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Towards a Creative Virtual Environment for Design Thinking

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Abstract

Background: *Digital transformation changes collaboration processes, particularly in rapidly digitalizing countries like ASEAN states. Co-creation and innovation processes become increasingly flexible and time and location independent. But virtual collaboration faces context-specific challenges like technical problems, lack of social presence, and ambiguous attitudes towards autonomy and accountability. Therefore, this study addresses two research questions to contribute to designing a creative virtual environment: First, which Design Principles (DPs) should be prioritized in designing a user-centered creative virtual environment? Second, which Design Features (DFs) effectively implement the DPs in creative virtual collaboration from a user perspective?*

Method: *A user-centered Design Science Research approach was chosen to identify, implement and evaluate DPs and DFs. DPs were derived from theories on creativity drivers in five areas: functionality, process, mood, meaning, and collaboration. The DPs were implemented in a virtual design thinking workshop at a German international university. A qualitative thematic analysis evaluated user feedback from 38 international students from Asia, Africa, America, and Europe.*

Results: *Insights from user feedback indicate that seven DPs should be prioritized and effectively implemented in a virtual environment for creative collaboration: (1) Provide rich, appropriate resources to inspire creative thinking; (2) Technical problems and connectivity issues must be anticipated and mitigated; (3) The environment must foster social presence and interaction, and (4) effective communication and visualization; (5) Methods and technologies must be adapted to the creative process and individual needs; (6) The group work benefits from structured but flexible tasks and time management support; (7) Provide space for individual work that allows autonomy and solitary contemplation.*

Conclusion: *A tailored setup that adapts to context-specific challenges distinct from the on-site collaboration is necessary to facilitate creative virtual collaboration. The study results apply and expand current theories on technology utilization and inform the practical design of a virtual environment for creative collaboration.*

Keywords: Creativity, Virtual Collaboration, Virtual Environments, Design Thinking.

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Introduction

Digital transformation profoundly changed traditional ways of collaboration through flexibilization, virtualization, and mediation of work practices (Aroles et al., 2021). Working remotely and work-from-home have become standard management practices (Kong et al., 2022). According to Intaratat (2021), 84% percent of white-collar employers in ASEAN countries are set to rapidly digitalize working processes, including a significant expansion of remote work with its trend to change 44% of their workforce to operate remotely. Innovative collaboration strategies and communication technologies designed with a user-centered approach are essential for promoting productivity and well-being among co-workers in the new way of working in the global and digital age, the concept of New Work (Aroles et al., 2021).

In this context, creativity, critical thinking, and collaboration are recognized as core competencies of the 21st century to keep pace with the challenges of a rapidly changing business world (Ananiadou & Claro, 2009; Lathinen & Flåten, 2022; MacGregor & Torres-Coronas, 2007; Yuhashi & Iijima, 2010). New Work modes offer innovative potentials as products and services are increasingly co-created across companies, locations, and time zones (Fischer et al., 2020; Yuhashi & Iijima, 2010). Virtual collaboration can bridge geographical separation and unleash the innovative capabilities of teams with diverse backgrounds, including those in geographically remote areas such as the Asia Pacific Region. Modern Information and Communication Technology (ICT) fosters creative collaboration in this context by connecting people to co-create, share, manage and store ideas effectively, facilitating networking, experience, and information sharing (Gebbing et al., 2021; Nemiro, 2007).

However, to guarantee the success of co-creation and innovation processes, New Work must support and harmonize diverse mindsets, working environments, and business practices (Aroles et al., 2021; Gerdenitsch & Korunka, 2019). The ideal circumstances for creative virtual collaboration differ based on the individual characteristics of groups and members, making it challenging to find a universal solution. For instance, in the Asia Pacific region, factors such as cultural norms, language barriers, technology infrastructure, and work styles may differ from other regions, which could impact how virtual collaboration is conducted. Increased visibility in group collaboration leads to pressure to perform and the fear of being judged or deviating from the group's opinion (Kakar & Kakar, 2018; Rosenberg, 2009). People are more reluctant to voice creative or unpopular ideas if they fear that their actions are monitored, recorded, or analyzed and used to assess their performance (Kakar & Kakar, 2018; Newman et al., 2017). In this case, concerns about autonomy, privacy, and accountability can be more significant due to the pervasive nature of technological tools.

Previous studies investigated different facets of creativity, such as the aesthetics of the creative environment (Dul, 2019), individual and group performance and behavior (Reiter-Palmon et al., 2012), and characteristics of innovation processes (Furmanek & Daurer, 2019; Guegan et al., 2017; Nemiro, 2002). Despite growing relevance and interest, there is still a research gap and a need to investigate the numerous factors affecting creativity in virtual collaboration (Yang et al., 2023). Furthermore, the practical design and implementation of an environment to foster creativity in virtual collaboration require comprehensive design solutions (Gabriel et al., 2016). Previous research has identified creativity drivers (Gebbing et al., 2022) and various design principles (DPs) for creativity support systems (Farooq et al., 2008; Pilcicki et al., 2022; Voigt et al., 2013). Considering the complexity of implementation, some of the identified DPs may have a more significant influence on virtual creative work than others (Dul, 2019), which raises the question of which DPs should be prioritized.

