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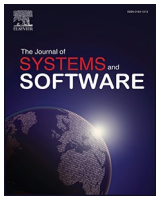

Learning to empathize with users through design thinking in hybrid mode: Insights from two educational case studies☆

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ABSTRACT

COVID-19 has imposed new educational challenges, including the need to prepare students to the new era of hybrid work. This research aimed to shed new light on the manner in which students learn and practice hybrid work in educational settings. To this end, two educational studies were performed, for examining students practicing design thinking (DT) in hybrid mode and the development of their empathy skills during this experience. The main case study was conducted in an academic hackathon-like course, where students addressed loneliness-related challenges during four full days using a configured web platform. In a follow-up case study, the adaptability of this approach to small-scale settings of a 90-minute DT workshop was explored. The students filled in questionnaires, which examined their empathy development in three dimensions: Skill, Orientation, and Being. The findings show the benefits of the web platform and the extent to which these academic educational programs fostered empathy and innovation and highlights the challenges, opportunities, and benefits of fostering new educational programs that allow hybrid participation, involving external stakeholders, and guide the students to handle real challenges. Such hybrid academic programs can prepare students for the hybrid, multidisciplinary work reality towards developing human-centered solutions.

1. Introduction

The COVID-19 pandemic has changed the workplace, possibly forever, inserting virtual and hybrid work modes as normative practices in industry (Bolshakova and Taratukhin, 2022). With the widespread acknowledgment that the era of hybrid work is here to stay, it is the responsibility of higher education institutions to equip future employees with the necessary skills to work in virtual, distributed teams, thus preparing their students for the new demands and expectations of industry (Saeedi and Visvizi, 2021; Miranda et al., 2021; Roberts, 2020).

An important part of learning is undergoing authentic experiences (Miranda et al., 2021). Therefore, preparing students for the hybrid work mode should involve hands-on team exercises, engaging the students in active hybrid collaborative work while they cope with real-world challenges (Chen and Zhang, 2021; Kohls, 2019).

In higher education, teaching methods and learning activities have evolved from traditional training to developing students' competencies that are aligned with the industry needs (Pink et al., 2022). These critical competencies encompass, beyond domain knowledge, personal, emotional, social, and intellectual capabilities. Thus, higher education should foster: (i) critical thinking, which provides opportunities for students' immersion in real problems through the implementation of different problem-solving techniques; (ii) cooperation, through activities that promote group work, responsibility sharing, and communication and collaboration during complex problem solving; (iii) presentation skills (e.g., pitches, project explanations) through activities that foster the ability to express ideas effectively in oral, graphic, or written ways, which can be enhanced by technological infrastructures; and (iv) creativity and innovation through activities that encourage creative and innovative problem solutions that can provide new services, processes, systems, or practices to specific users (Miranda et al., 2021). In this regard, design thinking (DT) has become widely adopted, drawing on "designerly tools" to drive innovation, organizational competitiveness, and performance (Randhawa et al., 2021).

This research aimed to shed new light on the manner in which students' skills, and in particular empathetic skills, can be developed in hybrid mode. To this end, an exploratory study was performed, including two – very different – educational studies. The objective of the

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study was identifying and understanding the challenges and opportunities faced by students and educators in the settings of experiencing hybrid work. We focused on learning the DT methodology, especially the empathy and creativity processes, using existing web platforms as facilitators of the hybrid settings, and analyzed the benefits gained from this learning experience. We formed the following research questions to guide our research:

1. How does practicing the DT process in hybrid mode develop the participants' skills? The following sub-questions guided our research in the context of the educational studies:
   1.1 How did the students practice the empathy stage of DT?
   1.2 How did the students' empathy, including all dimensions of the empathy model, evolve over the Jam Week and the DT workshop?
2. How does the web platform facilitate the DT process performed in hybrid mode? The following sub-question guided our research in the context of the educational studies:
   2.1 How did the web platform come into play when the students were learning and practicing DT in hybrid mode?

Since hybrid mode cannot exist without a technological facilitator, it cannot be studied independently of the facilitator used. We therefore selected, and somewhat enhanced, the platform that we deemed as supporting well the objective of the study. The second research question above guided the examination of the benefits achieved via the different characteristics of the facilitator.

The use of DT in the exercise of the educational studies included the Empathy, Define, Ideation, and Prototype stages (Brenner and Uebernickel, 2016). The exercise as a whole was virtual, using Zoom as the communication platform and a virtual collaborative environment. The teams were allowed to choose whether to work in virtual, hybrid, or physical mode. Beyond these commonalities, the two case studies (Yin, 2009) differed in terms of the student population, the challenges the teams addressed, the platform on which they collaborated, and the timeframe in which the exercise took place.

The subject of the case study was an annual educational event, titled *Jam Week,* at a college of engineering, design, and art, where multidisciplinary teams of students from the schools of engineering and design addressed the same theme, presented as specific welfare-oriented challenges by external organizations. The teams used both technology and design practices to address their respective challenges. The follow-up study was of a 90-min DT workshop, conducted at a university, in a final projects course given to university Information Systems students in their last year of study. In this course, each team develops an information system for a real customer. The teams applied the DT principles and process taught in the workshop to their respective projects.

Our findings highlight the benefits and challenges of using hybrid mode for this type of learning activities, while facilitating a hybrid workspace such that different collaborative spaces are allowed for different activities. The findings further provide indications about the outcomes that can be expected in each of the two extreme timeframes and settings experienced in our research, which could be instrumental for guiding the design of future hybrid educational endeavors in different settings enjoying different extents and types of resources.

The rest of the paper is organized as follows. Section 2 briefly reviews related work regarding the DT methodology, with emphasis on the empathy model as well as technological platforms for hybrid teaching experience. Section 3 presents our extended concept of a hybrid environment for the DT experience. Section 4 continues with the description of the two educational studies. Finally, Section 5 concludes with a discussion and suggestions for future research directions.

2. Related work

2.1. Empathy in engineering

The ability to empathize is considered a necessary professional skill for students in general (Mccurdy et al., 2020) and engineers in the 21st century (Walther et al., 2020; Penzenstadler et al., 2009) in particular, and is among the soft skills that "may have as great an influence over an engineer's overall career success as technical competence" (Hecker, 1997, p. 62), such as active listening, showing concern, and having a positive attitude. The understanding of the importance of educating engineering students to develop empathy skills is constantly increasing (Rasoal et al., 2012) as one component of emotional intelligence, alongside self-awareness, motivation, self-regulation, and adeptness in relationships (Goleman, 1998). Yet, while recognition of the importance of empathy for contemporary engineering practice is growing, the literature provides sparse guidance for fostering empathy in undergraduate engineering programs (Walther et al., 2020). The literature does discuss other activities, such as role playing and peer reviews, that support the development of emotional intelligence, and hence, the ability to empathize seems to be a teachable and learnable skill as well (Riemer, 2016).

Previous research identified a reciprocal inhibitory relationship between social cognition — i.e., reasoning about the mental state of another person, and physical cognition, i.e., reasoning about the causal/mechanical properties of a system (Jack et al., 2013). A follow-up study illustrated, for engineering work, the inverse relationship between non-technical concerns and analytical thoughts (Cech, 2014). Both studies showed the importance of including empathy development in engineering programs, particularly in the context of design thinking and interdisciplinary learning.

According to Walther et al. (2020), however, engineering educators wishing to integrate empathy training into undergraduate programs are challenged because of a lack of conceptual clarity regarding the nature and purpose of empathy. To close this gap, the authors developed a model that conceptualizes empathy in three dimensions (Walther et al., 2020). The first dimension – Skill – focuses on enhancing empathic communication, building relationships, and making decisions. The second dimension – Orientation – captures a range of mental dispositions, assumptions, and personal values that influence the way engineers empathically engage with others. The third dimension – Being – situates empathic skills and practices within a contextualizing framework of broader values, such as service to society, the dignity and worth of all stakeholders, and the integration of personal values and beliefs with professional goals and actions (Fig. 5 in Appendix A presents the model). Their model was used to develop the research questionnaire and analyze the findings (presented in Section 4).

2.2. Design thinking: Practice and education

In recent years, design has been acknowledged as a method of developing innovations that is capable of disrupting the market through its architecture, functionality, and aesthetics. Design has gained the reputation of not only addressing a product's appearance but also of encompassing the strategic aspects of business (Almeida et al., 2019). According to the authors of (Kumar, 2011), design-based techniques and solutions have brought numerous benefits to companies related to the development of user-focused innovations and their needs. DT is a future-oriented innovation methodology (Dimitra Chasanidou, 2015), "a discipline that uses the designer's sensibility and methods to match people's needs with what is technologically feasible and what a viable business strategy can convert into customer value and market opportunity" (Brown, 2008, p. 86). It involves three perspectives: (1) mindset, (2) process, and (3) toolbox (Brenner and Uebernickel, 2016). From the mindset perspective, DT exhibits a combination of divergent and convergent thinking, a strong orientation toward both the explicit and

implicit needs of customers and users, and prototyping. From the process perspective, DT combines both a micro and a macro process. The micro process consists of defining the problem, finding and synthesizing needs, generating ideas, prototyping, testing, and targeting for innovation. The macro process consists of managing milestones while developing prototypes that fulfill the defined requirements. From the toolbox perspective, DT refers to the application of numerous methods and techniques taken from the design, engineering, informatics, and psychology disciplines (Dimitra Chasanidou, 2015; Hehn et al., 2020; Levy and Huli, 2019).

Empathy is essential when practicing DT. Indeed, empathy-driven design differs from other user-centered design techniques in that all stakeholders are genuinely engaged and involved in the development of solutions that best fit their needs (Brenner and Uebernickel, 2016). To determine user needs, the persona tool is often used to analyze conversations with stakeholders, especially end users (Dimitra Chasanidou, 2015). The real or imagined user persona is then further described using the four categories of the empathy map tool: Says (quotes and main terms), Does (observed behaviors), Thinks (assumed thoughts), and Feels (assumed emotions).

Additional DT methods include defining the identified gaps or problems before conducting ideation, which involves brainstorming to allow divergent and convergent thinking, motivating team members to suggest multiple ideas without considering their feasibility to reduce criticism, and encouraging associative thinking that may lead to innovation (Dimitra Chasanidou, 2015). The final step in the workshop consisted of creating prototypes of possible solutions to be examined by various relevant stakeholders (Dimitra Chasanidou, 2015).

