planet and its communities through digital technologies is one of the objectives of the future talents.
- *Ethics*—Once the specific theme is defined, students must practice their own ethical way of thinking and operating, adopting an ethical attitude and behaviour. Before the Visioning step, learners are asked to practice their abilities in understanding the ethical implications of facts, ideas, and actions, to drive digital strategies and pave the path for just and fair future scenarios.
- *Tech-foresight*—Future talents must learn to scout emerging technologies, understand the future opportunities they might generate, as much as their impact on people and planet with associated implications. This allows learners to grasp the potential of new digital technologies before moving to the Ideating & Prototyping phase where new applicative solutions can be envisioned.

Once mastered each driver, each learner should feel more and more confident in facing new digital challenges through the different steps of the design future process. The preparatory activities are crucial for generating the final digital concepts, where emerging digital technologies play a significant role.

4.2. DC4DM Learning Lab Training Format

Learning Labs (LLabs) are intensive, interdisciplinary and design future-led workshops which use the DC4DM methodology at the core of the creative process. The Learning Lab Format guides in applying the DC4DM methodology, setting all the key components and sets of actions up for a successful educational workshop and results. From how to select the participating students, companies and start-ups, and mentors, how to organise the logistics and workspaces, to how to build active interdisciplinary teams, facilitate and promote collaboration, and finally how to go through each DC4DM design process step. This will support and empower educators to facilitate and teach design methods and practices to nurture digital creativity towards digital maturity.

In particular, the format defines some important condition to apply the methodology, which comes from the literature analysis:

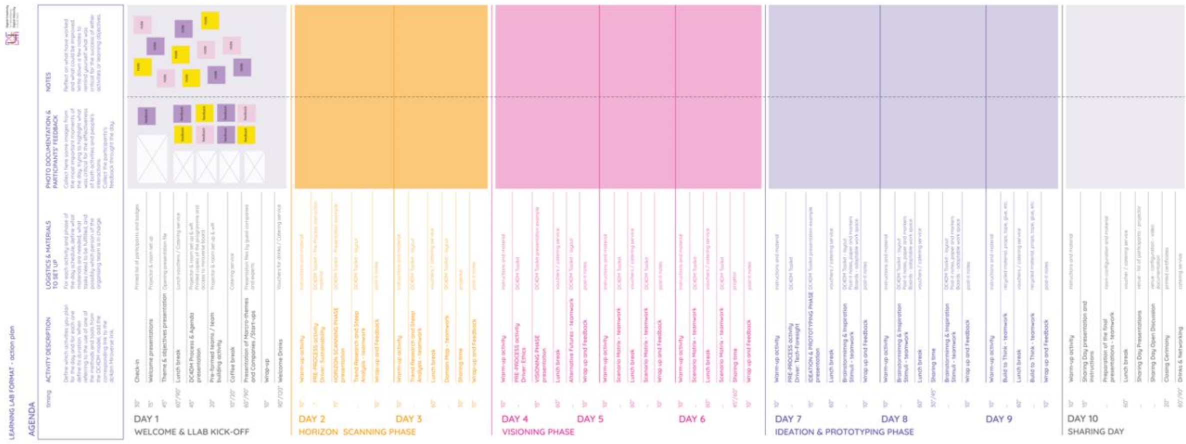
- *Create cross-disciplinary teams of design, engineer, and management students*: their mixed background is needed to design future technological solutions. The format includes therefore activities to create successful teams and initial warm up to facilitate team trust and their cooperative behaviour.
- *Promoting project-based activities addressing real-world problems*: involving companies to launch crucial future challenges and tech-driven start-ups to provide a digital technology to apply. Educators should involve SMEs and start-ups and define with them a brief that will be solved by the students with

the support of dedicated mentors. This will make learners actively apply their creative process on actual problems, making them feel motivated and engaged while facilitating academic-business cooperation.

- *Providing technological and methodological mentorship* to enable students to involve relevant stakeholders in their creative process, such as experts in design futures, digital technologies, and the topic at hand, activating a process of co-creation with experts relevant for improving their work. Students, SMEs & Start-ups will therefore have the possibility to work together on design challenges for designing new future technologies applications.

The DC4DM training format (Fig. 8) is therefore meant as an intensive training sessions in which participants will receive training and mentoring that will contribute to their employability through the development of digital creativity skills. LLabs would support and empower educators to facilitate and teach practices towards digital maturity and students, SMEs & Start-ups will have the possibility to work together on design challenges for designing new future technologies applications. LLabs allow to learn about digital transformation, guide participants to create a working environment that enhances the value of individuals, increasing personal motivation and fostering integration with other members of the group, so as to improve project results.

Figure 8: DC4DM training format for Learning Labs organization developed by the DC4DM project consortium.



4.3. The Action Model in Practice: Learning Lab Milan

The Learning Lab Milan was the third Llab organized within the DC4DM project. It was held at Politecnico di Milano from January 30 to February 9, 2023, and aimed at exploring the concept of "care" in short-term future scenarios. The LLab was entitled "FUTURING CARE. Rethinking well-being by envisioning digital solutions seamlessly integrated into daily life" and challenged students to create visions of how digital technologies—and specifically AI & Robotics; Wearable technologies; Additive Manufacturing; Augmented, Virtual and Extended Reality (AR, VR & XR); Human-Machine Interaction and Data—will reshape care and wellbeing in 2030.

4.3.1. Topic

The topic of care was selected by the research team as it is a theme that will increasingly gain relevance in the near future. Indeed, care did not encompass only human health or healthcare systems, rather it assumed a broader and holistic meaning of planetary wellbeing and its fundamental connectedness to human wellness (Frumkin, 2020). To tackle the "future of care" challenge, three macro-themes have been defined in collaboration with companies and organization active on the topic. Their role was to inspire and guide students throughout the journey providing them with the necessary knowledge on the specific topic selected in the different steps of the process. The three macro-themes and the related organization are:

- *Food as medicine* that concerns the opportunities for a sustainable food chain to optimise both human health and environmental sustainability. The topic has been mentored by Foodtech Acceleration

Platform[4], a think tank powered by Deloitte Italia that supports food companies and startups in developing innovation strategies.

- *Mental and emotional care* that concerns the opportunities for overcoming the increasing anxiety towards sustainability, income, employment, education, food, housing that is affecting both adults and GenZ. The topic has been mentored by two organizations: MIDA SpA[5], an Italian consultancy firm specialized in HR consulting, people development and Diversity & Inclusion; and Unicef[6], a United Nations agency that provides humanitarian aid for children worldwide.
- *Everywhere's care* that concerns the opportunities for an integrated, co-managed, and person-centred healthcare model based on community cooperation and on the convergence of many stakeholders. The topic has been mentored by Medtronic[7] a multinational company that deals with the development and application of biomedical technologies for the healthcare sector.

4.3.2. Mentorship

In the LLab students will explore the opportunities brought by new emerging technologies to innovate the future of care. Therefore, tech-driven startups and SMEs were involved to provide their technological product and to inspire students on how their specific digital technologies might develop in the future, mentoring students in their responsible application. Six tech-driven startups and SMEs were involved covering diverse type of emerging digital technologies in the field of AI and Robotics (Yape[8]), wearable technologies and sensors (H-Cube[9], Ab.Acus[10]), haptic technologies (Weart[11]), 3D printing (Additive Italia[12]), AR, VR and XR (AnotheReality[13]). Their involvement motivated students enabling them to connect their work with real world applications.

During the workshop, mentorship on the DC4DM methodology was performed by previously trained educators with design and engineering backgrounds coming from different universities. Also to promote the adoption of a future oriented creative thinking throughout the LLab, a consultancy firm specialized in Futures Thinking (ForwardTo[14]) was involved to provide an introductory overview on the importance of Futures Thinking for strategic innovation.

4.3.3. Cross-Functional Teams

The LLab hosted 40 participants from 4 European universities in 3 different countries—Italy, France, and Portugal. Both bachelor and master's students with backgrounds in Product, Digital & Interaction, Communication and Service Design, Design & Engineering, Electrical and Mechanical Engineering took part in the workshop.

Participants were divided into 8 interdisciplinary groups of 5/6 people, which were created by the research team before the Learning Lab ensuring a mix of disciplinary and cultural background. Each one was randomly associated to one of the three above-mentioned macro-themes: 2 groups worked on Food as medicine; 2 groups on Mental and emotional care—Adults; 2 groups on Mental and emotional care—GenZ; and 2 groups on Everywhere's care.

[4] https://www.foodtechaccelerationplatform.io/
[5] https://www.mida.biz/
[6] https://www.unicef.org/
[7] https://www.medtronic.com/it-it/index.html
[8] https://yapemobility.it/
[9] https://h3cube.net/
[10] https://www.ab-acus.eu/
[11] https://weart.it/
[12] https://www.add-it.tech/
[13] https://www.anothereality.io/it/
[14] https://www.forwardto.it/

4.3.4. Workspace and Work Material

The LLab was run mainly at Campus Bovisa of Politecnico di Milano. The building and the campus are the core of the Design School and participants could enjoy and benefit from all the campus facilities. The space was versatile, furnished with modular tables that allowed participants to arrange their working space according to the team's needs of the moment. The room was also equipped with a projector, lockers, and a food hall for breaks. A garden area inside the campus was used as an alternative working space, to relax and for networking as well as for warmup activities. One area of the room was dedicated for presentations and 'Sharing Moments' phases; also, a coffee break area was dedicated for the participants to some social moments.

Teams were provided with different types of educational materials to work either online or offline. Each team was equipped with a whiteboard, markers, pens, papers, and sticky notes. The DC4DM toolkit was available on Miroverse thus wi-fi connection was provided to all. A shared folder was used to share the kit of the introductory activity as well as to collect the final presentations.

4.3.5. Programme

The LLab Milan was organized as a 10-day intensive workshop where each team of students, starting from the assigned macro-theme, had to develop digital solutions in a 10-year future.

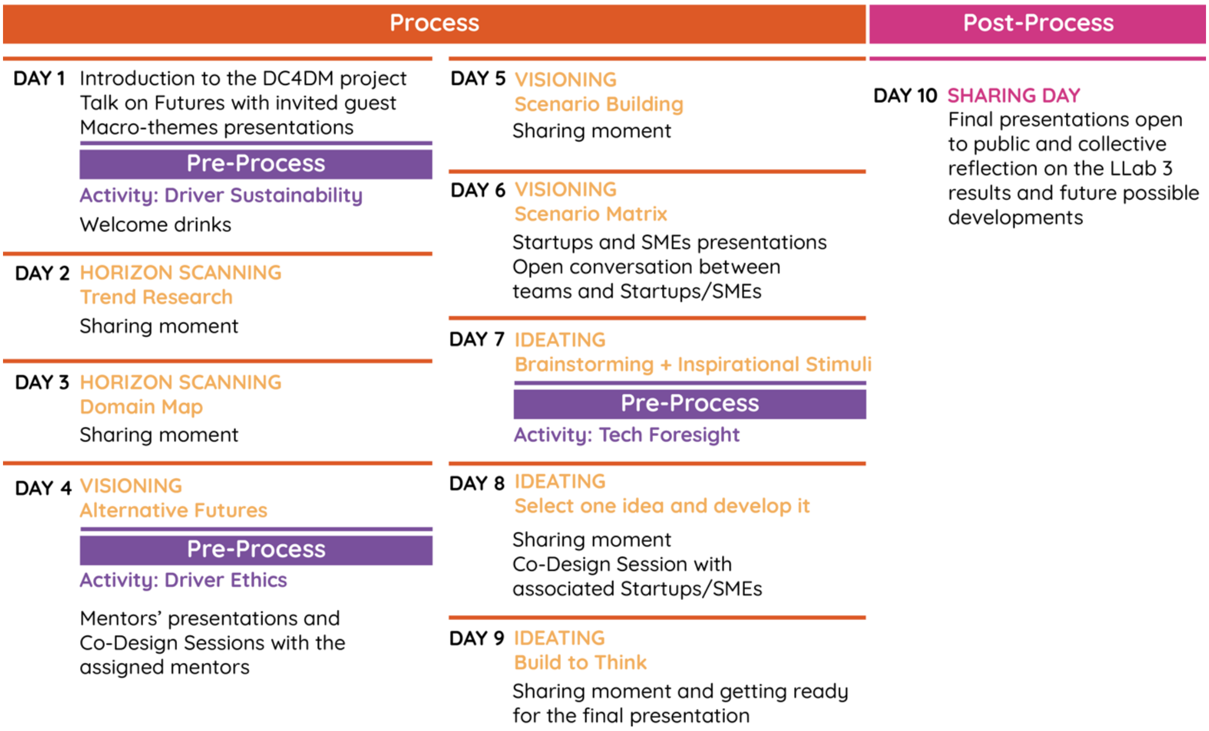
The DC4DM methodology was adopted, and the different preparatory activities and process steps were distributed over the 10 days (Fig. 4) ensuring a balanced alternation of classroom work, mentoring activities, and sharing moments in which participants were asked to offer constructive feedback to their peers as well as to welcome suggestions for moving forward with their work.

The week before the LLab, participants were asked to conduct an individual introductory activity to get acquainted with the assigned macro-themes, gain an understanding of what constitutes a trend and initiate the trend research activity within the Horizon Scanning step. They received a kit containing all the necessary information to perform the introductory activity. The kit included: a video-lecture presenting the importance of trend research; instructions to collect at least 3 trends related to the macro-themes they were assigned to; and a Trend Card to summarize and share their findings during the first day of the LLab.

The first day of the LLab was launched by the organizers who introduced the DC4DM educational model—as well as the agenda for the following days leaving then the stage to the representatives of the involved companies to present the topic and the macro-themes. Indeed, the LLab was kick started by the presentations held by the guest speakers who gave inspiring talks regarding the relevance of the macro-themes in a short-term future timespan. Right after the panel and before officially entering the Horizon Scanning phase, a pre-process activity belonging to the Sustainability driver was planned. The activity was selected among the options available in the DC4DM toolkit used for the LLab. The same procedure was followed to also select the pre-process activities for the drivers of Ethics and Tech Foresight proposed respectively before the Visioning and Ideating phase.

Considering the introductory activity performed asynchronously before the workshop and the opening day, 2 full days were allocated to Horizon Scanning phase, 3 days for Visioning and 3 days for Ideating and rapid prototyping to ensure a balanced agenda and guarantee enough time for teamwork and sharing moments (Fig. 9). The last day was reserved for the final presentations which saw the students create performances and pitches to showcase their overall experience in engaging with the activities and applying the DC4DM process as well as the final results. Sharing Day was an open event that gathered a diverse audience including students and professionals that, following teams' presentations, shared opinions through an interactive exchange of feedback and comments.

Figure 9: Agenda Learning Lab 3 Milano. Visualization developed by the DC4DM project consortium.



Each working day was designed to start with brief activities to motivate participants, stimulate creativity and productivity. Icebreakers, warmups, and energizers were proposed and conducted either in the classroom or outdoors every morning before starting to work in teams. Participants particularly appreciated these activities since they represented an informal and playful opportunity to get to know people from other universities better and improve collaborative dynamics within multidisciplinary teams.

Similarly, plenary sharing moments were planned to conclude each working day and allow peer-to-peer feedback sessions. Sharing moments were facilitated by the methodological mentors and conducted as informal discussions to welcome opinions, suggestions, and observations from participants both regarding their specific team works and the overall LLab experience. Indeed, the feedback provided was useful for participants to advance their research as well as for the organizers who were able to make the necessary adjustments throughout the LLab to ensure a successful learning experience.

Constant methodological mentorship to support participants in navigating the DC4DM process coupled with thematic guidance provided by involved companies to help teams narrow down their macro-themes and define a specific topic to investigate was offered. In addition, technological tutoring to develop digital future-proof solutions was provided during the Visioning and Ideating phases.

On the one hand, methodological mentorship was supplied throughout the duration of the LLab to support participants in exploring the process, its phases and performing the related activities. Mentors would engage in discussions and brainstorming sessions with the teams facilitating peer-to-peer sharing moments and encouraging constructive feedback.

On the other hand, companies and technological mentors were involved in an active and participatory way in specific moments of the process.

Representatives from the companies involved and organizations oversaw introducing the specificities of each macro-theme referring to their own experiences and expertise. They worked closely with the teams dealing with their macro-themes and provided feedback and suggestions to implement and advance in the project. Thematic mentors also engaged in co-creative sessions at the beginning of the Visioning phase to help teams shape promising and preferable visions of the future.

Tech startups and SMEs intervened at the end of the Visioning phase when teams started working on the actual scenarios. They presented their relevant products highlighting technology's potential with the aim of inspiring participants to develop future visions including these technologies. Afterwards, each team had the chance to meet the professional realities to establish a collaboration for the following steps. The match-making process between teams and tech experts was facilitated by the methodological mentors considering the topics and preferences of each team. The insights and advice from tech mentors guided teams in the creation of digital scenarios for care. They actively also engaged in co-design sessions with their associated teams to assist them during the brainstorming activity as well as advise them in selecting the most promising idea for concept implementation.

All co-design sessions were held either online (in Teams) or in person and were useful sharing and networking moments for students to engage in fruitful discussions with experts and professionals from different fields.

5. Discussion

The application of the action model within a real-world context involving students, educators, organizations, startups, and SMEs allowed to effectively test the DC4DM methodology and the training format. Several reflections arose from this experience both in terms of the action model's potential and of its operationality through the training format. On the one hand, a concrete scenario of application of the model revealed its potential to train the future generation of digital creators and entrepreneurs. Indeed, the model equip educators with the right instruments to emphasize digital creativity and human-centric innovation, guided by principles of ethics and sustainability, which are crucial for training modern digital entrepreneurs. The LLab experience was not only an opportunity for students to enrich their skillset but also a great chance to connect with professionals. The close collaboration with the world of companies and tech-driven startups, encouraged during the LLab, allowed them to establish unexpected work relationships and, in some cases, also to find employment in the digital entrepreneurial sector, proving the effectiveness of the DC4DM format. On the other hand, reflections regarding the operationality of the action model emerged and were useful to further refine it in its latest version and release it openly to the public via online platforms coupled with a revised training format.

One of the first lessons learnt relates to the flexibility in the application of the DC4DM action model, which is adaptable to different time scales. Although the Milan workshop was structured over 10 days, it was clear that the model can be temporally scaled down or extended depending on the context of application and the time availability of all stakeholders involved. This is also evident from the comparison with universities educators and the corporate entities involved, which have very different time frames dedicated to training activities. However, it is essential to consider that a variation in duration requires a restructuring of workshop goals and intended outcomes.

The future oriented creative process offered students a long-term vision, leading to the definition of scenarios and solutions that extended up to 10 years into the future. However, the limited period of 10 days led to the definitions of scenarios and solutions that were at a very embryonic stage and required much more time and several iterations to work out the details and a roadmap that would allow the organizations involved to plan the path from now to achieve that projected preferable future. In fact, for the companies involved, the results of the workshop were seen more as a breath of inspiration for possible future directions that may exist and be taken rather than feasible and viable solutions.

The preparatory activities resulted in open discussions on ethical and sustainable issues representing moments of both personal and collective critical growth for the development of an ethical and sustainable mindset. These activities, as well, proved adaptable in terms of time and type according to context and specific needs, involving start-ups, students, and educators' expertise.

Working on real and urgent challenges in the future, interacting with existing realities that are working on the proposed topics and technologies proved to be a powerful motivational catalyst for students, making them very participatory and involved both in the process and in finding solutions to the challenges presented.

The importance of mentoring, both methodologically and technologically, has been widely emphasized. Methodological mentoring requires a deep understanding of the process, and educators were trained appropriately before the workshop precisely to guide students through the various stages. Educators' preparation and their ability to facilitate a design process and a future-oriented creative thinking is definitely one of the pre-requisites for the adoption of the model and its effective application. In addition, the importance of providing a comprehensive view of the future-oriented methodology also emerged for the technological mentors and the organizations involved in the three sub-topics, to make them better understand the value and potential of the model and to prevent them from remaining anchored in the present.

Finally, another lesson learnt from the application of the model is that cross-disciplinary collaboration is neither easy nor obvious and requires dedicated moments of mentoring and facilitation specifically on collaboration issues. Warm-ups and activities carried out to facilitate collaboration among multidisciplinary teams were indeed key to creating a dynamic, energetic, and creative environment, but were not sufficient to actually facilitate collaboration and to clarify the disciplinary contribution during the process. This difficulty in knowledge contribution was reported mostly by engineers that had to fit in a design-oriented creative process. The heterogeneity that characterizes cross-functional teams tends to lower the level of trust among team members, especially considering the members' different professional backgrounds. Therefore, keeping a high level of trust plays a major role in a context of cross-functional collaboration and leads to higher levels of productivity and effectiveness (Brownlee, 2019) improving communication and interpersonal relations. This suggests a necessary implementation of activity fostering team trust and interdisciplinary cooperative behaviour for future iterations of the process.

6. Conclusion

The article presented a design-based action model to enable design, management and engineer educators in training future professionals, Digital Maturity Enablers, able to apply their digital creativity abilities for strategically innovate through digital technologies. The DC4DM model highlights the crucial role of design in digital transformation processes, as it puts the creative design process at the centre of the training activity. In the last few years, companies and organizations have started to recognize the value of design approach and methods as a means for fostering sustainable innovation to rethink their business strategies and react resiliently to the ongoing transformations. Therefore, design must be seen as a tool for transformation that uses the future-thinking approach as a redirecting technique for bringing about change, specifically within business organizations. Being considered as all-round professional figures, designers should therefore acquire a whole new set of hard and soft skills to creatively tackle complex problems, deal with complexity, and gain the ability to anticipate future possibilities to address decision-making activities in the present. As traditional design education struggles to keep pace with rapid transformations, the DC4DM model fills this gap by providing a comprehensive approach to digital creativity and strategic innovation.

Key objectives of the DC4DM model include:

- **Human-Centered Digital Solutions:** the model trains students to understand the potential of digital technologies and apply them to design solutions with a human-centered approach, ensuring that innovation remains grounded in real-world needs.
- **Creative Self-Enhancement and Knowledge Sharing:** The model promotes a digitally minded culture, encouraging individual creativity and teamwork, where participants from diverse backgrounds can share knowledge and communicate effectively.

- **Future and Anticipatory Thinking:** The DC4DM model helps students develop a mindset capable of generating long-term strategic visions. This enables them to face complex challenges, anticipate future scenarios, and leverage digital technologies for innovative solutions.

The DC4DM action model was tested three times through three different Learning Labs with the aim of creating a practical and usable learning methodology for educators, companies, and individuals who wish to guide people digital transformation. The three LLabs were organised and run each one with a different topic and involving different type of stakeholders, because the goal was to understand how flexible and adaptable the methodology and the format are; how to involve SMEs and Startups along the process to bridge their needs with the training objectives; and finally, how to engage students coming from different disciplinary backgrounds along the whole process. Therefore, LLab 3 was designed taking into consideration the insights and observations collected during the two previous workshops to ensure a fruitful and enriching learning experience for students.

The action model has been particularly developed for academic training within academia and outside in startup and business incubator to support digital entrepreneurship in nurturing their ideas. An application in a different context, such as in a training setting for company employees, might not work well as is. Future implementation of the model can see the translation of the model for different context of application such as the organizational one, and the integration of specific activities to address cross-functional collaborations.

Ultimately, the DC4DM model represents a significant step forward in design-based digital entrepreneurship education. By focusing on human-centered design, sustainable innovation, and future-oriented thinking, it prepares the next generation of entrepreneurs to lead in a rapidly changing digital world.

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Preparing humane ML experts for a better future. Experiments with design and engineering students

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Abstract

Recognizing the rising demand for well-trained professionals in the responsible AI (RAI) landscape, the study explores which skills might characterize humane ML experts. A literature review outlines human centricity, ML-savvy, and value sensitivity as pivotal qualities for responsible practices, materializing an overarching multidisciplinary approach to the design of meaningful ML-infused solutions. For a preliminary and qualitative investigation, four experimental workshops were conducted in different European universities, targeting design and computer engineering students across different educational levels. They were intended to (i) translate the presented skills into educational experiences; (Q2) assess the effectiveness of the experimentations to foster these competences; and (Q3) evaluate their suitability and meaningfulness. Adapting the theoretical assumptions to the target audiences' backgrounds, positive results emerged. Both design and engineering students exhibited receptiveness and appreciation for the contents, methods, and tools presented in the workshops, emphasizing the transversal and essential nature of the proposed skills in diverse educational contexts. Despite the limits of the experimentations, the research argues that the depicted skills might orient designerly and technical ML experts toward meaningful outcomes, especially if they build effective collaborations leveraging their complementary strengths. Hopefully the contribution offers insights to advance the discourse about future professional figures in RAI.

Keywords: Humanity-Centered Design; ML Design Education; ML-Savvy; RAI Design Skills; Value Sensitivity.

Introduction

Technological innovations have always had a unique capability to shape the evolution of human history, in ways that go far beyond products, services and other applications. Electricity, personal computers, the Internet, just to name a few, have dramatically impacted people's lives and, indirectly, affected their entire ecosystems. Repercussions, in fact, can be measured in personal well-being, social dimension, natural environment, and even climate.

Recent advancements in technology have significantly boosted computational power and data storage and retrieval capabilities. This, together with substantial investments by public and private entities — China and the US being exemplar cases — has created an ideal environment for the flourishing and spreading of machine learning (ML), which has emerged as a crucial subset of artificial intelligence (AI). Undoubtedly, ML has the potential to improve people's lives in ways that are not fully foreseeable yet. However, this newfound power also entails new responsibilities, as malicious scopes could lead to harmful outcomes. From deepfakes and misinformation, to reinforcement of discrimination and even social manipulation, there are several risks to watch out for.

As technological development and profit prospects have fueled the current growth of ML, the design of products and services incorporating this technology is predominantly driven by marketing objectives or technological experimentations, motivated by the desire to unveil novel frontiers. Unfortunately, these approaches tend to overlook broader perspectives rooted in the socio-technical nature of these systems (Antonelli, 2018; van de Poel, 2020; Yang, Banovic, et al., 2018). This issue is acknowledged both by computer science and ethics fields, and has led to the emergence of several research, experimentations, and theoretical assumptions aimed at mitigating the risks associated with the unchallenged advancement of AI and ML. Human-related disciplines are particularly keen at questioning, rising concerns, and attempting at reframing AI-related principles, as evidenced by the escalation of publications of ethical guidelines (Algorithmic Watch, 2020).

Two main barriers hinder the trustworthiness of this technology and contribute to undesired outcomes, such as confusion, uncertainty, frustration, and ultimately, mistrust, which the public interprets as a sense of *creepiness* (Fruchter & Liccardi, 2018). First, AI remains overly opaque, especially — but not only — for those who are not experts in the field. Starting from the ambiguous allusion to human intelligence, which is a difficult point for even computer scientists to agree on (Russell & Norvig, 2020), the narrative around AI is often misleading. The inner functioning and capabilities are rarely properly communicated, which often leads to the perception of AI as overly technical and arcane. Several authors have noted how it can be conceived as a mysterious or even monstrous entity, placing users in a context of unfamiliarity and lack of control that not only generates concern but also instills fear (Antonelli, 2018; Dove & Fayard, 2020; Johnson & Verdicchio, 2017; Kulesz, 2018). A further layer of unclarity is related to the concept of responsibility which, for AI and ML systems, may be contested among different human parties and the technology itself. In particular, this brings us back to the second barrier: human factors are often not considered or incorporated. As noted by Johnson and Verdicchio (2017), on the one hand, the prevalent narrative tends to associate the autonomy of ML systems to the idea that machines can operate beyond human control. On the other, the authors highlight a *sociotechnical blindness*, meaning that "the essential role played by humans at every stage of the design and deployment of an AI system" is often neglected. Indeed, Ibo van de Poel (2020), professor in ethics and technology at TU Delft, sustains that AI systems should be regarded as *socio-technical systems*, implying that they should be considered in combination with human behavior, social arrangements, and meaning at a larger scale. What sets AI systems apart is their peculiarity as *artificial agents*, enabling them to actively influence other components within the larger systems they are part of.

Failing at acknowledging the socio-technical dimension of products and services integrating AI and ML systems means that users' expectations, needs, and mental models are not addressed in their development. As a consequence, at best, ML-infused artifacts turn out to be gadgets and toys (Levinson, 1977) that crowd people's homes without actually enriching their lives. Yet, incautious design policies might lead to more worrisome situations like misinformation, power imbalance, manipulation, or intendedly harmful outcomes.

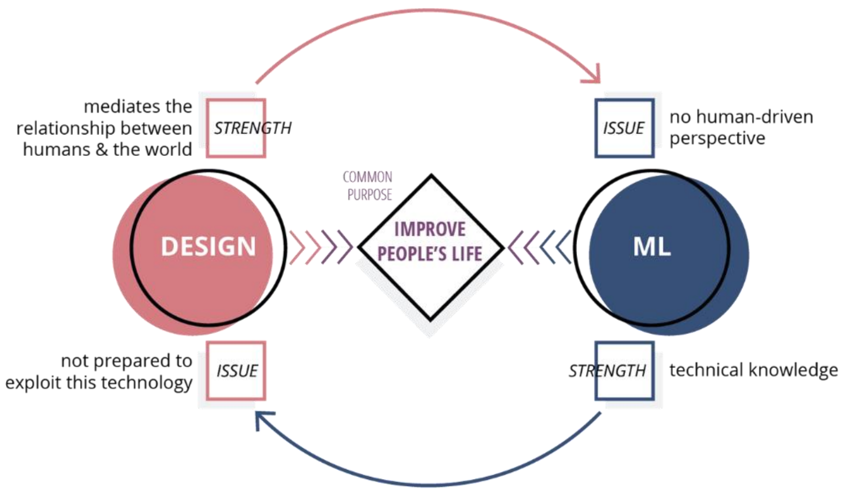
Therefore, although the work of AI and ML experts is essential to implement and further this technology, a more holistic perspective is imperative. In this rapidly evolving field, additional competences and professionals from other domains might complement current practices. New, essential figures should possess the ability to comprehend and navigate a context determined by the intricate web of relationships within it. This aligns with the principles of the Actor-Network-Theory (Latour, 1996), for which a clear distinction between humans and non-humans, people and technology, science and nature (Law, 2015) cannot be traced, as they are all actors in an interconnected reality. Thus, multi-competencies teamwork, as advocated by several researchers and practitioners (Davis, n.d.; Frascara, 2020; K. Friedman et al., 2019; M. W. Meyer & Norman, 2020; Rismani & Moon, 2023; Voûte et al., 2020; Wang et al., 2023), might play a central role in the future of digital transformation.

Based on these premises and considering the swift broadening of AI-related job positions, especially toward AI ethics expertise (Rismani & Moon, 2023), the research presented in this article aims at identifying the basic skills that future practitioners dealing with ML — especially from a design and development perspective — need to acquire for an adequate preparation to conceive and implement responsible ML-based solutions. Specifically, a theoretical inquiry allowed the identification of three main competencies for humane ML experts (human-centricity, ML-savvy, and value sensitivity) with an overarching need for multidisciplinarity. Their effectiveness and meaningfulness for the context under investigation has been tested in workshops addressing ML and design students, envisioned as primary actors in the future of designing ML-infused artifacts.

Indeed, incorporating diversity and multidisciplinary competences in development teams is widely advocated, as it is essential for the responsible exploration of AI and ML. This is warmly recommended by multiple sources such as Cutler et al. (n.d.), the High-Level Expert Group on Artificial Intelligence (2019b), and the World Economic Forum Global Future Council on Human & Rights 2016–18 (2018). In particular, while the fundamental importance of the role of ML engineers and computer scientists is obvious, that of designers is starting to be recognized (sometimes implicitly) and encouraged but not yet effectively fostered in practice. To go beyond technology and market-driven solutions, designers are equipped with relevant skills to handle the uncertainties that ML presents today (Antonelli, 2018; Yang, 2020), especially leveraging multidisciplinary approaches (M. W. Meyer & Norman, 2020). Designers are accustomed to navigating through ill-defined, fluid, and constantly evolving contexts (Auernhammer & Ford, 2022; M. W. Meyer & Norman, 2020). Thanks to their long-standing "experience with technology, transformative influence, cross-disciplinary predisposition, system-level thinking, and empathy" (Sciannamè, 2023), they best respond to several requirements that technology companies are looking for but in different disciplinary fields.