Further, prior research on DP development has concentrated on optimizing the creative outcome, such as fluency and flexibility of idea generation or quality of the solutions (Voigt et al., 2013). By emphasizing social collaboration and user satisfaction in creative performance,

a user-centered approach can improve technology acceptance and deepen understanding of its complex impact on individuals (Abras et al., 2004).

Subsequently, this study aims to examine the following two research questions: Which Design Principles (DPs) should be prioritized in designing a user-centered creative virtual environment? Which Design Features (DFs) effectively implement the DPs in creative virtual collaboration from a user perspective?

To answer the two research questions, we apply a user-centered Design Science Research (DSR) approach (Hevner et al., 2004), to synthesize design knowledge from literature and implement conceptually constructed DPs, referred to as creativity drivers or factors facilitating creative virtual collaboration (Gebbing et al., 2022; Khalil et al., 2019; Klein et al., 2021). The DPs and DFs are implemented and evaluated in the application context of online design thinking workshops, which have gained popularity and widespread adoption in innovation management (Johansson-Sköldberg et al., 2013). Design thinking is an innovation and problem-solving approach that fosters creativity, empathy, and iterative prototyping to develop novel and practical solutions (Brenner et al., 2016; Johansson-Sköldberg et al., 2013). In addition, we collected user feedback to prioritize relevant DFs, understood as exemplary representations or instantiations of the DPs (Salomons et al., 1993).

The identified DPs and DFs for user-centered virtual creative collaboration provide an original scientific contribution as the implementation in online design thinking workshops allows the observation of the interaction of different creativity drivers (Hevner et al., 2004). Our results further help practitioners identify best practices for designing and managing virtual teams, leading to more creative, efficient, and effective co-creation and innovative outcomes. DSR further acknowledges that technological possibilities are constantly evolving and suggests how creative virtual collaboration can be continuously enhanced and improved.

This paper is organized as follows: The introduction presents the motivation and relevance of the problem and defines the research questions. The theoretical background describes the existing knowledge base and research gaps in virtual creative collaboration. The methodology section details the DSR approach, artifact description, and research design. The results section presents the outcomes of the coding and qualitative analysis. The discussion contextualizes the study results with prior work and findings of other researchers. The conclusion summarizes revised DPs and highlights theoretical and practical implications.

Theoretical Background

Creative collaboration can be defined as the collective effort of a group to produce novel and useful ideas (Alahuhta et al., 2014; Nemiro, 2007; Reiter-Palmon et al., 2012). In addition, creative virtual collaboration refers to creative group work facilitated by ICT and is also known as computer-supported creativity (Schmidt & Bannon, 1992).

There are various perspectives from which creativity can be examined and impacted (Lubart & Thornhill-Miller, 2019). The framework on creativity drivers (Gebbing et al., 2022) provides a systematic overview of DPs that influence creative virtual collaboration from a user's perspective. It identifies five dimensions of creativity drivers in virtual collaboration, which encompass a total of 14 DPs (see Table 1): (1) functionality, (2) creative process, (3) meaningful affordances of the virtual environment, (4) group collaboration, and (5) mood states and stressors stimulated by the virtual setting. In the following, the theoretical underpinnings of the different DPs are further explained.

Table 1 – Creativity Drivers for Creative Virtual Collaboration					
Dimensions	**Functionality**	**Process**	**Meaning**	**Collaboration**	**Mood**
Design Principles	(DP1) Sufficient and Appropriate Resources	(DP3) Anonymity in Divergent Processes	(DP7) Freedom & Self-expression	(DP10) Human contact	(DP13) Attention Management
	(DP2) Adaptation and Customization	(DP4) Accountability in Convergent Processes	(DP8) Stimulation and Inspiration	(DP11) Psychological Safety	(DP14) Tolerance for Ambiguity & Dealing with Frustration
		(DP5) Task- & time-management	(DP9) Passion & Intrinsic Motivation	(DP12) Effective Communication	
		(DP6) Supervision			

Functionality

Sufficient and appropriate resources. From a user perspective, the most noticeable impediment to creative virtual collaboration is the dysfunctionality or failure of technologies (Gebbing et al., 2022). Therefore, a reliable, functional environment is necessary for creative work (Dul, 2019). Furthermore, functionalities must be sufficient and appropriate regarding variation and complexity, enabling the user to perform the task effectively (Dul, 2019). Research has shown that a team's creative performance depends on the variety of strategies available to the team to solve a task and benefits from the recombination of existing knowledge in novel ways (Cropley, 2006) or the application of diverse creative techniques, methods, and tools (Leopoldino et al., 2016). Further, to be perceived as appropriate, tools should be useful and easy to use (Davis, 1989). Hence, providing a rich portfolio of functional resources, i.e., information, methodologies, and techniques, allows more diverse results and combination possibilities (Cropley, 2006).