The above-mentioned DT methods and tools were practiced by the students of the Jam Week event and the DT workshop. The focus in this paper is on the development of empathy and creativity among the students while working in hybrid mode and practicing the DT methodology.

DT is a discipline that embraces a designers' mindset, sensitivity, and methods for creating solutions that satisfy end users while considering technological feasibility and business value, and is considered an essential part of 21st century education (Lor, 2017). DT education often includes a design studio, which is well recognized as a teaching environment that is paradigmatic for many other professional domains (Schon̈, 1983). In this regard, Brandt et al. (2013) discussed the importance of embracing the designer mindset:

> "Managing the complexity of ill-structured, open-ended problems is key to design work where the work of a designer involves working with uncertain parameters in particular settings that evoke meta-knowledge, a sense of how to go about building an understanding of the problem at hand." (p. 3)

DT has been practiced in real life by engineers and scientists, especially in innovation practices, thus requiring that technology and entrepreneurial education be combined through DT (Lynch et al., 2019). The value of DT has been recognized in entrepreneurship pedagogy, especially in that it helps students step back from the *solution mode* to the *discover mode* while adopting an empathetic, user-centric lens (Huq and Gilbert, 2017). DT can enhance student satisfaction and learning outcomes by integrating notions of constructivism, justice, and equality, humor and role-playing in entrepreneurship education, and in particular by developing students' empathy skills and taking other perspectives (Lynch et al., 2019). DT was also found valuable in an academic course that aimed to prepare STEM educational programs for K-12 students. Both the course's instructors and students embraced a human-centered and prototyping mindset and increased their ability to put themselves in other's shoes (Carroll, 2015).

DT is acknowledged as a human-centered approach that identifies needs and is specifically relevant to handling societal and environmental sustainability engineering challenges (Clark et al., 2020). Learning and practicing DT in an undergraduate course, in class, were shown to improve the students' creativity and perceptions regarding sustainability challenges and their future sustainability practices (Clark et al., 2020).

The Open University developed a remote DT course, aimed to help diverse populations develop creative skills and engage with the world around them in a more productive, solution-oriented manner, rather than solve management and organizational problems (Lloyd, 2013). Teaching DT in hybrid and digital settings of graduate and undergraduate level courses was found to exhibit a transformative learning experience (Taimur and Onuki, 2021), i.e., one in which the learning process extends beyond gaining knowledge to becoming aware of one's own and others' perspectives, leading to a revised or new interpretation of the meaning of one's experience to guide future action (Burns, 2015) . DT provokes disorienting dilemmas, discourse, and critical reflections, which lead to students' confidence in their abilities to solve challenges in real-world situations and intentions to apply their learnings in the real world (Taimur and Onuki, 2021).

Recent studies posit that the COVID-19 pandemic and the supremacy of digital technologies have amplified global market volatility in all industries. The new work market will impact students' employability and thus educators, particularly universities, should refocus their learning objectives (Randhawa et al., 2021; Velu, 2023). In our study, we aimed at engaging diverse students with societal challenges in a short, intensive hybrid DT experience. While former studies reported on the way DT fosters innovation and creativity (Velu, 2023), innovation process management (Randhawa et al., 2021), the hybrid model for teaching DT (Bolshakova and Taratukhin, 2022), and digital transformation (Magistretti et al., 2021), our study focuses on skill development during the hybrid DT experience.

2.3. Technological platforms for hybrid educational settings

Several technological platforms have been used in hybrid educational settings. For example, A mobile-based hybrid teaching model, including five components: analysis, design, development, implementation, and evaluation, was examined. The experimental results showed that the model effectively achieved the course objectives, enhanced students' sense of participation and achievement, and developed students' potential learning abilities, such as independent learning and communication and collaboration (Hu and Yan, 2021). Another example is the Small Private Online Course (SPOC) environment, that matured from the Massive Open Online Course (MOOC), enabling a better mix of online and in-person meetings in academic courses (Li et al., 2019). Another study focused on the new relationship between teacher and designer of the hybrid platform, for creating authentic design tasks and scaffolding design work. It may also include development of a personal teaching toolkit for designing the hybrid environments during the hybrid educational settings based on student learning needs (Green, 2022). A hybrid DT practice took place in another study, using the Zoom environment for communication and the Figma tool for developing prototypes. The paper reports on the participants perceptions, demonstrating preference of in-person DT practice, but suggesting a better construction of the hybrid model that will be relevant in the post-pandemic work environment (Bolshakova and Taratukhin, 2022). Finally, Kohls' concept of DT Hybrid Learning Spaces aims to engage university students in learning, understanding, experiencing, and using DT for their own projects (Kohls, 2019). This environment includes Planning, Thinker, Innovation, Maker, and Open Educational spaces and shows promise in the context of our research.

3. Technological platform for the hybrid design thinking study

In order to allow the implementation of the DT process in full in hybrid mode, a supportive virtual environment had to be prepared for the teams' work. We extended Kohls' concept (Kohls, 2019) of DT Hybrid Learning Spaces with additional DT materials, tools and

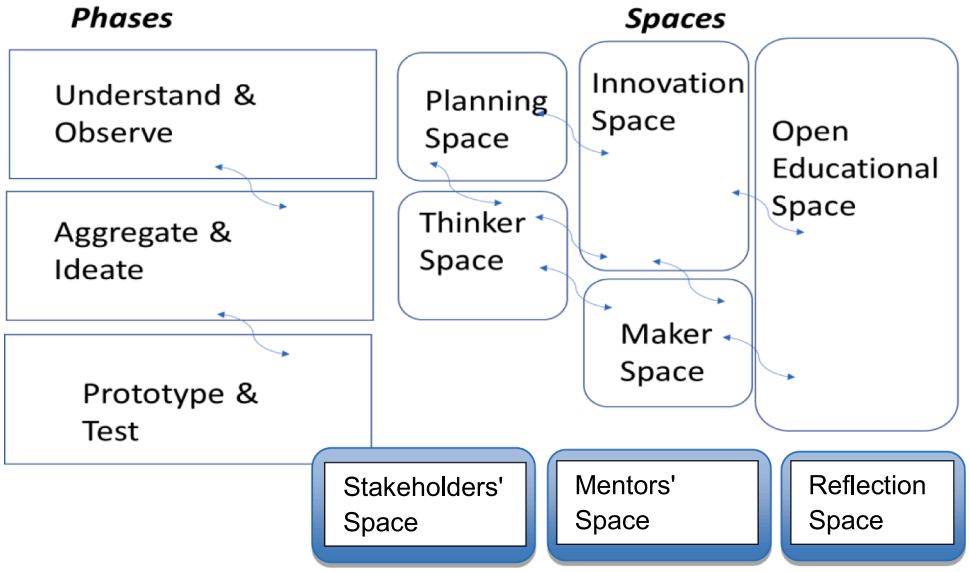

Fig. 1. Configured hybrid learning spaces for design thinking. .
Adapted from the original model (Kohls, 2019), with our additions below.

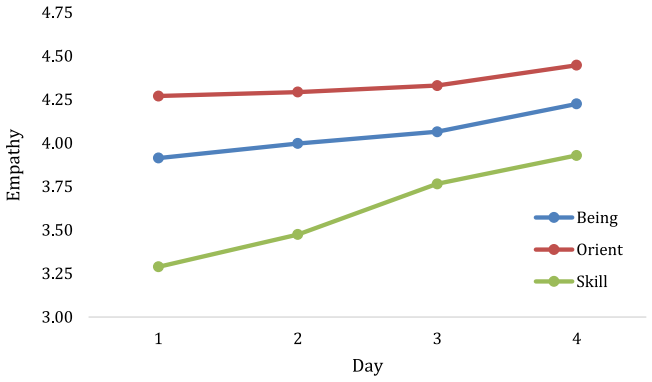

Fig. 2. Empathy dimensions over the days of the event.

instructions, and Stakeholders and Mentors spaces (Fig. 1). The DT material includes information about the DT methodology and process. The tools include the Persona and Empathy map. The stakeholders are the organizations' representatives, from whom the team could learn the relevant domain knowledge. The mentors include guiding mentors for the teams as well as expert advisors.

During the Empathy stage, the data about the challenge, gathered by each participant and/or collaboratively by the team, are captured in the planning and thinker spaces (depending on the type of data), enabling all participants who work either physically or remotely together to access the data. The Innovation space is used during the divergent and convergent stages, allowing the realization of the team's perceptions and considerations. The Maker space is used for presenting the process artifacts created by each team. The Open Educational Space includes the DT instructions and tools. Our extension further includes Stakeholders' space, where stakeholders can insert material about their organization, the domain in which it operates, and their needs, Mentors' space, where the teams can meet their mentor for explanation and discussions, and another space for scheduling meetings with expert advisors, and Reflection space where participant reflect about their experiences on each DT stage.

3.1. The collaborative environment used in the first case study

In the Jam Week case study, we used Zoom as the main communication tool, and Miro[1] as the online collaborative whiteboard platform, for the teams' work on artifacts, exhibiting the different spaces presented in Fig. 2. A week before the event, a preparation meeting was held for familiarizing the teams with the challenge, the external organizations' representatives, the mentors, and the Miro platform. Before the Jam Week, videos explaining DT and human-centered design, including exercises to follow, had been taped and inserted into Miro. The online videos were viewed by all the participants together in their shared space. Each class's mentor was responsible for viewing the videos online together with the students and answering any questions the students raised following the video. The Miro platform included a shared space for the entire group activities as well as separate spaces for each individual team. Each mentor was allocated to support six or seven teams. Following their creation of the artifacts, the teams were asked to prepare a 3-min video pitch and a poster, all in the same environment.

3.2. The collaborative environment used in the second educational study

In the Projects Course case study, time was very restricted (90 min in total). This led us to choose simple, commonly known tools for collaboration. We used Zoom as the main communication tool and a pre-prepared Power Point file shared on Google Drive as the teams' online collaborative platform, on which they added their artifacts. The workshop started with an introduction to DT, given by the lecturer before the workshop to all the students via a Zoom session. Each step was first presented by the lecturer and then instructions on how to perform it were provided. The teams were given highly restricted time segments for each step. The teams were asked to perform the exercise based on their yearly projects, with which they had been well familiar prior to the workshop. The artifacts were collaboratively developed in the slides themselves, which included the instructions as well as spaces for the students' work. Two mentors visited each team at each step, for answering any questions the teams might have.