Therefore, both ML experts and designers possess pivotal capabilities to affect the development of ML-infused solutions and they have the potential to steer it towards meaningful applications for a flourishing future (Figure 1). However, some skills to overcome existing gaps need to be identified and nurtured. In the following, the results of this investigation are presented to contribute to the conversation about the future of professional figures embodying digital maturity and responsibility.

Figure 1: Framework for Design and ML cooperation.



Source: Developed by the author.

2. Identifying Strategic Skills for Humane ML Experts. A Literature Review

Over the last five years, substantial research has surfaced across academia, public institutions, and private sector, aiming to instill greater ethical considerations into AI and ML. This has led to the generation of research strands such as Explainable AI (XAI), Interpretable ML, Responsible AI (RAI), and Fair ML. Yet, coherently with the premises and the scope of this study, two main weaknesses can be recognized in the plethora of publications about this subject. On the one hand, most of the explorations are computational in nature, solely relying on computer science and engineering principles and practices (Varanasi & Goyal, 2023). Focusing on solutions exclusively related to the creation of datasets, models performances and similar issues, they perpetuate the *sociotechnical blindness* (Johnson & Verdicchio, 2017) discussed above. On the other, a lot of ethics frameworks and guidelines emerged but they predominantly remain at a theoretical level, delineating principles and values without often delving into practical implementation strategies or emphasizing the essential skills needed to effectively advocate for responsible practices. Only very recent studies are recognizing the necessity to broaden the purview and focus on practical skills and applications (Rismani & Moon, 2023; Varanasi & Goyal, 2023; Wang et al., 2023).

In this variegated context, a thematic analysis was employed to identify relevant elements for inferring key skills to make the professionals who deal with the design of ML-infused solutions more responsible and humane. As the specific research for necessary competences or recommendations for responsible AI or ML produced scarce pertinent results from Scopus and ACM Library, the ethics guidelines for AI collected in the online repository Algorithmic Watch (2020) composed the main reference set. Only documents in English were incorporated, specifically those directly touching on the design and development of AI and ML systems that did not present an exclusively technical and specialized perspective. Particularly noteworthy ethics toolkits, which offered principles that otherwise were not well-represented, were identified through snowball sampling and subsequently included.

Given the frequent absence of explicitly mentioned desirable skills or competencies, the analysis focused on extracting the emphasized values, the impediments posing risks to responsible ML outcomes, and potential measures and solutions. Despite the granularity of the results, the author identified four overarching areas of interest, with three of them acknowledged as transferable skills for humane ML experts. These areas aim to highlight the most notable competences that are currently missing and would be beneficial in the development of meaningful ML-infused artifacts. Namely, human-centricity, ML-savvy and value sensitivity, under the encompassing need for multidisciplinarity, resulted the most relevant for achieving responsible practices (Norman, 2023; Umbrello & van de Poel, 2021).

2.1. Human Centricity

Probably a direct consequence to the acknowledgement of ML solutions lacking the inclusion of human factors, human centricity is the most pervasive competence encountered. Considering the possible threats that ML systems might pose, *misuse* was the most recurrent (with 17 occurrences). Major concerns are the harmfulness, weaponization, and abusability of the systems, mischievous tracking purposes, as well as possible discrimination and oppression. Dependency on (biased) training data (14 occurrences) and non-neutrality of the technology (9), because it embeds and amplifies beliefs and behaviors, are the following retrieved risks. All of them imply the poor consideration of people's influence, interests, and mental models throughout the design process. This is also reflected in the most common possible solutions to current flaws of ML-infused solutions, which encompass: including different perspectives and people (28), facilitating the understanding of ML systems behavior (26), monitoring and evaluating with not only technical parameters (22), using foresight methodologies (13), and applying a design-driven approach for problem framing (11). How literature leans toward human-centered approaches and methods as beneficial means to achieve meaningful solutions is confirmed by some studies aiming at identifying ways and skills to design responsible AI. Specifically, Wang and colleagues (2023) report the underrated but essential work that some UX practitioners and RAI experts at a big tech company are doing to sensitize AI teams toward possible responsible practices by exploring and introducing AI users' mental models, feasibility and user acceptance, UX methods and tools to conduct user tests early in the process, and participatory approaches to AI design. Furthermore, while investigating responsible AI practitioners' roles and skills from a computer science-centric perspective, Rismani and Moon (2023) manifest the need for "*creative problem solvers* who can work in a *fast-changing environment*" for "translating research into design, technology development, and policy." Interestingly, their depiction of the role of a more human-centered researcher does not explicitly recognize designers as suitable figures, while outlining most of their characterizing qualities. Instead, they suggest looking for individuals with backgrounds in, for instance, human-computer interaction, cognitive psychology, experimental psychology, digital anthropology, and social sciences. Still, this is further confirmation of the pivotal role a human-centered perspective can play in addressing the multifaceted challenges posed by ML systems.

2.2. ML-Savvy

In-depth technical expertise is undisputedly a fundamental requirement for the realization of ML systems. However, current products and services prove that it is not sufficient to achieve meaningful results. In order to find a purpose for ML applications in the real world, a different level of knowledge is needed. It should be more oriented toward practice and making sound judgments, as reported especially in the literature outside of computer science. Several sources note how just high-level conceptualizations allow UX practitioners to envision ML solutions (Wang et al., 2023; Zdanowska & Taylor, 2022; Yang, Scuito, et al., 2018).

Indeed, lacking specific disciplinary knowledge, methods, and tools, some UX designers developed a functional understanding of this technology, utilizing abstractions to comprehend the capabilities of ML systems in relation to users' needs (Yang, Scuito, et al., 2018). They found ways to adapt traditional UX ways of prototyping and testing to better grasp ML models capabilities and communicate them to users, to set their mental models in the right direction, and anticipate potential harms (Wang et al., 2023). Additionally, they managed to navigate ML complexity, sometimes with PoCs that helped them comprehend the constraints of models, datasets, and technical feasibility at large. They were also enabled to clarify the scope, potential issues, and acceptability of a solution with respect to the problem to solve (Zdanowska & Taylor, 2022).

Therefore, multiple layers for acknowledging ML systems can be uncovered and refined to cope with very practical issues. Interestingly, these approaches diverge significantly from conventional ML educational contents and express a different modality to make sense of this technology, possibly favoring the identification of meaningful applications.

2.3. Value Sensitivity

The massive efforts in outlining principles and values to steer the development of AI and ML systems has limited value in terms of practical applications. Yet, it provides a useful indication about what is still missing: a value sensitive approach to design. Even human-centered methods and tools have no guarantee of ethically acceptable outcomes.

Recently, ethics guidelines, Responsible Research and Innovation (RRI), and vertical studies on responsible AI practices have spotlighted the necessity to think about the values a ML-infused solution might threaten, promote, or preserve. Value Sensitive Design (VSD), a methodology that Batya Friedman depicted in the 1990s to advocate human principles in the planning of technology (2019), has gained renewed significance. Umbrello and Van de Poel (2021) proposed a value-sensitive design process tailored for AI, encompassing the entire life cycle of AI systems to monitor algorithm evolution and proactively detect potential unintended consequences. Their adaptation of VSD encompasses four phases. The first, *context analysis*, considers societal challenges, existing technology, and stakeholder values. The second, *values identification*, recommends conceptual, empirical, and technical investigations, with a differentiation between promoted and respected values. The authors particularly insist on an explicit orientation toward positive impacts, like the Sustainable Development Goals of the United Nations. The third phase involves the formulation of design requirements based on the previous steps. Finally, the prototyping phase tests whether the system meets design requirements and incorporates the identified values.

The challenge of translating theoretical concepts into tangible strategies and measures persists. Even regulatory efforts, like the AI Act, primarily operate at a high level. Nevertheless, there is a growing acknowledgment of the imperative to integrate value sensitivity into everyday practices. (Rismani & Moon, 2023; Varanasi & Goyal, 2023; Wang et al., 2023).

2.4. Multidisciplinarity

Finally, it is worth mentioning how being able to deal with and mediate across multiple disciplines is a competence that was encountered in almost all the resources during the analysis. Having multidisciplinary teams, multidisciplinary ML practitioners able to bridge disciplinary boundaries, work across different functionalities and disciplines, and act as facilitators or translators (High-Level Expert Group on Artificial Intelligence, 2019b; Rismani & Moon, 2023; Varanasi & Goyal, 2023; Wang et al., 2023) are only some examples of how the discourse articulate, and they build on a larger debate about necessary skills for tackling complex challenges (K. Friedman et al., 2014; M. Meyer, 2010).

However, this was not included in the set of transferrable competences for humane ML because, according to the researcher it corresponds to a higher level that is difficult to observe and measure. Yet, it can be considered an overarching requirement that is inherently intertwined and can be effectively conveyed through the combination of the previously identified skills. In fact, these are representative of three different disciplinary components, respectively, design, ML, and ethics.

3. Methodology

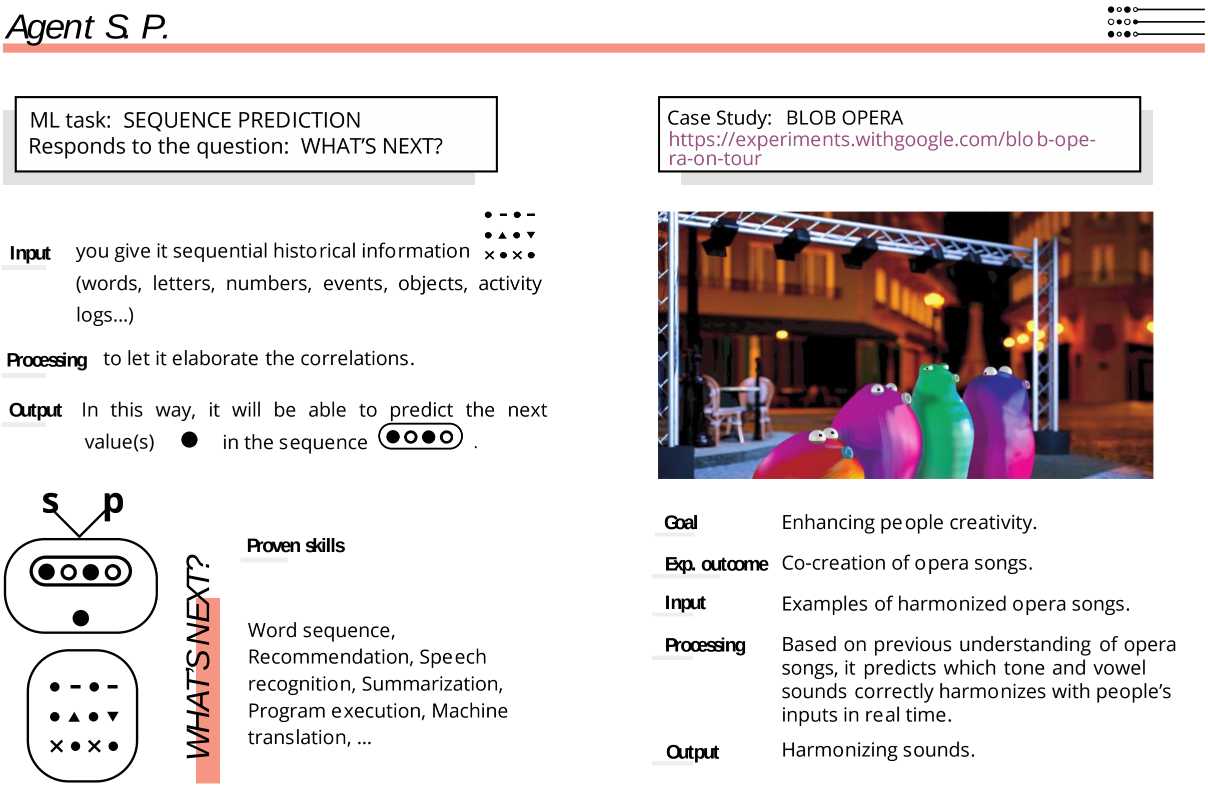
Due to the relatively recent attention AI and ML are attracting, especially from the empirical perspective of the design discipline, an action research approach has been selected to test the theoretical assumptions emerging from the literature review through a practical and systematic investigation (Archer, 1995). Specifically, following a long-lasting tradition (Bresler, 2021; Robson & McCartan, 2015), the action research enquiry applies to the educational context as a natural sandbox to nurture new skills and experiment with formative modalities, and it acquires a mainly qualitative character, building on *a reflection-in-action* process (Schön, 1983).

Therefore, four experimental workshops, addressing design and engineering students as key figures for the future development of meaningful ML-infused products and services, were organized, and are presented here as case studies. Their main purposes were to (Q1) understand how to translate the presented skills for humane ML experts into educational experiences; (Q2) assess the effectiveness of the workshops to elicit such competences (considering aspects like the contents, the format, the principles, the methods, and the tools provided); and (Q3) understand the suitability and meaningfulness of the promoted skills.

To grant diversity, the workshops took place in different European universities and involved international students at different stages of their formative paths. More precisely, W1 and W2 targeted design students. The first was held in FH Joanneum University of Applied Science, in Graz (Austria). It developed over three days, for a total of 18 hours, and engaged seven students (5 females and 2 males) attending their first year of master's degree in interaction design (6) and in media design (1). They worked in groups of two or three people. The second 16-hours workshop also spanned over three days and involved 15 third-year bachelor design students (13 females and 4 males) from the Universidade da Madeira, where the program is not differentiated in any design specialization. They were organized into 3 groups of 5 people. The other two workshops (W3 and W4) were open to both design and engineering students and took place in Politecnico di Milano as part of an ATHENS network initiative. Eventually, though, they resulted in workshops for people with a technical background and quite familiar with ML. Indeed, W3 involved 17 students (11 males, 6 females), of which only two had an industrial design background and one was enrolled in a computing architecture program — all at Istanbul Technical University. The others were studying computer science (6), computer or software engineering (7), and technical physics (1). W4 counted 24 students (17 males, 7 females) from diverse technical backgrounds — industrial engineering and management (6), computer science (5), computer engineering (5), economy and finance (3), data science (1), telecommunication (1), geomatics (1), aerospace (1), physics (1) — and none from a design background. The participants to both the latter workshops differed by year of enrollment (first through sixth) and by university of origin, namely Instituto Superior Técnico (Lisbon, Portugal), Istanbul Technical University (Turkey), KU Leuven (Belgium), Paris Tech (France), Technische Universität München (Germany), TU Wien (Austria), TU Delft (Netherlands), University Politehnica of Bucharest (Romania), and Warsaw University of Technology (Poland).

All the workshops shared the theoretical assumptions previously presented as constituents of the formative experience as well as the main objectives of (i) putting the essential skills for humane ML experts in practice, and (ii) enabling the participants to envision meaningful solutions that integrate ML capabilities for improving the quality of life (at the level preferred by the participants) to ensure a better future. Additionally, the same tools were used to facilitate the comprehension and application of ML systems towards responsible applications. For the first purpose, the *ML Agents* (Figure 2) aimed at transferring basic ML knowledge, focusing on the main capabilities the technology offers and synthesizing its description according to an input-processing-output structure and complementing it with a concise question, a graphic representation and an example.

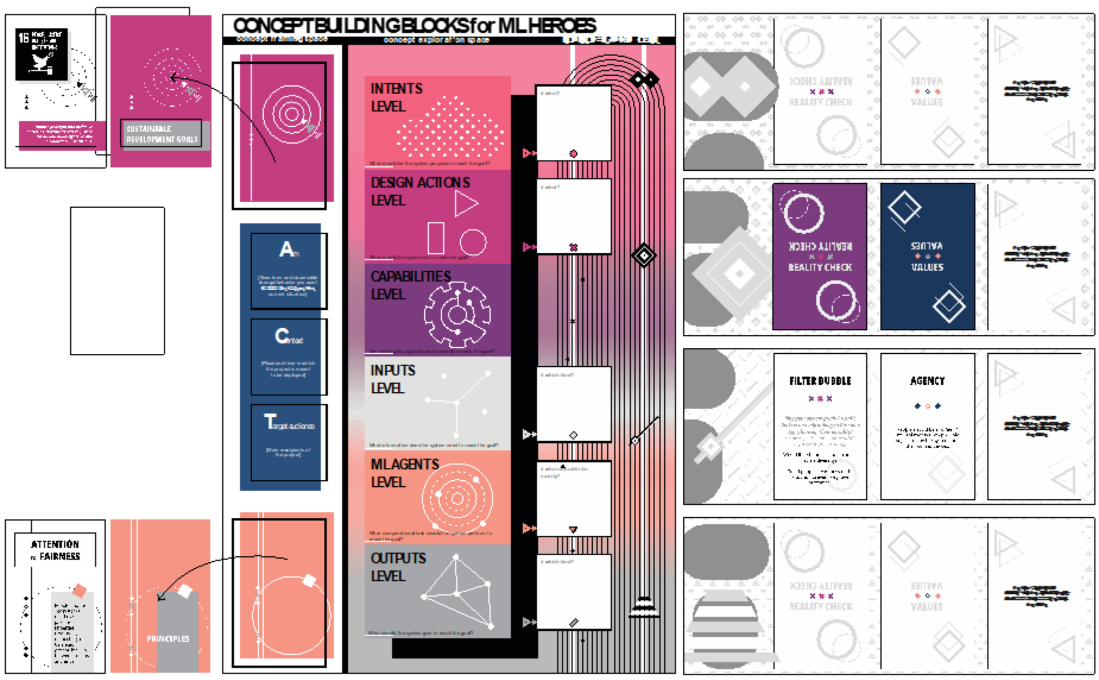
Figure 2: ML Agent example: Sequence Prediction Agent.



Source: Developed by the author.

For the latter, the *Concept Building Blocks* (CBB) and *VALUable by Design Expansion* (VDE) (Figure 3) were meant to give procedural support and inspiration for envisioning meaningful ML-infused artifacts, respectively focusing on the materialization of the technical possibilities into design requirements and actions and on the ethical implications. Further details can be found in the author's doctoral thesis (Sciannamè, 2023).

Figure 3: Concept Building Blocks and VALUable by Design Expansion.



Source: Developed by the author.

For the scope described in this article, qualitative methods were applied to collect data, specifically observation, analysis of the workshops' outcomes, oral and written feedback (Robson & McCartan, 2015), and rigorous procedures were followed to ensure the validity and reliability of the data. To support the researcher's observation, an annotation sheet was structured to report on student's reactions and responses to teaching-learning activities, contents, and tools. The delivered concepts were evaluated by both the researcher and the class according to their relevance, consistency with the technological capabilities, ethical acceptability, (personal, social, environmental) sustainability, and overall desirability. The feedback collection, instead, was encouraged both in an anonymous, paper-based form, via the digital platform used throughout the workshops (Miro), and in a final semi-structured focus group. It revolved around assessing the effectiveness of educational experience in transferring the identified skills for humane ML experts, as well as their usefulness. A thematic analysis was employed to identify recurring themes and patterns serving the purposes of the investigation.

Of course, the study presents some limitations. Because of its qualitative nature the researcher's perspective and the contexts in which the workshops took place may affect the non-deterministic results. Additionally, the workshops produced *"local"* understanding (Koskinen et al., 2011), which might hinder the generalization of the findings. For this reason, some mitigating measures have been adopted, such as involving a diverse target audience — in terms of cultural and educational background — and collecting rich and detailed feedback for analysis.

4. Q1 Results: an Educational Framework for Humane ML Experts

The identified skills for humane ML experts are assimilable to the soft skills domain. In fact, even if they have a specific objective, they can be transversally applied to different fields and, more importantly, they do not rely on any predetermined formula, but rather on personal understanding and elaboration. For this reason, a *constructivist approach* was adopted as the foundation for the design of the educational experience. It is based on the premise that knowledge arises through the construction of meaning, individually produced through the internal synthesis of emotions, prior knowledge, value systems, and beliefs. Accordingly, and in line with the practical goal of envisioning meaningful ML applications, a *project-centered* pedagogical framework was proposed to engage students in activities grounded in experiences, abstractions, inferences, problem-solving, information recombination, and collaboration with peers (Sancassani et al., 2019). Indeed, Kirschener and Norman's (2021) perspective underlines how a project-centered approach resonates with the holistic character of the skills to be elicited, as it entails a wider scope than just solving a problem. It includes *"social, societal, economic, ethical, ecological aspects and so further of that solution"* (Kirschener & Norman, 2021). Therefore, finally, the *studio format*, dear to the design education tradition, was implemented in all the workshops.

Additional references for the construction of the educational framework are the key principles for RRI (von Schomberg, 2013), Gagné's *events of instruction* (Gagné et al., 1992), and the prior experimentations unfolded throughout the author's doctoral research (Sciannamè, 2023). After a few preliminary workshops to test and determine the preferable forms, language, essential contents and tools for synthesizing ML technical knowledge and related ethics principles and make them operational materials for designing meaningful ML solutions, an educational framework was outlined by adjusting Gagné's *events of instruction* (Gagné et al., 1992) to include prior findings and RRI focal points.

Specifically, three main parts characterized the workshops that had to lead students to the definition of a meaningful ML-infused concept: (i) an initial *context introduction* (including steps 1-3 described below), (ii) *exploration & framing* (steps 4–5), and (iii) a conclusive *critical reflection and evaluation* stage (steps 6–8) (Figure 4). These articulated as follows:

1. **Engagement and responsibility.** The first step focuses on capturing students' attention and arousing their interest in the topic. In light of Gagné's work, a learner-centered and holistic approach is emphasized since the beginning, trying to leverage their sense of responsibility and understanding of their role as designers of ML solutions. To achieve this, the workshops problematized the current

development of ML-infused artifacts to elicit practical and ethical commitment, encouraging the participants to make a difference by experimenting with non-technology-driven approaches.

2. **Expectations and impact.** Beyond explaining the objectives and intended learning outcomes of the educational activity, as Gagné envisioned this step, an infusion of RRI principles would be beneficial. To set the initial stages of the experimental design process on a positive note, the expectations should be broadened to include relevant challenges to address and strong motivations behind them. Indeed, "*designing for the right impact*" (von Schomberg, 2013) clarifies the purpose of the activity also from a higher level, and it can make students feel involved and aware of the relevance of the solution they should envision.

3. **Interaction with design materials.** Given that design and engineering are practical fields of study, this point underlines the significance of an interactive approach to knowledge transfer, which has demonstrated considerable success in workshops, and it emphasizes that every nurtured notion or skill becomes an integral part of a designer's toolkit for their work. This encompasses theoretical content (such as machine learning and ethics), tools (like ML Agents, CBB and VDE), values, examples, and case studies. The activation of metaphors, following Schön's perspective (1983), is also a component of this stage, contrasting with prior knowledge that may not be readily available to the target audience. These elements can be presented to students or left for independent discovery through research, observation, experiences, or prompts. The crucial aspect is active involvement in the learning process.

4. **Practical exploration.** Subsequently, the newly acquired materials need to be applied in practice to acquaint individuals with and comprehend the potential ways to utilize and benefit from them.

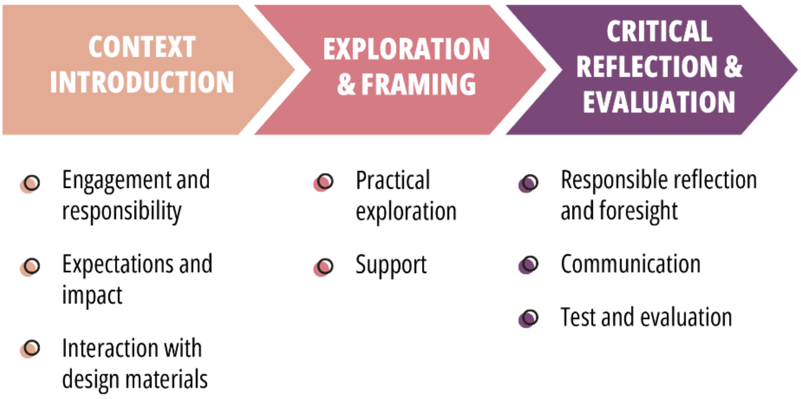
5. **Support.** Like in any studio format, support throughout all the practical activities has a pivotal importance and, as Gagné did, it needs to be marked as a specific point. Indeed, the figure of a facilitator reassuring, giving feedback, and orienting students in their explorations with new materials proved to be indispensable.

6. **Responsible reflection and foresight.** Necessarily, the generative phase should be complemented by explicit questioning and evaluating the emerging ideas. This involves contemplating UX and ethical aspects, guiding the concepts toward positive impacts with a value-driven approach, and foreseeing potential positive and negative outcomes to proactively address or mitigate certain risks. The VDE can serve as a valuable tool for this purpose.

7. **Communication.** This skill is overarching those identified for humane ML experts, which is why it should be expressly cultivated as part of the educational method. Indeed, for a successful design and development of meaningful ML solutions, multiple professional figures should be able to effectively collaborate. Thus, having the right vocabulary and means to properly communicate one's idea is essential for engaging with colleagues, users, or experts with different specializations, even if they share the same skills for humane ML experts.

8. **Test and evaluation.** Finally, testing and evaluation activities complete the learning process and contribute to determine how a responsible approach can unfold. While the workshops could not result in the practical development of the envisioned solutions, limited to low-fidelity prototyping, this stage holds importance even at the concept generation level. In fact, early foresight, along with peer and user evaluations, can help prevent unnecessary costs and efforts that might otherwise arise only after the deployment.

Figure 4: Workshops educational framework.



Source: Developed by the author.

From a content perspective, a few key elements were identified to stimulate the development of the skills for humane ML experts. Human centricity is pivotal in designerly processes and methods, which acquired a primary and pervasive importance, as already evident in the educational framework. To achieve ML-savvy, a significant way to synthesize ML knowledge as a tool to achieve meaningful ends was outlined to be useful for both designers and engineers. It bridged ML and design disciplines by merging the technical capabilities — ML tasks in (Russell & Norvig, 2020) — and the potential value this technology can bring to people through concrete design actions. For the comprehension of the basic functioning principle beneath the technology at hand, the definition of ML systems as agents (High-Level Expert Group on Artificial Intelligence, 2019a; Russell & Norvig, 2020), with a core input-processing-output structure, was retained as the founding element for the synthesis, resulting in the *ML Agents* knowledge-transferring tool. Eventually, value sensitivity, was encouraged by highlighting two main concepts: (i) ML systems are special kinds of sociotechnical systems in which the technology plays an active role in affecting people responses and behaviors (van de Poel, 2020), and (ii) embedding values in artifacts early in the design process should be an essential and explicit activity (van den Hoven, 2013).

Inevitably, different methodological approaches were adopted to structure the educational activities based on the different background and mindset of the target audience. Specifically, the workshops intended for design students insisted on the transfer of technical knowledge, leaving them more freedom in the development of their ideas, as they were following a process they were familiar with. On the contrary, engineering students needed more guidance for designing humanity-centered ML applications, as the conveyed design and value-driven process took them out of their comfort zone. However, in both cases, an introduction of ethics principles to be openly and intentionally introduced in the design process was necessary. Though, while ethics opened the theoretical argumentation of the workshops involving ML-related students, it was introduced to design students only after they intuitively started to figure out possible applications of ML capabilities, as a way to assess and iterate their concepts for improvements. Both strategies proved quite effective for their audiences, even if improvements might be implemented, as the following section depicts.

5. Findings for Q2: Assessing Skills Transfer for Humane ML Experts

As discussed in the previous sections, the transfer of skills to cultivate humane ML expertise involves a multifaceted strategy. This is explicitly outlined based on the inherent components of educational experiences, namely: the theoretical contents discussed and the fostered practical knowledge; the methods characterizing the educational activities and adopted to convey the skills; and the tools provided in support. Consequently, the results derived from the thematic analysis of delivered concepts, observation and feedback notes are synthesized and presented highlighting these dimensions and differentiating on the three skills under investigation — human centricity, tech-savvy, and value sensitivity.

5.1. Human Centricity

Contents. As prior knowledge and experience with this skill was expected from the design students involved in the workshops, their educational experience fostered human centricity completely through the practical definition of the design problem and the envisioning of a possible solution. The unfolding of the workshop and the final outputs confirmed that the future designers were already equipped with a people-oriented vision from an individual level to more comprehensive social and environmental scales. Having the implementation of (at least) one ML capability as a project constraint and giving design students the freedom to approach the development of the idea following a *problem-based, data-driven, technology-driven, artifact-driven, value-based,* or *human-driven* perspective could have compromised the results. However, the workshops demonstrated that no matter the starting point, finding a relevant solution for people was always central in the participants minds and they confirmed that they felt to have always followed a human-centered process.

On the contrary, in workshops with a predominance of attendees from an engineering background it was essential to clearly depict the theoretical principles characterizing the design process and to highlight, step-by-step, how the practical activities related to the procedural structure. In general, during the classes, it was difficult to assess whether these abstract contents were effectively interesting and comprehensible for the audience, as the researcher observed a moderate attention level. Nonetheless, some of the students, in both W3 and W4, followed up with questions comparing their technical design experience with what was being explained. They expressed appreciation for the simple examples describing the different approaches to the same design problem (technology, data, human, and value-driven). However, further practical examples or case studies would have been desirable for a better understanding.

Methods. Promoting a studio environment, with the researchers' constant support and feedback provision throughout all the stages of the concept development and following a design-thinking process prioritizing people's perspectives (users and stakeholders alike) was expectedly very functional to the purpose at hand. Again, whether it did not represent a novelty for design students, it was useful for them to consistently define their problem setting (aim, context, and target audience) in a limited timeframe and with no possibility to conduct proper preliminary research.

Very different was the perception of engineering students, who were sufficiently disoriented and positively impressed by the common designerly way of approaching the development of a project. Two main aspects emerged as fundamental to shift their mindset toward a human-centered one: (i) the initial problem framing and (ii) the encouragement to iterate the idea. (i) All the groups presented a solution-oriented approach to the definition of the challenge to tackle, which means that instead of identifying possible issues or needs for people to fulfill they directly and regardless determined the solution they wanted to design. Only by providing several case-by-case examples and possibilities to start the design process from people's problems and perspectives (reframing the solution they were exploring in terms of a human-centered problem definition), the participants started to modify the narrative depicting their starting point in a way that focused on a problem to solve and opened the space to multiple possibilities. Ultimately, most of the groups were able to integrate a human-centered problem framing, even if after several attempts and with some effort. (ii) Analogously, once they set the outline of their solution, it was difficult to make them consider alternatives that could as well or better address their design problem, even if they encountered obstacles that hindered the feasibility or effectiveness of the idea itself. Here, the researcher's intervention, challenging them to explore further options, was essential to steer the solution toward a more meaningful result for the target audience. Although radical iterations have faced much resistance, realizing that they had the opportunity to pursue different paths, even after a first idea had been portrayed, was game changing in leaning toward human centricity. An example of this troubled process is represented by a group in W3. They aimed to detect employees' burnout through the collection of several physiological data, causing relevant privacy and accuracy issues. Being at an *impasse*, the researcher suggested they look at how people suffering from burnout are diagnosed and treated by professionals, hinting at the use of conversational data instead of physiological ones. However, while they seemed to get the point and the importance of looking at the problem from a lateral perspective, they finally could not strongly detach from their initial idea. They finally introduced a compromise: they kept the physiological parameters, which were transparently available to the users, and their ML solution would point at possible burnout indicators for them to raise their awareness (self-defining whether substantial changes were caused by physical activity or anxiety states) and communicate with their psychologist, who had further information to help them diagnose their patient's condition and provide personalized suggestions.

Despite the final outcomes, in the end, even the most technology-based thinkers attested that they have understood the value of framing the problem and iterate the solution trying to put themselves in the shoes of the people that should benefit from their projects. Some even affirmed that they wanted to implement these methods in their own university projects, despite the common optimization-oriented approach promoted by their professors.

An additional help to foster a human-centric mindset consisted in assigning to each group member a different role and personality to embody during the design and peer evaluation processes, similarly to de Bono's thinking hats (De Bono, 2016). Nonetheless, this strategy has led to limited outcomes, and the students involved in W4 conclusively recognized the potential of the role-playing but would have preferred even more explicit activities in this sense.