Adaptation. The selection and variety of tools must be adapted to the collaboration in the group (Dennis & Valacich, 1999) and the specific needs and requirements of the person, process, or context (Elo et al., 2022; Furmanek & Daurer, 2019; Gebbing et al., 2021). Research on constraints in creative collaboration has shown that, on some occasions, limiting functionalities may benefit creative collaboration, mainly by reducing complexity and restraining communication (Biskjaer et al., 2020; Pilcicki et al., 2021). Hence, the second essential principle for a virtual collaborative setting is adaptation, which entails selecting resources based on the creative process, individual preferences, and expertise in ICT usage and creative activities (Gebbing et al., 2022). Incorporating design features that endorse creative work methodologies involves pre-selecting high-quality, user-friendly tools, techniques, and information resources.

The Creative Process

A creative process describes the sequence of thoughts and actions that leads to an original, valuable idea or result (Lubart & Thornhill-Miller, 2019). The modalities of collaborative teamwork vary across stages of the creative process. As a result, some creativity support systems are developed as tools that specifically support the creative process (Voigt et al., 2013). A classic distinction in the creative process is made between *convergent* and *divergent thinking* (Guilford, 1957). Divergent thinking refers to generating many unstructured, open-minded, and non-judgmental ideas (Guilford, 1957). Convergent thinking refers to a cognitive process of narrowing down multiple ideas and involves eliminating extraneous options using

logical reasoning, analysis, and critical thinking skills (Cropley, 2006). Many innovation approaches, such as the double diamond model in design thinking, combine divergent and convergent phases in the creative process (Brenner et al., 2016).

Anonymity in divergent processes. An inherent challenge in brainstorming is that group members can unintentionally influence each other's thoughts and limit each other's creativity, resulting in fewer and less innovative ideas (Michinov, 2012). Therefore, to facilitate divergent thinking, interactions, and visibility between team members are often constrained (Biskjaer et al., 2020; Furmanek & Daurer, 2019). Electronic brainstorming advises separating group members in the idea-generation stage before sharing ideas with the entire group (Maaravi et al., 2021). Participants further benefit from the anonymity of constrained virtual environments, creating a space of seclusion that allows for reflection, experimentation, and risk-taking by reducing the perception of being observed and judged (Gebbing et al., 2021; Hite et al., 2014; Maaravi et al., 2021).

Accountability in convergent processes. In contrast, convergent thinking involves comparing, evaluating, and coordinating ideas to single out the best and most creative solution (Cropley, 2006). Activities involving convergent thinking are constructing a shared understanding to improve the problem definition (Redlich et al., 2017), idea evaluation, and decision-making (Cropley, 2006). Facilitating a shared understanding can result in a more comprehensive solution perspective, ultimately improving the practical applicability of the generated ideas (Redlich et al., 2017). Therefore, convergent phases need rich communication channels and an open, unbiased exchange of ideas (Dennis & Valacich, 1999; Furmanek & Daurer, 2019).

Task and time management. Classic time management mechanisms, such as scheduling, task division, and progress evaluation, focus on the most effective use of time (Achtziger & Gollwitzer, 2009; Lund & Wiese, 2021). However, the creative process is often non-linear and demands a high degree of flexibility and iteration. Especially when a group feels "stuck," breaks and distractions help create space for inspiration and incubation (Ritter & Dijksterhuis, 2014). Through incubation, new ideas suddenly emerge when one is distracted or occupied with a completely different task (Benedek & Jauk, 2019; Ritter & Dijksterhuis, 2014). The resulting DP entails that task and time management should endorse agility, flexibility, and iteration, mirrored in process planning and progress monitoring features.

Supervision. In classic innovation approaches, like Design Thinking, the role of a coach or supervisor is to help the group steer through the different phases of the creative process such as developing, evaluating, selecting, and improving ideas, and to adapt collaboration modes and tools accordingly (Furmanek & Daurer, 2019). Different creativity support systems were designed to support a group in different phases of the creative process, from problem analysis and ideation to idea evaluation and presentation (Gabriel et al., 2016). However, most current creativity support systems either focus on ideation or aid problem analysis and idea evaluation (Gabriel et al., 2016). Few studies have developed group creativity support systems that aid in divergent and convergent processes, e.g., adapting communication synchronicity, trust, and group awareness (Voigt & Bergener, 2013; Voigt et al., 2013).

A persisting challenge stressed in previous studies on virtual team creativity is that the right balance between shared time and individual work varies for each team and is difficult to determine (Nemiro, 2007). The role of the supervisor is therefore also to "read the room" and determine the current status of the social dynamics (Gebbing et al., 2021; Nijstad & Dreu, 2002; Reiter-Palmon et al., 2012). To facilitate this retrospective, a support system could initiate reflections to improve the collaborative experience through features such as social games, sentiment analysis, or prompts for discussion groups.