[1] https://miro.com/.

Table 1
Categories that emerged from the analysis of empathy stage.

Main category	Sub-categories	Quotes from board's notes/Reflections/ Example summaries
Aspects of the challenge (as identified by the students) (Skill - self and other awareness)	Awareness and sensitivity toward the challenged people	"How do we identify people who are coping with a mental challenge?"
	The ways in which the environment copes with the challenge	"How should we approach these people?"
	The effects of the challenge on other stakeholders	"I am afraid that they will think that I am a weak mother".
	The ways in which the challenged people cope with their challenge	"Sometimes I feel part of the social gathering, keeping my feelings to myself, and at other times I feel lonely and a stranger among the people I meet".
	Challenged people's needs	"We need to leverage their self-dependence, self-belief, self-acceptance".
Values promoted by the social organizations (Being - dignity, worth of people)	Organization's proactiveness	"Did the organization organize social events and services during the Covid?"
	Employment and living concerns of the challenged people	"Who is organizing courses for employment for people who cope with mental challenges?"
Personal relatedness (Skill - self and other awareness)	Referring to an acquaintance or a relative who faces the same problem	Several teams created empathic questionnaires and asked their (challenged) relatives to reply. They asked people to share a personal experience when they felt lonely, and asked about their feelings, fears, and the way they overcame the situation. They also encouraged them to suggest solutions, based on their experience or expectations from authorities.
	Putting themselves in the persona's shoes	"She sees the reaction from the environment: people stare at her, talk about her".
	Bringing their capabilities to the persona (even if it was irrelevant sometimes)	When students developed the persona, they sometimes gave it physical characteristics and aspirations that fit the student's aspirations better. However, these aspirations could not be accomplished by the persona (because of their physical state).
Meeting a real stakeholder or elements from the environment (Skill -self and other awareness)	Talking with a real person who faces the challenge	When students met a particular person who faces the challenge, they became highly engaged, asking many questions and showing interest.
	Talking with someone from the organization who helps people who face the challenge	"I loved the honest talk that came from the heart (after talking with the head of one of the clinics that participated)".
	Getting elements that help visualize the real settings	"Having authentic, visual elements from the environment where the children live was critical and helped me to understand this; no explanation could replace these images".
Empathy in multidisciplinary groups (Orientation -commitment to value pluralism & Being-holistic service to society)	Diverse opinions	"We had good teamwork, encouragement, listening to each other".
	Addressing emotional and practical aspects	Addressing needs of health, freedom, creativity, dreams, love.

4. Educational studies: Method and findings

4.1. Jam week case study

4.1.1. Method

Settings: The main purpose of Jam Week is to educate students to work collaboratively in multidisciplinary teams and develop awareness of and curiosity about other domains, while realizing their responsibility to address social concerns in their professional career. The challenge in this event was to cope with loneliness, which is one of the major problems in the 21st century (Lim et al., 2020). Loneliness decreases well-being (WB), which has been recognized as a major modern life challenge that is characterized by tension, stress, consumption of unhealthy food, and reduced physical activity (Johnson et al., 2016). The World Health Organization calls for an inclusive health concept that encompasses physical, mental, and social WB and not merely the absence of disease or infirmity (Schulte et al., 2015). The loneliness challenges are related to different populations as presented by the five welfare organizations: elderly people, COVID'19 hospital departments' staff, mentally challenged people, children with neurological problems, and the Z-generation. The students were asked to follow the DT process and develop a designed technological solution concept and prototype to address their respective challenges.

Participants: The event participants consisted of 700 students from the college and 30 international students from European universities, who were divided into 150 teams, 5 external organizations, who presented challenges related to loneliness, 50 college lecturers from diverse disciplines, and 3 international lecturers and 1 professor who is an expert in gerontology (since one of the challenges addressed the aging population). Twenty-five of the college's lecturers, as well as the three international lecturers, served as mentors of students' teams and the rest of the college's lecturers and the gerontology expert acted as expert consultants for the teams.

Data collection: The collected data included the artifacts constructed by each team in the Miro platform and the students' reflections collected via the questionnaire (see Appendix B). The questionnaire was developed following the empathy model (Walther et al., 2020) and included statements related to empathy development in all dimensions. For example, the statement "I improved my listening skills" referred to the *Skill* dimension, the statement "I learned new methodologies" referred to the *Orientation* dimension, and the statement "My profession has

important values beyond the professional ones" referred to the *Being* dimension. The questions and their mapping to the model are presented in Appendix B . The students were requested to rank each statement on a 5-point Likert scale of agreement. We did not include reverse items, as the questionnaire was quite short, and we were concerned that this might confuse the participants. For each item, the students were invited to add free text to elaborate on their choice.

We received during the 4 days of the event 418, 401, 236, and 215 replies, respectively; that is, the number of replies declined from the first to the last day. Alpha Cronbach was calculated for each of the three empathy dimensions: 0.89 for Skill, 0.85 for Orientation, and 0.78 for Being. These results are sufficiently high, especially given the number of items per measure, for indicating that the measures are meaningful by averaging their respective dimensions. Over the 4 days. we also received 2642 free text answers (1885 in the Skill dimension, 326 in the Orientation dimension and 431 in the Being dimension).

Data analysis: To answer the research questions, we performed thematic analysis (Cruzes and Dybå, 2011) of the data gathered on the Miro collaborative boards based on the principles of the grounded theory methodology (Strauss and Corbin, 1998) in conjunction with interpretive research principles (Walsham, 2006). This combination, offered by Walsham (2006), was chosen for this research study because of its systematic guidance for analyzing human-centered contexts and actions while considering the full complexity of the social context. Furthermore, the aim of this study was not to offer a full and comprehensive theory, but rather to learn from the data about manifestations of hybrid learning in the contexts of our case studies and interpret their role in forming skills and competencies in both the knowledge domain (performing RE with DT) and the hybrid work mode.

The authors independently coded the data, identifying emergent themes representing the empathic process the students went through, as well as important insights regarding the DT process in hybrid mode. The coding was performed iteratively; in each iteration, the two coders compared and discussed the codes until they reached agreement toward the next analysis iteration.

The results of the questionnaire were analyzed by calculating the mean value for each statement. For the open questions, we analyzed the data in light of the three dimensions of empathy, following the principles of provisional coding (J. Miles et al., 2014), allowing the input of prior theorizing while we analyzed the data.

4.1.2. Results

Empathy during the empathy stage

The Miro boards captured the DT process the students went through, enabling us to learn about their implementation of this process and its outcomes. To understand the manner in which the students practiced the empathy stage, we analyzed the persona empathy maps captured in the Miro boards and relevant answers from the open questions in the reflection questionnaires. We also analyzed the links to resources they found and the comments they wrote that reflect their research and inspirations. Several categories emerged in the analysis, indicating the ways in which the students practiced empathy through their associations. More specifically, the analysis reveals that the students used personal perspectives regarding the challenge they were facing, met relevant people facing these challenges, and were able to later apply these challenges to an imaginary person, producing an empathy map that made their own emotional involvement explicit. Our analysis also shows that their hybrid teamwork fostered empathy within the teams (similarly to the observed empathy in physically co-located teams (Levy, 2018)). Table 1 lists the emergent categories and their relatedness to the empathy model dimensions (Skill, Orientation, and Being) (Walther et al., 2020) and sub-categories and demonstrates each of them with quoted data or summarized examples.

Empathy development

We used a linear mixed model to explain the three empathy dimensions. In this model, empathy is the dependent variable, and the participant is defined as a random effect. The day of response (1–4) and the empathy dimension (Skill, Orientation, Being) are defined as fixed effects, and the interaction between the two fixed effects is also defined as a fixed effect. The assumptions of this model were confirmed. The intra-class correlation (ICC) = 0.57, which justifies the use of this model.

The two main effects and the interaction were found to be significant (see Fig. 2; additional details are presented in Appendix D): Day: $F(3, 3273) = 68.4$, $p < 0.0001$; Dimension: $F(2, 3272) = 601.55$, $p < 0.0001$; Day * Dimension: $F(6, 3273) = 15.37$, $p < 0.0001$. A post-hoc test was conducted, using Bonferroni adjustment, to explain the difference between the 12 combinations of dimensions and days. The results show that the empathy skill on the first day is significantly lower than all other empathy dimensions on all the other days; overall Skill was the empathy dimension that showed the greatest improvement over time (0.64). On each day, there is a significant difference between each pair of empathy dimensions, with *Orientation* as the highest, *Being* the middle, and *Skill* as the lowest dimension. Note that the *Being* and *Orientation* were significantly higher than *Skill* from the start of the Jam event, indicating that the participants felt generally confident in their professional knowledge and their ethical approach toward society, but less confident in their concrete skills for actualizing this potential in the multidisciplinary teams. By the end of the event, this gap, while still existing, was reduced.

Students also expressed their perceptions in free text. Several quotes demonstrating manifestations of the different empathy dimensions are as follows.

Skill dimension: "I learned to understand what motivates people to think the way they do"; "I learned to listen and understand the problem before jumping into solutions".; "Engaging with people with design orientation honed my design talent"; "My creativity improved following the collaborative ideation process and leading the main idea".

Orientation dimension: "Everyone in the group came with his state of mind and contributed from their world"; "It opens one's mind, arouses curiosity, and opens new ways of thinking".

Being dimension: "In the deep emotional aspect, and everything that I create can influence the whole society"; "Values of thoroughness, thinking about others, users and their needs, considering safety and trust".

Interestingly, the vast majority of the free text responses were related to the Skill dimension (1885 replies, compared to 326 in the Orientation dimension and 431 in the Being dimension) providing an additional indication that the main development of their empathy capabilities is focused on this dimension.