Tools. The CBB tool was specifically intended to facilitate and support the definition of the structural features of a meaningful ML-infused idea by combining a technical perspective (input data, ML capability represented by a ML agent, and expected output) with a human-centered one, articulating in three main phases. First, the *concept framing* phase required the definition of the problem in terms of aim, context, and target audience. Then, the *concept exploration* space equipped by a deck of multi-level cards (providing guidance and inspiration) allowed the connection of technical possibilities to a general intent and a more specific design action aimed at helping people achieve their goals. Finally, the *concept definition* space encouraged the participants to better explain how the elements previously identified could actually benefit their intended users. This tool was used for all workshops indistinctly, introduced by a collective example of use to show the underlying mechanics and purposes. All design students pointed out the effectiveness of the tool in helping them envision a meaningful experience. However, very few of them recognized "creating value for people" as its main strength. Instead, they mostly appreciated it for its guidance, procedural, and inspirational value. In their opinion, the VDE — meant to promote ethical reflections — played a crucial role in encouraging a human-centered approach. In fact, they openly said that it fostered the envisioning of problems otherwise missed, and that it was eye opening in exploring different perspectives and making decisions.

None of the ML-related students shared explicit comments about the tools effectiveness in conveying a human centered approach. However, as anticipated, some inferences can be drawn by the activities the CBB encouraged. Throughout the three phases presented, it clearly pushed the participants out of the familiarity of the processes they were used to and toward considering other people's points of view more than their own. Both problem framing and defining user-oriented objectives for their ML-infused artifacts were challenging exercises that required some attempts before being consistently aligned with the requests. Eventually, most of the participants seemed to get the principles behind these activities, and even if some groups also succeeded in accomplish them, it was patent that a five-day workshop was not enough for the students to fully interiorize them. Further iterations would be needed. At least, though, it managed to raise awareness and appreciation for human centricity.

5.2. ML-Savvy

Contents. The weight and significance of the synthesis of ML theoretical knowledge for meaningful applications are evidently different for the two workshop typologies. Anyways, the same contents were provided with different tones and scopes. As previously depicted, ML systems were explained by characterizing them as agents and focusing on their practical capabilities instead of more technical functioning specifications. Additionally, basic information such as definitions, differences with traditional programming and demystification of the most common myths complemented the knowledge transfer.

Design students had no or little prior knowledge on the subject. Therefore, the offered introduction represented the first approach to the technical discipline for many of them. It was essential that the language was clear and that the contents could relate to something familiar for them. For this reason, different examples were provided in support of the structured theoretical explanations and elicited also from the class. From the researchers' perspective and the final outcomes, design students seemed to have grasped the foundational principles of what ML is, what it is not, and how it can be exploited for meaningful causes. However, they suggested that even more examples and case studies were presented for better comprehension. Nonetheless, in both the bachelor and master level workshops, students showed a great interest toward the topic and the graduated ones, who intentionally decided to participate to the educational activity, were also more active in making consistent interventions and asking questions. Overall, the covered arguments proved to be sufficient for making ML a new design material. Still, on the last day some basic ML concepts were weaker in students' minds than on the first day, when they had been introduced. This might be the consequence of the shift of attention toward further design aspects there were more familiar to them, but it might also imply that more practice and exercise requiring the application of ML knowledge could be useful.

Engineering students, on the other hand, were required to have prior knowledge and experience with ML systems. Therefore, the approach was much more interactive. The students were prompted to anticipate the contents that were then explained from the researcher's perspective, and this includes the definition of ML capabilities based on a couple of exemplar applications that the participants could interact with before providing their interpretation. This modality favored the conditions for opening debates about the topic and allowed the author to get in touch with the audience's point of view. As she could only know from literature reviews and reported testimonies, the engineering students involved in the workshops seemed quite unaware of the practical implications and possibilities offered by ML, being more focused on the technical details underneath the algorithms. Also, none of them could provide a complete definition of ML, mostly outlining its statistical nature and capability to improve over time. Indeed, they clearly stated that they were not used to reason about ML systems as presented by the author, yet they were able to draw interesting insights from it. Surprisingly, the fuzzy conception of AI as a technology able to imitate human reasoning was also frequent. In both workshops some fruitful discussions emerged to better specify the capabilities of ML systems or related examples starting from what the researcher proposed, even though the class of W4 appeared less interested in paying attention to what they thought they already knew. Eventually, the researcher's synthesis of ML knowledge proved more necessary than expected to guide engineering students toward meaningful applications of the technology, but they were particularly quick and proficient in applying the lessons learned.

Finally, in both workshop typologies, the researcher and the participants agreed that more practical experimentations with the technology would have been utterly beneficial to have a deeper understanding of the design material and to acquire a more complete ML-savvy.

Methods. To help sediment the basic understanding of ML, not only the theoretical presentations were very interactive, but they were complemented by simple formative tests to reiterate the foundational concepts by both eliciting a response and explaining which answers were correct and why. They gained much more success than expected among design students, who attributed a great part of their comprehension of the subject to these questions and, especially, to making mistakes. The researcher equally assumed that the formative tests could be too easy for her more technical audience, but it really was not the case. While the majority of the class correctly answered, a good number of respondents also indicated wrong options, giving the chance to fellow students to clarify the underlying motivations.

Anyway, the focal method for assessing and crystallizing the participants' ML-savvy was its practical application into a meaningful design challenge. Ultimately, all the ML-infused concepts were intendedly consistent with the ML Agent selected. Though, some design students required further explanations for a couple of capabilities (namely, action selection and regression), which were also rarely considered for implementation. Instead, engineering students also proved capable of suggesting coherent alternatives to achieve the goals depicted by their colleagues during the peer review sessions.

Tools. Two main ingredients were considered to convey ML-savvy: basic ML knowledge and practical experimentation, although only at a conceptual level. For these, two different tools were designed to support educational activities. The former was fostered by ML Agents, the latter by the CBB.

Both design and engineering students did not consult the ML Agents booklet during the design process, primarily relying on their previous introduction by the researcher. The questions synthesizing the principle beneath each capability seemed useful to facilitate the comprehension of the related ML Agent. Yet, in the end, the name of the capability was the most referred to in the next stages, therefore it was important for them to be directly intelligible. The visual representations of the ML Agents had a limited impact on students' understanding. Indeed, a design student in W1 suggested the implementation of animated ones. The examples provided to complement the definition of ML capabilities worked fine, especially with engineering students who were asked to use them to deduce the ML task. In both classes, the recognition of a capability was not immediate, but this reversed process gave the occasion to discuss and depict differences. However, even more examples would have been appreciated by both target audiences.

Regarding the CBB, all design students agreed on the effectiveness of the tool to help envision a meaningful ML-infused artifact. The input — ML capability (ML Agent) — output structure was straightforward regardless of familiarity with the subject. Many affirmed that the guidance provided by the tool gave them the confidence to experiment in the ideation phase, like ML systems were common design materials. Indeed, all the groups delivered concepts that consistently integrated ML. However, besides the coherent application of this technology to serve a predefined purpose, a further step to handover their ideas to their technical counterparts, in a slightly more detailed and effective way was missing.

This also emerged in W4, as some students noted that the CBB tool was missing a more technical part they could better relate to. Indeed, an additional level of more operative knowledge was outlined by the researcher in the theoretical framework beneath the construction of the CBB tool, the ML Designerly Taxonomy (Sciannamè, 2023), but it was not yet included in the tool. Overall, the participants with a technical background appreciated the tool and, more specifically, the modality of thinking to the purpose of the technological solution that it fostered, because it was something they were not used to. Additionally, all the groups in the W3 were grateful for the physical nature of the tool, as it gave them the possibility to design without their laptops, incentivizing discussion and divergent thinking. Although following the tool as a guide in their creative process instead of jumping to a possible solution right away was more of a challenge for engineering students, the CBB ultimately was a helpful support for questioning and modifying initial ideas, allowing them to look at the project from different angles. Thus, despite some difficulties in approaching the design process differently and considering new variables (like the intent and design actions beyond the technical core of the solution), ML-savvy resulted a complementary way to think of ML even for those who already possessed technical knowledge.

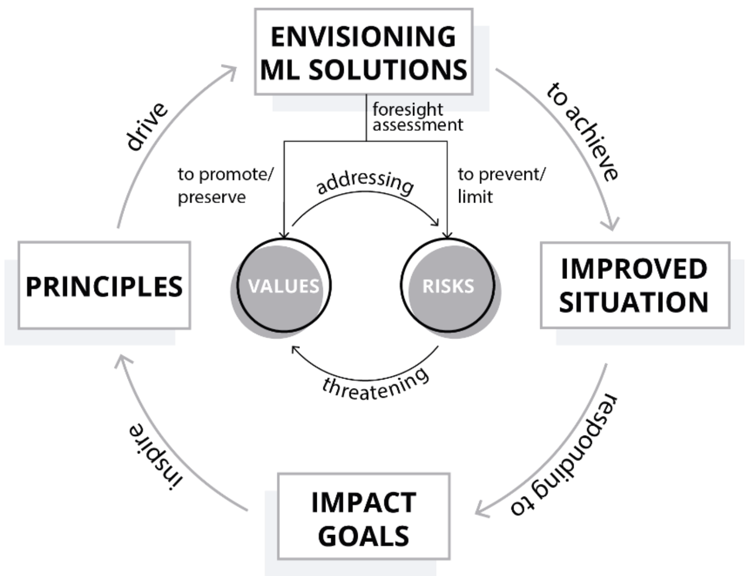
5.3. Value Sensitivity

Contents. As depicted above, two main concepts were at the base of transferring value sensitivity: (i) ML systems as special kinds of sociotechnical systems (van de Poel, 2020), and (ii) embedding values in the design process (van den Hoven, 2013). To convey them, all the workshops presented basic principles of RRI, the definition of sociotechnical systems in relation to ML, and a focus on value-sensitive design. To underline the ethical and social implications of the design of ML systems, and because W3 and W4 were longer, they also introduced the concepts of nudging and the non-neutrality of design and technology, case studies representing questionable and beneficial applications of ML capabilities, and an extended explanation of the value sensitive design process in relation to common designerly ones. Having an entire morning dedicated to this topic resulted in sessions planned to be very much participative, where students were necessarily required to critically reflect on the arising issues, providing examples and personal sense-making. Despite being the same, the lectures for the technical workshops encountered very different responses. In W3, the students intervened with many pertinent and thoughtful comments and questions, demonstrating interest and critical reasoning; in W4, active participation was poor. Once again, the students indicated that augmenting the number of practical examples might engage them more, limiting theoretical concepts to the bare minimum.

For design students, who practically demonstrated their implicit orientation toward responsible solutions but lacked formal preparation on ethical issues, the theoretical presentation was much more limited, and the transferring of value sensitivity was deferred to the design activity. Indeed, because of their background, they did not need to understand the importance of ethics principles as many of them overlap with common design practices. However, the discussion of debatable and positive case studies would have enriched their educational experience.

Methods. Based on a systematic analysis of the main AI ethical guidelines collected in the online repository Algorithmic Watch (2020), a *Responsible Cycle for ML Design* (Figure 5) was outlined by the author (Sciannamè, 2023) to encourage a responsible approach toward the design of ML-infused solutions. The focal implied assumption, included and tested in all the workshop, established that, in order to educate humane ML experts, the translation should frame essential ethical concerns and incentivize reflection-in-action, without providing predefined solutions. Indeed, the available guidelines mainly portray principles and values to overcome or limit unexpected or undesirable implications of AI and ML systems. They rarely suggest possible remedies to prevent or limit negative impacts. And when they do, these highly resonate with common human-centered design approaches. For this reason, while ethics can be a fruitful source for unfolding critical insights throughout the design process, the development of valuable solutions should be a designers' responsibility. As this was implemented through the VDE, the considerations about this approach are depicted in the following point.

Figure 5: Concept Building Blocks and VALUable by Design Expansion.



Source: Developed by the author.

A characterizing difference between the workshops involving design and ML-related students regards the actual introduction and operationalization of value sensitivity. As mentioned, the ethical aspects of designing with and for ML capabilities are the opening argumentation of the educational path for engineering students. For this, the starting point of their design process is the identification of a great challenge, one of the Sustainable Development Goals (SDGs), to help them frame a more specific problem to tackle (aim, context, and target audience) with a principle in mind from the very beginning. Design students, instead, were required to frame and define their idea starting from personal intuition, so that the researcher could assess the human centricity of their approach, only based on the design brief and no predefined processes. Only after the first draft, they were asked to reframe their problem, aiming at an SDG and including an ethical principle as main reference for the development, and iterating their idea accordingly. Both methods were adequate for their intended targets. In the first case, as framing the design problem in a human-centered way was already a novelty for engineering students, setting high-level ethical boundaries helped them intuitively orient the concept generation toward relevant challenges. Indeed, they appreciated having a significant context to start with, even if identifying a more specific problem within their topic required a little effort. For design students, identifying a valuable problem to address was more natural. At the beginning they needed to focus on the consistency with the technological possibilities they were dealing with for the first time, and adding too many variables would have been counterproductive. The subsequent inclusion of ethics principles was quite seamless, as most of the ideas would perfectly fit or were implicitly inspired by SDGs. This method reflected the processes that they, more or less implicitly, usually follow.

Tools. The VDE tool was developed to explicitly guide the participants to intentionally and explicitly introduce a value-driven approach to the design process. It encompasses the already mentioned SDGs and ethics principles to inform problem framing, and risks and values (all in card form) to consider in impact anticipation and foresight activities at a concept generation level. Once an idea was firstly drafted, the focus shifted on identifying the possible issues that might emerge and finding value-inspired ways to prevent or limit them from happening. In general, not having predetermined solutions to draw from did not seem a problem. Indeed, all the groups, regardless of their background, could find mitigating measures to address the *reality check* cards (depicting possible risks) quite easily. Even if no particularly innovative solutions emerged, the participants were free and managed to look at multiple aspects for addressing their issues.

This facilitated anticipatory exercise was certainly unusual for engineering students, especially because it required them to find solutions beyond the technical system and embracing aspects like communication, user experience, or social behavior. Although at first it was difficult for them not to concentrate only on datasets and algorithms, after the researchers' feedback, they understood how to holistically reason about the sociotechnical system they were envisioning. In these workshops, the researcher observed how the value cards played a crucial role in inspiring implementable solutions to prevent or limit possible risks. Moreover, having a role / personality to impersonate brought to light very interesting insights about the values of the different stakeholders, especially during peer review sessions. In the end, engineering students admitted it was a fun experience and, even if they do not know how much of this value sensitive approach can be directly included in their day-to-day practice as it is framed today, they surely recognized its importance.

The design students attending the workshops found the VDE an intuitive and enjoyable tool, suitable as reflection starter, able to provide a general overview and "perfect to start from scratch," but also a synthetic tool "that really put everything together." Its capability to give direction to the design process was particularly valued. As well, "introducing more perspectives," "pushing ML Heroes [how their concepts were defined in the design brief] further" and "making [them] sustainable and acceptable products" are among the main qualities that the students reported. Overall, the researcher's assumptions for triggering value sensitive solutions were largely confirmed by the comments and final outputs. Especially, the explicitness and intentionality of a value sensitive approach proved useful also in designerly contexts. In fact, although design students are more inclined to look for valuable solutions for people, this does not automatically correspond to actual responsible outcomes, as the lack of deliberate reasoning can easily lead to some key features being overlooked. This was underlined by a student who appreciated the VDE "because it forces you to be critical on your work," translating abstract concepts into practice.

6. Q3: Understanding the Suitability and Meaningfulness of the Promoted Skills

No objective measure can determine the suitability and meaningfulness of the proposed skills for humane ML experts only based on the presented educational activities. Nonetheless, to understand whether these skills were appropriately tuned for their target audiences, it is possible to draw some qualitative inferences considering three main factors: the consistency and quality of students' interventions throughout the workshops, their ability to accomplish the different design tasks, and the final outputs. Regarding the meaningfulness of these skills, students' feedback is the only available source for the argumentation. Certainly, this implies that the reported results are context-specific, and their generalization cannot be assured.

The experimentations in design institutions (different from the researcher's one) confirmed that a human-centered approach is at the core of design education and can be considered a fundamental prerequisite of designers. Thus, a project-based activity, with the broad brief to envision meaningful ML solutions and no related theoretical contents, was sufficient to convey human centricity to design students. Differently, the participants with an engineering background needed some theoretical introduction to justify the process and activities required. Abstract theories and frameworks were not enough, while examples were the most significant means to favor the comprehension of the peculiarity of human-centered perspective. During the workshops, the students could recognize that engineers and designers have different mindsets, distinguishing their strengths and pain points. Some curiosity was also raised to better understand the differences, overlaps or possible integrations between the agile method and the design thinking process. Additionally, after initial difficulties and a few attempts, the groups of engineering students managed to grasp how to frame a human-centered problem and develop a concept accordingly. Eventually, all their ML-infused solutions showed some empathy toward the users or people otherwise impacted (also because of the value-driven specifications), demonstrating a marked change of attitude and, in some cases, even deeper reflections than in the projects of their design counterparts. Finally, it is complicated to assess how meaningful human centricity is for design students, as it can be considered an identity mark for them, who almost take it for granted. Greater importance was recognized by engineering students, who reported that they benefited from the exposure to a different way of approaching a project.

In current times, the significance of having basic knowledge about ML is undisputed. How this could be framed to be practice-oriented was the focal point of the exploration. The workshops highlighted that the way in which ML knowledge was synthesized and communicated to foster tech-savvy for the envisioning of meaningful ML applications suited both the participants from a designerly and a ML-related background. Indeed, it represented the first formal approach to the topic for the former, but also offered a complementary perspective to the latter. As depicted above, the contents, their form and language were appropriate for both novices and more expert audiences, specifically with the aim of finding relevant ways to apply this technology to real-world problems. In all cases examples provided by both the researcher and the class were essential and they should have a central role when designing educational activities for all kinds of humane ML experts. All the participants could structure technologically consistent ML-infused solutions, even if restricting them to portray one prominent capability (for the sake of simplicity and time) can be perceived as limiting. Probably, giving space for the complexity of these systems to be acknowledged and implemented would enrich their understanding and awareness.

The incorporation of ethical principles into the design process through a value-driven approach represented a novel experience for all participants. Echoing earlier points, the use of examples to provoke questioning and reflection proved to be an effective means. Nonetheless, the hands-on activity was pivotal. It revealed the transversal nature of this skill, making it easily attainable for diverse target audiences. Indeed, universal values, easily relatable to everyone, required minimal explanations but necessitated the right guidance to ensure their conscious and intentional integration. Still, a couple of issues need attention. On the one hand, the workshops primarily focused on concept generation. This is why the envisioned solutions provided broad value-based indications rather than detailed ones, thus possibly overlooking viability and feasibility. On the one hand, participants across all workshops acknowledged how this approach could enhance design perspectives, fostering increased thoughtfulness. Yet, an engineering student raised a noteworthy concern, highlighting the potential conflict between the undeniable importance of embedding values in ML-infused solution design and the practical constraints faced by employees in real-world scenarios.

7. Discussion

Before delving into identifying the implications that could be inferred by the results of the presented experimentations, it is crucial to emphasize that they were set in safe educational environments. Therefore, the effectiveness of the activities might not have an immediate transposition in the professional field, as they offer a partial perspective on the actual development of ML-infused solutions. For instance, the most pragmatic constraints are not included, such as the actual communication possibilities among different stakeholders and organizational structures (Rakova et al., 2021). Nevertheless, preliminary insights to inform some essential traits for future professionals involved in the development of ML-infused artifacts can be drawn. Hopefully, they might inspire further experiments in business contexts, for more comprehensive analyses.

7.1. The Converging Pathways of Design and Engineering Students

How design and engineering students coped with the workshop activities does not differ significantly. Indeed, the influence of the promoted skills can be detected in the final outcomes. All the concepts showcase meaningful use of ML systems, fairly aligned with their capabilities. They address problems that affect people at personal, societal, or environmental level and include measures to enhance their ethical acceptability. Of course, for optimal results, the learning path should extend over a single learning experience, including more iterations, practical experimentations, or even contaminating current academic programs.

The diverse backgrounds of the participants did not compromise skill transfer but influenced the educational strategy (contents and approach to the design activity), and their performance in specific tasks. Expectedly, engineering students initially struggled to focus on people-centered problems, being used to a more straightforward declination of solutions. Additionally, they did not expect to explore multiple ideas instead of optimizing their first option, while this is the common way designers operate. On the contrary, the groups with a technical background could find suitable applications for ML systems, demonstrating a deeper understanding of their requirements and complexity. Instead, their designerly counterparts limited the reflections about the technology to the essential elements elicited. In the end, the participants from both disciplinary areas managed to reach the goal of envisioning meaningful ML solutions and understood the value of the contents and approach proposed — those having a broader expertise with ML more than the others. Still, the demonstrated disciplinary strengths would perfectly complement the weaknesses of the other and emphasizing them in a collaborative perspective could benefit everyone.

7.2. Future Humane ML Experts Bridging Disciplinary Gaps

The synthesis of needed competences, based on the deficiencies of current ML applications, highlights the importance of the conjunction of different disciplinary perspectives for preparing future ML experts. Moreover, they represent pivotal features that anyone engaged in the design of ML-infused solutions should and can be aware of, regardless of their educational background. Their disciplinary expertise, however, should be valorized. Therefore, in the domain of the design of products and services integrating ML, humane ML experts should maintain the specificity of the roles of programmers and designers, but in a context of close collaboration. Thus, they should be able to effectively communicate and work together, sharing enough knowledge and skills to comprehend the challenges, the potential, and the limitations of their counterparts. Then, while the technical ML experts would be in charge of materializing ideas and making things work, the designerly ML experts should focus on delivering value and meaning to people. But only together they could make sense of what ML can and should do, leveraging human centricity, ML-savvy, and value sensitivity.

8. Conclusion

In the evolving industry of AI, the research explores fruitful skills for humane ML experts. Human centricity, ML-savvy, and value sensitivity emerged from the thematic analysis of recent studies, guidelines, and toolkits. These were implemented and tested in four experimental workshops, targeting design and engineering students as pivotal contributors to the future creation of meaningful ML-infused artifacts. The workshops aimed at (Q1) understanding how to translate the presented skills into educational experiences; (Q2) assessing the effectiveness of the experimentations to foster such competences; and (Q3) evaluating their suitability and meaningfulness.

Despite the preliminary and qualitative nature of the investigation, positive results could be observed. The experimented skills for humane ML experts demonstrated to be transversal and useful for the two educational contexts. In particular, the explicit orientation towards meaningful and responsible solutions, with an attentive initial problem framing, an encouraged value-driven approach, and a non-technical starting point (focusing instead on ML capabilities) proved effective with both target audiences. Designers were introduced a new material to design with. Engineers were exposed to a new mindset.

However, being set in the educational context, the study does not encompass the complexities of business organizations, including the optimization of time and resources. Therefore, while educational activities have value for formative purposes and to foster the skills for humane ML experts, they do not reflect the working reality. Instead, they suggest a viable possibility for the two professional figures involved to effectively communicate and understand each other, valuing their complementary competencies and sharing the same scopes.

Finally, the research intends to bring a qualitative contribution to the ongoing conversation about the prospective competences of professionals in the emerging RAI field, paving the way to further inquiries. Potential areas for expansion include evaluating the long-term influence of the workshops on students' academic and professional careers. Additionally, the scope can be broadened to finding innovative approaches to translate the suggested skills in both educational and professional settings, or to critically discuss and build upon them. In any case, furthering the exploration of the essential characteristics of future AI-related professionals is indeed a first step toward ensuring a more responsible and meaningful future.

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Ethical navigation in the development of healthcare digital applications: a case study of the DC4DM Learning Lab on Madeira Island

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Abstract

The digitization of industry sectors is revolutionizing business practices, enhancing efficiency, agility, and data-driven decision-making. However, healthcare professionals face barriers such as insufficient computer literacy, cybersecurity concerns, and ethical considerations, which hinder the adoption of innovative technologies. Interdisciplinary initiatives like the *Digital Creativity for developing Digital Maturity future skills* (DC4DM) project aim to equip future Digital Maturity Enablers to support healthcare professionals with creative and strategic digital solutions, allowing healthcare systems and organizations to transform and achieve maturity. The paper presents an empirical study to critically reflect on the importance of including specific considerations and attitudes toward ethics while designing future digital applications for the healthcare sector. Despite the limitations of the proposed study, the paper aims to provoke a wider debate on how higher education curricula should align with real-world needs while connecting with Small and Medium Enterprises (SMEs) in search of innovative ideas towards digital transformation. The paper presents the knowledge exchange which occurred between a specialized health solutions startup, *Musiquence Technology* (*MT*) and an international and multidisciplinary team of students (*Sensitiva* project team) while developing possible future digital healthcare applications through the DC4DM methodology at the very first DC4DM Learning Lab (DC4DM LLab1). Then it reports the results from a later conversation that occurred between *Musiquence Technology* Startup and *Sensitiva* project team in February 2024. While trying to understand the value of involving real SMEs within the creative process of intensive design and learning experiences, such as the DC4DM LLab1, this empirical study aims to highlight how the connection with real world challenges and organizations could effectively instill a strong sense of ethical responsibility among young digital technology experts and businesses.

Keywords: Design Education; Digital Health Technologies; Digital Transformation in Healthcare; Ethics; Future.

1. Introduction

Digital transformation has become a major interest for small and medium-scale enterprises (SMEs) as it would allow them to pursue innovative and competitive solutions to respond both to internal needs and market conditions. For example, through digitalization companies can 1) substitute manual and repetitive labor using technologies such as artificial intelligence and robotics (Ayoko, 2021), 2) access real-time metrics on the overall performance of their business (Holopainen et al., 2021), and 3) achieve economic, social, and political improvements among many other advantages (Sabbagh et al., 2012). Many business models evolved to enhance their operations, efficiency, and competitiveness through the digitalization of their operations. Just to mention, the use of digital platforms for online marketing, e-commerce and social media purposes enables SMEs to reach out to wider audiences and the global market. Improved customer relationship management (CRM) systems help in providing personalized and efficient customer service (Matt et al., 2023). Finally, some digital tools can help in optimizing the supply chain by providing real-time visibility, reducing lead times, and enhancing overall efficiency (Matt et al., 2023).

While businesses and organizations transition towards complete digitalization, the need to update and enhance workforce skills accordingly becomes crucial. Particularly in the case of SMEs, high is the demand for digitally mature professionals (Vezzani et al. 2023, Bruno & Canina, 2019; *The Future of Jobs Report 2020*, n.d.). These individuals own Digital Creative Abilities (Vezzani et al. 2023, Bruno & Canina, 2019; Canina & Bruno, 2021) and can demonstrate technological knowledge and skills in robotics, artificial intelligence, Internet of Things, Augmented Reality (Sousa & Wilks, 2018), including, among others, digital hard skills such as programming, digital marketing, and others (Bernhard & Russmann, 2023).

As in all sectors, the advancements in digital applications and systems are transforming the healthcare industry on different levels. Specifically to this sector then, it is urgent to shift business models to encourage a universal approach to digital healthcare, combining patient empowerment, purposeful use of digital technologies, and data-driven care for improved outcomes (Kraus et al., 2021).

When analyzing more specific cases in the healthcare field, healthcare professionals (HP) are required to develop digital competencies to use them responsibly in the context of patient care. To ensure a smooth transition among healthcare professionals to the new era of digitalization, Konttila et al. recommend that healthcare organizations focus on cultivating a supportive social environment within the workplace. The authors emphasize that fostering a positive atmosphere is crucial, as the successful adoption of new technologies depends heavily on both organizational and collegial support (Konttila et al., 2019).

Another aspect to take into consideration in this constantly evolving scenario is that as digital health technologies (DHT) continue to mature, public concerns regarding ethical issues have become increasingly prominent. These ethical and legal concerns encompass a range of issues, including patient data breaches and the potential for the dehumanization of patient-doctor relationships, patient autonomy and empowerment, and other issues (Cordeiro, 2021). Also, inflated publicity regarding DHT's alleged benefits for improving mental health can be misleading (Torous & Roberts, 2017). These concerns have led to heightened resistance towards the development and usage of DHT, both within healthcare organizations and among private users (Torous & Roberts, 2017).

Upon examining the far-reaching implications of digitalization across multiple industry sectors for SMEs, numerous scholars argue for a necessary shift in the educational paradigm (Halverson & Collins, 2009). Collaboration between technology leaders and educators is encouraged to harness learning technologies effectively. A societal shift in thinking is required for political changes to make new educational resources accessible to all (Halverson & Collins, 2009).

Efforts towards achieving a necessary shift in the educational paradigm, including collaboration between technology leaders and educators, have been supported by initiatives such as the *DC4DM—Digital Creativity for Developing Digital Maturity Future Skills* project (www.dc4dm.eu). The DC4DM methodology aims to encourage an interdisciplinary and collaborative way of educating future professionals who will help SMEs become digitally mature (Vezzani et al., 2023).

This article focuses on the knowledge exchange which occurred between a specialized health solutions startup*,* *Musiquence Technology* (*MT*), and an international and multidisciplinary team of students (*Sensitiva* project team) while developing possible future digital healthcare applications for the very first DC4DM Learning Lab (DC4DM LLab1). This article presents an empirical study to critically reflect on the importance of including specific considerations and attitudes toward ethics while designing future digital applications for the healthcare sector. Despite the limitations of the proposed study, the paper aims to provoke a wider debate on how higher education curricula should align with real-world needs while connecting with Small and Medium Enterprises (SMEs) in search of innovative ideas towards digital transformation.

After contextualizing the study within the current digital technologies for healthcare scenario, the article provides an overview on both the type of learning conditions and type of knowledge exchange which occurred between *MT* startup and *Sensitiva* project team and led to the development of *Sensitiva* at the DC4DM LLab1 (July 2022). The article then reflects on subsequent discussions between the parties in February 2024, examining how the DC4DM educational model and the direct interaction with a tech partner like MT influenced attitudes and critical considerations towards ethics in designing digital healthcare solutions like *Sensitiva*. Grounded in the insights provided by MT representatives and *Sensitiva* team members during and after the DC4DM LLab1, this empirical study aims to highlight areas that still need reinforcement within higher education curricula to better prepare future professionals for the complexities of the digital world. The article concludes by inviting educators, digital technology experts, and healthcare businesses to collaborate in fostering a strong sense of ethical responsibility among young professionals and organizations in the creative, tech, and business fields.

2. Digital Technologies in Healthcare and Health Services: Challenges, Risks, and Opportunities

While recognizing the needs and potential for digitizing health services, several studies found barriers that make HP reluctant to use digital tools in their clinical practice. For example, failing to recognize the impact of digital competence poses a potential threat to patient safety by increasing the likelihood of human errors, which can lead to ethical issues (Konttila et al., 2019).

For example, Pereira et al. performed a SWOT analysis of electronic health records at *Centro Hospitalar do Porto* (Pereira et al., 2013). The SWOT analysis tool is designed to help, for example, organizations and individuals identify and assess major internal and external factors that can impact goals and objectives. They identified that the lack of financial resources can affect the purchase of new IT resources. Additional ethical concerns associated with digitalization include safeguarding patient autonomy and ensuring transparency in algorithms (Konttila et al., 2019; Pereira et al., 2013). Also, automation is becoming a reality; with sophisticated technologies such as Artificial Intelligence (AI) and the Internet of Things (IoT), businesses can stay competitive, foster innovation, and enhance customer service. Such technologies may raise concerns regarding the privacy and security of sensitive information.

Nevertheless, some opportunities that can increase the adherence of digitized-based resources have been identified. Thanks to the adoption of digital technologies, health services can 1) rely on the use of digital files instead of traditional records on paper, certainly less efficient and environmentally friendly; 2) exploit the use of mobile applications to enhance remote access to other systems and data within them; 3) actively design and enhance existing security protocols; 4) seek government incentives to modernize equipment, among other strategic incentives (Pereira et al., 2013; Philips Future Health Index 2021, n.d.).