Meaningful Affordances

Affordances describe an immediately perceptible character of objects in an environment (Gibson, 1977). Particular physical attributes and characteristics of the surroundings possess an innate significance or meaning that can provoke specific states or behaviors, including creativity (Dul, 2019). Designers use affordances to direct people's attention and gaze and trigger emotional responses and reactions. Behaviors can be seen as an expression of the interaction of a person with their environment (Deci & Ryan, 1980). In the following, we present three affordances associated with creativity (Amabile, 2006; Dul, 2019):

Freedom and self-expression. To instill a creative mindset, the environment should provide a sense of freedom and possibilities for self-expression (Dul, 2019). This involves explicitly encouraging creativity and the permission to take risks, think out of the box, and experiment (Khan et al., 2018). Further, the setting should provide possibilities to work autonomously and be self-directed, according to one's needs and preferences (Deci & Ryan, 1980; Garfield, 2008). Finally, this principle is supported by features that help self-expression, e.g., through visualization (Candy, 1997) and the possibility to present and "sell" ideas by convincing people of their value (Sternberg, 2019).

Stimulation and inspiration. Creative exploration should be supported by a stimulating environment that triggers curiosity and exploration (Dul, 2019; Gebbing et al., 2022). In addition, the virtual environment should provide access to rich sources of information and the possibility to dive deeper. Yet, practitioners have recognized that virtual work can increase the likelihood of producing unoriginal ideas due to over-reliance on online resources (Borjas & Gebbing, 2021). To mitigate this risk, it is advisable to incorporate offline experiences into the planning of virtual collaboration, allowing individuals to take breaks from their screens and seek inspiration from the real world.

Passion and intrinsic motivation. To create a meaningful environment that instills creativity, the environment should be motivating (Amabile et al., 1996; Dul, 2019; Gebbing et al., 2021). Extrinsic motivation can be triggered by presenting rewards (e.g., a progress bar, recognition) or punishments (e.g., through a ticking clock) (Amabile, 2006; Vallerand, 1997). Intrinsic motivation stems from a person's genuine interest and predicts creative achievement better than extrinsic motivators (Ivcevic & Hoffmann, 2019; Vallerand, 1997). However, there is a persisting research gap regarding general rules on making an environment "intrinsically motivating" since the ideal conditions for intrinsic motivation, passion, and flow vary among individuals (Vallerand, 1997). Two closely related concepts to intrinsic motivation are the experience of passion and flow. Passion represents the highest form of intrinsic motivation and enthusiasm when engaging in activities central to one's identity (Ivcevic & Hoffmann, 2019). The flow experience describes a blissful engagement in a task that makes one forget about time and everything else (Nakamura & Csikszentmihalyi, 2014). Flow occurs when skills are neither overmatched nor underutilized to meet a given challenge.

Collaboration and Individual Differences

As mentioned earlier, creative collaboration can be defined as the collective effort of a group to produce novel and valuable ideas (Alahuhta et al., 2014; Nemiro, 2007; Reiter-Palmon et al., 2012). However, a group always consists of individuals who must coordinate their actions, needs, and contributions. In creative collaboration, complex group dynamics can prevent ideas from being heard and treated equally (Kakar & Kakar, 2018; Nijstad & Dreu, 2002). For example, evaluation apprehension predicts that a member of a creative group might express ideas less openly or feel pressured by the fear of being judged (Rosenberg, 2009). Opinion leadership describes how formal or informal group leaders often disproportionately influence group discussion and that others tend to follow their ideas instead of presenting their own (Nijstad & Dreu, 2002). Finally, preference consistency predicts that people are more likely to

choose ideas consistent with their existing opinions than to be receptive to novel, innovative ideas (Faulmüller et al., 2012).

Human contact. Social presence refers to feeling close and socially and emotionally involved in a community (Chae, 2016; Jones-Roberts, 2018; Kock, 2005) and is a strong predictor for overall satisfaction in virtual collaboration (Bulu, 2012). Further, co-presence is discussed in this context as the sense of being together in a (virtual) environment where individuals are accessible, available, and subject to each other (Bulu, 2012; Goffman, 2008). In virtual interaction, it is challenging to fulfill the innate needs of human contact and social presence (Kock, 2005). A persisting issue is the difficulty of conveying emotions and intentions via non-verbal cues (Bailenson, 2021). Media vary in their ability to give the impression that others are genuinely present (Dennis & Valacich, 1999). Using highly synchronous media (e.g., videoconferencing or telephone) allows thus for a more substantial social presence than asynchronous media (e.g., email). In addition, gamification and features such as social games and icebreakers are often used to establish a connection between team members and facilitate human contact (Meske et al., 2017).