Hybrid Mode DT Practice

The figures in Appendix E illustrate the structure of actual Miro boards and the way students practiced the DT methodology. The students were divided into separate virtual classes according to the challenges they addressed. Each class consisted of six or seven teams that addressed the challenges of a specific organization. The organization's representatives created relevant material for the teams (videos, documents, photos, etc.), which were inserted into the board. In addition, there were private boards on which each group could work and a shared collaborative board for gathering all the teams from the same class for mutual discussions. We developed the private Miro boards, following the DT stages: Empathy, Define, Ideation, and Prototype. Into each DT stage board, we inserted a short lecture, given by an expert DT lecturer, that explained the DT stage and its process and tools, and clean DT worksheets on which the students could work. The students worked on these sheets and added to the boards additional material they found in their research, as well as ideas that came up during their work. At the end of the event, they uploaded their prototype in the form of a pitch video and a poster. Fig. 6 (Appendix E) presents the shared space board for the Empathy stage. There are videos presenting lectures about multicultural listening skills, the empathy DT practice, and human-centered design, as well as links to the teams' private boards.

Fig. 7 (Appendix E) presents three empathy boards. The working sheets that were prepared in advance included the Persona and Empathy

Table 2
Students' answers to the DT stages questionnaire (number of students who agreed with the statements out of 25).

Stage	*Item*	# of Students
Empathy	The Empathy Phase allowed me to understand and define the challenge better	14
	The Empathy Phase allowed me to understand the customer functional needs better	17
	The Empathy Phase allowed me to understand the customer emotional needs better	14
	The Empathy Phase allowed me to understand the contribution of my system to the customer better	15
Ideation - Divergent	The Ideation - Divergent Phase allowed me to understand my teammates' solutions better	12
	The Ideation - Divergent Phase improved my listening skills	12
	The Ideation - Divergent Phase improved my intuitive thinking skills	16
	The Ideation - Divergent Phase improved my initial solutions	13
	The Ideation - Divergent Phase improved my creative skills	14
Ideation - Convergent	The Ideation - Convergent Phase allowed my team to arrive at agreed solutions	17
	The Ideation - Convergent Phase improved my argumentation skills	9
	The Ideation - Convergent Phase improved my analytic thinking skills	12
Prototype	The Prototype Phase allowed my team to realize better the agreed solution	17
	The Prototype Phase improved my design skills	12
	The Prototype Phase improved my creative skills	11

Map tools. The video that was prepared by the organization was added to the boards, and additional space was devoted, with specific instructions, to further research that the teams had to follow. The sticky notes are the students' additional insights they gained during this stage. At the bottom of the page there was a specific space for reflection regarding the DT process they went through.

In the Define stage board the students mapped their challenge stakeholders, namely the people who need help, their caregivers, or the organization that supports them. After discussing and selecting the most important stakeholder, in the context of their solution, they prioritized the stakeholder's challenges according to their importance. The board captured all the data they had gathered in the Empathy stage and helped summarize what they had discovered. At the end of this stage, the students phrased the sentence: "How can I help (a stakeholder) to do (what) in order to get (the value of)?" (see Appendix E, Fig. 8).

During the Ideation stage, students used the board to present their ideas. First, they raised ideas and related them to the challenge in the divergent stage. Then, they created a list of criteria, ordering them according to their importance, and voted accordingly on their best choice in the convergent stage. The boards captured their ideas and choices, which allowed us to follow their discussions and thinking processes. This helped us realize that the challenges they analyzed in the empathy stage were meaningful to them and that their ideas indeed were appropriate for addressing these challenges. For example, they realized the importance of the need for self-acceptance and developed an application that helped the target population's social inclusion.

Fig. 9 (Appendix E) presents the Ideation-Divergent stage board, showing the manner in which they connect a specific service or feature to the challenge and the benefit it provides in this context. For example, they suggested a mindfulness practice application that can relax people in lonely conditions and that can help young people to relax and connect better. Fig. 10 (Appendix E) presents the Ideation-Convergent stage board where they decide that the application should be gamified, with social connectivity that fosters acceptance of one's situation. Finally, Fig. 11 (Appendix E) presents a prototype of a solution of a social application that connects the Z-generation around cultural events.

4.2. Design thinking workshop case

4.2.1. Method

Setting: A 90-min crash DT workshop was conducted as part of a final projects course given to Information Systems students in their last year of study. The workshop started with an introduction to DT, which was given by the lecturer before the workshop to all the students via a Zoom session. Each step was first presented by the lecturer and then instructions on how to perform it were provided. The teams were allowed very restricted times for each step. At the end of the event, the students were asked to submit their artifacts and reflection forms, including an empathy questionnaire (see Appendix C).

Participants: The students were in their last year of studies for a bachelor's degree in Information Systems. They had already studied all basic programming, software design, and analysis courses, as well as some advanced courses. Thirty three students from 12 project teams, each consisting of 2–4 students, each worked to develop a software system for real customers.

Data collection: Being a very short experience, we could not expect the students to learn to work with an unfamiliar, dedicated collaboration tool such as Miro, so that we could capture the process in full. We could therefore not learn as extensively about the process they went through as in the previous case study, but rather learned mostly about its final outcome. The online PowerPoint slides captured the DT activities students performed, as well as their final prototype.

At the end of the workshop, the students filled a questionnaire regarding their DT experience (see Appendix C). Our expectations about students' development skills were rather modest, given the timeframe. We therefore formed the questionnaire for the purpose of gaining an indication as to whether this experience contributed to their professional skills in any sense. Accordingly, we chose questions that were answered with a yes or no response, rather than on a Likert scale, for a clear single-point indication (rather than progress over time as in the first case study). Of the 33 students, 25 filled the questionnaire.

Data analysis: To answer the research questions, we performed thematic analysis (Cruzes and Dybå, 2011) of the data gathered on the online PowerPoint slides. The authors independently categorized the gathered data to discover the DT process the students went through. We did not anticipate significant empathic skill development in such a short time, but rather to discover the feasibility of conducting a short hybrid DT workshop and learning its impact.

The results of the questionnaire were analyzed by calculating the number of answers expressing agreement for each statement. We further analyzed the answers to the open questions to identify indications of specific skill development. The following sections report on the study results.

4.2.2. Results

Empathy during the empathy stage

Twelve project teams participated in the case study and followed the DT instructions in the online PowerPoint slides. All the teams defined their challenge and created a persona. Eight projects filled the Empathy map, with very good descriptions regarding explicit behavior (say and do) and implicit behavior (think and feel). In the questionnaire, students reported that the Empathy stage allowed them to understand and define the challenge better and to understand better the customer functional needs, the customer emotional needs, and the contribution of their system to the customer, as can be seen in Table 2.

Ideation Stage Performance

The most difficult part for the teams was the divergent–convergent stages, which in most cases resulted in the same solutions in the divergent and convergent stages or with a few additional requirements. Only in one case could we see separate processes with arguments for why a

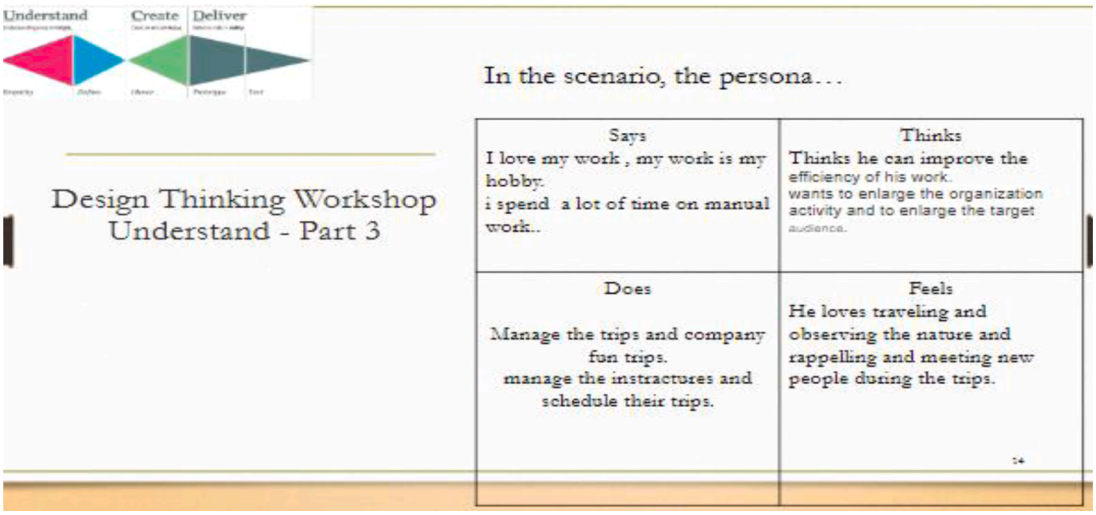

Fig. 3. Empathy map created in the DT workshop.

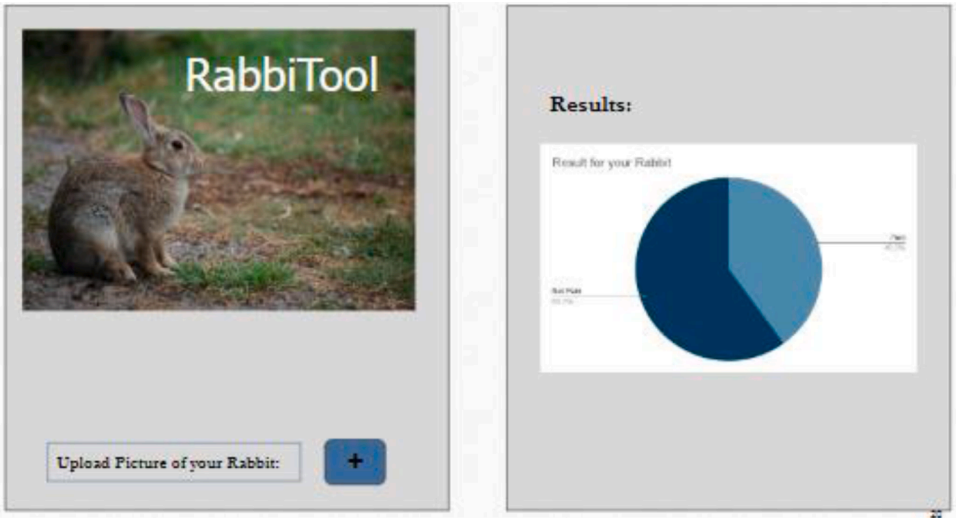

Fig. 4. Prototype created in the DT workshop.

specific solution was chosen. This could result from the DT workshop's rather late location in the students' project development when they had already arrived at their preferred solution, and also due to the short time allowed to perform the task. In the questionnaire, the students reported that the Ideation-Divergent stage allowed them to understand their teammates' solutions better and improved their listening and intuitive thinking skills, initial solutions, and creative skills, as can be seen in Table 2.