Recognizing the benefits of digital transformation holds significant potential for improving efficiency, accessibility, and overall quality of healthcare. A summary of the effects that digital technology can have in the healthcare sector can be seen in Table 1.

Table 1: A SWOT analysis concerning the impact of digital technology in the healthcare sector.

Strengths	**Weaknesses**
▪ Cost effectiveness. ▪ Customization of user interface to the skill set of the user. ▪ Easy maintenance. ▪ Easy to expand.	▪ Ethics and privacy concerns. ▪ Lack of system documentation. ▪ Lack of training of users. ▪ Lack of clinical evidence.
Opportunities	**Threats**
▪ Promoting environmentally friendly practices. ▪ Remote access of systems. ▪ Enhance security protocols. ▪ Governance assistance to modernize systems. ▪ Worldwide interest in digital healthcare transformation.	▪ Patient autonomy. ▪ Data Security. ▪ Economic constraints. ▪ Scarce talented IT personnel. ▪ One-size-fits-all approach. ▪ Low acceptance and adoption

Source: This table gathers different aspects identified through research by Konttila et al. (2019) and Pereira et al. (2013).

3. Preparing Digital Maturity Enablers to Navigate the Complexity of an Ever-Changing Technological Landscape. The DC4DM Methodology at Test During the LLab1 Funchal

The overview on DHT presented in the introduction seeks to highlight some of the current concerns and reluctance to adopt new digital applications in healthcare. Particular attention is given to the ethical and legal implications when adopting new digital tools and systems for healthcare services. However, in a digital landscape in constant transformation, individuals and organizations must develop new competencies and skills to navigate the complexity of the digital world.

Through the Erasmus+ funded project *DC4DM—Digital Creativity for developing Digital Maturity future skills,* a human-centered design model to educate Digital Maturity Enablers (DMEs) was developed and tested. DMEs are creative professionals who will be able to drive small and medium organizations toward their digital transformation and maturity. By possessing specific creative digital skills, they will be able to extract value from what the technological landscape offers and respond to human needs through the principles of ethics and sustainability (Vezzani et al., 2023).

The DC4DM educational model was implemented through practical application during three *Digital Maturity Learning Labs*, intensive design-led workshops characterized by cross-functional and interdisciplinary teamwork, a future thinking approach, and tech-driven SMEs or Start-Ups participation. The first *Digital Maturity Learning Lab* happened on Madeira Island in July 2022. LLab1 was titled “Feeding Madeira. Regenerative and Distributive Food Systems for Sustainable Island Futures” and aimed at challenging the participants to think about the island as a testbed for sustainable and potentially circular systems where digital technologies can enable the shift towards distributive and regenerative local food systems. The participants were invited to respond creatively to the general challenge through the lens of one of the following macro-themes: (1) Agrobiodiversity is our safety net; (2) Forest & Water as island lifeblood; (3) Pollinators our saviors; (4) Waste as opportunity. The LLab1 lasted 10 days and involved 36 master’s and undergraduate students from Politecnico di Milano (Italy), Télécom Saint-Etienne, Mines Saint-Etienne (France), and Universidade da Madeira (Portugal), with different study backgrounds in the areas of design, engineering, business and organic agriculture. Organized into six multidisciplinary and multicultural teams, the participants encountered numerous and various local stakeholders able to stimulate their understanding of the island’s challenges concerning sustainable development.

Six local start-ups were selected, each one assigned to one of the teams, to become part of this creative process towards Madeira's digital transformation (Vezzani, 2023). This paper focuses on the development of one specific project and future scenario within the macrotheme (3) *Pollinators our saviors*. Named *Sensitiva*, inspired by the plant that reacts quickly to external stimuli and is common in tropical regions, this project deserved peculiar attention. Compared with others developed during the LLab1, it is the product of a constant dialogue with a startup whose expertise is in healthcare applications. None of the other teams had the opportunity to receive such guidance along the design process, to reflect on ethics and other implications.

The Sensitiva project team was made of six students from three different European countries, ranging from second-year bachelor's to second-year master's programs. This international mix brought diverse perspectives and advanced insights, fostering innovative problem-solving. However, the variety in experience levels, methodologies, expectations, and cultural perspectives introduced significant communication and coordination challenges. Robust team dynamics and conflict resolution strategies were essential to fully harness the multidisciplinary expertise in interaction design, integrated design, graphic design, computer science engineering, and product design. This diversity enriched the project but also highlighted the need for effective collaboration mechanisms.

The collaborative workspace was designed to inspire creativity and innovation, equipped with tools for rapid prototyping and iterative testing. This environment promoted open idea-sharing and collective growth but also exposed disparities in familiarity with advanced tools and methodologies. Regular workshops and brainstorming sessions aimed to bridge these gaps, but their effectiveness varied, revealing the need for more tailored approaches to skill development. Critically evaluating these interventions is essential to ensure all team members can contribute effectively and address any gaps in technical proficiency.

Musiquence Technologies (MT) played a pivotal role in guiding the project. MT's continuous support and expert guidance provided invaluable insights into technological developments and ethical considerations specific to healthcare. They directed and supported the team's understanding of healthcare complexities, helping maintain a critical perspective on supporting vulnerable communities and assessing the ethical impact of the project. This collaboration was crucial in navigating regulatory landscapes and ensuring ethical alignment. However, the team's reliance on MT for ethical and practical validation exposed a potential gap in their ability to independently address these critical aspects. This dependency underscores the necessity for building internal capacity for ethical decision-making.

The ongoing dialogue with MT was crucial for identifying innovative solutions and aligning project objectives with ethical standards. MT's guidance, delivered through dynamic tutoring sessions during the project's development, helped navigate regulatory complexities and supported the team in maintaining a critical vision of the project's impact on vulnerable communities. This support highlighted the importance of ethical decision-making and provided a robust framework for assessing the project's ethical implications. However, the reliance on MT also indicated that the team had some gaps in their internal capacity for independently navigating these challenges, emphasizing the need for further enhancing their capabilities in these areas.

The Sensitiva project was characterized by an open-dialogue approach, where initial misunderstandings and conflicts were seen as opportunities for deeper engagement and learning. Triggers for these interactions included the team's varied expertise

3.1. Using the DC4DM Methodology to Develop Future Digital Scenarios and Applications in Healthcare. The *Sensitiva* Project

During LLab1, a multidisciplinary and international team of students developed the *Sensitiva* concept alongside the constant dialogue with the representatives of *Musiquence Technologies* (*MT*), a digital health startup specializing in creating digital interventions to enhance cognitive and physical well-being across various clinical populations. The purpose of such direct interaction between start-ups and students was to provide insights into current technological developments in the healthcare system. Also, *MT* was asked to showcase some of their projects to help the students understand the enterprise mindset, needs, and future potential developments. The project's objective for *MT* was to investigate emerging technological trends that hold potential value (or lack thereof) in future healthcare scenarios. This will enable *MT* to gain a more comprehensive understanding of the most probable scenario to be embraced in the healthcare field.

Sensitiva envisions a future where patients are the central focus when utilizing DHT. By integrating advanced diagnostic and therapeutic technologies with human-centered design principles, *Sensitiva* aims to provide personalized care pathways that are adaptive to individual patient needs and contexts. The project employs a holistic approach to healthcare, wherein technology not only supports clinical decisions but also enhances patient autonomy and engagement in their health management.

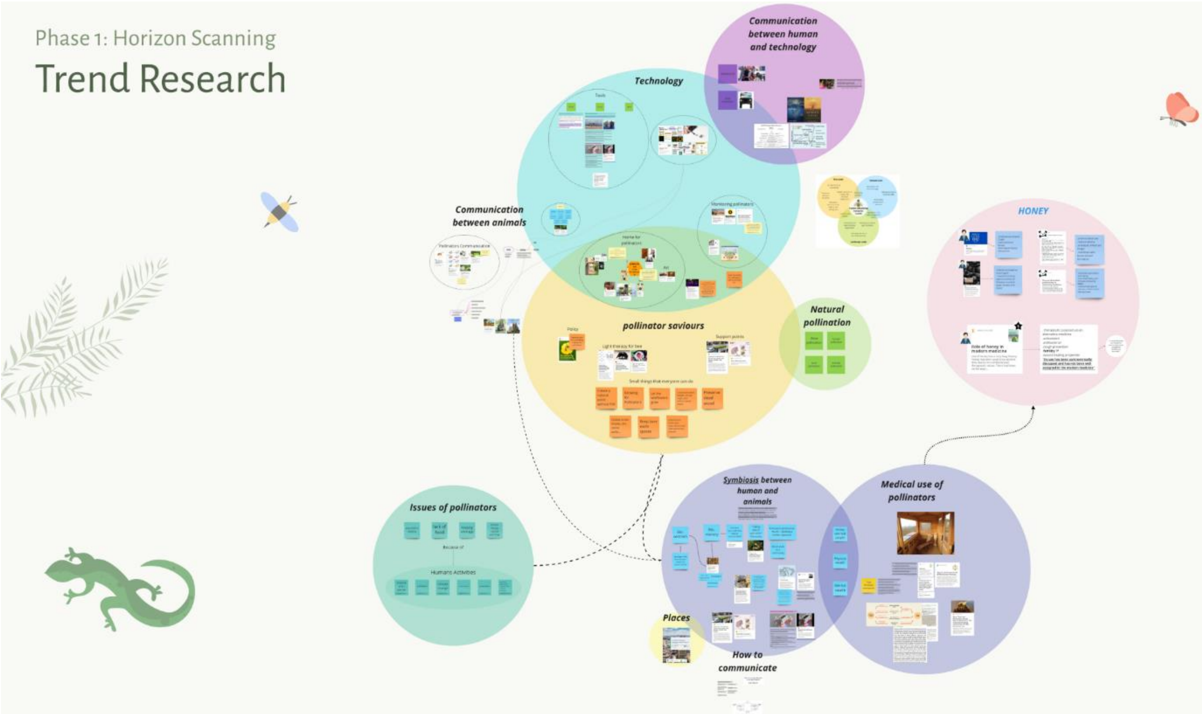
The development process of *Sensitiva* was structured through the DC4DM model, which aimed to facilitate the systematic exploration of the technological and ethical landscapes of healthcare innovations. This model ensured that the solutions proposed were not only technologically feasible but also socially acceptable and ethically viable.

Sensitiva adopts the approach and philosophy of "*Taking care of each other*" integrating advanced diagnostic and therapeutic technologies based on the symbiosis between humans and animals, with human-centered design principles. It offers personalized care pathways tailored to individual needs, positioned within a futuristic vision of 2032. Employing a holistic approach, the project aims to enhance patient autonomy and involvement in health management using advanced sensors and augmented reality, which amplify the perception of others' conditions. This vision focuses on how the needs of various entities will become central to mutual understanding and collaboration in creating a new, respectful equilibrium based on a biocentric approach, essential for facilitating shared survival and coexistence. The reflection extends to themes of pollinating insects and the question of how to care for local ecosystems. The *Sensitiva* project went through different iterations phases guided by the provided DC4DM toolkit (www.dc4dm.eu/model-and-tools).

3.1.1. Phase 1: Horizon Scanning

In the *Horizon Scanning* phase of this research project, the *Sensitiva* team delved into emerging trends and signals of change to anticipate transformations within the context of "Pollinators our saviors." Utilizing comprehensive research from academic and sector-specific sources, the team identified key actors and analyzed their social and environmental impacts (Figure 1). Special attention was given to pollinators, crucial for biodiversity and severely threatened by unsustainable agricultural practices and environmental changes, as observed in specific regions such as Madeira.

Figure 1: An exploratory mapping of research and brainstorming conducted during the Horizon Scanning phase, highlighting various emerging trends and signals of change. The diagram includes elements such as AI and robotic pollination technologies, human-animal communication interfaces, and the utilization of drones and robotized insects for pollination.

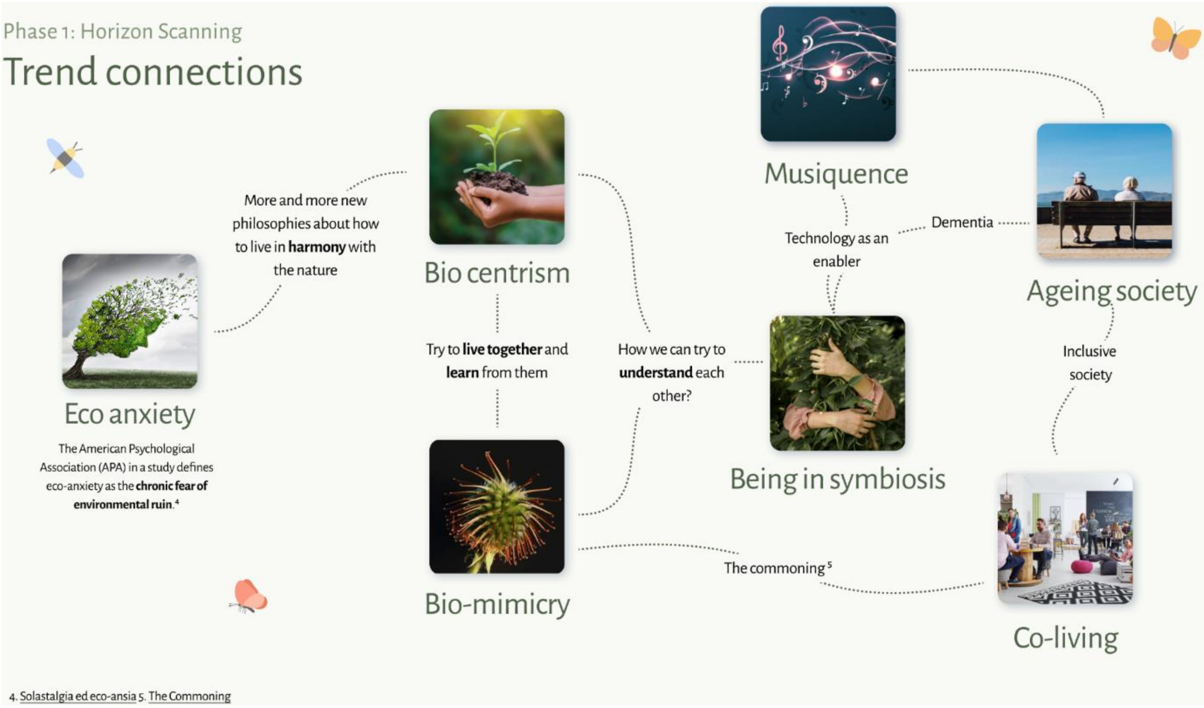


Source: *Sensitiva* project, Final Presentation, DC4DM Learning Lab 1, July 2022.

During this phase, the team members also addressed fundamental ethical issues such as consent and autonomy of non-human entities, biodiversity impact, data privacy and security, technological dependency, equity, access, and the long-term consequences of proposed interactions. The STEEP analysis (Social, Technological, Economic, Environmental, and Political analysis) facilitated an examination of various factors that could influence the project. This method helped the team incorporate considerations such as demographics, technological innovation, economic conditions, and environmental regulations. Key elements include advancements in empathetic robots, biocentric government policies, eco-anxiety, and symbiosis between humans and nature. The analysis highlights the interplay between societal values, technological innovations, environmental sustainability, economic factors, and political regulations, providing a comprehensive overview of the factors influencing future scenarios in digital healthcare design. Additionally, the diagram identifies regions at risk and emphasizes the importance of monitoring local pollinators to protect public health and economic well-being.

Among the emerging trends, the team identified biocentrism, human-animal symbiosis, biomimicry, eco-anxiety, societal aging, and innovative forms of cohabitation. They explored how advanced technologies, including optoelectronic and motion sensors, could facilitate a symbiotic relationship between humans and nature, enhancing life quality and reducing anxiety and depressive symptoms (Figure 2).

Figure 2: A visual representation of trend connections identified during the Horizon Scanning phase. This figure demonstrates the interplay between new philosophies on living harmoniously with nature, technological enablers, biocentrism, societal aging, and eco-anxiety. It underscores the significance of symbiotic relationships with nature, the communing approach, and the "Taking care of each other" philosophy.



Source: *Sensitiva* project, Final Presentation, DC4DM Learning Lab 1, July 2022.

The domain mapping allowed for a visualization of the theme's complexity, organizing the collected data in a structure that aids in understanding the interactions among various trends. This approach provided the team with a profound understanding of the evolving dynamics of the external context, essential for the development of targeted strategies to promote an inclusive and sustainable society.

In conclusion, the Horizon Scanning phase was pivotal in laying the groundwork for future interventions, integrating ethical considerations at the core of the design process to ensure responsible and sustainable solutions. Collaboration with *MT* enabled a thorough analysis of technological advancements and their impact on future care environments, identifying macro themes such as approaches to personalized care and the integration of advanced diagnostic technologies.

3.1.2. Phase 2: Visioning

In the Visioning phase, the team transitioned from the initial insights gathered during the Horizon Scanning phase to a comprehensive formulation of potential future scenarios. This phase was characterized by the creation of a structured 2x2 Scenario Matrix, meticulously combining the critical uncertainties identified previously to forecast diverse but plausible future outcomes (Figure 3).

Figure 3. A scenario matrix developed during the Visioning phase, outlining various future scenarios such as MultiEcoSense and Traits of Life. This matrix explores sensorial communication, universal language, off-grid communities, and the balance between emotive and functional interactions. It emphasizes the role of education and holistic vision in creating an inclusive society.

Source: *Sensitiva* project, Final Presentation, DC4DM Learning Lab 1, July 2022.

These scenarios explored the complex interplay between technological advancement and ecological stewardship within the context of human and non-human interactions. The 2x2 Scenario Matrix facilitated the exploration of varied approaches to integrating humans and non-humans in ecological contexts (Figure 4). The scenarios envisioned included:

- MultiEcoSense: A world without boundaries, where advanced sensorial communications and holistic visions foster a deep, all-encompassing symbiosis across species. This scenario emphasizes non-verbal, emotive communication, allowing communities to thrive in off-grid, fully integrated ecosystems.
- Traits of Life: Also set in a boundaryless environment, focusing on the educational aspects of symbiosis. Using biomimicry and a universal language, this scenario fosters mutual learning and understanding across species.
- Nourished Soul: Shaped as an intimate, therapeutic experience within defined spaces, promoting mental well-being through empathetic, one-to-one relationships and shared residential gardens.
- Feeding Harmony: Illustrates a respectful, collaborative approach to food production within communal gardens, where multiple species work together to create sustainable food systems.

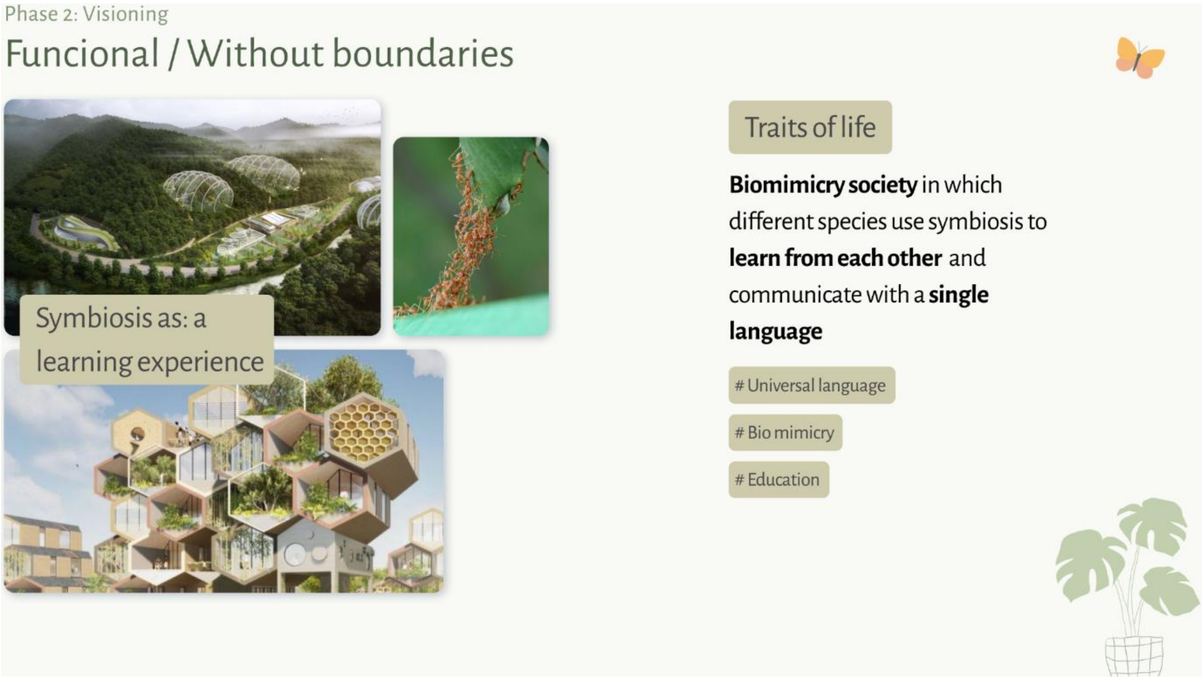
The team investigated the balance between emotionally driven and task-focused interactions (emotive vs. functional dialogue) and assessed the impact of spatial definitions on symbiotic relationships (with boundaries vs. without boundaries ambient).

Throughout the Visioning phase, each scenario was critically evaluated for its ethical implications. The focus was on consent and autonomy of non-human entities, the impact on biodiversity, and the equitable distribution of technological benefits. This ethical scrutiny ensured that the proposed futures not only aligned with technological feasibility and ecological necessity but also adhered to principles of fairness and respect for all species involved.

To envision possible issues and impacts, hypothetical news articles from the future were created. These narratives illustrated how the scenarios might unfold in real-world settings, helping to foresee challenges such as the overwork of pollinators in agricultural settings, societal shifts towards sustainable living, and technological innovations that enhance interspecies communication.

The scenarios were brought to life through detailed narrative descriptions, supported by visual aids such as diagrams and mood boards. These visual representations articulated the nuances of each scenario, making them accessible and comprehensible to stakeholders, thereby facilitating informed decision-making.

Figure 4: A conceptual illustration from the Visioning phase showing the exploration of functional and boundary-less environments. The image focuses on the Traits of Life scenario, highlighting symbiosis as a learning experience and the use of biomimicry for interspecies communication and cooperation. Key elements include universal language and biomimicry.



Source: *Sensitiva* project, Final Presentation, DC4DM Learning Lab 1, July 2022.

The Visioning phase was essential in mapping out the trajectory of the project's impact on future ecological and social systems. By carefully considering a range of dynamic interactions and potential outcomes, the team laid a robust foundation for subsequent project phases. This phase not only highlighted the project's commitment to sustainable and ethical practices but also underscored the potential for innovative solutions to enhance the cohabitation of humans and non-humans. As a result, the project is well-positioned to advocate for and implement strategies that promote a balanced, thriving ecosystem for future generations.

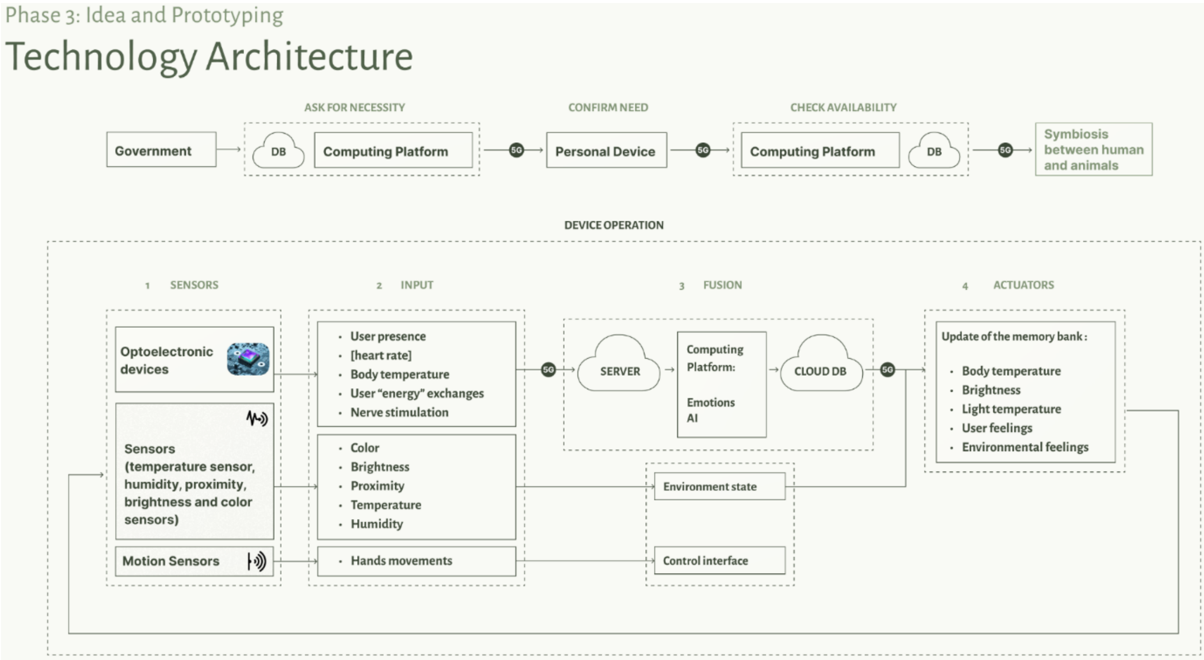
Throughout the process, collaboration *MT* was crucial. *MT* provided insights on the practical and ethical deployment of digital healthcare technologies, highlighting issues such as patient privacy, data security, and the ethical use of AI in healthcare. This partnership ensured that *Sensitiva* aligned with values promoting cognitive and physical well-being through ethical digital interventions, fostering innovative research paths for ethical digital healthcare solutions.

3.1.3. Phase 3: Idea and Prototyping

In the Idea and Prototyping phase, the team transformed the visionary concepts into tangible prototypes, focusing on the practical and ethical dimensions of technology use in ecological contexts (Figure 5). This phase was driven by a set of creative rules aimed at fostering innovation while ensuring clarity and feasibility.

The *Sensitiva* concept revolves around enhancing the autonomy and symbiotic experiences of both humans and non-humans. By employing advanced sensors and augmented reality, the project aims to amplify sensory experiences, allowing individuals to perceive and understand the conditions and emotions of other species. This holistic approach is designed to improve the quality of life for all beings by fostering deeper mutual understanding and cooperation.

Figure 5: A schematic of the technology architecture developed during the Idea and Prototyping phase. This figure includes the framework of ASK FOR NECESSITY, CONFIRM NEED, CHECK AVAILABILITY, and illustrates the roles of government, databases, and computing platforms. It highlights the integration of 5G technology, personal devices, sensors, and optoelectronic devices to facilitate symbiosis between humans and animals.



Source: *Sensitiva* project, Final Presentation, DC4DM Learning Lab 1, July 2022.

The technological framework of *Sensitiva* integrates various advanced components to support seamless interaction and data sharing:

1. Sensors and Input Devices: Utilizes temperature, humidity, proximity, brightness, and color sensors to gather environmental data. Optoelectronic devices and motion sensors capture user presence and physical interactions, including heart rate and body temperature.
2. Computing Platform: The centralized computing platform processes the data collected from sensors, updating the memory bank, and facilitating real-time interaction. This platform supports the integration of AI to enhance user experiences and environmental feedback.
3. 5G and Cloud Infrastructure: Ensures high-speed data transmission and storage, allowing for real-time updates and access to the shared memory bank. The infrastructure supports a distributed network of personal devices and centralized databases.

The prototyping phase involved creating mockups and early prototypes to visualize and test the system. This iterative process was crucial for refining the concept and ensuring practical implementation:

- Brainstorming and Ideation: The team engaged in intensive brainstorming sessions, utilizing techniques like Build to Think to generate and refine ideas. Visual aids, sketches, and role-playing were used to explore various aspects of the concept.
- Early Prototypes: Initial prototypes were developed to test the feasibility of the technology. These included wearable devices with embedded sensors and augmented reality interfaces that allowed users to interact with the environment and other species.

The key functions of the *Sensitiva* system are designed to enhance the symbiotic relationship between humans and non-humans:

- Memories Bank: Collects and stores experiences from various species in a centralized database, enabling users to upload and relive memories. This fosters a deeper understanding and empathy across species.
- Augmented Reality: Uses AR to visualize environmental data and enhance sensory perceptions, making it easier for users to connect with and understand other species.
- Global Trends Visualization: Analyzes collected data to identify and visualize trends, providing insights into the effectiveness of ecological interventions and guiding future actions.

Throughout the prototyping phase, ethical considerations remained central. The team focused on ensuring consent and autonomy for all entities involved, protecting data privacy, and promoting equitable access to technological benefits. Hypothetical news articles from the future were created to envision potential challenges and impacts, such as overworking pollinators and societal shifts toward sustainable living.

An additional tool for the community was developed to facilitate broader engagement and support. This tool, exemplified by a wearable holographic interface, provides real-time data on environmental conditions and pollinator recovery rates, empowering users to contribute to and benefit from the shared ecological network (Figure 6).

The Idea and Prototyping phase of *Sensitiva* was pivotal in bringing visionary concepts to life. By integrating advanced technologies and adhering to ethical principles, the team created a robust framework for enhancing the symbiotic relationship between humans and non-humans. This phase not only demonstrated the practical feasibility of the project but also reinforced its commitment to fostering a balanced and thriving ecosystem for future generations.

Figure 6: An illustrative mockup of an additional tool for the community, developed during the Idea and Prototyping phase. The tool is based on the ©Cicret Bracelet concept and provides real-time data on environmental conditions and pollinator recovery rates. It aims to empower community engagement and support the shared ecological network.

Source: *Sensitiva* project, Final Presentation, DC4DM Learning Lab 1, July 2022.

The presence of *MT* throughout the *Sensitiva* design-thinking process allowed more attention and reflection on the ethical implications of the proposed ideas compared to all the other teams participating in the LLab1. The stress on ethics expressed by MT during the development of the *Sensitiva* digital application for healthcare reflected their interest and value as an enterprise; at the same time the belief that such understanding can lead to additional and innovative research interests.

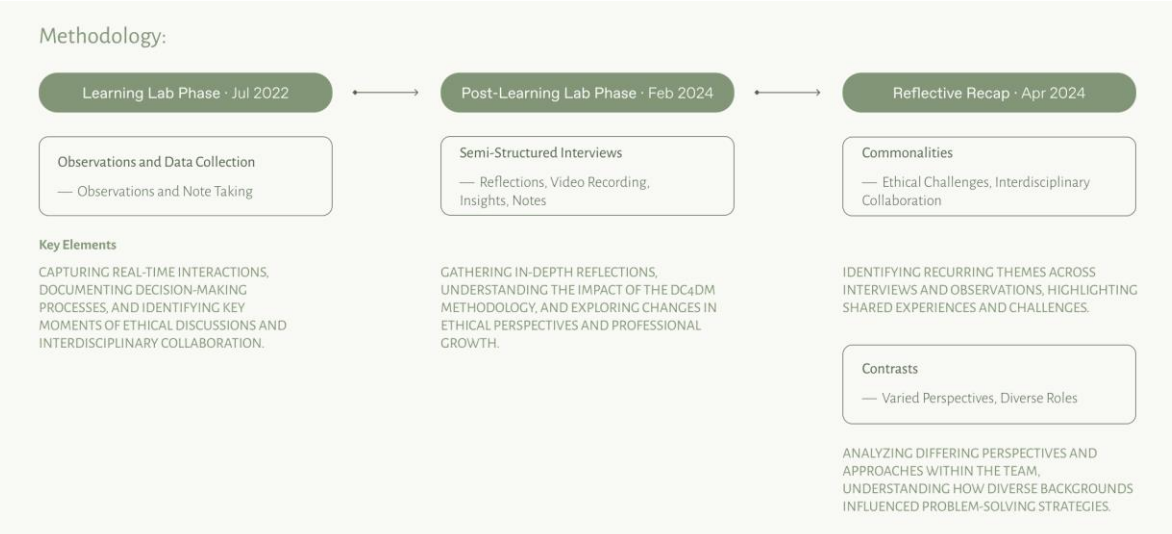
Using the DC4DM methodology and the guidance by *MT*, the *Sensitiva* team members were encouraged to start with wide research on the current technological developments in healthcare, coupled with an exploration of ongoing technological trends. This initial research phase was crucial to establishing a foundation that not only highlighted existing solutions but also identified gaps and opportunities for innovation in the healthcare sector. By leveraging insights and resources from *MT*, the team was able to gain a deeper understanding of market dynamics and the regulatory environment, which are critical for designing applications intended for clinical use, even when envisioned in a speculative and visionary context.