Effective communication. Research on information sharing and decision-making investigates effective group communication strategies to prevent negative group dynamics (Faulmüller et al., 2012; Paulus & Nijstad, 2003; Stroebe et al., 2010). Communication in virtual environments appears less natural due to the lack of social cues like mimicking, gestures, and intonations (Kock, 2005). Therefore, effective communication must be explicitly supported, e.g., by facilitating metacommunication, as a conversation about working and communicating together to make implicit group dynamics explicit (Craig, 2016). Features like a group retrospective and a constructive feedback culture allow communication channels to be adapted based on the task and group setting (Dennis & Valacich, 1999), e.g., regarding the creative process.

Psychological safety and sense of security. For an open, unbiased exchange of ideas between group members, it is essential to experience psychological safety, be able to express oneself freely, give feedback, and ask for feedback without fear of negative consequences for one's self-image or status in the group (Newman et al., 2017). Psychological safety is defined as the shared belief among individuals that it is safe to take interpersonal risks (Edmondson, 1999; Edmondson & Daley, 2020; Newman et al., 2017). In creativity, psychological safety enables expressing radical and unusual ideas without fear of judgment or criticism (Amabile et al., 1996; Newman et al., 2017). Psychological safety is not achieved through frequent interactions alone but requires strong relationship networks based on empathy, trust, social support, and social capital (Davis, 2015; Feng et al., 2004; Newman et al., 2017).

Mood States and Stressors

Studies show that a good mood positively impacts creativity (Baas et al., 2008). Yet, in the virtual context, long hours in front of the screen and many video conferences can cause a feeling of technostress and "zoom fatigue" (Bailenson, 2021; Chandra et al., 2019; Gerdiken et al., 2021). Typical triggers for technostress are high complexity and invasiveness, an overload of too much technology, disruption of cognitive processes, uncertainty, and insecurity, e.g., regarding the correct use of new technologies (Chandra et al., 2019). The aim should therefore be to instill a positive, conducive atmosphere in the group, to maintain a positive mood (Borjas & Gebbing, 2021; Dul, 2019).

Attention management. The human mind can only process a limited amount of information at once, and an increased mental overload might decrease the attention span and cognitive flexibility (Johnston & Dark, 1986). It is therefore suggested that the creative virtual collaboration actively employs strategies for attention management and concentration enhancement, i.e., through features like scheduling breaks and time away from the screen.

Tolerance for ambiguity and dealing with frustration. Sociotechnical blockages and organizational impediments can cause frustrations, which might block the creative flow (Ceci & Kumar, 2016). Therefore, to maintain a positive mood, the group must develop a tolerance for ambiguity and coping strategies to deal with frustrations (Borjas & Gebbing, 2021; Jones-Roberts, 2018). A helpful feature could be to define contingency plans and time buffers and be prepared to use alternative sources or ICT.

Research Procedure and Methodology

This study applied a user-centered DSR approach (Hevner, 2007; Möller et al., 2020), as displayed in Figure 1. This approach differentiates the problem space from the solution space of a design challenge.

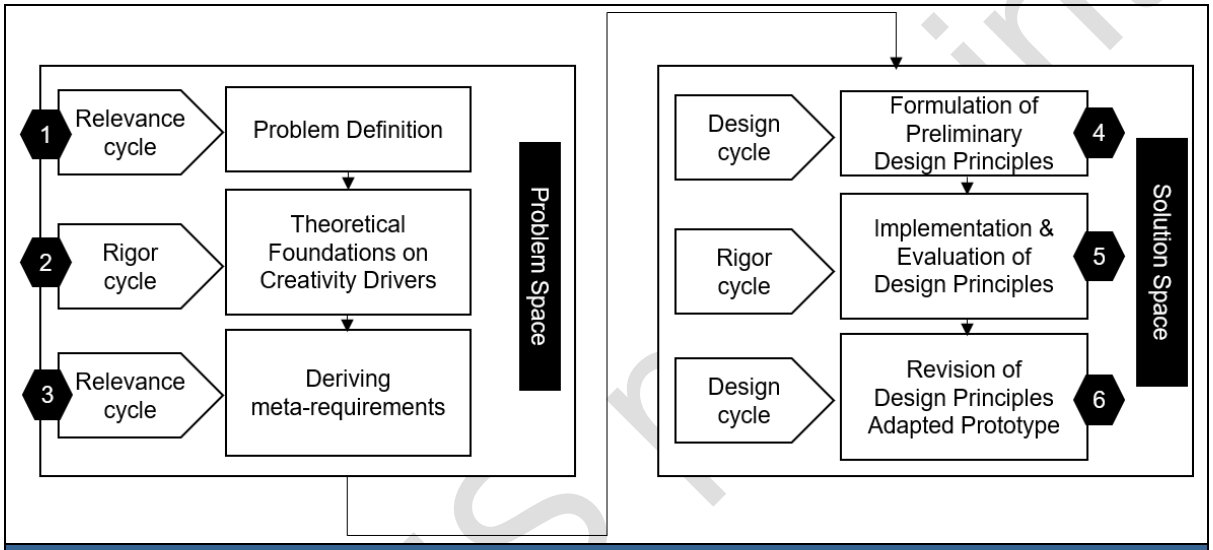

Figure 1 – DSR Approach Adapted by Möller et al. (2020) and Hevner (2007)

The problem definition, motivation, and research questions presented in the introduction of this paper reflect the relevance of the development of design knowledge for creative virtual collaboration. Theoretical studies on design requirements have mainly focused on the problem space, proposing various DPs that require practical validation. Table 1 presents the DPs for creativity drivers, which were chosen for their user-centered approach and lay the foundation for the theory section of this paper. These conceptually derived DPs were previously evaluated for necessity, insightfulness, accessibility, actability, and effectiveness by experts in a focus group using a light reusability evaluation framework, confirming the value of the proposed DPs in terms of necessary, insightful, accessible, actable, and effective (Gebbing et al., 2022).