In the questionnaire, students reported that the Ideation-Convergent phase helped their teams to arrive at agreed solutions and improved their argumentation and analytical thinking skills, as can be seen in Table 2. Their answers showed that, although in the projects' slides their discussions in the divergent–convergent stages were often missing (i.e., not captured as an artifact, possibly because of the very short time available), it seems that in the groups they did practice these stages relatively well and found them very useful.

The students created several prototypes and reported in the questionnaire that the prototype stage allowed their teams to understand the agreed-upon solution better and improved their design and creativity skills, according to their reflections shown in Table 2.

In the free text, students reported their experience during the DT workshop, showing that even in the short duration of the workshop they felt they had improved their empathy capabilities in two of the empathy model dimensions: Skill and Orientation.

Skill dimension: "Better understanding what the system will provide and which problems it will solve and how it will do it"; "I think it was very good and focused when doing the main steps in the analysis and development quickly"; "Learning how to brainstorm efficiently regarding possible solutions"; "How to turn ideas into usable solutions for the consumer needs"; "If you free yourself from criticism, you can come up with the most amazing ideas".

Orientation dimension: "We learned to work better as a team and we improved our team communication"; "It is a good preparation before meeting with customers, helps you to relate to the user's workflow"; "It was lots of fun to have time with the teammates to work on the project in this way".

Hybrid Mode of DT Practice

The students received the DT instructions both verbally from the lecturer during the workshop and as on online PowerPoint slides and were asked to apply the methodology in the context of their final projects. In Figs. 3 and 4, examples of their DT tool usage and final prototype development are presented. In this case, the collaborative space served mainly as a shared working space, with specified DT instructions, thus capturing mainly the final outcome and less of the process as was

Table 3
Lessons learned about the web platform in the DT hybrid educational studies.

Extended collaboration space	The inclusion of stakeholders and mentors in the shared space (e.g., as implemented in Miro) provided meaningful and important domain knowledge, enhancing the empathy and ideation stages.
Stakeholders' involvement	Stakeholders' participation during the DT practice is absolutely critical. The hybrid mode enabled the involvement of a higher number and better quality of such stakeholders as compared to physical events.
International stakeholders	The hybrid mode enables international stakeholders, students, mentors, and lecturers to be part of the DT practice, rendering the educational experience more meaningful with global impact and relatedness.
Domain knowledge	The inclusion of domain knowledge that related to the challenge in the form of videos, photos, relevant links, and emails promoted the students' understanding of the challenge.
Reflection	Allowing space for a team's reflections allows frustrations, missing data, or any other concerns to be handled by seeking and receiving immediate feedback for overcoming the situation.
Time allocation	For a meaningful DT practice, the 90-min DT workshop seems to be too short. We recommend practicing the full scale of the DT methodology as part of the final projects course, given the very encouraging results demonstrated in the full week event. That being said, even in this very short workshop we could see some beneficial outcomes in terms of both skills and artifacts.

described in the Jam Week case.

5. Discussion

5.1. Answering the research questions

In the two educational events, the students practiced the DT methodology in hybrid mode. The educational material and instructions were available online, and the students could work in teams in virtual, physical, or hybrid mode. Based on the data collected in these events, we can answer the research questions presented in the Introduction. Not surprisingly, it is evident that as a result of the longer duration of the Jam Week and the interdisciplinary teams setting, the students were able to extend their work and become considerably more engaged with the challenge and to enhance their empathy skills. In the DT workshop, the students belonged to the same domain - information systems, which allowed them mainly to become acquainted with the DT methodology and deepen their solution value proposition based on their understanding of customer needs, but without cross-fertilization by teammates or mentors from other domains. In this section, we present the answers to our research questions, taking into account the insight gained in both case studies.

RQ1. How does practicing the DT process in hybrid mode develop the students' skills?

We answered this question via the two sub-questions relating to the educational studies' context, as follows.

RQ1.1. How did the students practice the empathy stage of DT?

The students were engaged in the empathy stage, conducted in-depth research, comprehended the emotional states and behavioral aspects of their users and the environment in which the challenge occurs, and often related the challenge to their own world. After finishing the research, they used the persona and empathy map tools to summarize their findings.

RQ1.2. How did the students' empathy, including all dimensions of the empathy model, evolve over the Jam Week and the DT workshop?

The students reported that the experience enhanced their empathy capabilities in the Skill and Orientation dimensions of the empathy model. Most dominant were their listening skills, acceptance of diverse opinions, and putting themselves in their customer's shoes. In the Jam Week, we could see their interactions with real customers and environments, which gave them opportunities to develop their empathy capabilities also in the Being dimension of the empathy model. The responses to the reflection questionnaires of both studies show a perceived improvement in all dimensions of the empathy mode (Skill, Orientation, and Being), with an observed development over time in the longer case study of the Jam Week.

The Jam Week students had more time to practice the DT stages than the DT workshop students. Specifically, during the ideation stage the DT workshop students, in some cases already had a solution idea prior to the workshop. In the Jam Week event, we could see the ideas that emerged and the students' arguments for accepting or rejecting them on the Miro boards. In the DT workshop, this process was not only shorter but, in most cases, not captured in the collaborative environment, and thus, was not available for our analysis and evaluation.

The students reported that the experience enhanced their creativity skills, which may have been facilitated by the multidisciplinary DT activities. In the Jam Week, we could see that the students conceived interesting ideas, pitches, and videos. During the DT workshop, there were no real customers present, which somewhat reduced the potential benefit of this activity. However, the students reported that the exercise made them think about their ideas from a fresh perspective.

To summarize the answer to RQ1, the educational studies demonstrated that during the DT process, performed in the hybrid mode, the students' empathy capabilities developed. This study follows other studies that showed how DT enhanced empathic capabilities, which are highly relevant when coping with societal and innovative challenges (Lynch et al., 2019; Huq and Gilbert, 2017; Carroll, 2015; Clark et al., 2020).

RQ2. How does the web platform facilitate the DT process performed in hybrid mode?

We answered this question via the following sub-question, relating to the educational studies' context.

RQ2.1. How did the web platform mode come into play when the students were learning and practicing DT in hybrid mode?

Based on the two educational studies, insights as to the role and contribution of the web platform emerged that may guide future hybrid DT educational practices. Table 3 presents the main lessons learned.

To summarize the answer to RQ2, the web platform facilitates the hybrid DT process by providing an extended collaboration space to include the involvement of external and internal stakeholders, gain from the domain knowledge of experts and capture this and the team's accumulated research results, and by providing a channel for reflection and support. For a smaller-case event experience, especially spreading over a very short timeframe, a simplified web platform is required. Former studies also acknowledged the applicability of learning DT in hybrid mode in that it enables learning others' perspectives, provokes discourse and critical dilemmas and reflections, and builds confidence to solve challenges (Taimur and Onuki, 2021; Burns, 2015).

The research contribution is two-fold. First, while former studies have demonstrated the contribution of the in-person DT process to students, focusing mainly on their innovation and creativity skills (Mccurdy et al., 2020; Velu, 2023), our study examined empathic skills development over the DT stages performed in hybrid mode. Our findings show the skill development and the actual impact of the DT process even when it occurs in hybrid mode and over a relatively short time. Second, while former studies pointed at the need to improve existing technological platforms for hybrid DT practice (Hu and Yan, 2021; Green, 2022), we used an existing platform, enhancing it and structuring its use to support the DT process as applied to the educational case studies, which resulted in a robust DT experience and skill development.

5.2. Limitations

Several limitations related to the findings of this study and the soundness of its conclusions should be considered. Using a qualitative case study approach, we examine the four elements of trustworthiness, namely, credibility, transferability, dependability, and confirmability (Guba, 1981), and discuss respective limitations stemming from the settings and method of this study.

Credibility is analogous to internal validity in positivist terms and addresses the "truth" of the research findings. Establishing the truth involves testing the credibility of the findings and their interpretations against several different sources of data.

The credibility of the findings, in our context, is inherently threatened by the use of self-report as a data source for participants' perceptions and behaviors, which could be affected by self-serving or social desirability biases. We attempted to mitigate these threats by assuring the participants that their data is fully anonymized. Still, we should consider the possibility that these threats, especially social desirability bias, that is, the tendency of subjects to respond in a way that presents them favorably and in socially acceptable terms in order to gain the approval of others (van de Mortel, 2008; Johnson and Fendrich, 2005) led to a somewhat optimistic picture of the development of the empathy dimensions: Skill, Orientation, and Being, as compared to the reality. Furthermore, acquiescence bias, which can lead to falsely positive conclusions, and the timeframe in which the reflections were gathered, namely during or immediately after the DT workshop, including the social experience and the accomplishments achieved, may contribute further to the more optimistic picture of the situation.

Another threat to credibility may stem from participants' misunderstanding or misinterpretation of the theoretical concepts under investigation. To mitigate this threat, the questions in the questionnaire were phrased using commonly understood everyday terms. For example, we did not ask directly about empathy, but rather about their experience in different manifestations of empathy, such as listening, sharing knowledge, and so on.

The credibility of our findings is further limited according to the data made accessible to us. We were able to collect the participants' reflections and all the artifacts they developed on the online platforms they used. However, since the work was performed in hybrid mode, with the participants' working from remote locations, we were not able to observe directly their activities that did not take place via the platforms. Nevertheless, as compared to previous psychical events of this nature, we found that we had access to a much larger volume of artifacts, thus increasing credibility in this dimension.

Finally, the findings based on the surveys' analysis should be treated with caution, as we observe a relatively substantial attrition in the main case study from the first to the fourth reflection surveys, resulting in a smaller number of filled questionnaires over time. This could potentially cause more optimistic conclusions, if those who were persistent were the ones who felt more satisfied with the development of their capabilities.