4. Reflecting on Ethics When Designing Healthcare Digital Applications Through the Experience of DC4DM LLab1 and *Sensitiva* Project Development

The presented study utilized a three-phase research methodology to explore ethical integration in digital healthcare design. During the DC4DM Learning Lab phase (July 2022), data was collected by capturing real-time interactions and ethical discussions through direct observation and notes. In the Post-DC4DM Learning Lab phase (February 2024), semi-structured interviews aimed to provide insights regarding the impact of both the DC4DM learning methodology and interaction with a tech-partner.

Finally, the Reflective Recap (April 2024) aimed to analyze commonalities and contrasts by critically examining shared ethical challenges such as data privacy, the subject, and the complexities of interdisciplinary collaboration (Figure 7). This phase highlighted how varying professional backgrounds influenced problem-solving approaches and ethical considerations. The recap underscored the necessity for a cohesive ethical approach that accommodates diverse perspectives, revealing both the strengths and potential conflicts inherent in multidisciplinary teams. This critical reflection on the dynamic interplay between different disciplines provided deeper insights into how ethical dilemmas were navigated and resolved, ultimately emphasizing the importance of fostering an environment where diverse viewpoints can converge to enhance ethical decision-making in digital healthcare design. This structured approach underscored the critical role of interdisciplinary collaboration in ethical digital innovation.

Figure 7: Illustrates the methodology employed in the Sensitiva project, encompassing three distinct phases: the DC4DM Learning Lab phase (July 2022), the Post-DC4DM Learning Lab phase (February 2024), and the Reflective Recap (April 2024). It includes activities such as observations, data collection, and semi-structured interviews, aimed at providing a comprehensive understanding of the research's development and insights gained. The figure highlights key elements such as capturing real-time interactions, documenting decision-making processes, gathering in-depth reflections, and identifying recurring themes and contrasts in ethical challenges and interdisciplinary collaboration.



Source: Project Methodology Overview, created for the purpose of this paper.

During the DC4DM LLab1 (July 2022), *MT* representatives followed through each step of the *Sensitiva* project development. A constant and mutual learning exchange between the start-up and the students was in place. Almost two years after that creative interaction, MT representatives were invited to meet again with the *Sensitiva* team members to discuss and reflect on the design of digital applications for the healthcare sector through the example of *Sensitiva* and the lens of the DC4DM methodology.

One of the co-founders of *MT* ran individual conversations with each of the *Sensitiva* project team members. These took place online in February 2024 and were recorded with the consent of the participants. The recordings were stored safely, as their transcriptions were to be used for analysis.

The *Sensitiva* project team members, who then took part in the latest conversations with MT, were university students from different disciplinary and cultural backgrounds. For data collection, they will be identified as: [**ID01**] Designer, BA in Design, University of Madeira; [**ID02**] Engineer, BSc in Informatic Engineering, University of Madeira; [**ID03**] Designer, MSc in Digital and Interaction Design, Politecnico di Milano.

The three conversations with the *Sensitiva* team members were organized following the topics listed below.

1. *Ethical considerations to make during the design thinking process.* This topic focuses on understanding how ethical issues were identified, considered, and addressed throughout the design process. It examines the continuous integration of ethical thinking and the challenges faced. Team members were discussed about the following: 1) what the project was about, 2) if they always presented ethical questions during the design process, and 3) if there was anything that made them feel uncomfortable when dealing with ethical issues during the process.
2. *Use of tools and resources for ethical development.* This topic evaluates the effectiveness of specific tools and resources, such as the DC4DM toolkit, in fostering ethical awareness and resolving ethical dilemmas. Team members discussed: 1) what they found useful from the DC4DM toolkit in developing

their attention towards ethics, and 2) whether they found the tool useful in solving ethical dilemmas they encountered.

3. *Ethical sensitivity development through interactions with the Startup*. This topic explores how interactions with the startup influenced the development of ethical sensitivity, emphasizing the role of stakeholder engagement in shaping ethical perspectives. Team members were invited to reflect on what they found useful from their dialogue with the startup in developing their ethical sensitivity.
4. *Ethical insights and reflections on project presentation.* This topic reflects on the ethical insights gained during the project presentation phase and how these insights influenced perceptions of the project's impact. Team members discussed: 1) what ethical insights they gained throughout the entire experience of presenting the project, and 2) how these considerations shaped their perspective on the project's impact and implications.
5. Influence of LLab1 experience on ethical thinking. Lastly, this topic assesses the long-term impact of the LLab1 experience on participants' approach to ethical considerations in future projects. Team members were invited to reflect on whether the LLab1 experience and the development of their project influenced the way they think about ethical implications when designing new digital products.

The purpose of these later conversations was to explore not just the impact of the DC4DM methodology and LLab1 experience on both start-up and team members, but especially to reflect on what aspects and phases of the design thinking process should focus on ethical considerations and possible implications.

4.1. Results

Sensitiva project team members were encouraged by the Startup to seek a forward-thinking solution to address the ever-increasing needs of clinical populations worldwide, all the while considering the ethical considerations inherent in their proposal. The students researched macro themes exploring the influence of nature on human experience. Additionally, they delved into trend research, establishing connections between technology and nature. Following their research, the students envisioned a future where patients would relate to the nature of bee pollinators through a symbiotic relationship facilitated by sensory technology, including optoelectronic devices, motion sensors, and weather sensors.

Furthermore, it also allowed for a deeper human connection with their environment as this allowed the collection and authorized sharing of pleasant memories among individuals. The goal of such symbiosis was to help reduce anxiety and depression-like symptoms while increasing the quality of life of the patients.

During the follow-up conversations, when asked about *1) the ethical considerations during the design process,* team member ID01, reported that she, indeed, had that into consideration as "*(they) have always been very human people"* and that they *"never saw the pollinators as a machine".* She also commented that *"this empathy (was) always present"*. As for ID02, she replied that *"to be honest, we (did not) pay much attention to some points".* Participant ID03 said that multiple ethical considerations were identified as the project involved the role of humans in the biodiversity and pollinators as they *"are like another living being"* and that "*they're like in a bad situation (because of) humans*".

Regarding *2) usage of tools and resources for ethical development*, ID01 admitted that at the beginning she was confused about how to use these tools as she *"(was) not used to using these methodologies as (she) is from informatics, and not design*". Nevertheless, she found it useful during the design process as she was able to focus on "*(...) the points we had to focus on and those that were a little more irrelevant".* ID02 said that despite this tool being interesting, "*(they) were (...) focused on trying to understand how it really worked that this part was left a little aside*". As for ID03, found it to be useful as "*the toolkit provided (...) support (...) in framing ethics, ethical framework, and guidelines*".

As for *3) Ethical sensitivity development through interactions with the Startup,* team member ID01 said she found it useful to have a representative that provides insights regarding ethical practices within healthcare. Participant ID02 said that *"they focused on the project"* so that it can benefit *MT* in the future and that communication with

MT was *"facilitated very much by having 'our' startup"* present during the design process. As for ID03, it was a fruitful conversation in the sense that it led to a discussion about the importance of safeguarding user data—"*Understanding (...) habits and their personal information (,) their stories and their fragility is really (...) important consideration about the privacy, understanding, security, safety and also how we could (...) involve (...) those topic(s) in a critical way in our project."*

For *4) Ethical insights and reflections on project presentation*, ID01 mentioned that ethical choices remained relatively consistent following the project presentation to other groups. However, they acknowledged the potential influence of the diverse multidisciplinary and cultural backgrounds within the groups on their ethical sensibility—*"(...) I don't think there was a drastic (ethical) change, but obviously there was a sensitivity there, especially if we go to a place with people from other countries, which is a different experience".* For ID02, she claimed that she gained more *"awareness"* regarding the "*pollinators (and) what they were going through and what could be done to reverse some situations".* As for ID03, presenting the project was useful as it allowed her to be more aware of the team's design decisions—"*you really have to think carefully about what you are designing (...), but also underscore the ethical responsibility to ensure that the human entities are not exploited or harmed."*

Lastly, *5) Influence of Llab1 experience on ethical thinking,* ID01 said that she viewed ethical thinking as *"secondary"* but believes it should be a priority. ID02, she said that it had influenced her. She also mentioned that the tools provided during the Llab1 are useful—*"It helps a lot to see the innovations that are already happening and those that are not happening. This whole process helps a lot in creating new ideas and trying to reach a new point".* Finally, ID03 reported that she *"felt like (...) an extra person, like a sustainable management project, and (...) like the lab was really like an exposure to a different perspective."*

These conceptual projects play a pivotal role in delivering innovative solutions and serving as a source of inspiration not only for professionals in the DHT industry but also for emerging companies that focus on developing DHT-related products. Consequently, through educational projects like DC4DM, we empower and help to remember both current and future DME personnel to create innovative, ethical, and human-centered technologies, thus enhancing trust between healthcare practitioners and patients.

Regarding *MT's* reflection on the Post-DC4DM LLab1 conversation, ethical considerations are crucial when developing digital health technologies as they ensure user trust and retention by addressing privacy, security, and fairness concerns: "Healthcare professionals become reluctant in using technologies if data protection is not safeguarded" Neglecting ethics in development can lead to significant consequences, including data breaches, loss of user trust, reduced user engagement, potential harm to patients, and legal liabilities. Ensuring ethical standards not only protects users but also enhances the credibility and sustainability of the technology. Another important aspect to have in mind in developing is user-experience: "Also, from an ethical point of view, technologies must be designed according to the user experience of healthcare professionals. Improper use of these technologies in clinical populations may lead to significant ethical issues."

5. Discussion

The ongoing digitization across various industry sectors is rapidly becoming a reality, profoundly impacting current business practices, and revolutionizing organizational operations. This transformation aims to enhance efficiency, agility, and responsiveness to evolving market needs. Digitized organizations benefit from streamlined operations and improved data-driven decision-making capabilities.

However, despite the identified strengths and opportunities, significant barriers impede healthcare professionals from fully leveraging technology in their daily practice. The SWOT analysis revealed prevalent obstacles in the literature, including insufficient computer literacy, cybersecurity concerns, and ethical considerations, which hinder the widespread adoption of innovative technologies despite their potential benefits. Therefore, a paradigm shift in education becomes essential.

Interdisciplinary educational initiatives like the DC4DM project are designed to foster collaborative and interdisciplinary approaches to educating future healthcare professionals. These initiatives aim to equip SMEs with the right skills and attitudes to achieve digital maturity, which means navigating and harnessing the potential of emerging technologies confidently and effectively.

The *Sensitiva* project exemplifies the critical interplay between design, engineering, and business disciplines. The collaboration between the *Sensitiva* team members, who brought diverse expertise in interaction design, computer science engineering, and integrated design, and *Musiquence Technologies (MT)* demonstrated the potential of interdisciplinary dialogue to foster innovative solutions. This integration facilitated a holistic approach to problem-solving, ensuring that technical feasibility, user experience, and business viability were all considered.

The design team contributed user-centered perspectives, ensuring that the solutions were intuitive and met user needs. The engineering team provided technical insights, addressing feasibility and implementation challenges. Meanwhile, the business-oriented members focused on market relevance and sustainability, ensuring that the solutions had viable business models.

This dynamic dialogue not only enriched the project outcomes but also highlighted the importance of effective communication and collaboration mechanisms. Regular workshops and brainstorming sessions enabled the seamless integration of these diverse perspectives, fostering a culture of continuous learning and innovation.

During the project, it became evident that bridging the gap between theoretical knowledge and practical application requires more than just technical skills. It demands an appreciation of the different perspectives each discipline brings and an ability to synthesize these insights into coherent and actionable strategies. This multidisciplinary approach is essential for developing robust, user-centered digital healthcare solutions that are both ethically responsible and commercially viable.

Following the DC4DM “Feeding Madeira” LLab1 in July 2022, the specialized health solutions startup *Musiquence Technologies*, and some of the *Sensitiva* project team re-met for further knowledge exchange and discussed the experience developing a healthcare application with DC4DM tools and how this experience influenced subsequent projects.

During a follow-up conversation, participant ID01 highlighted the importance of ethical considerations in the design process, emphasizing a human-centered approach and stating that they never viewed pollinators merely as machines. ID03 also highlighted significant ethical reflections, particularly concerning the role of humans in biodiversity and the plight of pollinators. In contrast, ID02 admitted that certain aspects were not given significant attention during their project.

Regarding the use of tools and resources for ethical development, ID01 initially struggled with using ethical development tools due to her informatics background but ultimately found them valuable for prioritizing key design aspects. ID02 prioritized understanding its functionality over addressing ethical considerations during the project. Conversely, ID03 found the toolkit beneficial for providing support in framing ethics and establishing an ethical framework and guidelines, indicating its value in structuring ethical considerations during the project.

As for ethical sensitivity development through interactions with the Startup, Participant ID01 valued having a representative from the startup who provided insights into ethical healthcare practices. ID02 highlighted that the presence of the Startup facilitated communication and focused efforts on the project’s future benefits. ID03 found the interactions particularly fruitful, as they led to important discussions about safeguarding user data and incorporating considerations of privacy, security, and safety into the project. Overall, these interactions significantly contributed to the team’s awareness and handling of ethical issues.

For the ethical insights and reflections on project presentation, after presenting the project to other groups, ID01 noted that ethical choices remained consistent, though they acknowledged the potential impact of diverse backgrounds on their ethical sensibility, particularly in multicultural settings. ID02 expressed gaining awareness about the pollinators' experiences and how to address challenging situations, indicating a deeper understanding and empathy developed through the project. ID03 highlighted the importance of project presentations in promoting careful consideration of design decisions and ethical responsibilities towards human entities. This underscores the role of project presentations in reinforcing ethical values and principles within teams.

Finally, regarding the Influence of LLab1 experience on ethical thinking, participant ID01 acknowledged that while she initially viewed ethical thinking as secondary, she now considers it a priority. On the other hand, ID02 mentioned that her experience in LLab1 had a significant influence on her ethical thinking and found the tools provided valuable for understanding existing innovations and generating new ideas. ID03 describes feeling like an "extra person" and mentions exposure to a different perspective, particularly in the context of sustainable management projects.

Based on the participants' responses, it can be inferred that individuals with different academic backgrounds may have varying levels of comfort and effectiveness when using tools for ethical development in design projects. ID02, with an informatics background, initially faced challenges but ultimately benefited from the tools in focusing on essential design elements. On the other hand, ID01, while interested in the tools, may have prioritized technical understanding over ethical considerations during project implementation. This highlights the importance of integrating ethical considerations seamlessly into design processes, regardless of academic background, to ensure comprehensive and responsible project outcomes.

Regarding the reflection of *MT,* ethical considerations in developing digital health technologies are crucial for ensuring user trust and retention by addressing privacy, security, and fairness concerns. Neglecting these ethics can lead to data breaches, loss of trust, reduced engagement, patient harm, and legal liabilities. Upholding ethical standards not only protects users but also enhances the credibility and sustainability of these technologies. Additionally, designing technologies with the user experience of healthcare professionals in mind is essential to prevent improper use and associated ethical issues in clinical settings.

Another observation that we made is that we were not able to relate to some of the topics identified in the SWOT analysis. This highlights a gap between theoretical frameworks and practical applications. Nevertheless, the inability to integrate major key factors identified in the scientific literature regarding SWOT analysis into their discussions highlights a significant gap, suggesting a disconnection between their academic training and the practical realities they face.

Conclusion

The ongoing digitization in various industries, especially healthcare, offers significant benefits like enhanced efficiency and data-driven decision-making. However, barriers such as insufficient computer and digital literacy, cybersecurity concerns, and ethical considerations impede the full adoption of these technologies. Insights from the DC4DM LLab1 reveal that while *Sensitiva* project team members struggled initially with integrating ethical aspects of the DC4DM methods, they ultimately recognized the importance of considering ethics within a design process. This highlights the need for higher education programs to better align theoretical frameworks with practical applications, ensuring that all participants can effectively and responsibly address ethical issues.

Incorporating ethical considerations into the development of digital health technologies is not just beneficial but essential for maintaining user trust and ensuring responsible innovation. Educational initiatives like DC4DM are essential for preparing healthcare professionals to navigate these challenges, fostering an ethically aware and competent workforce capable of leveraging the full potential of digital advancements in healthcare.

By addressing these aspects, a comprehensive understanding emerges of how the conditions and quality of dialogue influenced the development of the Sensitiva project. The involvement of students from three different disciplinary and cultural backgrounds brought a rich diversity of approaches and perspectives, which greatly enhanced the project despite the challenges. Multidisciplinary teams can drive innovation but require effective coordination and conflict resolution strategies to harness their full potential. Tailored interventions are necessary to bridge skill gaps in collaborative environments, ensuring all team members can contribute effectively.

While external expertise, such as that provided by MT, is invaluable, it is crucial to build internal capacity for ethical decision-making. This balance ensures that teams can innovate responsibly and independently. Engaging with a diverse range of stakeholders enriches project outcomes, but it requires careful integration of different perspectives. Understanding these elements helps educators, practitioners, and organizations better prepare for and navigate the complexities of digital transformation in healthcare.

These insights emphasize the importance of ethical considerations, internal capacity building, and effective stakeholder engagement in developing digital healthcare applications. Learning from the Sensitiva project can inform future projects, fostering innovation while maintaining a strong ethical foundation, ultimately contributing to more effective and responsible digital transformation in healthcare.

Future research steps should expand the scope to include a greater number and variety of projects to validate and extend these findings. Additionally, developing and testing educational curricula that better prepare future professionals to tackle ethical issues in digital transformation is imperative. By addressing these limitations and enhancing the ethical dimension of digital healthcare education, we can bridge the gap between theoretical knowledge and practical application, ultimately fostering a more ethical and effective digital healthcare landscape.

Limitations and Future Steps

While this study provides valuable insights, it is not without limitations. The limited scope of projects and the specific context of the DC4DM LLab1 may restrict the generalizability of the findings. Future research must address these gaps by focusing on larger sample sizes and a more diverse range of projects to validate and expand upon these results. Furthermore, the long-term impact of integrating ethical considerations into digital healthcare design education remains underexplored and warrants further investigation.

Future work should prioritize broadening the scope of the study to encompass a wider variety of projects. This would enhance the robustness of the findings and uncover specific ethical challenges and their resolutions within digital healthcare design. Additionally, there is a pressing need to develop and rigorously test educational curricula that better prepare future professionals to tackle ethical issues inherent in digital transformation.

Incorporating ethical considerations into the development of digital health technologies is not merely beneficial; it is imperative for maintaining user trust and ensuring responsible innovation. Educational initiatives like the DC4DM project are pivotal in this regard, as they equip healthcare professionals with the ethical awareness and competencies necessary to navigate the complexities of digital advancements. By fostering a workforce that is both technologically adept and ethically grounded, we can ensure that the evolution of healthcare technology serves the best interests of society.

Without a concerted effort to address these limitations and enhance the ethical dimension of digital healthcare education, the potential for innovation may be compromised by the very issues it seeks to solve. Thus, future research and educational reforms must align to bridge the gap between theoretical knowledge and practical application, ultimately fostering a more ethical and effective digital healthcare landscape.

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Agile future creation methodology. Innovation method for startups to build future-proof solutions

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Abstract

The startup industry is a hub of innovation; however, the majority of new ventures fail. Current startup innovation methods do not address the underlying causes of this failure trend. One of the missing directions in the current startup innovations method is the focus on future direction and vision. It has been found that integrating various methods to cover both the creative and business aspects of a venture can help achieve better outcomes. The integration of different methods covers a wider point of view. To that, adding Future Thinking can help reframe the innovation process in a better way. It is a future-proof approach that can help analyze the changes in society to find weak signals or drivers. That can present potential opportunities for businesses to focus. As an outcome of this research Agile Future Creation toolkit is introduced as a method to address the shortcomings identified. It provides startups with an innovative method to explore future possibilities in a more planned and efficient manner. The toolkit uses a mixed approach of Future Thinking, Design Thinking, and Agile practices bestowing more hard and soft skills to guide startups to success.

Keywords: Agile; Future Thinking; Innovation; Opportunities; Startups.

Introduction

1.1. Startup

Startup: how can we define it? We have multiple definitions on the internet. Eric Ries (Ries, 2011) defined it as a human institution designed to create new products and services under conditions of extreme uncertainty. Or a stage of the organization "is a temporary status—a term for an organization whose vital objective is to launch a new business model or open up a new market" (Dominguez, 2017) and many more if you start an internet search about it.

The startups are many times linked to the beginning of Silicon Valley. These tech companies surrounding Stanford University had a huge impact on technological development. However, the real rise of the startups didn't really happen till the end of the 1990s when the dot com bubble hit the market (Prezm, 2018). The availability of the internet and access to technology created immense opportunities for companies to grow rapidly. These startups have now a huge impact on the world. For example, the world's largest media company, Facebook, has no content creators on their payroll. The world's largest hotel chain, Airbnb, owns no hotels. The world's largest taxi company, Uber, doesn't own a single taxi. And so forth. Technology companies have shaken many industries and captured markets from traditional companies (Alto Starting Up, n.d.).

To dive deeper into the destination all of the startups share some common characteristics:

1. **Innovation:** The idea of innovation has multiple meanings taken in different contexts. From the consumer's point of view, it can be experiencing something new in product technology or a use case. It isn't necessary that innovation can happen only by incorporating new technology and applying new experiences or viewpoints, resulting in a new model. From the market point of view, innovation means adding value. Based on these reflections normally, a startups innovation framework can be divided into three categories:

- Framework 1: Change what does not work.
- Framework 2: Making things easier for the customer.
- Framework 3: Make things more affordable.

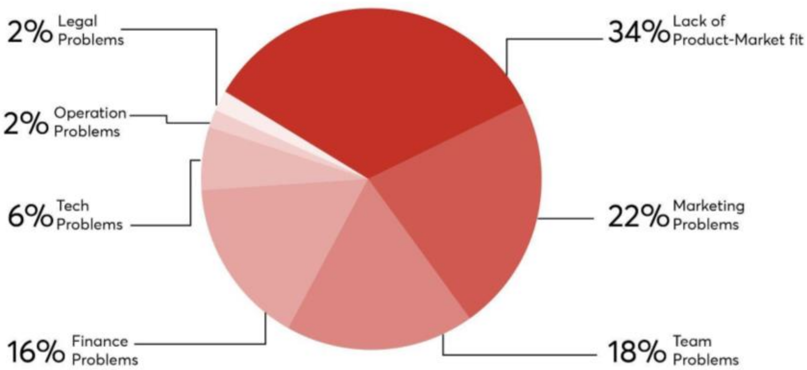
2. **Growth:** The growth in startups happens exponentially rather than linear compared to other organizations. The reason for this can be leverage provided by technological advances, not resource quantity (Dominguez, 2017).

1.2. Startup Failure

The startup industry is a hub of innovation; however, the majority of new ventures fail. Traditional businesses have a 20% chance of failing in their first year (Bureau of Labor), but startups face even higher odds against them because of their innovative path. Kotashev (2022) identified the primary causes of failure (Figure 1) as follows:

- Marketing issues (56%) The most significant contributing factor was marketing-related mistakes, with lack of product-market fit being the most prevalent issue.
- Team-related issues (18%) Problems such as insufficient domain, marketing, technical, and business knowledge were the major contributors to failure.
- Financial difficulties (16%) Although more than 50% of the interviewed founders lacked a budget for their project, only 16% cited financial problems as the reason for their failure, with 75% being self-funded.
- Tech Problems (6%) Despite the majority of startups having technology at their core, over-investment in technology before validating marketing assumptions was the most significant mistake.
- Operations Problems (2%) For software startups, operational problems were infrequent, but for startups dealing with physical products, they may be more common.
- Legal Problems (2%) Although legal obstacles are rarely the cause of failure, heavily regulated industries such as food and finance may present such challenges.

Figure 1: Common Reasons for Startup Failure.



Source: Failory.

1.3. Current Innovation Methods

Innovation in the industry is usually divided between the two most followed processes. The first one is structured or Robust methodology followed by big corporations and scientific fields. The second one, More Agile methods that are flexible and can be re-adjusted according to their need, is used by firms recently started as "Startups" (Freeman, 2007). Young companies have the inexperience of being new in the field and small, so they fail more often than their older, larger competitors. However, the structural and regulatory advantages associated with established companies also disadvantage them in contributing freely to innovation.

To understand the fields covered by the various innovation methods like Agile innovation, Waterfall innovation, Design Thinking, Lean startup, and Hybrid methods that combine various innovation strategies were studied and a comparative matrix (Table 1) was generated. The matrix provides a comparison review for the set of parameters that are present in various innovation methods.

The extensive research into the current literature and insights we gathered from field research have led to the insights. Innovation methods for a startup can be improved significantly by improving the current methodologies and adapting to some new ones to provide a medium of reframing the whole situation.

Table 1: Innovation method comparative matrix.

Method name / parameter	Design Thinking	Lean Start-up	Scrum	Kanban	Concept-erlize	Agile and Gated	DT,LD and Agile	Agile Road-maping	DETHIS
Assume Uncertainity	●	●			●	●	●	●	●
Trend Forcasting									
Future Literacy									
Shared Vision								●	
Ideation	●				●	●	●	●	●
Hypothesis		●							
Viability		●	●		●			●	●
MVP		●			●	●	●		●
Prototype	●		●	●	●	●	●	●	●
User Centered	●				●		●	●	●
Qualitative		●	●	●	●	●		●	
Quantative	●				●				●
Process Planning			●	●				●	●
Quality Check			●						●
Partnership Guidance									●

Source: Developed by the author.

Let's start with the most used methods of innovation in entrepreneurship avenues Design Thinking (DT) and Lean Startup (LS). Both innovative methods hold their benefits, but they can be more beneficial if they are worked together instead of individual approaches. First DT, Pivoting is a point that can be beneficial by adopting it before the prototype phase in the iteration loop. That can lead to early testing of the project. Also incorporating BMC can be a good start to focus on viability in DT and also include quantitative testing methods to measure feedback. On the other hand, the LS could add more parts to collecting research and input data. e.g. ethnographic research. LS could also greatly benefit from ideation practices to widen the scope of solutions as it is often based on a single concrete business idea. Also, qualitative methods of feedback as interviews can be added to the qualitative metric evaluation (Mueller, 2012).

So different tools that offer a unique point of view benefit the process. The future site of the design is utilized less by the people who want to design for the not-far future. But these tools can help reframe the future in a better way. This can help analyze the changes in society to find weak signals or drivers that can be potential opportunities for the business in the future. So, the products/ Services can be made for the needs of the customer in the near future Instead of focusing completely on today.

This brings us to the research question: "How can we align a set of practical tools that will allow startups or young businesses to create future-proof products/services?"

2. Literature Review

As far as we can see humankind is always trying to look beyond the present. Predicting the future provides us with a sense of security and sensemaking. The feeling of learning the upcoming is driven by the curiosity to learn, explore, and experiment (Schultz, 2015).

A few thousand years ago the future of the people used to be the past of their parents. The predictions answer the large questions of the far future, it used to be a complex job for God's servants or people close to God. That was later in modern times replaced by the Oracle for Applied Systems Analysis (IIASA). Still, the future was predicted for the academic, political, and economic elites.

Methods of Predictive notion in the human system were the later development that came into many technological fields for maintenance and efficiency (Coleman et al., 2017). This later led to starting to decentralize the power of future thinking by using crowdsourcing and gamification enabling widespread grassroots futures exploration. The following grew into the academic field, known variously as futures studies, foresight, anticipatory studies, technology forecasting, assessment, and scenario planning, among other titles. Many names refer to the investigation of the future. Future Studies, Foresight, Future Literacy, Future Thinking, Futurism, and many more. The terms are often used or mixed without providing the details on the similarities. The one we are focused on is called Future Thinking.

2.1. Future Thinking

Future Thinking is a methodology used in strategic design that considers the variables of the future to reflect in strategic planning. It reveals the possible outcomes that can occur by present situations, actions, and decisions. FT provides future scenarios that will happen and lets us make the best choices to get there, also known as the selection of preferred future. FT doesn't provide tools to predict the future, instead highlights the weak signals of today to allow people involved to actively design a desirable future. Its emphasis isn't on what will happen but on what could happen, given the observed drivers (Corthell, 2019).

This is done by creating a shared vision of the future in the organization/ community. The future thinking process involves the use of both divergent and convergent thinking in the various steps throughout the process (Iversen, 2006). The five main steps in the Future Thinking methodology are described (Goertzel, 2019):

1. **Identifying and Monitoring Change.** Current forecasts and macro and micro trends related to the topic should be studied. Many factors like political, economic, social, and technological factors could be key factors influencing your topic.
2. **Analyzing change.** Not all the trends and information are gathered to offer the promise of the future. The identification of weak signals can help in analyzing the positive change.
3. **Thinking about the alternative futures.** After gathering the right insights and assumptions about the future. Now multiple future scenarios can be created by considering all the possible future outcomes.
4. **Envisioning the preferred alternative.** Deeping into the scenario by using various tools to identify the environment and artifacts of the future can help to fit yourself in the future to gather insights.
5. **Plan and implement.** As we deepened the preferred future. After that final step is to Backcast and trace the steps that can lead to this future to make it a reality.

2.2. Future Thinking Tools

The Future thinking methods are descriptive/ explorative which helps in objectifying the future and perspective/ normative methods which help to develop the vision of the future (European Foresight Platform, n.d.). There are many methods developed by different futurists and everyone adds things to methods to make them fit their needs. Despite that, some methods are followed by researchers while investigating the future. Although using multiple methods in combination with other methods filters the results to provide a more defined result. Some of the popularly used methods are:

1. **Trend analysis.** This method involves several processes from identifying an emerging trend and then looking up for change in the society around us. Then analyzing the trend to compare it to historical data to make sense of the pattern by projecting it in the future and its implications (Jain, 2023).
2. **Technology Forecasting.** Technology forecasters usually make a forecast of how soon various technologies will be possible and characteristics they might have given the reason actual tech will be dependent on economic, social, and political considerations. TF tracks the advance of tech using individual or combining multiple methods. In which “stages of innovation” to track the market application of the product plays a significant role (Monestier, 2022).
3. **Horizon Scanning** This method is used to recognize early signs of change by systematic information gathering and analysis to get insights about the future. This step is based on research without using much imagination (Nesta Futures). Some of the methods in horizon scanning can be identifying weak signals, macro and micro trends, Pestle and Steep analysis, and more.
4. **Scenarios.** Scenarios focus on creating an exploratory version of the future concerned with the uncertainties of the future. These are created to understand the different futures and the changes that can be driven by them. The more divergent the scenarios are, the bigger and better the “scenario space” it offers in which futures and logic are different (Jonas XXXX). Consequently, exploratory scenarios should be 1. Plausible: Logical, consistent, and believable 2. Relevant: They should highlight key challenges and dynamics of the future 3. Divergent: They should differ from one another in strategically significant ways 4. Challenging: They should challenge fundamental beliefs and assumptions
5. **Visioning** This technique helps in developing the vision of the desirable future. Generally, visioning involves identifying the source of pleasure or problems in the current time which will drive people to get a sense of the drivers. which can help them imagine a conscious of the preferred vision of the future. The vision attracts the goals and spirit to achieve the desired future (Nicolussi, 2017).
6. **Backcasting.** After creating a vision, it is necessary to organize that into a possible path to achieve. To allow reaching that vision so that the transformation does not disintegrate into a set of unrelated and confusing directions and activities (Fernandez & Rainey, 2006). Backcasting of the future involves working backward from the future vision to the present timeline and identifying major goals, opportunities, and actions that need to be done in a timeline to complete the future timeline. The foresight practice of backcasting, or reverse-engineering of futures provides a means by which participants can align on steps to achievement (Nicolussi, 2017).