This contribution focuses on the solution space of the DSR process, which involves implementing, evaluating, and revising artifacts like DPs and DFs. Therefore, in this study, 14 identified DPs from previous research (Gebbing et al., 2022) were instantiated and assessed in the specific application context of online design thinking workshops, providing concrete guidelines and effective methods to steer the creative process (Brenner et al., 2016). However, design thinking has primarily been implemented in face-to-face situations and benefits from further developments in virtual collaboration. Therefore, we seek to answer two underlying research questions: “Which DPs should be prioritized in designing a user-centered creative virtual environment?”; and “Which DFs effectively implement the DPs in creative virtual collaboration from a user perspective?”.

Participants

DFs representing the 14 DPs for creative virtual collaboration were implemented in three online design thinking workshops where participants worked on complex, real-world design challenges. The workshops took place at an international English-speaking university in Germany, with 50 participants from diverse cultural backgrounds across four continents (Asia, Africa, America, and Europe). The online design thinking workshops were held in January 2021 as a 5-days workshop with 21 participants and in August 2021 and August 2022 as one-day workshops with 12, respectively, 5 participants.

User feedback was collected through a qualitative survey after each design thinking workshop. In total, 38 students completed the study and provided user feedback on how the virtual setting helped (1) or hindered (2) them from being creative. The participants' ages ranged from 18 to 27, with an average age of 21. Studies suggest that diverse teams have greater creative potential (Carte et al., 2007; Taras et al., 2019). Therefore, to promote diversity, each group comprised four to six members who were systematically assigned based on differences in age, gender, nationality, and study-related areas.

Implementation of Design Thinking in Online Workshop Formats

The DPs were implemented in a prototypical environment for online design thinking workshops. A mock-up application was created to better illustrate how the DPs were implemented (https://app.uizard.io/p/b38957d5). Figure 2 illustrates the group space with access to the knowledge library, digital whiteboard, time and task management tools, and a coach contact point. The operationalization of the virtual creative environment for the online design thinking workshop consisted of five features: (1) a 6-step design thinking innovation process; (2) provision of multiple creativity methods; (3) provision of digital whiteboards for creativity work; (4) tools for verbal and visual communication; and (5) online supervision by an experienced coach. In the following, we will describe these features in the context of the DPs.