Transferability (Guba, 1981) is analogous to external validity in positivistic terms and addresses the applicability of the findings to other contexts or populations. This is the weakest link in a single case-study research, as it is very difficult to speculate on the extent to which the conclusions of such a specific study can be transferred to different cases in terms of settings, populations, resources, etc. To mitigate this limitation, at least to some extent, we conducted a follow-up study that differed greatly in these characteristics. The follow-up study demonstrated that even with greatly reduced resources and timeframe, some benefits found in the original study are achievable. These data allow the comparison of the settings in which our findings were obtained and a better understanding of the contexts to which the applicability of the approach and its outcomes may be transferred.

Dependability is analogous to reliability in positivistic terms and addresses the consistency or stability of the findings, indicating the potential replicability of the results. Dependability was addressed in the data analysis procedure according to the principles of stepwise replication and dependability audits (Guba, 1981) as follows. The coding procedure was individually executed by the first author and evaluated by the second author. When a disagreement occurred, the two authors discussed the issue and consulted the literature, until an informed agreement was achieved. Following the agreement of coding, the data were re-analyzed to ensure consistency. In parallel to the thematic data analysis (Cruzes and Dybå, 2011), the quantitative Likert-scale data elicited were statistically analyzed, providing additional support for the qualitative outcomes.

Confirmability is analogous to objectivity in positivistic terms and addresses the neutrality of the findings. To reduce the potential effect of biases, we included the following activities during the study: (1) Triangulation (Guba, 1981) was applied to the data collection by investigating a variety of data sources and settings, as described above in the contexts of credibility and transferability. (2) In each of the case studies, one of the authors was involved in the case itself, whereas the other remained external to the event. These points of view were instrumental in mitigating researchers' biases stemming from a priori expectations due to familiarity with the research field when interpreting the research data.

6. Conclusion

The hybrid mode of learning has been shown to improve student satisfaction and learning outcomes by increasing their autonomy, enthusiasm, and creativity (Zhu, 2021; Wu et al., 2021). The two unique educational events presented in this paper, where the students experienced the DT practice in hybrid mode, allowing them to choose their preferred meeting mode (virtual, physical, or hybrid) giving them access to experts, and providing an online structured environment for the co-creation of artifact, facilitated the development of their empathy and creativity skills. Furthermore, in the Jam Week event, the student's recognition of the profession's social responsibilities, following the social challenge presented, was also achieved.

The COVID-19 pandemic has led to some positive effects and improvement opportunities in higher education, in particular regarding online learning environments, indicating that the future mode of higher education should be hybrid (Benito et al., 2021). The hybrid mode of the case study events showed that hybrid DT practices are feasible and may develop students' empathy and creative skills, thus achieving the same objective as those of face-to-face events, in addition to providing authentic experience in the hybrid mode of work. Effective hybrid learning activities require the development of structured collaborative tools using which students can share their process and co-create artifacts, while working remotely or with colleagues in the same physical space. Such educational experiences can enhance students' capabilities to cope with real challenges in today's hybrid workspace and produce creative solutions that provide value. Follow-up quantitative studies, including surveys and controlled experiments, may provide additional validation and generalization of our conclusions. Future studies can further examine additional implementations of hybrid DT and other practices in educational or organizational settings. Another research direction can follow the Design Science Research (DSR) (Hevner et al., 2004; Engström et al., 2020), extending our exploratory study to a full DSR research for developing the hybrid learning space, and evaluating the developed platform in comparison to existing ones, toward fulfilling the potential of hybrid DT learning and practice.

CRediT authorship contribution statement

Meira Levy: Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing. **Irit Hadar:** Conceptualization, Formal analysis, Investigation, Methodology, Writing – original draft, Writing – review & editing.

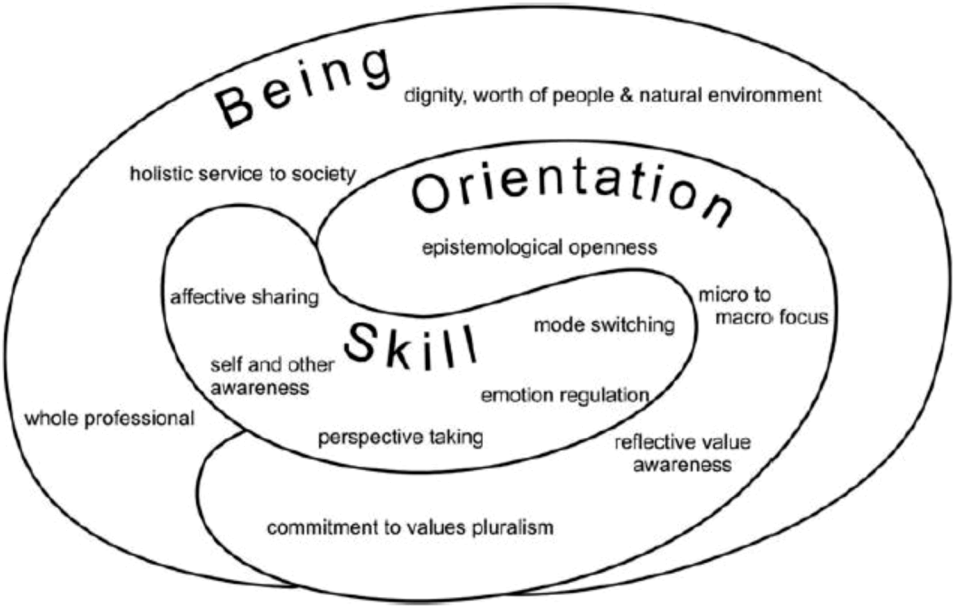

Fig. 5. Model of empathy for engineering.
Taken from Walther et al. (2020).

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

Appendix A

See Fig. 5.

Appendix B

Hello, we are asking for your help in answering a daily questionnaire that examines your personal experiences during Jam Week #9 that deals with the loneliness challenge. The purpose of this questionnaire is to examine various aspects of learning and working in a multidisciplinary team during the Jam Week and will help us understand the contribution of the Jam Week and its improvement in the future. All requested confidentiality rules will be observed regarding the information collected. Thank you for your cooperation.

The Jam Week organizers

1. I.d. _____

2. Group No. and Team No. _____

3. Mark the response that best expresses your feelings regarding the following statements: 1 strongly disagree, 2 disagree, 3 neutral/irrelevant, 4 agree, and 5 strongly agree, and if you can, please give an example.

The sentence and its relevance to the Model of Empathy (Walther et al., 2020)	1	2	3	4	5	Example
I learned to listen better (Skill - self and other awareness)						
I was able to overcome frustrations (Skill - emotional regulation)						
I gained a new perspective (Skill - self and other awareness)						
I was empathetic to others' needs (Skill - self and other awareness)						
I became aware of myself and other (Skill – self and other awareness)						
I shared my knowledge (Skill - affective sharing)						

(*continued on next page*)

(*continued*)

The sentence and its relevance to the Model of Empathy (Walther et al., 2020)	1	2	3	4	5	Example
My creativity has improved (Skill - creativity)						
I got better at creating a poster (Skill – creativity)						
I got better at presenting an idea (Skill - creativity)						
I overcame my fear of speaking in front of people (Skill - emotion regulation)						
I realized that my profession is very relevant to other professions (Being - whole professional)						
I learned new methodologies (Orientation -epistemological openness)						
It is important to me to hear different and varied opinions (Orientation - commitment to value pluralism)						
I understand the importance of personal feedback on the experience (Orientation-reflective value awareness)						
I understand the importance of group feedback on the experience (Orientation - reflective value awareness)						
I understood the importance of multidisciplinary work beyond the current project (Being - dignity, worth of people)						
It is important to me to serve society through my profession (Being - holistic service to society)						
It is important to me to respect people (Being - dignity, worth of people)						
Professional ethics are very important to me (Being - dignity, worth of people)						
My profession has important values, beyond the professional aspect. (Being - whole professional)						
It is important to give a social contribution (Being - holistic service to society)						

Appendix C

Please provide your personal insights regarding your DT experience
In what domain is your challenge?
The Empathy Phase - Please indicate with which of the following sentences you agree:
The Empathy Phase allowed me to understand and define the challenge better
The Empathy Phase allowed me to understand the customer functional needs better

Table D.1
Conservative Bonferroni Grouping for Day * Dimension Least Squares Means (Alpha = 0.05.

LS-means with the same letter are not significantly different.

Day	Dimension	Estimate			
4	Orient	4.4468		A	
				A	
3	Orient	4.3296	B	A	
			B		
2	Orient	4.2924	B		
			B		
1	Orient	4.2698	B		
			B		
4	Being	4.2245	B	C	
				C	
3	Being	4.0642	D	C	
			D		
2	Being	3.9969	D	E	
			D	E	
4	Skill	3.9284	D	E	F
				E	F
1	Being	3.9130		E	F
					F
3	Skill	3.7650			F
2	Skill	3.4736		G	
1	Skill	3.2880		H	

The LINES display does not reflect all significant comparisons. The following additional pairs are significantly different: (1 Being, 3 Skill).

Table D.2
Conservative Bonferroni Grouping for Day * Dimension Least Squares Means (Alpha=0.05).