2.3. Mixing FT

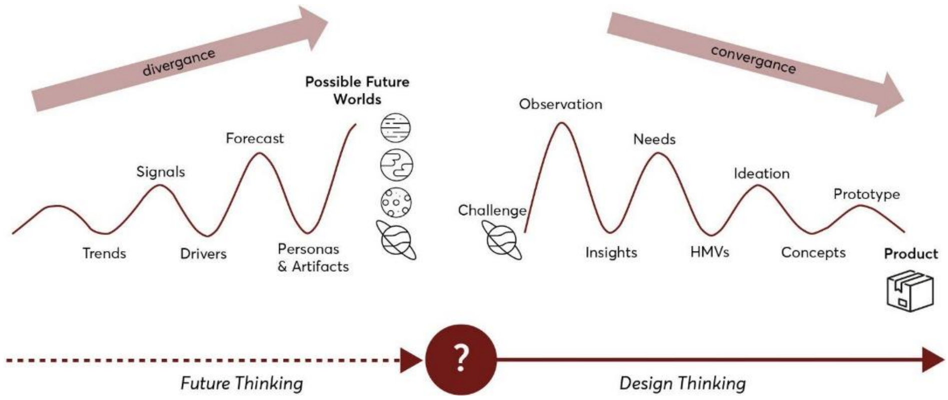
The idea of adapting future thinking into industry practice innovation methods has been mentioned a few times in various articles. Where the possible integration of it with other methods has been highlighted, e.g., mixing design Thinking with future thinking (Figure 2) highlights that Design thinking as more focused on a closer timeline and solution-focused outcome and, on the other hand, Future thinking as a process to discover potential future opportunities in a bigger timeframe to inspire people’s actions. Despite their differences these processes if looked through a wider lens share a set of similarities. That can enable them to combine into an integral process to create products and services that are more future proof.

Some of the strategies by which these two methods can be linked can be 1) Adding the element of past which is the main focus in the DT to go more towards the past in FT. 2) Looking for the weak signals in the user interactions by understanding the unusual and nice options developing throughout the process. 3) Linking trends and data forecasts with user behaviors to understand the micro trends that can lead to bigger changes. 4)Exploring more opportunities by also focusing on the solutions that are a little different for the current time period (Roumiantseva, 2016).

Another study highlights the strategic application of backcasting, a future-oriented methodology, particularly in the context of startups. It highlights the importance of treating the future as a spectrum of possibilities rather than a singular entity. It advocates for the adoption of backcasting by startups for strategic decision-making, enabling them to anticipate and navigate potential changes in technology, customer needs, and other critical aspects, letting them maintain a long-term strategy for the future (BBVA, 2021).

There are many more possibilities highlighted by other authors and organizations for using FT by combining it not only with DT but also with other innovative methods to benefit from future literacy.

Figure 2: Comparison between Design Thinking and Futures Thinking.



Source: Anna Roumiantseva.

3. Methodology

Startups don't last forever. It's a stage of an organization or more like an experiment to test that can lead to a fruitful venture. If a startup is a success it may end up getting an exit in the form of growth through an acquisition, merger, or public listing. If unsuccessful, that can lead to shutdown or bankruptcy for the venture. In some rare situations, it can also be converted into a normal stable business (Alto, Starting Up, n.d.). To analyze the growth factors that can lead to either of the mentioned cases startup research was conducted with two overlapping methods.

3.1. Analytical Research Method

To better understand the startup landscape, we undertook a thorough exploration of the current shortcomings and the practices used to overcome them. This involved conducting desk research to gather information on the latest trends, techniques, and tools in the industry. We also conducted a literature review to provide a more comprehensive understanding of the context of our project. Once we had gathered the necessary data, we began to identify the various tools and methods that could be used to solve the problems we had identified. This involved testing a range of different approaches to determine which were most effective in achieving our goals. Finally, we developed a process that would help maintain a natural flow of information throughout the project. This involved creating a clear and concise plan for gathering, analyzing, and sharing information, as well as establishing systems for monitoring progress and evaluating outcomes.

3.2. Semi-Structured Interview

To further validate the findings of the previous stage and gain a more in-depth understanding of the situation, semi-structured interviews were conducted. The purpose of the interviews was to compare the results from the secondary stage and identify any gaps in the startup ecosystem. The interviews followed a structured script that allowed participants to provide additional content on various topics, including current trends, building for the future, shared vision, and more.

A total of 12 startups from four different countries, Italy, France, Georgia, and India, were selected to participate in the interviews to provide a broader range of perspectives on the issue. The startups were chosen based on several criteria, including their life stage, market revenue, operating sectors, industry experience of the founders, and number of team members. The goal was to ensure that the sample was representative of a diverse range of startups operating in different settings. The interviews were conducted in a semi-structured format to allow for a more natural conversation flow while still ensuring that all relevant topics were covered. The participants were asked open-ended questions based on the script, and they were encouraged to elaborate on their ideas and experiences.

The primary objective of this phase of the research was to identify any inconsistencies in the best, poor, and mainstream practices in strategic planning in real settings. The interviews provided valuable insights into the challenges faced by startups in different countries and sectors, as well as the strategies that proved successful in overcoming these challenges. The results of this phase of the research guided the next stage of the study and helped to develop a comprehensive understanding of the startup ecosystem.

The interview mini script is attached in the appendix.

Confidentiality. The study undertakes to keep confidential all personal data collected, whether intentionally or unintentionally. Study summaries may be retained indefinitely but do not reveal the names or identifiable information of participants. Access to this data is restricted to the researcher. Participants were informed that they could decide at any time to withdraw from this study or to request the withdrawal of their data within 14 days of their interview.

4. Data Analysis

The results of this study provide valuable insights into the factors contributing to the failure of startups. By conducting qualitative interviews and analyzing quantitative survey data, the research has identified key themes and patterns that illuminate the dynamics of methods employed by startups throughout product life cycle development.

4.1. Shortcomings

The regularly quoted number is that 9 out of 10 startups fail (Kotashev, 2022) or more recently saying that only 1 in 12 entrepreneurs succeed. The focus here is not the accuracy of numbers but the fact that startups remain extremely risky as seen in the Failory "interviews with failed startups" where you can find hundreds of interviews from founders about how they didn't make it 10 percent of success. Startups operate in a highly uncertain field with half of them not even aware of customers or their products. Which makes old management methods hard for them to apply normally based on more static environments (Ries, 2011). So, reasons other than obvious ones like empty cash reserves. There is a big reason for failure that are often overlooked, some of them listed as:

1. **Not focusing on Viability (partners, revenue & plan).** Innovation methods used by designers usually start by asking users, observing people's needs and wants (desirability), and then they see if the solution/idea. On the other side non-designers focus solely on the market need ignoring the insights and user feedback in the initial stage. Hence unable to reframe the problem completely and later on when they test the product with the customer it is too late to include the feedback (Skok, 2010). The main goal of the startup founders is to develop a product fitting the market demand, be profitable, and provide value to the user. The theme of viability is important because designers tend to fall short of the "viability" factor of innovation and non-designers are short on the insights to include to make the market fit (Roy et al., 2019). Viability is also dependent on factors like involving the right people from the start, Planning, funding, and keeping stakeholders engaged in the business usually not mentioned in any process (Allen, 2022).
2. **Not having a shared vision of the future.** According to Data found by Harvard Business Review 60% of new ventures fail due to problems within the team (Mol, 2019). The successful team for a startup is normally defined as one with entrepreneurial experience to face the challenges, startup experience, and product knowledge and skills (Alto, Starting Up, n.d.). But Most of the time skillset isn't the problem whereas there isn't a balance between team member experience (hard skills) and passion and vision (soft skills). If team members are super smart and experienced, but they don't feel like sharing this knowledge due to a lack of alignment about the vision for the company, their knowledge proves to be useless for the business. Even teams with normal experiences had led greater startups in the market.

The teams with greater performance only yield better results if there is a shared strategic vision for the company that everyone agrees and believes in. In a diverse team such as a startup, where people don't speak each other's language. Because of different knowledge and values attained by the various backgrounds, individual points of view of team members Representational gaps occur (Cronin, 2007). These gaps are quite impactful in the early stages of a venture's development, but that tends to stretch over time because of not having clear role definitions in various situations. So, it is important that the team share common goals and values to avoid these gaps.

3. **Future view and Trend identification**. Creating a new idea that can stir up the market takes capturing the right signals and insights that are usually overlooked by most startups. In the design process model, the purpose of the problem articulation part is to explore the breadth and depth of contextual knowledge in the early problem identification stages of this innovation process. These steps are even part of design thinking or lean startup processes. But, for organizations, research leads us to contemplate that background knowledge gathering is relatively insufficient (Marion, 2021). Within the Problem Identification step, a wide range of technology and market trends should be studied. Even analyzing the current field is not enough to get even better insights. It is essential to consider a large number of external factors that will make the initial part longer than considered in the default of design thinking or lean startup efforts (FDT). In gathering preparatory knowledge, can be useful for casting a broader net on the market and more long-term trends and weak signals should be understood. However, these indicators of future change pose basic problems of identification and interpretation. Thus, the practical significance of these future signals is that they can be transformed into meaningful insight. However, these insights don't emerge automatically. Realizing this potential requires a degree of tolerance and fluidity of the collective cognitive frameworks by which weak signals can be apprehended, assessed, and acted upon (Mendonça et al., 2012)
4. **Steps to reach the desired future.** Smaller organizations like Startups and SMEs tend to plan very little for the future (Nicloussi, 2017). This is due to the uncertainty with the area they are operating in. So, they tend to Focus less on the bigger picture and align the future and more on the iteration loop and they believe they will get their final products through experimentation and customer feedback. Even business plans are discouraged in the community in the lean startup approach because business plan fails to contact the customer (Blank, 2013; cf. Blank and Dorf, 2012). Instead, they are so focused on the current product or service they are exploring they lose sight of vision. Also, none of the innovation methods provides startups with specific guidance about the firm's unique strategy, commitment, and point of view. The Business Canvas Model can be seen as a reality map for a strategy or an effort to map everything. But without providing guidance on how to navigate around this map. The map should provide the starting and end state and how to reach these states but in the case of BMC, it is not that simple (Felina et al., 2019). Working through the nine business model sections does not provide the definition useful for a map or a unique or useful strategy or theory. Given this reason, the elements lack a clear definition (Foss and Saebi, 2017; cf. Teece, 2010). While vision, strategy, and theory are mentioned throughout the lean startup literature are not given much-needed importance. Therefore, more defined tools are needed to guide startup journeys and provide them with more planning assistance.
5. **Faster development makes it harder to maintain quality.** Development in most startups is done in strict timeframes and resource constraints; still the focus is on faster products and services (Aleem, 2021). Speed offers the competitive advantage in the landscape of being the first one to capture the market, namely "first mover advantage" (Cooper, 2019). Speed enables the means to launch the product in the same market unchanged by moving time and also speed quicker realization of gains. That is why the goal of reducing development time is valuable. However, that speed is only an interim objective, the ultimate goal being profitability as quickly as possible. Studies also reveal that speed and profitability are connected, and the relationship is proportional closely to one by one (Griffin, 2002). On the contrary, methods used to reduce development time turnout have the opposite effect and in many cases are

proven very costly (Crawford, 1992). The objective of startups is to make successful products, not a series of fast failures. Often emphasized in many startup theories as "Fail Fast". Additionally, increasing too much speed results in a compromise in the product. Even the faster development in some organizations – a lot of product modifications and line extensions that can be done quickly, results in a shortage of truly innovative products. Unfortunately, the quality of execution on many new product projects is noticeably poor. Decades ago, the causes of the failure of new products were identified and serious shortcomings in the implementation of new product projects were revealed: lack of market research, poorly implemented launches, weak business cases, etc. One early study of new product failures showed that market research was poorly done in 73% of projects, product launches were weak in 54%, and product testing was deficient in 49% of the product failures studied (Cooper, 2019).

5. Discussion

According to the data, we gathered most of the startup bases there have gaps in their decision-making process driven by incomplete guidance of countless methods. The following section presents a detailed (Table 2) comparison of both gaps identified in the innovation strategies, based on the aforementioned data sources (related literature interviews, and process models), and how these strategies can be aligned to provide solutions. More detailed descriptions of the respective issues can be seen in Chapter 4.1: Shortcomings.

The research conducted led to ideas of what a successful solution should consist of. After gathering background information, a blend of FT, DT, Lean, and Agile processes was applied to prototype a solution tailored to Startups and their needs. Once insights were gained from each interview, comparisons with the literature led to strategic gaps. These gaps have been strongly emphasized in both the text and the solution.

Table 2: Comparison table of the failure reasons gathered and solution to the problems.

STRATEGIC GAPS IDENTIFIED	RECOMMENDED SOLUTIONS
1. Future views & Trends knowledge not considered.	Introduce macro, and micro trend identification and weak signals early in the process.
2. Missing a common Vision of the future within the team	Enable sharing of Mental Models So everyone can agree on the shared future vision.
Ideas Viability not considered fully	Enabling the insertion of market and user data points and implementing feedback at right time.
Unable to Maintain Steady Quality	Introducing the quality gates in the process to be passed before moving to the next feature.
Steps to reach the desired future	Allowing detailed planning of the steps with teams and sharing ownership and dependencies of the tasks.

Source: Developed by the author.

The solution and design for the process had the following steps:

1. Studying the literature on startup innovation methods and failure reasons.
2. Conduct Interviews with startups to get field insights.
3. Develop solutions-based tools for different gaps.
4. Iteration of the solution prototype.
5. Evaluate the success factor by testing with a startup.

5.1. Platform

To create a seamless collaboration toolkit that can be used on different platforms and also make it easy to manage the platform "Miro" is selected. It is an online whiteboard app used for visual collaboration. This platform was used, by me, during the Covid era collaborating on different projects that included planning and execution of various projects. It is an easily adaptable tool that makes working in distance mode simple. It also offers various features for solid brainstorming sessions, such as creating simple wireframes, digital sticky notes, strategy mapping, Agile cards, and more that are used in the toolkit. Miro also integrates with 100+ tools that you already use such as Google Docs, Jira, and Zoom. Also, Miro is free to use with most of the features available (in the free version) and anyone can sign up on it even without an organization emailing it.

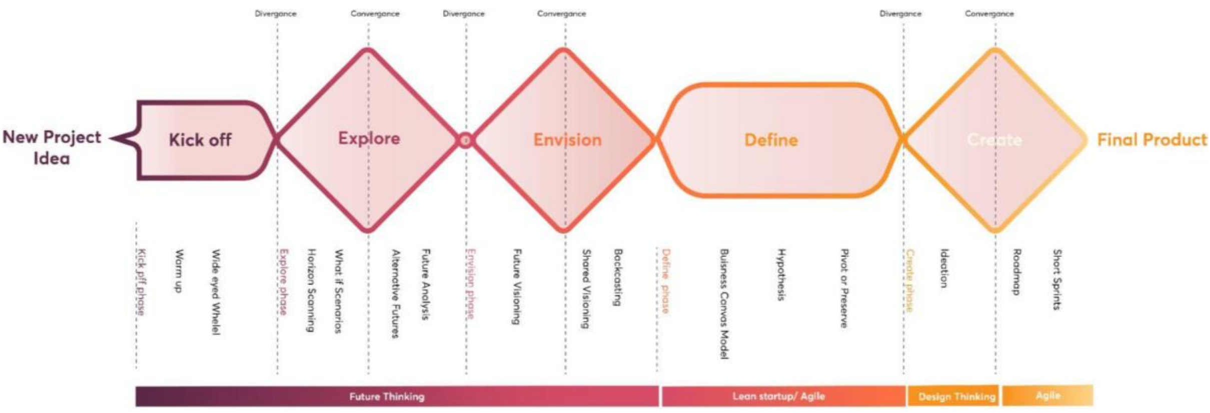
5.2. Process Design

The solution to the problem started with thinking of a tool that can help to provide useful input. But on later studying the literature it came out the tools are often used incorrectly or not to their complete potential. This led to the evolution of a workshop for the Agile Future Creation toolkit. That later grew to a complete method that follows the project from start to end, more or less a long-term plan.

This was given the need for a new innovative method that is hinted at by many articles and journals but none of them properly defined it to give a shape. The AFC methodology was developed, reframed, and iterated multiple times to ensure the free flow of information gathered in each step. At the same time remember that this toolkit is still at its initial prototype stage that is to be improved after a course of action in the industry

The time duration of the steps can be adjusted depending on the organization and the stage of their development. The toolkit can be used by startups at any stage to reframe or future-proof their solution. However, it is recommended to use this toolkit at the initial stage of the venture or at the beginning of the project to avoid getting stuck on more worked ideas. The AFC methodology can be divided into 5 phases which follow the direction of divergence where the phase explores multiple exploratory frameworks and Convergence where various ideas are combined to create a more aligned direction (Figure 3) listed as:

Figure 3: Agile Future Creation Methodology.



Source: Developed by the author.

0. Introduction. The process starts with a small meeting with the company or representative of the project where the hopes and goals expected from this project are discussed. The initial meeting also discusses the timeline, problems, and opportunities the company sees in its current state. Then the number of participants according to organization size is discussed, to include the members with decision powers and direct involvement with the project. The goal of the toolkit is to simplify it to the maximum effect, allowing the use without the help of the external consultant or agency. In that case, a person with familiarity with the innovation method can guide the process to summarize the steps and keep track of insights produced.

1. Start/ Kick Off. The project begins with a consultant introduction to the team. The first part is focused on creating an open dialogue among the team to get everyone inspired to make contributions. The part starts with a team-building warmup activity that enables appreciation for the diverse thinking mindset required for the workshop to proceed. After the activity, it's time to indulge the team in the topic and get their current understanding of the topic about the opportunities and threats. This creates an open environment for the exchange of ideas about the current project based on the current mental model. This step can be defined as the start of divergence.

2. Explore/ Discover. This part picks after the previous part to highlight how different parts of the organization have different insights. So, it's time to deepen what the future market can be for the organization. This tool of Horizon Scanning is introduced with prompts to guide the team to focus on findings that are posted on the common board to let everyone be aware of others' results. This part runs for 2 days after that the results are discussed to highlight some interesting findings.

For the next part of exploring the future, signals from the future are selected. Based on the interest and pre-defined signals from the consultant. These signals let members of each team create a future version of the selected signals.

In the next step, the different futures are placed on a single board where each member describes their designed futures. These futures are then reorganized by the teams based on the preferences of all team members.

The last part includes the analysis of different preferred futures to gain new opportunities, threats, and actions for different realities. The step widens the horizon of the people in the organization and also educates them about selecting the future that is beneficial for them. This phase starts with the divergence into the future and converges into the selection of drivers and later again diverges to different realities.

3. Visualize/Envision. After gaining new perspectives, this step unfolds the participants to dream about the organization's future in 5 years. It is done by using visual tools, a Magazine cover of the future. First, in this phase, every member visualizes their version of it. In the later step, all of the future is discussed and combined by the team members to agree on a Shared vision of the future. This includes fusing the most promising attributes of the future and envisioning creating a new shared future where everyone sees himself contributing to making it happen.

After achieving the vision now it's time to trace back the steps to the present and decide how to make it happen. For this part, Backcasting is used to plan timelines, goals, opportunities, and resources to make this future happen. This step starts with diverging. to different futures to converge to create a common one.

4. Define. This phase encompasses more vivid planning of the idea to understand the different segments of viability. It begins by reframing the BMC (Business Model Canvas) after new-found directions for the venture. It can be explored by going through each section and reading the prompts.

After filling this a business hypothesis is generated. This is the core behind the business that leads to the experimentation of Hypothesis by using a Minimum Viable Product (MVP). This MVP is tested with the customer and results are reviewed with the team and stakeholders. Based on feedback the pivot or preserve approach is tested to finalize the direction. This phase is based on converging on an idea to define its elements.

5. Create. The creation begins with the Ideation of the solution proposed by MVP. Now the solution is defined in more directions and the best one is chosen by team voting and analysis.

In the next step, the team is involved in deciding the detailed Roadmap for the next set of periods by highlighting the short-term and long-term goals. The goals are converted to tasks that are distributed and shared between different departments. This also includes the details like ownership and responsibilities of tasks and tracking of the timeline function.

The task is completed by running interdepartmental sprints that are tested with the user to build production quality and then repeat for the next task. The goal of this step is to let a transparent development work culture with an open sense of responsibility emerge. This helps the team to work on details without losing the bigger picture. This Step starts by diverging and then later converges.

5.1. Optional Step. Building a Partnership is an optional step that depends on the venture's need to develop a partnership or alliance with another venture if the need arises. This tool walks through the steps of how to manage the alliance while updating the team on the timeline that should be followed in this scenario.

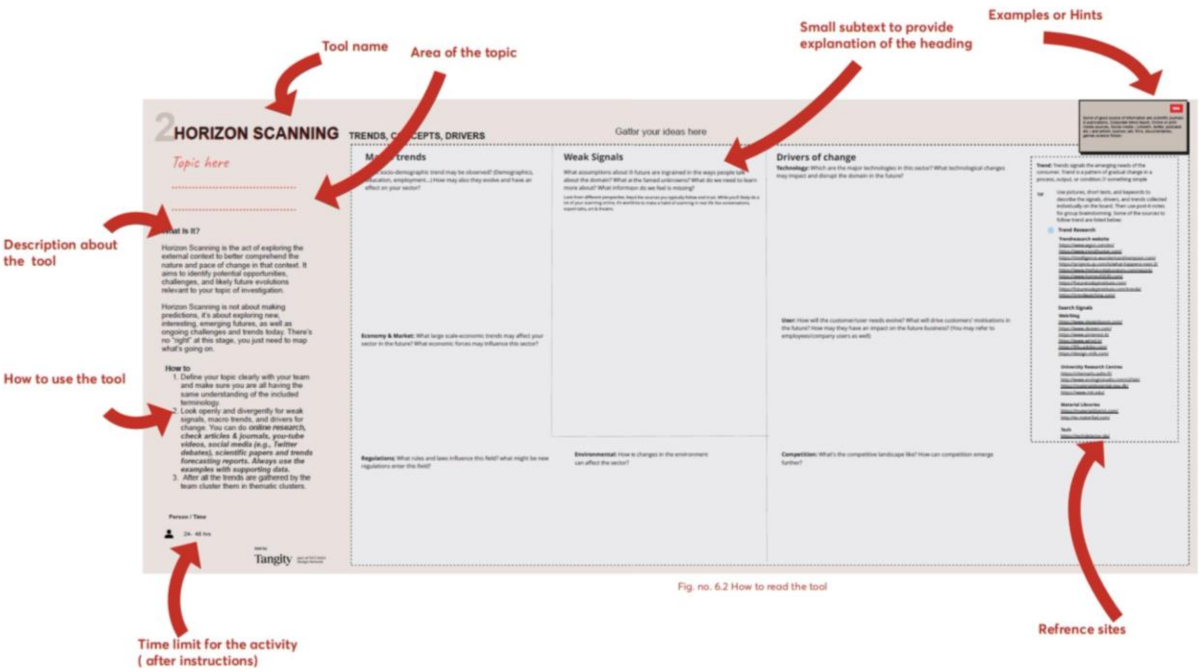
5.3. Facilitator Guide

This AFC toolkit provides a guide to introduce future thinking tools in addition to industry-opted DT and Lean startup methodologies. The toolkit can be accessed online at the Miro link. The Miro link also includes a facilitator guide with an explanation of each tool. From the link, it can be copied and pasted onto other Miro boards to allow modification of the tools. The link is as follows: https://cutt.ly/h7pbzCR.

5.3.1. How to Use (Figure 4)

i. The Index. Table 3 provides a brief description of each tool. These tools can be used separately to achieve a particular goal or in the cycles mentioned.
ii. Detailed info. The first page of every tool has detailed information on what this tool is and how you can use it by following the steps.
iii. Tips. These sections provide clues, hints, and examples for the tools.

Figure 4: How to use the toolkit.



Source: Developed by the author.

5.3.2. When to Use

i. i. Starting of a project. Using the explore phase helps you map out the innovation drivers in a systematic manner.

ii. ii. Reframing the project. Tools can also be used to reframe existing projects to add more drivers to include in the existing project.

5.3.3. Who to Involve

Bringing a diverse group of people from different departments will offer greater results. By considering each side of the project. Including external stakeholders can also be beneficial. The number of people to be involved depends directly upon the complexity of the project. The goal is to think of all the sides of the project.

5.3.4. How Much Time to Spend

The time you spend on each tool should depend on factors such as Participants' previous experience with forecasting, their knowledge of contextual factors, and what you want to take away from the workshop. The suggested times for each tool are a guide only and you should assess what is right for your group.

Table 3: The Index of Agile Future Creation Methodology.

	Tool	Use	Duration
Future Thinking	The wideeyed wheel	Reflection on current knowledge about hopes and worries about the organization	60 minutes
	Horizon Scanning	Deepen the knowledge current and future market prospects	24-48 hrs
	What If	Provides open and lateral thinkinga-bilities by creating future dialogs.	60 minutes
	The Alternative futures	A discussion channel to slect prob-able and prefrable future for the organization.	60 minutes
	Future Analysis	A tool to sum up the future explora-tion journey to gather new oppurtuni-ties, threats and actions needed.	60 minutes
	Future Visioning	A tool to help create a Shared Visual-ization of future for the orgnization in next 5 years .	1 hr 30 minutes
	Backcasting	A toohelp mapping the future by cre-ating the possible actions in present.	60 minutes
Lean Startup	BMC	A visual repersentation of founda-tions of a buisness idea to test its viability.	1 hr- 4 hrs
	Hypothesis	A tool to create a early stage low cost testingenvironment for Buisness Idea.	May vary
	Pivot or Preserve	A set of Questions to ask after measuring milestone performance to determine change in direction.	Ask after achiving milestones.
Agile and DT	Ideation	A set of methods to create product ideas from MVP.	12-24 hrs
	Roadmap	A tool to plan, execute and monitor-product devolpment journey.	1 hr- 2hrs
	Short Sprints	Devolpment method to create the product using roadmap backlog.	Depends upon the feature
	Building PartnerShip Map	Tool to manage and create partner-ship aliiances.	May vary

Source: Developed by the author.

5.3.5. Additional Tips

Remind participants to keep an open mind. by learning from each other and about the process in order to gain a better understanding of the company and identify possible differences in how the company is perceived. Try to encourage the "less powerful" to speak up first. and "more powerful" to speak at the last Distributed materials (i.e., worksheets) only after the step has been explained.

6. Conclusion

The process started with a personal goal of finding reasons for most startups not making it in the big game. Through extensive research, I was able to identify some of the generic reasons and also the reasons (team sharing a similar vision, viability, quality, etc.) that are often overlooked but play an important role in the success factor of a venture.

The other important discovery was the missing knowledge about Future literacy in the startup community and also in industry-practiced innovation methods. Currently, these methods are only used in academic sectors and advanced policy sectors. It is often seen as new ventures often give very little consideration for the future. They never try to identify the bigger trends and weak signals data from the industry. So only focusing on very short-term trends often are already saturated and by the time the product is ready they often fade away. Relying on the market to drive the venture direction often led them without any solid vision.

Incorporating FT can help change the mindset and prepare a more exploring direction in the venture. To identify better opportunities and threats provided by the market. Also doing so can provide a better shared vision between the team members. So, they can guide their startup to success. The outcome of this research was a toolkit that uses already market-practiced Design thinking and Agile practices in the blend of adopted Future Thinking to work in a more flexible startup world.

To make this toolkit an approach of mixing literature with semi-structured interviews with startups was used. To get a bigger frame of reference the startups were chosen from different phases of their life, product development stages, and domains and 4 different countries were selected. But the sample size is too small to put all the startups with similar problems.

Due to the huge time frame required for testing the toolkit, it is very hard to follow up on this complete toolkit during the duration of the research. So, more testing and reviews are required to refine and improve this toolkit better. Also, a data set of problems and insights from more startups can provide more useful insights and patterns that haven't appeared yet.

One goal of the toolkit was also to design it to make it so simple and easy to use so it can be used by startups on their own but while doing reviews with startups it has been realized that without the need for an external agency or facilitator but without having an open mindset and future literacy the results are often constrained. So, an initial innovation workshop like the one hosted by IDEACTIVITY lab DC4DM can help build these skills. And later on, the toolkit can be made easier to use with more samples collected on the open-source platform. So, this Toolkit work will be modified after reaching more runs with the different ventures.

This research aims to develop a set of tools that will be implemented on an open-source website. The template is already added to Miroverse, which is a platform that allows for easy sharing and replication of templates. This will ensure that the tools created can be accessed and used by anyone for their product development. Additionally, a tutorial series on toolkit implementation with examples will be added to the website to assist users in understanding how to use the tools effectively. The toolkit will undergo numerous iterations and feedback collection to ensure it takes a better shape over time. Information will be added and removed as necessary to improve the tools' functionality.

One of the major goals for future development is to create more user-friendly multi-party platforms. These platforms will be equipped with prompts and sorting features to make it easier for users to navigate. The system will also provide real-time suggestions and track the progress of the project. The objective is to make the tools operational without the need for a facilitator. This will be achieved by utilizing AI-generated tips and responses to create a software variation similar to the failure reporting, analysis, and corrective action system (F.R.A.C.A.S.).

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This work continues the work on Future Thinking and literacy done by others. It wouldn't be possible without the research material of DC4DM, Futurice, Tangity, and Nesta.

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Appendix

Interview Mini Script:

[Introductions] Thank you so much for taking the time to participate in this research. It means a lot to me, and will hopefully contribute a lot to the startup community.

[Review of Consent, Emphasizing the right to withdraw within 14 days]

1. First, can you please tell me your position title, organization, and industry to confirm the information I have? Your personal identifiers will be secured and private, nothing will be published or publicly accessible.
2. What is the approximate number of employees in your organization?
3. Do you have a role in your organization's articulation of strategy? Please explain the process. a. What works and what doesn't work? b. Are there any aspects that could be improved during planning? c. How far into the future does your organization plan?
4. Do you feel a need to set up the vision? If yes, what were your wishes and goals at that moment?
5. Were you visioning techniques used to develop a shared vision of the future and, if so, which? a. If yes, were they useful? b. If not, do you think your organization could benefit from the use of visioning techniques?
6. Does your company consider the outside environment (market trends & changes in society) while making strategies? a. If yes how (any toolkit or method) b. Do you categorize them?
7. Does your organization ever use a goal you want to reach and work backward to the present?
8. How does your organization articulate its vision? Has it changed? a. How often is it reviewed? b. Do you think your organization would benefit from periodic reviews of the vision and its progress? c. Please provide examples.

9. Are you familiar with BMC (Business Model Canvas)? a. When did you create it and with whom? b. Was your core team involved in it? If not, why?
10. How does your organization work with new idea development? a. How do you decide if you will stick to it? or change the direction?
11. How do you plan the product development cycle/ Plan? a. Who are people included while planning?
12. Do you rely on partnerships for development needs that don't come into your area of expertise? a. How do you identify them b. How do you decide to keep working with them?
13. Thank you so much. Is there anything else you would like to add?

Ethical Statement

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Psyment: advancing digital transformation in psychological assessments and diagnosis for healthcare facilities and organizations

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Abstract

This project analyses and discusses the current methodologies employed by mental health professionals in using cognitive assessment tools within clinical settings, presenting a comparative analysis of traditional and modern approaches. The study aims to address the evolving needs of healthcare professionals by exploring innovative digital solutions. Through interviews with four healthcare professionals, we sought to identify the challenges and opportunities associated with existing cognitive assessment practices. Participants highlighted the overwhelming nature of traditional paper-pencil methods and expressed interest in digital tools that could facilitate psychological testing processes. Healthcare professionals emphasized the need for a supportive platform to aid in the application and management of cognitive assessments. Based on these insights, our primary objective is the development of *Psyment*, a user-centered web-based platform designed to streamline the creation, administration, and evaluation of cognitive assessment tools. The introduction of *Psyment* is expected to equip healthcare professionals with adaptable resources that enhance patient communication and optimize workflow efficiency in dynamic clinical environments. Our overarching goal is to drive digital transformation within psychology and healthcare organizations. *Psyment* aims to significantly improve patient outcomes by providing healthcare professionals with intuitive digital tools tailored to their needs. This study emphasizes the importance of user-centered design in addressing the evolving demands placed on mental health professionals. In conclusion, this project underscores the exploration and development of user-centric digital solutions to support mental health professionals in their daily practices. The creation of *Psyment* represents a step towards enhancing clinical efficiency and patient care through innovative technology.