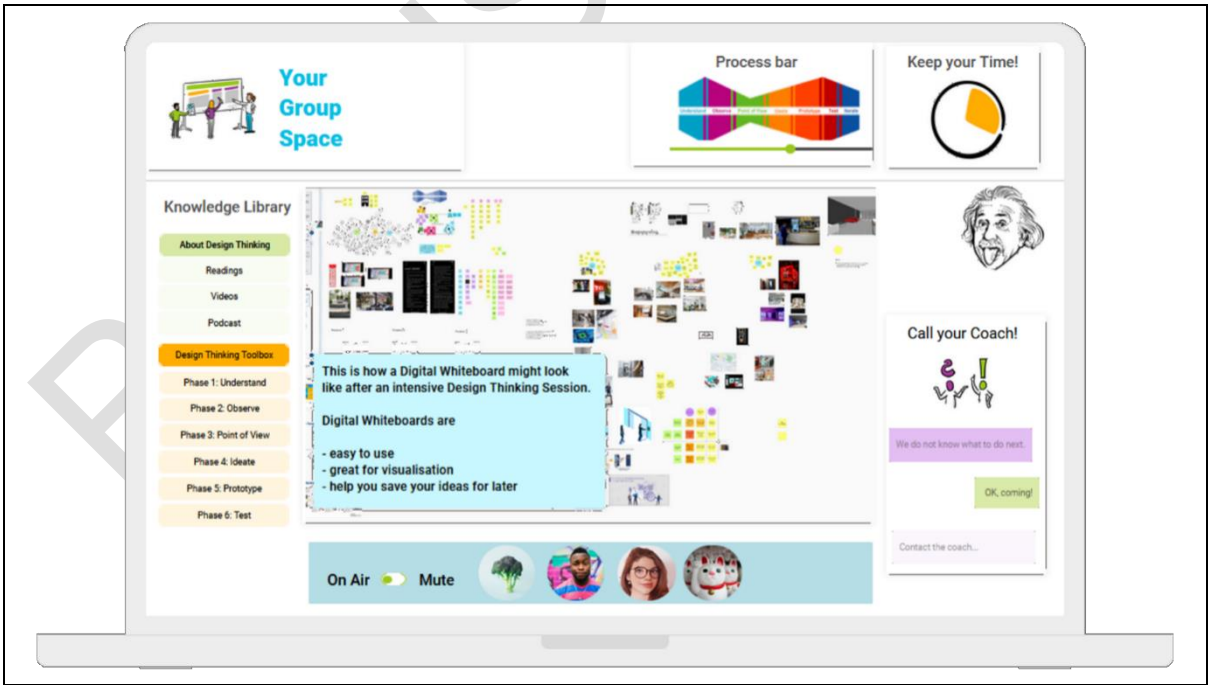

Figure 2 – Mockup of a Virtual Design Thinking Environment

The Design Thinking Process. To guide students, the design thinking process was visualized, representing the six iterative phases "Understand," "Observe," "Re-Define," "Ideate," Prototype," and "Test" (Brenner et al., 2016; Brown, 2008). This visualization allows process tracking and supports task and time management (DP 5).

Each group worked autonomously and decided how to divide the tasks (DP 5). The groups were self-managed and flexible regarding time management and free to schedule breaks and react to signs of techno-stress and fatigue (DP 5, DP 13). To promote intrinsic motivation, groups were encouraged to take task ownership right from the start (DP 9). After a phase of understanding, they were encouraged to reformulate the given challenge into an intrinsically motivating task.

Creative Methods and Templates. An experienced supervisor provided instructions and guidance on methods and background information, while also mentoring and supporting the practical learning experience. According to the design thinking process, methods were presented that support divergent thinking (DP 3) or convergent thinking (DP4). Divergent methods are characterized by generative and individual work (e.g., brainwriting, interviewing, research). In divergent tasks, students were instructed to engage in individual work, e.g., turning off cameras and audio or leaving the video conference to conduct offline research and interviews. Convergent methods aim to evaluate, select, expand, and test ideas (e.g., rephrasing the problem definition, clustering ideas, prototyping, and collecting user feedback). These tasks involved more communication and increased accountability. The coach explicitly encouraged the groups to be creative, experiment, use additional materials, and express themselves freely (DP 7). Features that support these collaborative efforts include video conferencing, discussion rounds, and a digital whiteboard equipped with visualization tools, scoring systems, voting mechanisms, and color-coded annotations.

Digital Whiteboards. The groups used digital whiteboards for creative interactions (e.g., Mural or Miro). Digital whiteboards are online collaboration platforms that provide distributed teams with various functionalities to collaborate effectively (DP1). The similarity to a physical whiteboard increases user-friendly, intuitive operations (DP 8). To stimulate a positive experience, the design of the virtual environment was adapted to the student's feedback. To increase visibility and accountability (DP 4), group members could collaborate simultaneously on the digital whiteboard, follow each other or create polls. An introduction to the whiteboard's functionality before the design thinking workshops ensured that all team members had at least a basic understanding of the tools (DP 2).

Communication. As a default, MS Teams was provided for verbal and visual communication. Features like video conferencing, screen-sharing, chat functions, and breakout rooms help facilitate human contact and effective communication (DP 12). The groups had access to a central video conference room where the welcome and briefing took place, general information was shared, and participants gathered after the teamwork phase to discuss the results. Private break-out rooms facilitated more intimate group work. To foster a sense of psychological safety, the group was encouraged to engage in metacommunication, i.e., discuss how they feel, what they need, and how they want to collaborate (DP 11). In addition, groups could collaboratively decide to use other ICT tools as required (e.g., WhatsApp, Slack) and were explicitly encouraged by the facilitator to use this flexibility when they reached sufficient proficiency and expertise (DP 2).

Supervision. Qualified design thinking coaches experienced in online training facilitated the workshops (DP 6). The groups worked independently but could always contact the coach for help via chat and video call (DP 7). The coaches applied reflective metacommunication techniques and social games like icebreakers to increase co-presence and psychological safety among group members (DP 10, 11). In addition, the coach was trained to anticipate difficult moments of frustration and provided technical and didactical support (DP 14).

Evaluation of the Instantiation in Online Design Thinking Workshops

After each workshop, students were asked to reflect on their group work and give feedback on factors that helped or hindered their creative virtual collaboration. The open-ended questions allow participants to respond in their own words, share experiences, and provide insights the researcher may not have anticipated. A broad question formulation was selected to prevent response bias when identifying what is most important to the user and to answer research question 2. Participants answered two questions: (1) Which aspects of the virtual collaboration helped your personal and your group's creative performance? (2) Which aspects of the virtual collaboration hindered your personal and your group's creative performance?

