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).

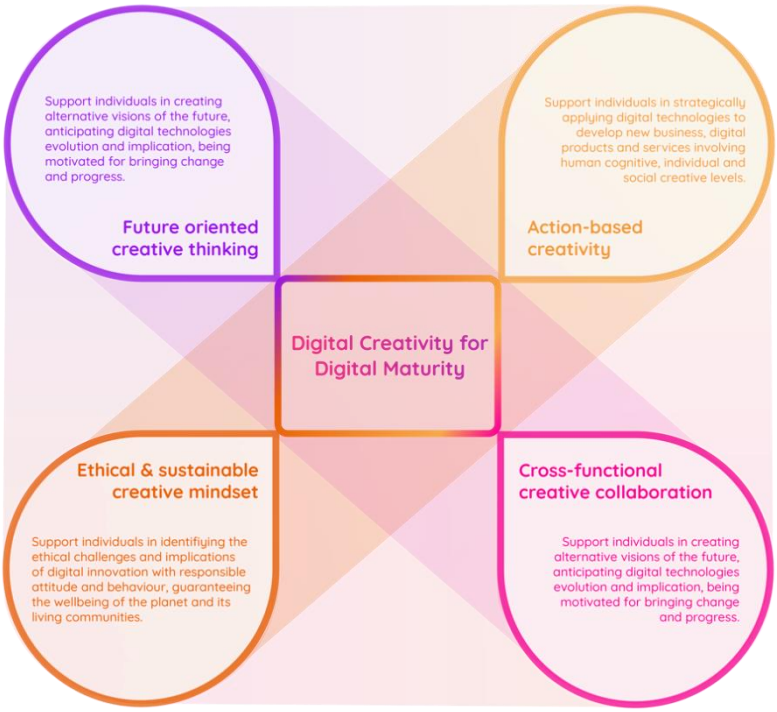
A design-oriented definition of digital creativity that merges both the above-mentioned perspectives state that "Digital Creativity is the ability to creatively and strategically apply digital technologies to innovate, thereby harnessing technological innovation to solve complex problems while keeping 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.

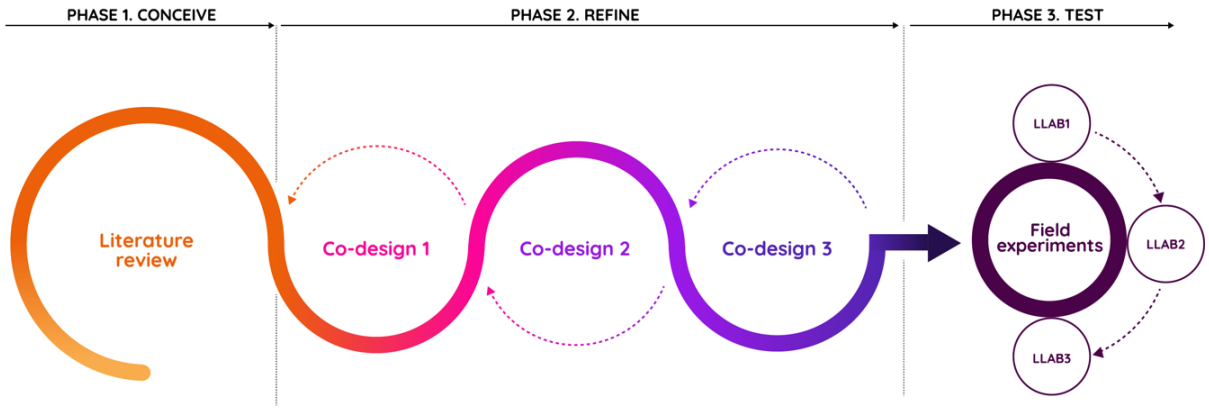
Team creativity is more than just the combined creativity of the individual team participants. There are factors that influence the contribution of the participants and their interactions. One of these is trust, which lies at the heart of teamwork and, since it influences how knowledge is shared, interpreted, 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.