Keywords: Digital Media; Digital Transformation; Technological Innovation; Technology.

Introduction

The amount of mental health problems is increasing in our society, and more people are displaying symptoms of different diseases (Pinto-Meza et al., 2013). Assessing and resolving these problems is the responsibility of mental health experts, who use a variety of tools and tests for diagnosis and treatment planning (Silva et al., 2022). However, many of these assessment instruments continue to be paper-based. Although these are methods that have been used for many years and have proven results, this process can be time-consuming (Zadikoff et al., 2008). Thus, there is an opportunity for modernization and enhancement of evaluation techniques.

Technology is increasingly present in people's daily lives and facilitates countless tasks of various natures. Health stands out among various dimensions as an area where the impact can be particularly significant. Semantha et al., claimed that *"In this digital age, we are observing an exponential proliferation of sophisticated hardware- and software-based solutions that can interact with the users at almost every sensitive aspect of our lives (…)"* (Semantha et al., 2020, p. 1). The rapid growth of technology has opened the door to novel solutions in mental health care, providing the opportunity to shorten assessment processes and improve patient care.

Also, according to Thimbleby, *"Technology drives healthcare more than any other force, and in the future, it will continue to develop in dramatic ways."* (Thimbleby, 2013, p. 160). It is unquestionable how much technology helps and drives the evolution of areas such as healthcare (Bardhan & Thouin, 2013; Heathfield et al., 1998); it provides several advances in the provision of services, new equipment, education, communication, and management (Aceto et al., 2018; Alloghani et al., 2018; Guo et al., 2016; Yao et al., 2012). Therefore, the lives of health professionals and patients are made more seamless and supported by the functionalities offered through technological evolution (Heathfield et al., 1998).

Following the COVID-19 outbreak, the healthcare landscape observed a flow in the adoption of information and communication technology (ICT), making its adoption into our daily routines more prevalent (Paul et al., 2023). These technologies are designed to enhance patient interactions, improve healthcare workflows, and change with the needs of the user. However, few platforms exist to help mental health professionals (HP) reduce their workload related to cognitive evaluation processes such as PsyPack (*Online Psychometric Testing Software for Behavioral Health Professionals—PsyPack*, n.d.) and Therasoft (*Practice Management Software for Therapists | Therasoft*, 2021); most of the technologies available are for scheduling appointments with health professionals and to reach and communicate with patients easily. They mainly facilitate the healthcare practitioner-patient interaction like PsicoReg (PsicoReg, n.d.), BetterHelp (*BetterHelp - Get Started & Sign-Up Today*, n.d.) and TalkSpace (Talkspace, n.d.).

Therefore, there is an opportunity for the digitalization of mental health professionals' methodologies. We found some technologies designed to assist psychologists during the assessment procedure such as PsyPack (*Online Psychometric Testing Software for Behavioral Health Professionals - PsyPack*, n.d.), Psytoolkit (Stoet, 2017) and PsicoReg (PsicoReg, n.d.). These can be used by healthcare professionals (HP) in daily practice. Nevertheless, the utilization of these tools is selective, presenting a potential constraint for HP. For example, one of the tools (Psytoolkit) requires some understanding of technology, as users are required to know programming. This technical requirement may serve as a barrier for individuals who lack coding skills. Another identified obstacle is the challenging transition and adaptation phase from traditional paper-and-pencil-based methods to technology-driven materials. Health professionals may face barriers due to their entrenched familiarity with conventional assessment techniques (Jarva et al., 2022; Konttila et al., 2019).

The inability of mental health practitioners to effectively use a digital tool or instrument hampers the realization of its maximum potential benefits. The level of competence is directly associated with it as reinforced by Konttila et al., stating that *"(…) In the healthcare sector, it is important to recognize the impacts of competence in digitalization, as insufficient competence of healthcare can (…) increase the incidence of errors (…)" and "(…) insufficient competence can lead to negative experiences of technology usage, which will influence attitudes towards the adaptation of other technologies (…)"* (Jarva et al., 2022; Konttila et al., 2019, p. 6).

Konttila et al. also stated that professionals' experience with digital tools has a direct impact on their willingness and motivation to use technology. Also, HP require extensive knowledge and skills to incorporate digital methods into their clinical process to maximize patient care (Konttila et al., 2019; van Gils et al., 2024). One possible solution to mitigate the potential consequences of a lack of competence is to integrate a systematic education program that prioritizes the development of individual skills alongside the digitalization process (Jarva et al., 2022; Konttila et al., 2019).

Additionally, collaborative design with multidisciplinary teams is key. By engaging health professionals, designers, and developers throughout the software development lifecycle, organizations can ensure that digital tools are user-centric, intuitive, and aligned with clinical needs. This inclusive approach not only enhances adoption but also fosters innovation and drives meaningful advancements in healthcare technology.

Examples of collaborative software developments can be seen in Berry, N., et al, who developed an application to deliver cognitive behavior therapy-based interventions by inviting several participants from different fields such as computer scientists, clinicians, software engineers, and academics (Berry et al., 2020). Further instances of collaborative efforts in software development are evident in (van Gils et al., 2024). The authors performed a usability study of a digital tool that supports the diagnostic work in a clinical context, employing both quantitative and qualitative data analyses to draw conclusive findings. Another important aspect to consider is privacy and cyberattack-related issues when developing digital applications for HPs. The impact of cyberattacks can be devastating, resulting in significant financial losses for affected companies and damaging their reputation and credibility. These incidents undermine essential values such as reliability and trustworthiness. (Kamiya et al., 2018; N, 2018; Whitler & Farris, 2017).

This article presents insights gathered from interviews with four HP, shedding light on the primary challenges and requirements they encounter when utilizing conventional assessment tools and to gather initial software requirements for the development of *Psyment*.

Methodology

Participants

We gathered qualitative data through three semi-structured interviews at the University of Madeira and one at Casa de Saúde São João de Deus to understand the current methodologies applied during clinical cognitive evaluation as well as to gather a better understanding of the main issues faced by them in this area of mental healthcare. The sample was a convenience sample as these participants were readily available to participate in this study. All the psychologists interviewed still apply or have applied cognitive tests at least once in their professional experience. All of them have different years of experience and specialties, which can affect their point of view regarding the usage of technology in their daily work. The demographic information is shown in Table *1*.

Table 1: Participants demographics.

Psychologists Identification	Years of Experience with Testing	Background of Application of Tests	Main Field of Experience	Institution
P01	4	Applying tests to children	Criminal psychology (justice) and research	Madeira University
P02	13	Applying tests to general people	Clinical psychology and research	Madeira University
P03	3	Applying tests to general people	Neuropsychology	Madeira University
P04	10	Applying tests to elderly people	Clinical psychology	*Casa de Saúde São João de Deus*

Procedures

The experimental setup of the interviews consisted of three semi-structured interviews at *Madeira University* that followed a script and one informal interview performed at *Casa de Saúde São João de Deus*. All psychologists interviewed consented to their participation in this study, which allowed the team to record the interview audio. Photo-taking was also allowed if necessary. However, the psychologists' identity is protected and confidential. During the interviews, we took notes on some topics considered important that were mentioned by the interviewees. Regarding the questions asked, within the script, they were created to specifically answer some doubts regarding the psychologists' methodology when applying paper-pencil-based assessment tools. We outline questions such as *"(...) In a real appointment, instead of using paper and pencil, do you think that it would be beneficial for psychologists to use a computer or a tablet?", "(...) Do you think the state of the technology used in psychology is still antiquated or is technology already well-established in the psychology area during tests*?*"* After analyzing the interviews, we divided all answers into four themes: *1) Problems with psychological test assessments, 2) Psychologists' methodologies, 3) Technologies used by psychologists,* and *4) Awareness about data security and security requirements.*

Results

Each of the four participants responded to the questions posed during the interviews. Regarding theme *1) Problems with psychological test assessments,* participants mentioned that some cognitive assessment tools (CAT) are too complex *"BSI analysis is complex because it has many scales (…)"* They also said that "*(…) paper-based psychological tests are too much work (…)"* and "(…) (they) would like apps to calculate the tests for us (…)". Also, they drew our attention that "*Test results (e.g., WMS, MoCA, MMSE) are relative (*to *interpretation)".* Regarding the theme *2) Psychologists' methodologies,* participants said that they normally share their tests with colleagues and/or compare the same test applied at different timings. As for *3) Technologies used by psychologists,* participants mentioned using *Microsoft Word, Excel,* and *Google Drive* as their choices for daily work. Finally, regarding *4) Awareness of data security and security requirements,* it is important to ensure the confidentiality and robust protection of patients' data and cognitive test results. While maintaining strict privacy standards, there may be instances where the exchange of information between healthcare providers is necessary. From a general point of view, the interviews conducted with HP indicated that there is a potential gap in the health industry to build an application capable of creating, managing, and assessing health-related tests since all participants in the interviews clearly showed interest in this idea.

Discussion

As previously outlined, we conducted three semi-structured interviews at the University of Madeira and one field study at *Casa de Saúde São João de Deus* to understand the current methodologies applied during clinical cognitive evaluation as well as to gather a better understanding of the main issues faced by them in this area of mental healthcare. All the psychologists interviewed still apply or have applied cognitive tests at least once in their professional experience. All of them have different years of experience and specialties, which can affect their point of view regarding the usage of technology in their daily work. Although they use some kind of technology (e.g., Excel, Google Drive) to support their paper-based assessments, there is currently no dedicated software in their workflow that comprehensively meets all their requirements. Depending on the institution they are affiliated with, mental health professionals employ various approaches to calculate test results. Common methods include manual calculations, inputting responses into an Excel file for analysis, and utilizing a projector with an acetate sheet overlaying correct answers on test sheets to expedite and streamline the assessment of correctness. This exacerbates the challenge for mental health professionals who rely on paper-and-pencil methods for test administration, as it renders their testing processes more intricate, necessitating numerous steps. Additionally, the requirement to employ various software solutions during the test application process can potentially lead to more tiresome procedures.

If we think about the fact that psychologists apply tests on paper, then they have a logical process of scanning the document (mentioned in the interviews), registering the results for each question or domain in a spreadsheet (*Excel*) or manual calculation, and finally storing the results in a *Google Drive* folder. It can be inferred that it is a laborious, time-consuming process and that it is based on several external and independent systems, which could lead to increases in human error (Sameera et al., 2021). Consequently, the psychologists claimed that there is a necessity for the creation of an application of this type stating, *"(...)* what we would like in tests, is for computer applications to automatically score them *(...)"*. Still according to them, *"(...) technology professionals have an opportunity to help us (...)"* and *"(...) steps need to be taken towards having the majority of the tests computerized (...)"*. These instructions highlight, again, the need for psychologists to have their work methods more computerized, following a digitalization trend that is seen in so many other areas.

Despite this, another fact that has been debated by psychologists is the fact that the lack of digitalization is costly for patients. According to the interviews, the time-consuming process of correcting a test means HPs are unable to provide an immediate evaluation in front of the patient. Therefore, they are forced to reschedule more sessions to complete a possible diagnosis. As stated by P01, *"(...) As we cannot rate the tests in front of the patient, we send the patient home, and we schedule another session (...)"*. This approach is inefficient and more expensive. The same psychologist mentioned that since they need to schedule another session, the patient needs to pay for the new appointment. Regarding Portugal law, the private health sector is paid while the public is free. As so, psychologist P01 specifically mentioned the private sector as *"(...) regarding the private sector, (...) they get more money in the second session (...)"*.

The transition process to digitalization in healthcare is not a straightforward one. The transition has a lot of specificities and particularities that need to be addressed. Additional barriers highlighted in the literature include factors such as high working hours and limited clinic time, which can hinder HP from effectively learning and integrating new tools into their daily routines (van Gils et al., 2024). While existing software solutions, provide useful functions for assessment and treatment planning, they may pose usability challenges for healthcare workers, particularly those with low technical skills. For example, the *Psytoolkit* (*PsyToolkit on the Web Server*, n.d.) requires users to program surveys which can be overwhelming for users with low technical skills. Furthermore, some tools lack integration with the Electronic Health Record (EHR) system, necessitating users to log in to a separate platform and duplicate data entry—once in the EHR and again in the tool which is time-consuming (van Gils et al., 2024).

Another arising concern with the adoption of technology for digitizing the testing process and its evaluation is the ownership of copyrights for most tests held by private organizations or associations. For psychologists to use these tests, they need to pay for each time they use them or pay for a right-to-use license, depending on whether the organization allows it or not. Hence, it incurs a financial cost, which must either be provided by the health professionals who wish to use the materials or sourced from their workplaces. This condition can be an inhibitor of the digitalization process, as organizations might not have the financial resources to acquire all the tools requested by the professionals, especially in some specific circumstances and/or realities (e.g., organizations led by governments).

Furthermore, given the variations in evaluation processes across institutions and among health professionals, the newly developed digitalization materials must exhibit a high degree of flexibility and adaptability. Divergent work methodologies reflect distinct perspectives on work, leading to disparities in knowledge and skills. However, developing a tool of this nature is intricate, involving the consideration of various levels of complexity and demanding a deep understanding of psychologists' methodologies. As mentioned in the interview with psychologist P01, *"(...) the analysis of each test depends a lot from test to test (...)"* and *"(...) the tests that evaluate more valences may be more challenging to be introduced on the platform (...)"*.

Another crucial aspect to consider in the digitalization process is ensuring the security of sensitive information. Digital applications handle confidential data that requires protection, a concern well acknowledged by HP. According to the interviews, *"(...) tests must be confidential (...)"* and *"(...) tests must be (...) destroyed after some time (...)"*. Furthermore, *"(...) ensure data confidentiality (...)"* and *"(...) psychologists should not be capable of accessing old registers (...)"*. As is known, the number of recent cyberattacks that have been witnessed in organizational sectors (Kamiya et al., 2018).

The literature study findings supplement the insights gathered from interviews with healthcare professionals, offering a thorough picture of the obstacles and opportunities in contemporary mental health screening procedures. Thus, the development of *Psyment* aims to close this gap by offering a user-friendly platform that simplifies assessment procedures and improves patient care. We aim to develop an easy interface with simplified procedures, allowing users to design, manage, and store assessment tools without needing substantial technical knowledge.

Drawing from strategies highlighted by (van Gils et al., 2024) and (Berry et al., 2020), a key approach in software development involves engaging potential stakeholders to assess their current needs within diverse contexts. In response to feedback gathered from these interviews, we initiated the development of an initial prototype called *Psyment* (short for Psychology + Assessment). *Psyment* is being developed as a web-based application using node.js (*Node.js—Run JavaScript Everywhere*, n.d.). We aim to develop a prototype that allows HP to create, modify, and utilize CAT. Moreover, to aid healthcare professionals during the CAT analysis, we aim to add functionalities to automate CAT result calculations based on predefined formulas established during CAT creation; also, it will feature a user-friendly graphical interface (GUI) for streamlined data analysis of patient results.

Another feature that we aim to implement is the sharing of data between other HPs, which is a functionality that was considered useful during the interviews. For example, P01 stated *"(...) There is an exchange of knowledge between psychologists (...)", "(…) this colleague sends it by e-mail or facilitates it in some way. That's usually how it works (…)"*. This platform will be designed to encompass a range of benefits, including enhanced accessibility, improved interoperability, and simplified maintenance, while prioritizing the security of all users, including healthcare professionals, patients, and their data. *Psyment* will be engineered to adapt to various healthcare contexts, ensuring compatibility not only with desktop systems but also with mobile devices during evaluation processes.

Through prioritizing usability and user experience design, this project hopes to increase the adoption and use of digital assessment tools among healthcare professionals, ultimately enhancing mental health treatment delivery. By integrating insights from both the literature review and interviews, our platform seeks to provide a solution that addresses the different demands of healthcare professionals while also improving the delivery of mental health services.

Our goal is to foster confidence among health professionals in the realm of these technologies. The ongoing challenge of transitioning is already impacted by deeply ingrained habits, and the existence of unreliable technologies could exacerbate difficulties or even jeopardize the overall shift to a fully digital approach. There must be trust between HP and technology. To achieve this, the engineering behind software systems must have high-quality standards, since the tools use the personal data of both health professionals and their patients.

Moreover, the effectiveness of these tools is compromised when mental health practitioners encounter usability issues or lack proficiency in their use. This underscores the importance of supporting healthcare professionals through training and assistance to maximize the benefits of digital tools. As stated previously (see Introduction) the inability of mental health practitioners to effectively use a digital tool or instrument hampers the realization of its maximum potential benefits. Thus, should *Psyment* be introduced to the market, some initial users may require assistance from the platform's team to become familiar with its usage. Holding regular workshops with stakeholders could serve as a solution to support HP in utilizing digital tools during medical practice, which can increase product retention (Konttila et al., 2019), but also enhance the user experience of the platform.

Conclusion and Ongoing Work

The initial findings of our comparison analysis between traditional and modern evaluation approaches in clinical assessment highlight an opportunity for digital transformation in mental health. As mental health disorders continue to rise in prevalence, updating and enhancing evaluation methods used by healthcare providers becomes increasingly important. While paper-based procedures are common, they can be time-consuming, as revealed by insights from interviews with HP.

Technology holds promise in improving patient care and streamlining assessment processes for HP. However, obstacles such as the lack of user-friendly tools hinder widespread adoption in the healthcare sector. With the *Psyment* project, we aim to address these challenges by offering a comprehensive and user-friendly interface for creating, assessing, managing, and storing assessment tools. *Psyment* will be designed to adapt to the evolving needs of HPs, ultimately enhancing patient care and optimizing operational efficiency.

Furthermore, based on the initial findings of our project and scientific literature, we advocate for greater investigation and adoption of digital tools to advance mental health treatments into the digital age. We have recently completed the initial round of usability tests with HPs to assess the functionality and usage of *Psyment*, and we are currently analyzing the results.

Limitations

This study has certain limitations. Notably, the interviews were conducted with only 4 participants, potentially constraining the generalizability of our conclusions based on the responses obtained. Also, the inclusion of only four participants from a specific work setting may limit the generalizability of the findings to broader healthcare contexts. Therefore, future studies should aim to include a more diverse sample across various healthcare institutions to draw further conclusions from the results.

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Towards an analytical framework for AI-powered creative support systems in interactive digital narratives

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Abstract

Interactive Digital Narratives (IDNs) is an interdisciplinary research area related mainly to Narrative Studies, Design, Human-Computer Interaction, and Gaming. In this field, empirical investigations on using Artificial Intelligence (AI) support systems for creating IDNs are growing, demonstrating the value of exploring their potential. However, a systematic categorization of AI support system features and key elements is missing. This paper addresses this gap by presenting an analytical framework to describe and map such systems. The analytical framework is the result of multimethod qualitative approach, that combines mainly case study analysis with interviews. A total of 60 empirical investigations retrieved through academic and grey literature have been collected and analyzed, enabling to identify: AI support systems' types (*AI-based Creative Support Tools*, *AI Authoring Systems*, and *AI Support Systems for Interactive Digital Narratives*) and categories (*AI system structure, Creativity, Interaction,* and *Narratives*). A cross-case analysis of seven selected exemplary cases of the type *AI Support Systems for Interactive Digital Narratives* reveals needs, challenges, and research opportunities to fulfil. The main contribution of the framework for researchers, practitioners, and designers is its use as an analytical and generative tool to acknowledge existing and future AI support systems for creating IDNs.

Keywords: AI Support Systems; Analytical Framework; Co-Creativity; Human-AI Collaboration.

Introduction

Transformation is about change. Digital transformation can be strictly related to the discourse of *Transition Design* (Tonkinwise, 2019; Escobar, 2018), which stimulates designers to embrace the change of design paradigms that will lead to radical positive social and environmental change (Davis et al., 1993). *Transition Design* proposes new approaches to design and problem-solving techniques based on a deep understanding of the dynamics of change within complex systems so that designers can act as agents for change (Escobar, 2018; Irwin, 2015). According to Irwin, transitional design proposes that more compelling future-oriented visions are needed to inform and inspire designs in the present (Irwin, 2015). Design tools, systems and methods can aid in developing these visions. Designers deal with processes, systems, and projects; they need ideas to propose creative solutions to given problems. This paper is based on the doctoral research on *Human-AI co-creativity* by the first author. The PhD thesis investigated the relationship between designer and ai systems in the field of interactive digital narrative, contributing to a nuanced understanding of the subject matter under investigation (Serbanescu, 2024).

An IDN is construed as an interactive narrative artefact specifically crafted for engagement by the end-user called *interactor* (Murray, 2011), for whom it is meticulously designed to elicit interaction and through this interaction gain insights in complex issues. The authoring of an *Interactive Digital Narrative* (IDN) can be considered a design process, as it is a creative process considering goals and constraints that result in a product, the narrative engine, which addresses aesthetic, functional, economic, or socio-political considerations that help the audience to get a better understanding of complex issues (Dorst & Dijkhuis, 1995). Authoring as a process can be brief or lengthy and complicated, involving considerable research, negotiation, reflection, modelling, interactive adjustment and re-design. It is based on good conceptual models, which require good communication. As the process of authoring entails inherent complexity, the utilization of artificial support systems emerges as a viable strategy to streamline and enhance the efforts of authors in realizing their goals in the design of an IDN.

In this contribution, the author of the IDN product identifies himself/herself with the figure of the designer, the one who creates the IDN system in cooperation with an AI for a given type of interactor. The designer and AI system are considered here as complementary partners who collaborate in the creative design process of the IDN artefact. Therefore, the authoring process is considered part of the creative design process. The collaborative partnership between the designer and the AI system underscores the imperative for the designer to cultivate a nuanced understanding of the AI system, thereby establishing the foundations of a co-creative relationship.

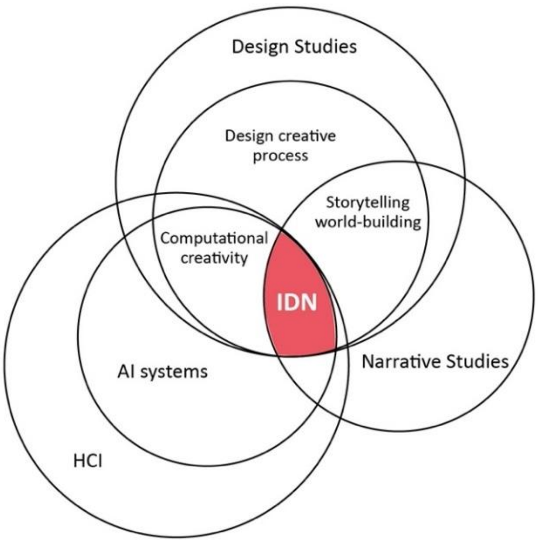
We look at the design process through an AI lens, where the AI acts as a complex support tool for creating IDNs in the form of interactive narrative co-creativity experiences. Many AI support systems help in creative design processes, such as *AI-based Creative Support Tools* (CST) capable of enhancing the creative process and *AI Authoring Systems* that help build stories. Examples of co-creativity experiences between AI and human designers can be found in systems for the design of stories and narrative worlds (Sineglossa, 2019; 0/0/0000 0:00:00 AM, storyboards (Bernal et al., 2019a), interactive stories on social platforms (Yanardag et al., 2021), or art installations that tell a story (Benediktsson, 2019).

The investigation presented in this study approaches the problem from a transitional design perspective and explores the role of AI in the designing of IDNs. In the present investigation, we introduce an analytical framework to provide the requisite information to enable the comprehension and mapping of AI systems. The objective is to facilitate the designer's comprehension and navigation of AI systems, thereby aiding in the development of IDN artefacts. Furthermore, we illustrate the practical application of this framework by examining case studies, thereby demonstrating its efficacy in realistic scenarios. The paper aims to understand better what type of artificial help in a system can be utilized to facilitate IDN designers in achieving their vision of building appropriate narrative environments that enable interactors to comprehend complex issues.

2. The Interdisciplinary Field of IDN and AI Support Systems

IDN as a domain is interdisciplinary, being situated between scientific and humanistic domains (Snow, 2012). From the point of view of tools, processes, and methods, it addresses three main disciplines relevant to this work: Design studies, Narrative studies, and Human-computer interaction (HCI) (Figure 1).

Figure 1: IDN research field map.



Source: (Serbanescu, 2024).

In *The living handbook of narratology,* narrativity is defined by Abbott (2011) as an adaptable term to the context of use, having intrinsic conflicts based on the role it assumes. This makes IDN a cover term for a rich set of ideas that also incorporate the process of interactive storytelling. In fact, according to Mateas and Sengers (1998), a narrative is not a single entity nor a single set of concepts; it is interdisciplinary, drawing on narrative concepts from humanistic perspectives. From an authoring point of view, IDNs questions the limits of what can be considered storytelling (Sethi, 2021), as IDNs challenge the author's and the reader's conventional role. For instance, a digital interactive storytelling system such as *Shelley* (Yanardag et al., 2021) is an AI system that creates stories but does so through interaction with the online community. At the same time, author and reader can converge in the same person; this can happen when the reader is considered the one who interprets the text, giving it meaning, becoming the author of a text written by someone else (Heath, 1977; Iser, 1972). *Shelly* can be considered a system that generates individualized narratives that humans and computers co-author. It is not our intention to focus on the dualism problem of authorship between reader and author since, in this contribution, AI systems and designers share authorship to some extent. Designers are planners who use stories to convey a message or obtain useful information during the creative design process for given purposes. Still, the example of *Shelley* serves to clarify that IDN, through its interactive component, involves multiple agents in creating stories, and new technologies can support this process. Interaction is a crucial component that can be a participatory process consisting of an interactor's engagement with a computer program to produce an output (Koenitz, 2010). From an interaction perspective, since the early 1990ties, it was also the narrative approach that turned HCI from engineering to design (Mateas & Sengers, 1998). Narratives are not reduced to the construction of stories but also include the way stories are told. They extend beyond mere story construction and encompass how stories are conveyed. Narratives are considered a broader concept of the IDN product; their meaning cannot be pinned down into a single definition. As articulated by Chatman in his seminal work *Story and discourse: narrative structure in fiction and film* (Chatman, 1980), narration comprises a narrative's substantive components and the narrative discourse, with diverse structural configurations (such as flashback, flashforward, and in medias res) and disseminated through different media (such as television, books, theater, and social media).

As a research area and practice, IDN experiences have an academic discontinuity (Crawford, 2013). According to Koenitz, there is an incomplete and sometimes confused body of knowledge and for this reason, there is an urgent need for systematization of the area through guidelines and taxonomies, adopted, and further developed (Crawford, 2013; Koenitz, 2018). When the topic of AI systems is introduced within the IDN context, scholars tend to refer to those AI systems designed to generate stories as procedural sequences of text and not as IND experiences since the developments of these systems are limited to story generation (Gervás et al., 2006; Roth & Koenitz, 2017; Szilas, 2015). *AI Authoring Systems* risk not being considered a support and creation tool for IDNs because most of their application and use is text grammar-based models of stories (Gervás et al., 2006) and revolves around automated story writing.

Hence, AI-driven authoring support systems should interface with the human agent who actively dialogues with the system. This interactive exchange of information serves a dual purpose: facilitating the learning process for the AI system and enabling the human agent to process data from an alternative perspective. This dialogue can turn into a collaboration, a perpetual interaction between two agents to improve one another. Collaboration is the key to supporting the very complementarity of the two agents. The AI system is mainly a helpful support tool because it is capable of processing and analyzing a large amount of data in a short time compared to humans, which do not achieve the same performance in speed and accuracy (Kasparov, 2017; Lovelock, 2019). AI automates learning processes starting from data, applying logic thinking, which humans prefer to replace with intuition by making assumptions instead of calculating every possible decision and outcome (Jarrahi, 2018). The support given by the AI system is often automation of the narrative authoring process, and the system takes over some tasks to be carried out that facilitate the process. For example, there are generative algorithms that create a story model starting from a dataset of stories (Li et al., 2012), that suggest through words or phrases the continuation of a story (*Metaphor Magnet*, 2019; Yanardag et al., 2021), or that automate the actions and events of the characters based on the designer's choices that influence the outcome of the story (Cavazza et al., 2002;

Mateas & Stern, 2002). In this way, there is not necessarily space and support for creativity, just for the automatization of the story writing process. However, it is, in particular, this aspect of analytical strength that can help in identifying interactor's patterns that can help creative work. The other category is that of AI systems that support creativity and is used within creative design processes (Jeon et al., 2021), which can result in the creation of music or songs (Carney et al., 2021; Huang et al., 2020), a sketch or coloring of a drawing (Kim et al., 2022; Bernal et al., 2019a), or 3D virtual spaces (Urban Davis et al., 2021). Creativity is here understood as *Human-AI co-creativity*, which distinguishes between *P-creativity* and *H-creativity*, taking Boden's definitions as reference (Boden, 1994). *P-creativity* refers to personal creativity concerning new findings, concepts, and ideas that a person has not been aware of before, which can bring value and novel to the individual who identifies an idea not previously considered. This knowledge is limited to the person's interests and limited in time. *H-creativity* refers to *Historic* creativity related to findings unpublished in the history of humanity. Therefore, AI support systems are considered creative if they result in a creative idea concerning the person with whom the system collaborates or with respect to the whole of humanity in the history of humankind. Clearly, in the case of *human-AI co-creativity*, P and H creativity refers to human and non-human agents and can be detected through analytical means in a corpus of individual or domain works (Serbanescu & Nack, 2023). Creativity brings with it a cultural tradition in which the anthropocentric vision is the dominant one, i.e. creativity can be considered as such only if the human being is its creator. On the other hand, if creativity emerges as the result of human-AI collaboration, we more correctly need to call this *co-creativity*. In the literature, we speak of *Computational Creativity* (CC) as an automated version of human creativity (Gu & Amini Behbahani, 2021), in which the AI agent is autonomous in creating ideas, which can be more or less valid.

On the other hand, AI lacks emotional characteristics, especially empathy (Lovelock, 2019). Sometimes not having to deal with emotions could be successful, for instance, in determining the result of a chess game (Kasparov, 2017), but feeling emotions such as fear, love, or loss, is necessary to establish narratives that are meaningful for humans. Both human and non-human agents are different but complementary. The strengths of one compensate for the weaknesses of the other, and the key to success stands in collaboration to reach common goals by combining the brute force of analyzing the data from AI with the intuitive capabilities of humans in problem-solving (Jarrahi, 2018). To date, IDNs have not explored their full potential through AI systems, though examples of AI-generated narratives are presented in section 4.

3. The Methodological Overview

The approach followed in the presented work is what Krogh defines as *drifting by intention* (Krogh & Koskinen, 2020). The practice of drifting is seen positively in Design as a discipline. It demonstrates how the design researcher learns and reshapes knowledge concerning their findings (Krogh & Koskinen, 2020). The conducted study classifies the observable AI support systems through a deductive approach that starts from the theory and goes on through empirical observations to validate the initial hypothesis of AI systems capable of supporting designers in the co-creation of IDNs. This contribution, therefore, presents *multimethod qualitative research* (Mik-Meyer, 2020) on the influence of AI support on IDN artefact creation based on a synthesis of Design studies, Narrative studies, and HCI. The investigation is conducted through a case study analysis that explores the topic of *human-AI system co-creativity* in and for IDN through several case studies of AI systems that support humans in creating IDNs. The case studies are exploratory, starting from a large body of system descriptive work of AI support systems (Koenitz, 2014), with little theory about them. The mapping of the case studies and their analysis is conducted to search for the support of or actual creative activity in those AI systems capable of creating INDs. The outcome of the case study is a framework that should help designers understand and apply AI systems into their design of IDN artefact that can address the needs skilled IDN designers use for creating IDN systems. Subsequently, an evaluative process is conducted on the analytical framework, involving interviews with academic experts drawn from the three distinct domains constituting the IDN discipline.