Differences of Day * Dimension Least Squares Means Adjustment for Multiple Comparisons: Bonferroni													
Day	sug	_Day	_sug	Estimate	Standard error	DF	t Value	Pr > | t|	Adj P	Alpha	Lower	Upper	Adj lower	Adj upper
1	Being	1	Orient	−0.3568	0.03517	3273	−10.15	<.0001	<.0001	0.05	−0.4258	−0.2878	−0.4754	−0.2382
1	Being	1	Skill	0.6249	0.03517	3273	17.77	<.0001	<.0001	0.05	0.5560	0.6939	0.5064	0.7435
1	Being	2	Being	−0.08395	0.03651	3273	−2.30	0.0216	1.0000	0.05	−0.1555	−0.01236	−0.2070	0.03914
1	Being	2	Orient	−0.3794	0.03651	3273	−10.39	<.0001	<.0001	0.05	−0.4510	−0.3078	−0.5025	−0.2563
1	Being	2	Skill	0.4394	0.03651	3273	12.03	<.0001	<.0001	0.05	0.3678	0.5110	0.3163	0.5625
1	Being	3	Being	−0.1512	0.04289	3273	−3.52	0.0004	0.0284	0.05	−0.2353	−0.06707	−0.2958	−0.00658
1	Being	3	Orient	−0.4166	0.04289	3273	−9.71	<.0001	<.0001	0.05	−0.5007	−0.3325	−0.5612	−0.2720
1	Being	3	Skill	0.1480	0.04289	3273	3.45	0.0006	0.0375	0.05	0.06387	0.2321	0.003376	0.2926
1	Being	4	Being	−0.3116	0.04455	3273	−6.99	<.0001	<.0001	0.05	−0.3989	−0.2242	−0.4617	−0.1614
1	Being	4	Orient	−0.5339	0.04455	3273	−11.98	<.0001	<.0001	0.05	−0.6212	−0.4465	−0.6840	−0.3837
1	Being	4	Skill	−0.01545	0.04455	3273	−0.35	0.7288	1.0000	0.05	−0.1028	0.07190	−0.1656	0.1347
1	Orient	1	Skill	0.9817	0.03517	3273	27.92	<.0001	<.0001	0.05	0.9128	1.0507	0.8632	1.1003
1	Orient	2	Being	0.2728	0.03651	3273	7.47	<.0001	<.0001	0.05	0.2012	0.3444	0.1498	0.3959
1	Orient	2	Orient	−0.02262	0.03651	3273	−0.62	0.5356	1.0000	0.05	−0.09421	0.04897	−0.1457	0.1005
1	Orient	2	Skill	0.7962	0.03651	3273	21.80	<.0001	<.0001	0.05	0.7246	0.8678	0.6731	0.9193
1	Orient	3	Being	0.2056	0.04289	3273	4.79	<.0001	0.0001	0.05	0.1215	0.2897	0.06102	0.3502
1	Orient	3	Orient	−0.05982	0.04289	3273	−1.39	0.1633	1.0000	0.05	−0.1439	0.02429	−0.2044	0.08478
1	Orient	3	Skill	0.5048	0.04289	3273	11.77	<.0001	<.0001	0.05	0.4207	0.5889	0.3602	0.6494
1	Orient	4	Being	0.04525	0.04455	3273	1.02	0.3099	1.0000	0.05	−0.04210	0.1326	−0.1049	0.1954
1	Orient	4	Orient	−0.1771	0.04455	3273	−3.97	<.0001	0.0048	0.05	−0.2644	−0.08972	−0.3273	−0.02688
1	Orient	4	Skill	0.3413	0.04455	3273	7.66	<.0001	<.0001	0.05	0.2540	0.4287	0.1912	0.4915
1	Skill	2	Being	−0.7089	0.03651	3273	−19.41	<.0001	<.0001	0.05	−0.7805	−0.6373	−0.8320	−0.5858
1	Skill	2	Orient	−1.0044	0.03651	3273	−27.51	<.0001	<.0001	0.05	−1.0759	−0.9328	−1.1274	−0.8813
1	Skill	2	Skill	−0.1856	0.03651	3273	−5.08	<.0001	<.0001	0.05	−0.2572	−0.1140	−0.3087	−0.06248
1	Skill	3	Being	−0.7761	0.04289	3273	−18.09	<.0001	<.0001	0.05	−0.8602	−0.6920	−0.9207	−0.6315
1	Skill	3	Orient	−1.0416	0.04289	3273	−24.28	<.0001	<.0001	0.05	−1.1257	−0.9574	−1.1862	−0.8970
1	Skill	3	Skill	−0.4770	0.04289	3273	−11.12	<.0001	<.0001	0.05	−0.5611	−0.3929	−0.6216	−0.3324
1	Skill	4	Being	−0.9365	0.04455	3273	−21.02	<.0001	<.0001	0.05	−1.0238	−0.8491	−1.0867	−0.7863
1	Skill	4	Orient	−1.1588	0.04455	3273	−26.01	<.0001	<.0001	0.05	−1.2462	−1.0715	−1.3090	−1.0086
1	Skill	4	Skill	−0.6404	0.04455	3273	−14.37	<.0001	<.0001	0.05	−0.7277	−0.5530	−0.7906	−0.4902
2	Being	2	Orient	−0.2955	0.03560	3273	−8.30	<.0001	<.0001	0.05	−0.3653	−0.2257	−0.4155	−0.1754
2	Being	2	Skill	0.5233	0.03560	3273	14.70	<.0001	<.0001	0.05	0.4535	0.5931	0.4033	0.6433
2	Being	3	Being	−0.06722	0.04300	3273	−1.56	0.1180	1.0000	0.05	−0.1515	0.01708	−0.2122	0.07772
2	Being	3	Orient	−0.3327	0.04300	3273	−7.74	<.0001	<.0001	0.05	−0.4170	−0.2484	−0.4776	−0.1877
2	Being	3	Skill	0.2319	0.04300	3273	5.39	<.0001	<.0001	0.05	0.1476	0.3162	0.08699	0.3769
2	Being	4	Being	−0.2276	0.04477	3273	−5.08	<.0001	<.0001	0.05	−0.3154	−0.1398	−0.3785	−0.07669
2	Being	4	Orient	−0.4499	0.04477	3273	−10.05	<.0001	<.0001	0.05	−0.5377	−0.3621	−0.6008	−0.2990
2	Being	4	Skill	0.06850	0.04477	3273	1.53	0.1260	1.0000	0.05	−0.01927	0.1563	−0.08240	0.2194
2	Orient	2	Skill	0.8188	0.03560	3273	23.00	<.0001	<.0001	0.05	0.7490	0.8886	0.6988	0.9388
2	Orient	3	Being	0.2282	0.04300	3273	5.31	<.0001	<.0001	0.05	0.1439	0.3125	0.08330	0.3732
2	Orient	3	Orient	−0.03720	0.04300	3273	−0.87	0.3870	1.0000	0.05	−0.1215	0.04710	−0.1821	0.1077
2	Orient	3	Skill	0.5274	0.04300	3273	12.27	<.0001	<.0001	0.05	0.4431	0.6117	0.3825	0.6723
2	Orient	4	Being	0.06787	0.04477	3273	1.52	0.1296	1.0000	0.05	−0.01991	0.1556	−0.08304	0.2188
2	Orient	4	Orient	−0.1544	0.04477	3273	−3.45	0.0006	0.0375	0.05	−0.2422	−0.06668	−0.3054	−0.00354
2	Orient	4	Skill	0.3640	0.04477	3273	8.13	<.0001	<.0001	0.05	0.2762	0.4517	0.2131	0.5149
2	Skill	3	Being	−0.5905	0.04300	3273	−13.74	<.0001	<.0001	0.05	−0.6748	−0.5062	−0.7355	−0.4456
2	Skill	3	Orient	−0.8560	0.04300	3273	−19.91	<.0001	<.0001	0.05	−0.9403	−0.7717	−1.0009	−0.7110
2	Skill	3	Skill	−0.2914	0.04300	3273	−6.78	<.0001	<.0001	0.05	−0.3757	−0.2071	−0.4363	−0.1465
2	Skill	4	Being	−0.7509	0.04477	3273	−16.77	<.0001	<.0001	0.05	−0.8387	−0.6631	−0.9018	−0.6000
2	Skill	4	Orient	−0.9732	0.04477	3273	−21.74	<.0001	<.0001	0.05	−1.0610	−0.8855	−1.1241	−0.8223
2	Skill	4	Skill	−0.4548	0.04477	3273	−10.16	<.0001	<.0001	0.05	−0.5426	−0.3670	−0.6057	−0.3039
3	Being	3	Orient	−0.2654	0.04652	3273	−5.71	<.0001	<.0001	0.05	−0.3567	−0.1742	−0.4223	−0.1086
3	Being	3	Skill	0.2992	0.04652	3273	6.43	<.0001	<.0001	0.05	0.2079	0.3904	0.1423	0.4560
3	Being	4	Being	−0.1604	0.05003	3273	−3.21	0.0014	0.0899	0.05	−0.2585	−0.06227	−0.3290	0.008290
3	Being	4	Orient	−0.3827	0.05003	3273	−7.65	<.0001	<.0001	0.05	−0.4808	−0.2846	−0.5514	−0.2140
3	Being	4	Skill	0.1357	0.05003	3273	2.71	0.0067	0.4427	0.05	0.03763	0.2338	−0.03294	0.3044
3	Orient	3	Skill	0.5646	0.04652	3273	12.14	<.0001	<.0001	0.05	0.4734	0.6558	0.4078	0.7214
3	Orient	4	Being	0.1051	0.05003	3273	2.10	0.0358	1.0000	0.05	0.006963	0.2032	−0.06360	0.2737
3	Orient	4	Orient	−0.1173	0.05003	3273	−2.34	0.0192	1.0000	0.05	−0.2154	−0.01915	−0.2859	0.05141
3	Orient	4	Skill	0.4012	0.05003	3273	8.02	<.0001	<.0001	0.05	0.3031	0.4993	0.2325	0.5698
3	Skill	4	Being	−0.4595	0.05003	3273	−9.18	<.0001	<.0001	0.05	−0.5576	−0.3614	−0.6282	−0.2909
3	Skill	4	Orient	−0.6818	0.05003	3273	−13.63	<.0001	<.0001	0.05	−0.7799	−0.5837	−0.8505	−0.5132
3	Skill	4	Skill	−0.1634	0.05003	3273	−3.27	0.0011	0.0726	0.05	−0.2615	−0.06533	−0.3321	0.005238
4	Being	4	Orient	−0.2223	0.04841	3273	−4.59	<.0001	0.0003	0.05	−0.3172	−0.1274	−0.3855	−0.05913
4	Being	4	Skill	0.2961	0.04841	3273	6.12	<.0001	<.0001	0.05	0.2012	0.3910	0.1329	0.4593
4	Orient	4	Skill	0.5184	0.04841	3273	10.71	<.0001	<.0001	0.05	0.4235	0.6133	0.3552	0.6816

The Empathy Phase allowed me to understand the customer emotional needs better
The Empathy Phase allowed me to understand the contribution of my system to the customer better
None of the above
The Ideation Phase - Divergent Thinking - Please indicate with which of the following sentences you agree:
The Ideation - Divergent Phase allowed me to understand my teammates' solutions better

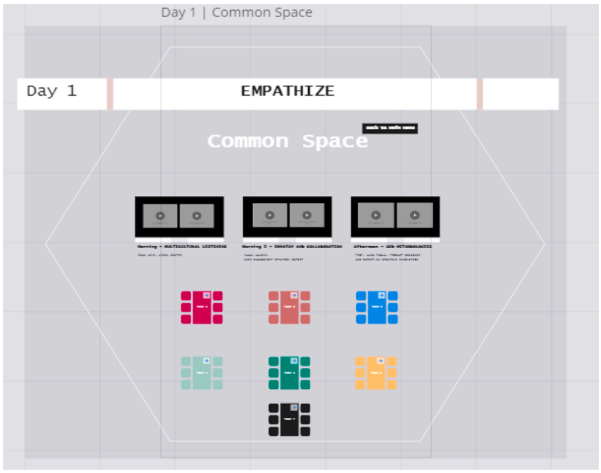

Fig. 6. Shared space board.