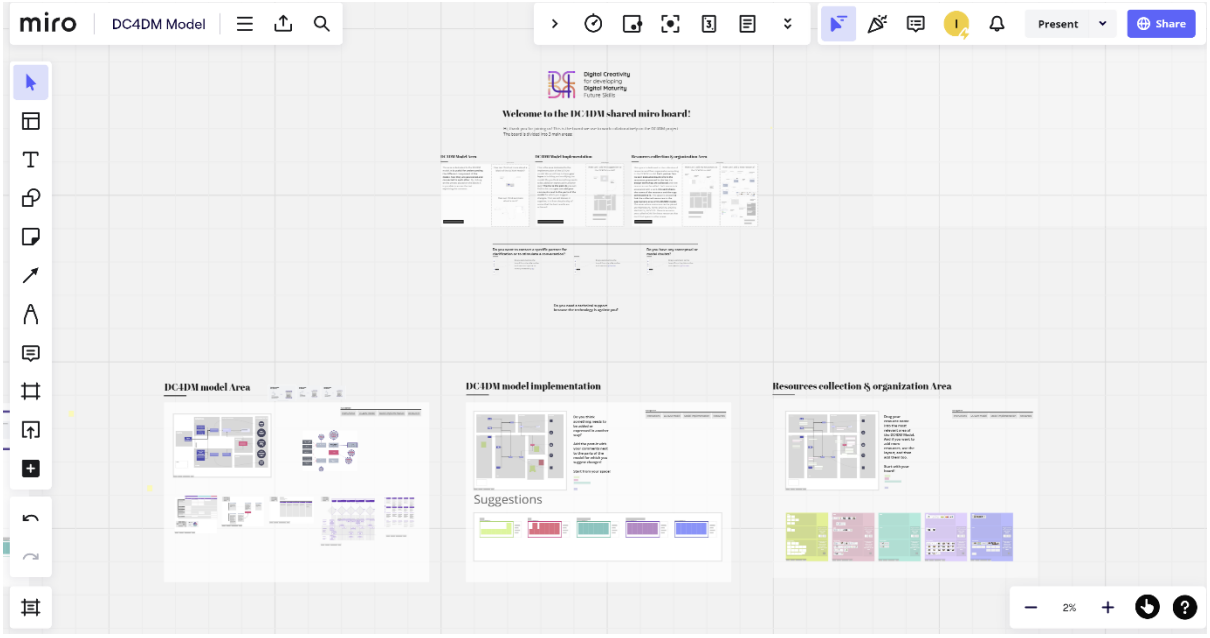
Figure 2: Schema of the employed methodology. Visualization created by the authors.



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.

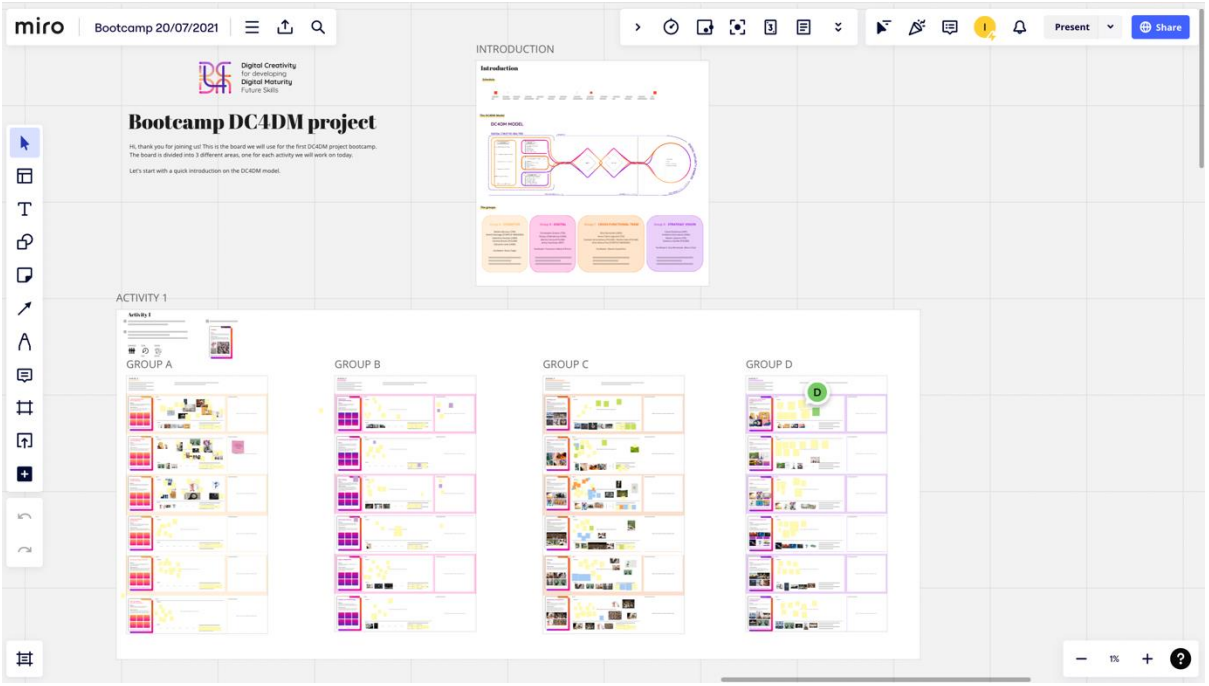
Each co-design session had specific objectives and the team of experts attended all three sessions. The first co-design session (Fig. 3) was dedicated to model refinement. Participants were asked to engage in brainstorming activities to provide critical feedback to improve and enrich the initial draft 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/