3.1. Case Study Method

The case study research was conducted on *Google Scholar*[1], the *ACM Digital Library*[2], and the *Scopus*[3] library. The sampling selection criteria consider only human-AI collaboration systems from the Design field and the IDN field created between 2000 and 2022, including models, prototypes, concepts, frameworks, and ready-made products. The original search started with the inclusive terms like *human-AI collaboration in Design* and *human-AI collaboration in IDN* and then refined them based on the findings. At first, 60 case studies were identified, and from those two categories of interest for designers emerged among the AI support systems:

- AI systems that support the creative design process, also called *Intelligent Creative Support Tools* (CST) (Main & Grierson M., 2020) or *AI-based CST* (Jeon et al., 2021).
- AI systems that support IDN creation are called *AI Authoring Systems* (Shibolet et al., 2018).

The collected case studies were then categorized and ordered according to these two categories. The 60 case studies are presented in a summary table (Table 1), showing that some case studies represent both *AI-based CST* and *AI Authoring Systems* categories. The case studies characterized by both categories constitute a third of all cases, which results from the observation of the case study categorization. This contribution shed light on a new category we define here as *AI Co-creativity Support Systems for IDNs.* That is, those AI systems that co-create with the designer in building IDNs, considering the definition of P and H creativity outlined earlier. The assumption is that this third hybrid category represents an emerging AI support system, despite being more complex to design and build, needs to be scholarly acknowledged to expand the research on that topic. Since the interest here is to find *AI Authoring Systems* that can support designers in the co-creativity process of IDNs, the seven case studies representing this third hybrid category (namely number 6, 30, 31, 43, 45, 51 and 52 in Table 1) are those picked for the analysis and comparison in Section 4.

Table 1: Case study evaluation.

#	Case Study	Year	AI-Based CST	AI Authoring Systems	#	Case Study	Year	AI-Based CST	AI Authoring Systems
1	A Graphical Platform for Building Storyworlds	2015		X	31	IAQOS - Roma	2019	X	X
2	Adobe Scene stich	2017	X		32	I-Storytelling	2002		X
3	Adobe Sensei	2017	X		33	InSight	2019	X	
4	Alan01 / AlanOnline	2009		X	34	IN-TALE	2006		X
5	AlterEgo	2019		X	35	ISRST-IS	2009		X
6	Ancona Centripeta	2019	X	X	36	Little Data Wranglers project	2017	X	
7	Angel_F	2006		X	37	Machine hallucination	2019		X
8	ArtBreeder	2018	X		38	Midjourney	2022	X	

[1] Google Scholar, for more info visit https://scholar.google.com (*Google scholar*, n.d.).
[2] ACM Digital Library, for more info visit https://dl.acm.org (*ACM Digital Library*, n.d.).
[3] Scopus, for more info, visit https://www.scopus.com/sources.uri?zone=TopNavBar&origin=searchauthorfreelookup (*Scopus*, n.d.).

9	BeeMe	2018		X	39	Mimesis	2003		X
10	Benjamin	2016		X	40	Minstrel remixed	2010		X
11	Calliope	2021	X		41	MuseNet	2019	X	
12	Colorbo	2022	X		42	NOLIST	2005		X
13	Creative Sketching Partner	2020	X		43	Omnia per Omnia	2018	X	X
14	Dall-E	2021	X		44	OPIATE system	2004		X
15	DeathKitchen	2006		X	45	Paper Dreams	2019	X	X
16	DED (Directed Emergent Drama)	2008		X	46	PASSAGE	2007		X
17	Deep dream generator	2015	X		47	PERSONAGE	2011		X
18	Deep — The Fabricant	2018	X		48	Scheherazade-IF	2012		X
19	Defacto	2005		X	49	Stereotrope Poetry Generation	2013		X
20	DINAH	2003		X	50	StoryLine	2017		X
21	D.O.U.G._2	2019	X		51	Shelley	2017	X	X
22	D.O.U.G._4	2020	X		52	TALEFORGE	2021	X	X
23	ENIGMA	2010		X	53	Teatrix	2000		X
24	Fabulist	2004		X	54	Tell a Story About Anything	2015		X
25	Façade	2002		X	55	The Virtual Storytellers	2003		X
26	FashionQ	2021	X		56	Thespian	2005		X
27	Flower	2020	X		57	The AniThings project	2017	X	
28	Human-AI co-creativity in songwriting	2020	X		58	Tone Transfer	2020	X	
29	Kuki (Mitsuku)	2013		X	59	Twine	2009		X
30	IAQOS — Bolzano	2020	X	X	60	U-Director	2006		X

Source: (Serbanescu, 2024).

4. The Case Study Analysis and Findings

In the initial stage of case study selection, which sought to identify distinctive features inherent to AI authoring tool systems fostering creativity, a decision was made to scrutinize seven chosen case studies through comparative analysis comprehensively. Subsequently, these case studies were systematically transformed into categorized and subcategorized units for analytical purposes, giving rise to an analytical framework. This framework elucidates recurrent and cross-cutting elements inherent in each case study, thereby facilitating their transformation into discernible categories and subcategories for systematic analysis. It is imperative to underscore that the exploratory nature of the case study analysis was undertaken with the overarching goal of comprehending the operational dynamics of the support systems and the salient elements that constitute their foundation.

The summary and comparative sheet of the selected case studies are presented in Figure 2 (see the following page). The figure highlights the case studies which aim to understand how an AI system can support the user in creating IDNs and better understand the constitution of these systems. Seven case studies are compared, starting from considering the input/output categories that analyze the type of data entered about the narrative elements. The input/output ratio identifies the incoming and outgoing narrative elements, thus framing the purpose of the authoring system and the final artefact. The grey boxes represent the story, not just the single fragments of the story (actions, events) but their concatenations. The *Degrees of automation* of the narrative elements are an essential category that identifies the design of an AI system. The table includes the analysis of the type of AI system, its learning paradigm and the level of knowledge it can acquire. All these categories related to the AI system flow into a more qualitative and reflective category regarding the type of support the system can provide to the designer as the creator. That is how the AI system can be a resource for the designer and what are its characteristics, potentials and limitations. The *Type of AI system support* category is divided into:

1) The AI system is built to execute tasks. It cannot reason about the given input but provides automation for processing the data.

2) The AI system cannot reason about the given input, but has provided suggestions to address the input, which in some cases may inadvertently propose a creative output.

3) The AI system can reason on the given input, suggest creative outputs and carry out an ongoing collaboration with the designer as a creator.

Finally, an important category is the *Type of interaction* that influences the creative component triggered between designers and AI systems. Interaction as collaboration stimulates creativity, which in Figure 2 appears as an analysis category. Upon initial examination of Figure 2, it becomes evident that two out of seven case studies insert stories as inputs into the AI system, even if most of the analyzed systems have stories as output. The cases with the stories as output are used to insert fragments of texts, videos, photos, or pre-set commands. The most common type of AI analysis method is a neural network. It facilitates deep learning to identify connections among contents and layers. It can also handle more than one content modality, namely analyzing visuals (images or video) with computer vision techniques or text with NLP. The established output of those analysis methods can result in unexpected patterns and connections between contents, which can be surprising to the designer. Often this surprise effect results in the view that the system is creative, where it is mainly analytic. All the case studies are AI support systems, but most of the type of interaction is explicit, meaning that the designer can select pre-determined inputs and expect not a creative output, at least a creativity that is just computational. When there is a direct collaboration between the designer and the AI system, the system supports the designer in finding suggestions based on the ongoing designer's input and AI output. By triggering the designer to give a new input based on the previous system output and interact to find a creative idea for creating an IDN. Many AI systems support designers, but only at the executive level, to carry out tasks, not at the level of what can be considered a genuine collaboration that leads to problem-solving through creativity.

Figure 2: Case study map of comparison and analysis.

#	Case study	Year	Input					Output					Narrative										Elements of the AI system						ML paradigm			Degrees of knowledge								Type of AI support			Type of interaction				Creativity			
			Media type	Narrative elements				Media type	Narrative elements				Degrees of automation										Application		Methods				Supervised learning	Unsupervised learning	Reinforcement learning	Reactive AI		Limited memory AI									No collaboration	Indirect collaboration		Direct collaboration	No creativity	Computational creativity	Human-AI co-creativity	
				Story		Narrative world			Story		Narrative world		Story					Narrative world					Computer vision	NLP	Neural network	Distributed AI	Knowledge representation	Statistical learning				No previous knowledge		One topic		Differen topics same field		Differen topics different fields		1	2	3								
				action	event	character	ambient		action	event	character	ambient	manual	modification	template	constrained	automated	manual	modification	template	constrained	automated										C	S	C	S	C	S	C	S					implicit	explicit				P	H
1	Shelley	2017	text (tweets)	x	x	x	x	text (tweets)	x	x	x	x				x					x			x	x				x						x	x					x					x			x	
2	Omnia per Omnia	2018	videos	x	x	x	x	movements	x	x	x	x					x					x	x		x	x		x	x	x				x	x							x				x			x	
3	IAQOS - Rome	2019	vocal messages, texts, pictures	x	x	x	x	interactive graph	x	x	x	x	x						x				x	x	x		x			x						x		x			x				x			x		
4	Paper Dreams	2019	drawings, text, audio	x	x	x	x	visual (storyboard)	x	x	x	x				x					x		x	x	x				x								x	x				x				x			x	
5	Ancona Centripeta	2020	text (info)	x	x	x	x	text (article)	x	x	x	x					x					x		x					x							x	x				x				x			x		
6	IAQOS - Bolzano	2021	text (data)	x	x		x	interactive graph	x	x	x	x	x						x					x	x		x		x	x						x	x				x				x			x		
7	Taleforge	2021	text and items	x	x	x	x	pictures	x	x	x	x				x				x			x	x					x							x	x					x				x		x		

Source: (Serbanescu, 2024).

4.1. Findings on Collaboration and Co-Creativity

Human-AI co-creativity is a collaborative relationship between humans and AI systems to support the creative design process. Co-creativity involves at least one human agent and one computer, considered a colleague, comparing its creativity to humans (Hoffmann, 2005). The type of interaction determines the degree of support for creativity or co-creativity when the AI system supports it and works with the designer as a creator to produce a creative idea. If the collaboration is direct, the outcome is more likely to be creative.

There is a slight difference between *computational creativity* (CC) and *human-AI co-creativity*. CC is an automated variant of human creativity (Gu & Amini Behbahani, 2021). Often AI systems are characterized by CC even if they are not designed to collaborate with humans. However, they can be *P-creative* for the designer when they suggest options that unintentionally become novel and innovative for the designer who did not have that in mind.

In *human-AI co-creativity*, the AI agent is more than a functional tool and acts as an autonomous creator that can give designers creative suggestions (Lopes et al., 2021). It is a tool for designers to collaboratively find novel ideas for stories (in content or structures) and, in this way, accelerates the storytelling process. In the comparison table presented in Figure 2, all the cases perform CC, except for cases one and two that facilitate human-AI co-creativity. Case number five, *Paper Dreams*[4] (Bernal et al., 2019a), is an example of CC. The system allows continuous dialogue with the designer about constructing a storyboard. In this case, the system supports the creation of the storyboard by suggesting sketches related to drawings or keywords entered the system through an interface. Creativity support is scarce, mainly because the AI system takes care of suggesting illustrations and sketches similar to those drawn by the designer, retrieving them from the AI system database. The AI then carries out a task assigned to it, and based on the designer's input, the system responds with a new suggestion from time to time.

[4] Read more about the Paper Dream project here https://arts.mit.edu/paper-dreams/ (Bernal, 2022).

Case number one, the *Shelley*[5] AI system (Yanardag et al., 2021), instead reacts to people's stories collaboratively, facilitating in this way human-AI co-creativity. The AI system proposes a story and publishes it on the dedicated X account (former Twitter), and the community suggests how the story continues. The AI then selects the scariest story and posts it on X as a follow-up. This is a good example of co-creativity since the system considers multiple parties collaborating in the creative process, sharing their ideas about the story and building a narrative together in an interactive manner.

In *Omnia per Omnia*[6] (Benediktsson, 2019), little robots with distributed AI help the artist reproduce the dynamic crowd flow from the city of New York on the canvas, working side by side with the artist. The result is a giant canvas that visually represents the dynamic crowd flow. Conceptually, it can be considered an interactive digital way to tell a story from New York from a spatial movement perspective. This project means creatively, something about the perception of daily spaces that, without the help of the AI system in processing all the video data of people walking on the streets, you could not have known. Except for *Omnia per Omnia* and *Shelley,* which work on human-AI co-creativity, the other cases deal with computational creativity in AI systems, which execute tasks that can help the designer build narratives, but not as a co-creative partner. At first glance, the seven selected case studies were considered part of the *AI-based CST* and *AI Authoring Systems*, as they support creativity and create IDNs. Still, this type of support does not translate for all cases into a relationship of co-creativity between designer and AI system, as represented by the *AI Co-creativity Support System for IDNs* category. In fact, by focusing on the categories of analysis and comparing the case studies (Figure 2), we realized that AI support systems are not clearly identifiable. The qualitative analysis implies structured reasoning to identify which systems can be recognised as CC or co-creative. The framework we introduce in section five (Figure 3) is a solution proposal that helps understand where to look and orient when dealing with *AI Co-creativity support systems for IDNs*.

4.2. Findings on the Narrative Elements

In this contribution, the construction of the narrative world (NW) is understood as the relational system of the characters that populate a digital and interactive environment through an AI system, where the NW establishes a relational system between characters-characters and environment-characters. The NW is, in fact, a container of potential narratives (Koenitz, 2015) triggered by the relationship between the various characters and the digital environment.

All seven case studies compared in Figure 2 are made up of a sort of NW, since the meaning assumed by the term does not respect the previous description. In our view, no selected case studies represent a narrative world. This awareness highlights, on the one hand, different interpretations of the same term and, on the other, a lack of investigation of the NW through AI support systems. In Figure 2, cases 3, 5 and 6 consider the NW as a space of stories. For instance, in *IAQOS Rome*[7] (Iaconesi & Persico, 2021), the AI system collects the stories of the inhabitants of the multicultural Torpignattara district of Rome. The NW, in this case, is a non-structured space that contains people's content about any topic, and the AI system finds correlations among them. Similarly, *Ancona Centripeta* (Sineglossa, 2019) collects all the stories from the citizens of Ancona concerning their city experience and their hopes and dreams about it. The AI system then provides futuristic output articles about Ancona 2030.

Case studies 1, 2, 4 and 7, consider the NW as an environment or a setting for actions performed by characters. In *TaleForge*[8] (Perez et al., 2021), for instance, the characters appear within a pre-established story, and the narrative world is considered a mere standing background. The same applies to *Paper Dreams* (Bernal et al.,

[5] Visit the following website to have more information about the AI system *Shelley* https://www.media.mit.edu/projects/shelley/overview/ (Yanardag et al., 2021).
[6] Visit here the website dedicated to *Omnia per Omnia* project https://sougwen.com/project/omniaperomnia (Benediktsson, 2019).
[7] Find more about the IAQOS project here https://iaqos.artisopensource.net (IAQOS, n.d.).
[8] TaleForge can be tested at the following link https://taleforge.streamlit.app/ (Perez et al., 2021).

2019a), where the NW is just a setting represented through a drawing scene in which characters are inserted. In *Omnia per Omnia* (Benediktsson, 2019), the robots are the AI support system that helps the designer as the creator to represent a narrative visually; they are not creating a NW as we intend.

4.3 Reflection on Findings

The chosen case studies for our comparative analysis should genuinely fit the hybrid category of *AI Authoring Systems* and *AI-based CSTs*, termed as *AI Co-creativity Systems for IDNs* in this study. Among the seven cases, only three show potential for establishing a co-creative relationship with interactors due to the original design focus on task automation rather than proactive collaboration. Evaluating creativity in human-AI collaboration presents challenges. For instance, *co-creativity* implies active AI participation in the creative process, collaborating with human creators. However, practical scenarios often involve passive AI roles, activated only upon interactor's request. Achieving true co-creativity proves challenging, especially in IDN contexts.

Another key finding underscores the inherent conflict between automation and co-creativity, revealing complexities in integrating *AI Authoring Systems* into creative processes. This calls for a deliberate approach to maximize narrative automation benefits while preserving human creativity integrity.

5. The Analytical Framework Proposal

The findings of the case study, in combination with the insights gained from the related work section, here in particular the work by Shibolet et al. (2018), this paper proposes a classification framework that allows designers to recognize and describe AI systems that collaborate creatively with humans in the creation of IDNs. The framework is outlined in Figure 3 and is a response and a proposal to understand and organize the body of knowledge related to AI support systems, which we assume will be increasingly present and prolific in the future developments of IDNs.

Two distinct categories of support emerged from the literature review that simultaneously accompanied the case study analysis: *AI-based CST* and *AI Authoring Systems*. The latter sees using an AI system that supports the author in creating IDNs. Still, this category of AI systems is part of the larger group called *Authoring Tools*, described by Shibolet as digital software capable of creating IDNs in the form of stories and/or storyworld (Shibolet et al., 2018). The support given by AI in authoring is often automation of the narrative authoring process, and the system takes over some tasks to be carried out that facilitate the process. We outlined earlier that in this way, there is no space and no support for creativity, just for the automatizations of the story writing process. It has also been shown that actual support of creativity requires an anthropocentric vision, i.e. creativity can be considered as such only if the human being is its creator. With the framework, we intend to show that creativity can also emerge as the result of human-AI collaboration, more correctly called co-creativity. In this context, Computational Creativity (CC) is seen as an automated version of human creativity, in which the AI agent is autonomous in creating ideas to support creativity and is used within creative design processes for designing music, drawings, or 3D virtual spaces. This type of creativity requires domain knowledge representations so that patterns can not only be recognised but also classified and interpreted. The framework's application area includes three types of AI support systems that emerged from the conducted case study analysis and literature review:

a) The *AI-based Creativity Support Tools* (CSTs) are AI systems that support creativity and can be used in the creative design process. The AI-based CSTs are mostly related to computational creativity, being generative AIs that mainly support humans in executing tasks rather than collaborating to solve problems (Jeon et al., 2021; Main & Grierson M., 2020). These AI systems generally involve designers in generative music, graphic, sketches, and image generation.

b) The *AI Authoring Systems* are those systems that generate co-authored narratives by humans and AI systems or AI algorithms that author their narratives (Shibolet et al., 2018).

c) The *AI Systems to Support Creativity in Building IDNs*, hybridizing the first two types of AI support systems above. This new category represents a new emerging typology of AI co-creativity support systems that involves the creation of IDNs thanks to a creative collaboration with the designer as a creator.

Figure 3: Visual representation of the analytical framework to categorize *AI Support Systems for IDNs*.

Source: (Serbanescu, 2024).

5.1. The Structure: Macro-Categories, Categories, and Sub-Categories

Building this framework is a work that resulted from reflective thinking mixed with findings from the literature review. Its construction originates and takes inspiration from the categories and descriptors in the structure classification table of Shibolet et al. (2018) authoring tools. It also follows the three research areas: HCI, Narrative Studies, and Design Studies, the equivalent of which has at least one corresponding representative category. To facilitate better integration of both approaches, a table with macro-categories has been created (grey color):

Identity kit, Project, Process, and *Other resources* (Figure 3). Categories and sub-categories characterize each macro-category.

5.2. Identity & Type

This macro-category is the framework's core and comprises four categories: AI system, Interaction, Creativity, and Narrative.

The AI system category is divided into five subcategories: *Application(s), Method(s), Machine Learning paradigms, Degrees of knowledge* and *Type of AI support.*

- Based on the system's complexity, the *Method* and *the Application* can be more than one and combined to perform different tasks. In defining those two categories, the study was carried out on schemes that cluster and position types of AI based on their function. Having found nothing authoritative in the literature, we decided to take them as a reference and combine categories that emerged from the index book *Artificial Intelligence — A Modern Approach* (Russell & Norvig, 2021) and the hierarchical system proposed by *ACM Computing Classification System* (*ACM Computing classification system*, 2012). This adaptation was made possible by the continuous comparison with the selected case studies, trying to choose categories to determine and describe existing items.
- The *Machine Learning paradigms* classification is also based on the book of Russell and Norvig (Russell & Norvig, 2021) and identifies supervised, unsupervised, and reinforcement learning.
- The *Degrees of knowledge* consider a limited level of knowledge of AI, or what AI has reached to date, which is beyond an understanding of a real awareness of content but more than a simulation of it (Searle, 1980). So, knowledge is divided between reactive AI, which has no memory and just responds to stimuli, and limited memory AI, a system capable of storing information and collecting it when needed (Joshi, 2022). Furthermore, knowledge is transversal concerning content and structure, where the content refers to the type of topic/s that the AI deals with, which may belong to the same or different areas. In the case of authoring systems, the story's subject may be based on one or different genres, but as the applied knowledge structure is of a taxonomy type, it might provide additional suggestions for genre extensions.
- Finally, the *Type of AI support* is inserted at the bottom of the AI system category since it results from reasoning that includes the items that precede it. This qualitative category serves to identify a type of practical support linked to problem-solving.

The *Interaction* category is built on the structure of the interaction mechanisms presented by Sauvé & Houben (Sauvé et al., 2022), which can be indirect or direct. In the case of the framework presented here, the type of interaction we are interested in analyzing is collaboration and based on this; the sub-categories vary slightly in meaning compared to the original setting.

The category relating to *Creativity*, representing the Design Studies side, is structured based on the findings from the literature review on creativity as a result of human collaboration with the AI system. Human-AI co-creativity is distinguished by *P-creativity* and *H-creativity*, taking Boden's definitions as a reference (Boden, 1994). The AI approaches covered here will be oriented towards pattern recognition concerning content and structure applied in the IDN design, where models are required that can memorize the individual IDN pattern of a creator as well as the pattern provided by the domain of accessible IDNs.

The Narrative category consists of *Narrative element*s and *Degrees of automation*.

- Concerning the representation of the narrative elements, the book *Il mondo narrative* (Pinardi & De Angelis, 2006) introduces a hierarchical classification of narrative elements adopted as descriptors in the analysis table. The *Narrative* is divided between the *Story* and the *Narrative world*; the latter element is essential and, at the same time, absent in relation to AI support systems, which deal with the procedurality of the stories. This subdivision between story and NW for AI support systems is also applied in the *Degrees of narratives* sub-category that takes its structure inspiration from the work on the *Degrees of Automation of Plot and Space Generation* conducted by Kybartas and Bidarra (Kybartas & Bidarra, 2016), in which the NW is considered a mere scene setting.

The *Identity kit* macro-category is more articulated than other macro-categories since it is essential to identify the *Type of AI support*. This categorization manifests through three discernible functions: task execution, trends prediction and collaboration.

5.3. Project

This macro-category addresses the AI support system as a whole and is represented as a sort of personal data CV of the AI support system. The primary data (name, year, creator, ownership) and the objective are introduced. Moreover, there is the chance to identify the research question and the target audience if they are present. The presence of a research question in the analyzed case study partly indicates the degree of complexity of the represented AI system. An AI system composed of multiple methods, applications and diverse and broad knowledge will be considered and built as an actual project with its research question rather than treated as a single-task algorithm.

5.4. Process

As for the process macro-category, the goal is to indicate the input and output categories. What matters is the qualitative part of describing the experience linked to the various stages of the process, which vary according to the type of AI system and the creative and narrative components.

5.5. Other Resources

Finally, the macro-category of other resources plays a marginal and optional role within the overall table but helps the designer keep track of practical information, such as links to external resources and keywords that help better identify the case study under analysis to similar ones. This category acts as a utility to navigate the framework and have external resources at hand to access.

In the context of IDN, the defined analytical framework acts as a systematic taxonomy meant to simplify the complex and heterogeneous knowledge of collaboration between designers and AI systems. The primary goal is to deliver crucial information to designers, allowing them to navigate the AI support system IDN landscape with knowledge and intent. This, in turn, encourages collaboration and potential co-creation opportunities between designers and AI support systems, leading to the development of robust IDN products. Individuals with experience in the three domains engaged in this contribution, namely Design studies, HCI, and Narrative studies, could further examine the framework's internal categories and overall structure. This underscores the rationale behind our initiation of a series of interviews with distinguished experts to enrich and refine the framework through their invaluable insights and perspectives.

6. Interviews Highlights and Discussion

Following the establishment of the framework proposal, an assessment of its categories and structure was undertaken through the administration of eight semi-structured interviews involving experts and academics specializing in disciplines relevant to IDN. This section presents a succinct summary of the key highlights resulting from the coding process of the interviews, facilitated by the utilization of *Quirkos*[9] software. This software enabled the creation of clusters comprising recurring topics, allowing for the systematic coding of textual data. The identification of overlapping topics and the extraction of noteworthy quotes informed the generation of Table 3. The subsequent analysis of the findings is approached critically, with the overarching objective of refining and enhancing the framework.

[9] Quirkos, is software that allows for qualitative data analysis, producing a clustering and visual representation of the data. For more info, visit https://www.quirkos.com/ (Quirkos, n.d.)

6.1. Setting the Stage

In relation to the interview phase, it is noteworthy that these sessions transpire subsequent to the culmination of the analysis of the case studies and the subsequent proposition of an analytical framework. A total of eight semi-structured interviews (Dearnley, 2005) were conducted with the primary aim of assessing the efficacy of the aforementioned framework. The participants enlisted for these interviews were drawn from the academic world, possessing expertise in at least one of the three disciplinary domains constituting the IDN discipline, as outlined in Table 2.

Table 2: The domain of expertise and its associated academic interviewees.

Interviewees	Design Studies	HCI	Narrative Studies
Dr. Carmen Bruno (Politecnico di Milano)	X		
Dr. Christian Roth (University of the Arts Utrecht)	X		
Dr. Francesca Arnavas (University of Tartu)			X
Dr. Lissa Holloway Attaway (Utrecht University)	X		X
Dr. Marco Colombetti (Politecnico di Milano)		X	
Dr. Paul Groth (University of Amsterdam)		X	
Dr. Peter Kristòf Makai (Kazimierz Wielki University)	X		X
Dr. Vincenzo Lombardo (Università di Torino)	X	X	

Source: (Serbanescu, 2024).

The interviews are characterized by a structured format, employing a predefined set of questions as a foundational guide. This questionnaire encompasses general inquiries regarding the framework posed uniformly to all participants, alongside more detailed queries tailored to specific facets of the framework, stratified according to the participants' disciplinary affiliations. Noteworthy is the online modality of these interviews, conducted through the *Teams*[10] and *Zoom*[11] platforms. Each interviewee is furnished with a virtual space on a *Miro*[12] board, housing an editable version of the framework, an exemplar application thereof, a terminological glossary, and interactor's instructions. This virtual space serves as a visual aid, facilitating a comprehensive comprehension of the framework and enhancing responses to posed inquiries. After the transcription of the interviews, the coding process had been executed utilizing the *Quirkos* software, which streamlines the categorization and analysis of emergent themes and topics.

6.2. The Findings

Table 3 provides a detailed overview of the primary outcomes, primarily centered around the theme of divergent opinions expressed by individual interviewees. Upon comprehensive examination of the framework, participants

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[10] Teams is a collaboration platform developed by Microsoft, designed to facilitate communication and teamwork within organizations. Visit here the website https://www.microsoft.com/en-us/microsoft-teams/group-chat-software. (Microsoft Teams, n.d.)

[11] Zoom is a video conferencing and online collaboration platform that facilitates virtual communication and meetings. Visit here the website https://zoom.us/it (Zoom, n.d.)

[12] Miro is also a collaborative, versatile platform which allows anyone to access it by sharing the link. For more info, visit https://miro.com (Miro, n.d.) The used Miro board can be found here: https://miro.com/app/board/uXjVOruCdnA=/

articulated a sense of being overwhelmed by its intricacies, prompting a collective call for simplification. When directed towards specific categories, respondents recommended the inclusion of illustrative examples to facilitate comprehension, suggesting either the expansion of existing categories or the incorporation of descriptive elements. This feedback underscores a delicate tension between the imperative to maintain complexity for comprehensiveness and the need for simplification for accessibility.

Table 3: Table of main findings of the semi-structured interviews.

Interviews' Insights
1. The inherent challenge lies in navigating the delicate balance between the intricate nature and the need for simplification in the contents of the framework.
2. A requisite for enhanced comprehension involves incorporating additional illustrative instances. Interviewees underscored the utility of leveraging examples from existing AI support systems to elucidate specific concepts.
3. There is a discernible demand for elucidations and deeper insights into the overarching objectives and intended targets of the framework.
4. Respondents possessing advanced engineering acumen advocate for a framework that prioritizes the practical application of the AI system rather than its underlying mechanisms.
5. Divergent viewpoints emerge regarding the same clusters, reflecting a polarized stance on their effectiveness or relevance.
6. A notable disparity arises between positive sentiments expressed about the framework's general overview and the critical concerns raised when scrutinizing the framework in finer detail.

Source: (Serbanescu, 2024).

A notable suggestion arising from the interviews is the incorporation of case studies to elucidate the glossary, offering a pragmatic solution to enhance understanding without augmenting the inherent complexity of the framework. This contrasts with the potential pitfalls associated with the continued expansion of categories and subcategories, which threatens to exacerbate the perceived complexity. Despite the evident organizational coherence and efficacy of the framework, there exists an opportunity for improvement in its visual representation. Recommendations put forth by interviewees advocate for enhancing the graphical depiction of the analytical framework. Dr. Bruno, for instance, highlights the prospect of optimizing the use of color codes to demarcate different sections, aiming to streamline the reading process. This sentiment is echoed by Dr. Roth, who emphasizes the need for clearer differentiation between categories. Dr. Attaway goes a step further by suggesting an exploration of color coding to assign distinct colors to categories based on their relative significance, thereby enhancing visual clarity. Additionally, to enhance conceptual comprehension, particularly regarding clustered topics and the overall compilation of the framework, another suggestion posits the provision of a pre-compiled version of the framework. This tailored version would cater to designers seeking a more succinct and readily accessible rendition of the framework.

In summary, the evaluation of the framework through expert interviews unveiled a nuanced interplay between the necessity for complexity and the demand for simplicity. The tension identified necessitates careful consideration in future iterations, with proposed solutions centered around the strategic inclusion of examples, case studies, and alternative versions of the framework to strike a harmonious balance between comprehensiveness and accessibility.

7. Conclusion and Further Developments

The framework presented in this paper is a qualitative analysis framework to identify and classify AI systems that support the designer who designs with *AI Co-creativity Support Systems for IDNs*. It is a dual-function framework that maps the area of the existing AI support systems for IDNs. Likewise, it is an awareness table concerning the functioning of the AI system employed. The framework can help design the AI support system intended to be built, as it provides an overall macro-structure and detailed categorizations that can stimulate the design and implementation of an authoring tool for rather complex IDNs. It, therefore, lays the foundations for understanding the necessary elements that an *AI Support System for IDNs* should have. Its application lies in constructing a record of case studies, of which examples are provided in section 4, which designers and anyone interested in or doing research in the field can access and further use to extend it. As a prospective trajectory of this investigation, the aim is to operationalize the conceptual framework through the assimilation of findings derived from conducted interviews and subsequent empirical examinations in the design practice. This incorporation will involve active collaboration with designers who express a willingness to engage alongside AI systems in the collaborative creation of IDNs.

The research identifies a newly emerging type of *AI support system* that creatively supports the designer in creating IDNs beyond systems that perform tasks and suggest options that can rarely be recognised as creative solutions and are not the result of continuous human and AI collaboration. The creativity does not lie in the automation tasks but the mutual joined forces between the two parties. For this to happen, the collaboration from a designer's perspective must be aware and directed toward a common explicit goal for both parties involved; otherwise, obtaining a co-creative IDN experience is difficult. With this framework, we want to invite academics and practitioners to expand the potential of AI support systems that can fill unexplored areas such as those of narrative worlds built thanks to the support of AI systems or emerging ones such as *AI Co-creativity Support Systems for IDNs*. A significant exploration space became apparent after the outlined case study, which showed that only 7 out of 60 investigated AI support systems can be considered *AI Support Systems for IDNs*. Therefore, the research aims to open a new path of study and analysis that sees the exploration of *AI Support Systems for IDNs* in a co-creative way, and the framework can be used as a starting point for this exploration.

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