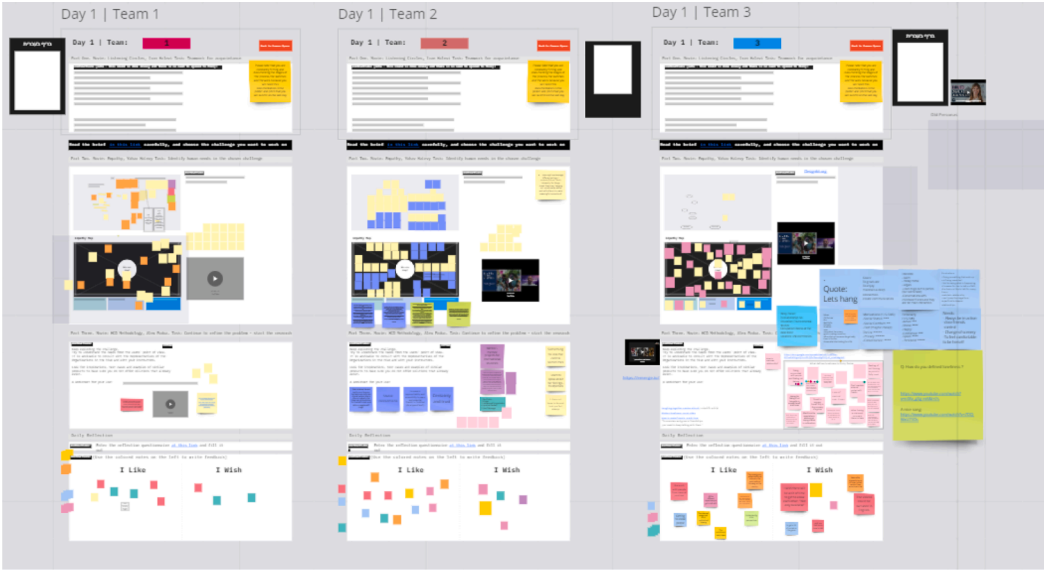

Fig. 7. Miro team board — The empathy stage.

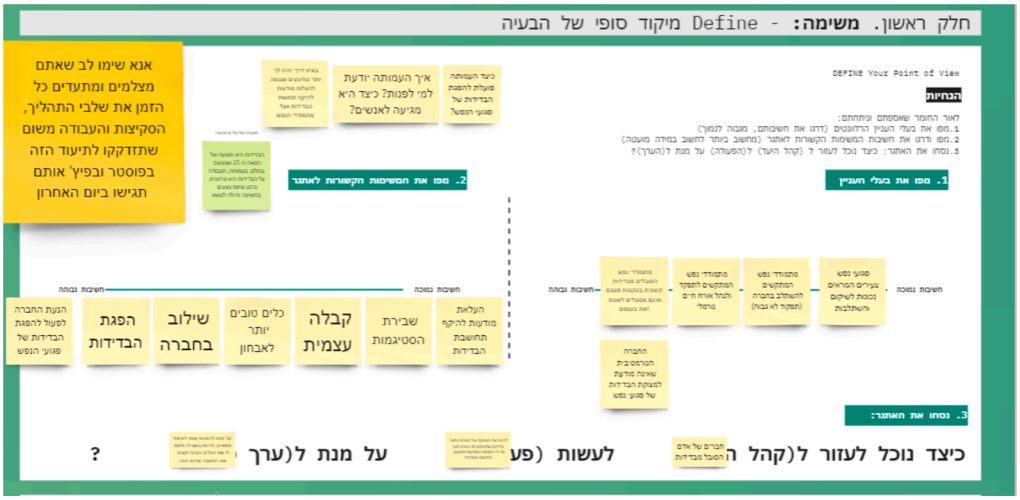

Fig. 8. Miro team board — The define stage.

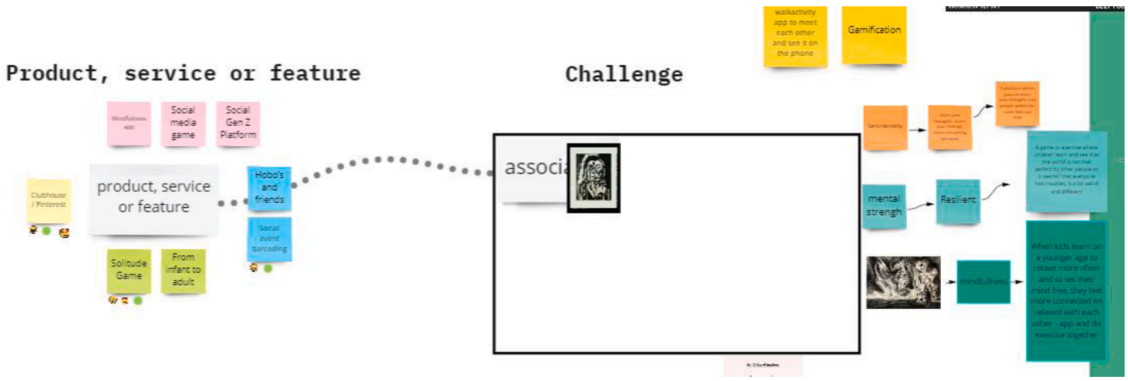

Fig. 9. Miro team board – The ideation stage – Divergent phase.

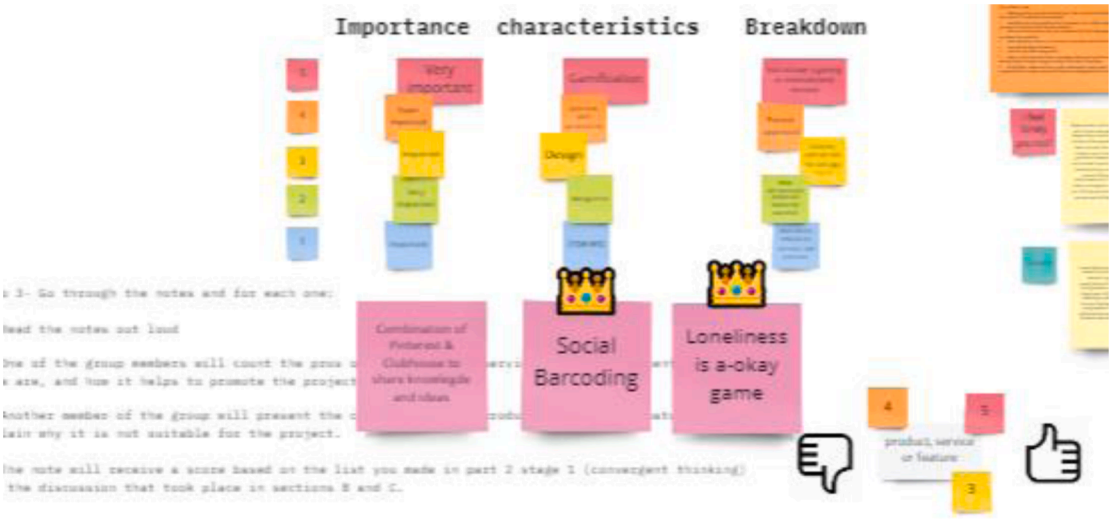

Fig. 10. Miro team board – The ideation stage – Convergent phase.

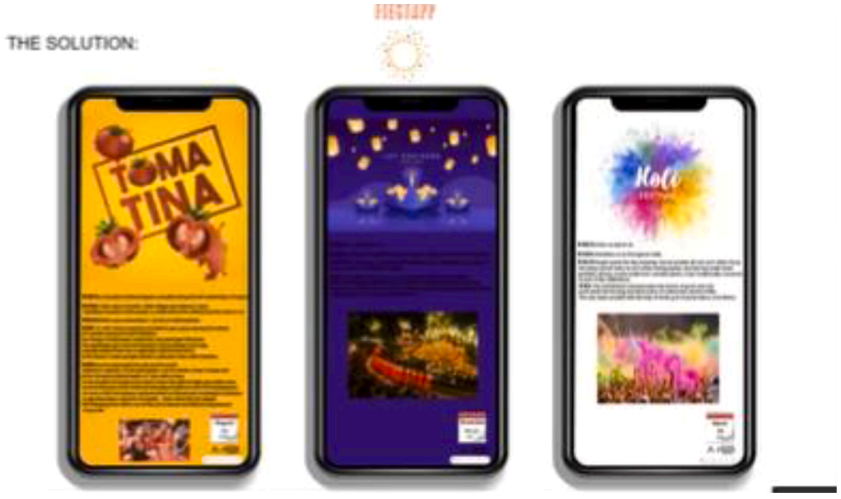

Fig. 11. Examples of prototypes.

The Ideation - Divergent Phase improved my listening skills
The Ideation - Divergent Phase improved my intuitive thinking skills
The Ideation - Divergent Phase improved my initial solutions
The Ideation - Divergent Phase improved my creative skills
None of the above
The Ideation Phase - Convergent Thinking - Please indicate with which of the following sentences you agree:

The Ideation - Convergent Phase allowed my team to arrive to agreed solutions
The Ideation - Convergent Phase improved my argumentation skills
The Ideation - Convergent Phase improved my analytic thinking skills
None of the above
The Prototype Phase - Please indicate with which of the following sentences you agree
The Prototype Phase allowed my team to realize the agreed solution better
The Prototype Phase improved my creative skills
None of the above

Appendix D

See Tables D.1 and D.2.

Appendix E

See Figs. 6–11.

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