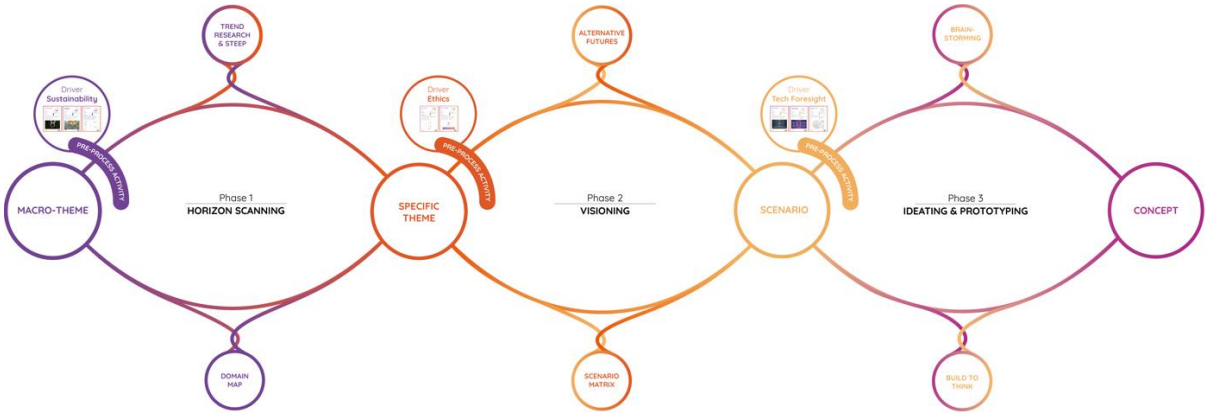
4.1. DC4DM Methodology

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.

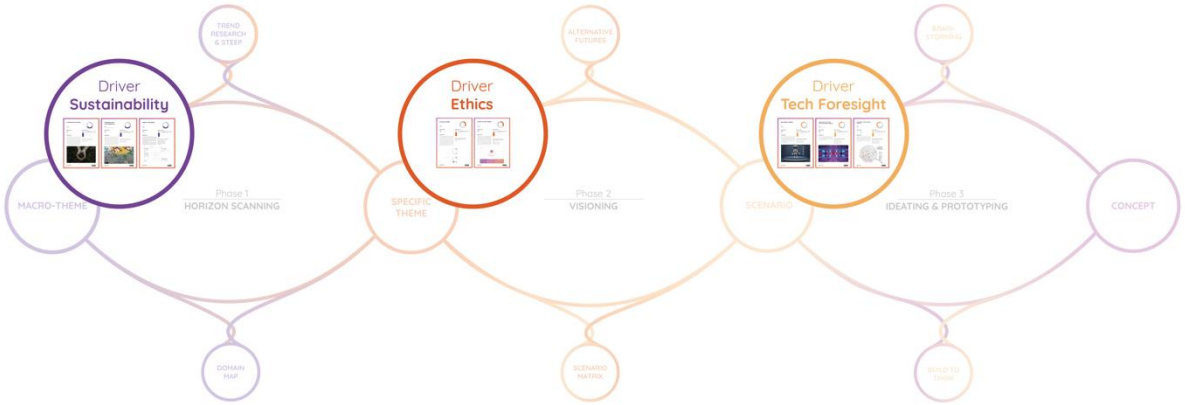
Figure 6: DC4DM Methodology. Visualization developed by the DC4DM project consortium.



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:

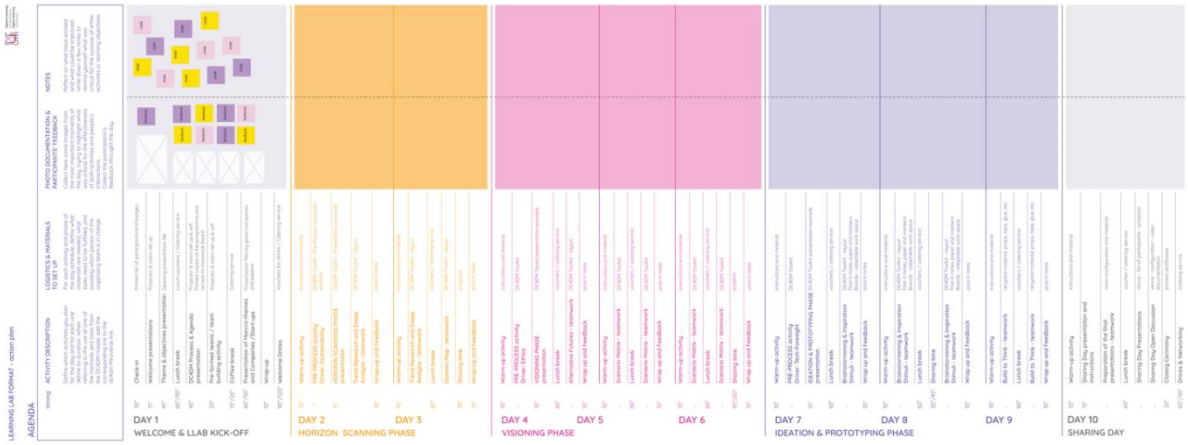
- *Create cross-disciplinary teams of design, engineer, and management students*: their mixed background is needed to design future technological solutions. The format includes therefore activities to create successful teams and initial warm up to facilitate team trust and their cooperative behaviour.
- *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.

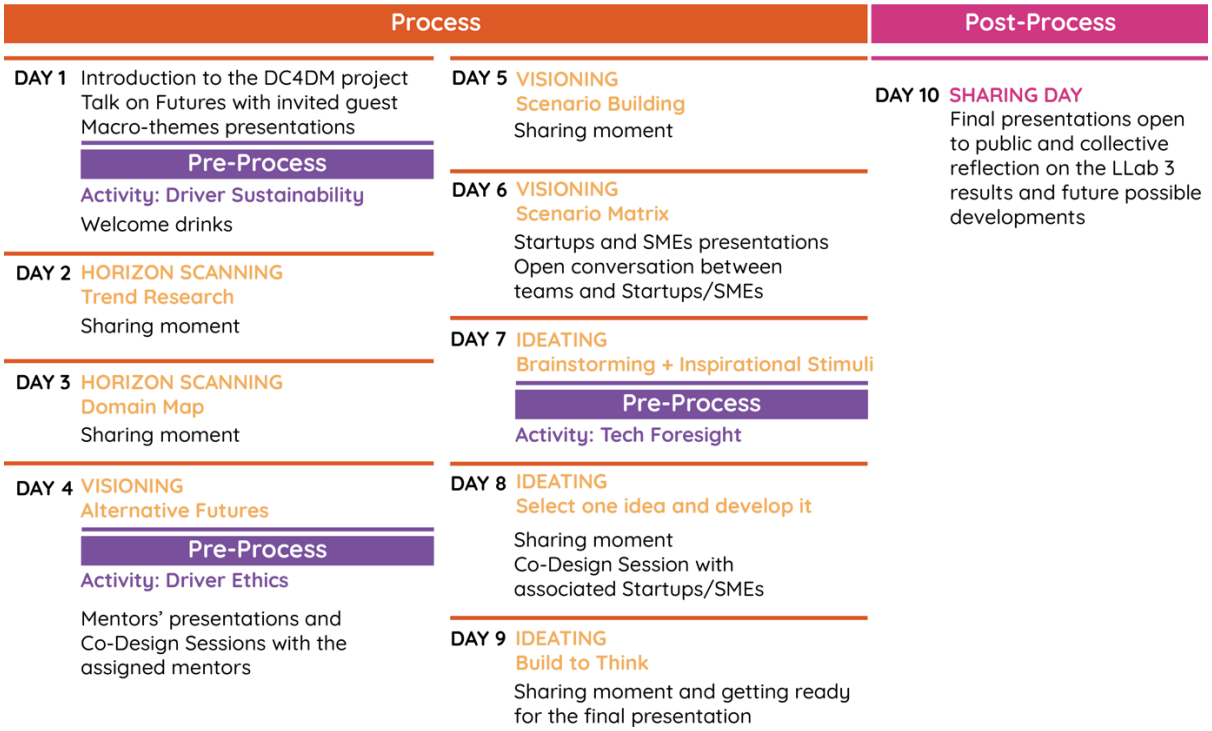
The DC4DM methodology was adopted, and the different preparatory activities and process steps were distributed over the 10 days (Fig. 4) ensuring a balanced alternation of classroom work, mentoring activities, and sharing moments in which participants were asked to offer constructive feedback to their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