Analysis of Survey Data

The analysis of the survey data followed a grounded theory approach where data analysis is iterative and guided by emerging themes. The thematic analysis followed a systematic deductive approach (Fereday & Muir-Cochrane, 2006). The coding scheme included five distinct dimensions: functionality, process, affordances, collaboration, and mood. The second-level themes were represented by the 14 DPs, as described in Table 1. First-level codes consist of particular DFs and core theories. For example, the dimension "functionality" covers a second-order theme related to providing sufficient and appropriate resources, which are indicated through first-level codes such as the availability of tools and information, perceived usefulness, and ease of use. The first-order codes were iteratively completed through the open coding of the novel, previously unrecorded DFs, which further led to revising the second-order themes through axial coding. The final version of the coding scheme is represented in the Annex.

The peer-coding process was conducted by two researchers with a psychology background who were familiar with creativity research and design thinking. Following a peer-review approach, the two reviewers first coded the answers separately. The factors were coded as facilitating (positive) or hindering (negative) creativity in the virtual design thinking environment. In addition, some statements were marked as "unclear" or "neutral." Following an initial trial, the coding scheme was iterated to encompass additional codes cited in the response sets and merge overlapping themes. A second coding round based on the revised coding scheme was conducted on all responses. Out of the 22 first and second-order themes, two raters determined the presence or absence of themes. Out of 836 decisions, there were 782 instances where the raters agreed and 54 cases in which they disagreed. The level of inter-rater reliability was deemed sufficiently high to proceed, as there was a 94% consensus rate among the peer reviewers. This was determined by calculating the percentage of agreements in relation to the total number of ratings. Percentage inter-rater reliability is most commonly used for categorical or nominal data, where the ratings are discrete and mutually exclusive. For the interpretation of the results, the coding was compared and discussed until an agreement was reached. The results present a revised and restructured set of DPs, following a template for structured DP formulation (Gregor et al., 2020).

Results

positive and negative factors influencing the virtual creative collaboration mentioned by the 38 students who participated in the study. 133 codes were assigned (N = 133, n_{pos} = 78, n_{neg} = 53). The median of the total count of responses is 6. On average, each factor was mentioned 6.33 times (M = 6.33, SD = 4.12). Two of the initial DPs were not encoded, as no statement was made about "Supervision" (DP 6) and "Passion and Intrinsic Motivation" (DP 9). The peer-reviewed open coding process resulted in 19 encoded factors that hinder or help creative collaboration. Twelve factors stem from the initial DPs, and seven factors were added inductively.

Table 2 – Encoded Categories Ordered by Response Frequency						
No	Domain	Design Principle	Pos.	Neg.	Unclear	Total
1	Functionality	Sufficient, Rich, Appropriate Resources	16	0	0	16*
2	Collaboration	Human Contact, Social Presence & Interaction	10	4	1	15*
3	Collaboration	Effective Communication	4	7	0	11*
4	Collaboration	Visualisation	9	1	0	10*
5	Functionality	Technical Problems and Connectivity	0	9	0	9*
6	Functionality	Adaptation	6	1	0	7*
7	Process	Task and Time Management	3	3	1	7*
8	Collaboration	Work in Isolation and Anonymity	3	4	0	7*
9	Functionality	Distraction	1	4	1	6
10	Process	Divergent Processes	4	2	0	6
11	Affordances	Freedom and Self-Expression	4	2	0	6
12	Process	Convergent Processes	2	3	0	5
13	Collaboration	Accountability when Working Together	2	3	0	5
14	Mood	Focus, Attention Span, Concentration	2	2	1	5
15	Affordances	Stimulation and Inspiration	4	1	0	5
16	Collaboration	Psychological Safety, Sense of Security	3	3	0	4
17	Process	Efficiency and Productivity	3	1	0	4
18	Mood	Frustration, Stress, and Ambiguity	0	3	0	3
19	Mood	Positive Activation	2	0	0	2
20	Process	Supervision	0	0	0	0
21	Affordances	Passion and Intrinsic Motivation	0	0	0	0
Notes: Response frequencies above the total mean of 6 are marked with an asterisk (*).						

Revision of the Design Principles for Creative Virtual Collaboration

To answer the second research question, which DPs should be prioritized in the design of virtual collaboration from a user perspective, we revised the initial DPs according to the frequency of the encoded factors. DPs were prioritized with a response frequency above the overall mean and median, including all mentioned factors at least seven times. Eight factors meet this cut-off criterion. The reviewers noted that "effective communication" and "visualization" were often mentioned together and therefore combined into "effective communication and visualization."

The results informed seven revised DPs, (see Table 3), which were formulated according to a scheme for specifying DPs (Gregor et al., 2020), including goals, application context, mechanisms, i.e., DFs, and theoretical rationales for achieving the goals. Insight into the specific DFs was obtained from feedback provided by creative professionals, design thinking coaches, and participants. In the following, we describe the revised DPs (DPrev. 1-7) in detail. To support our arguments, we use quotes from workshop participants.

Table 3 – Prioritized and Revised Design Principles			
Dimensions	**Functionality**	**Process**	**Meaning**
Design Principles	($DP_{rev.}1$) Provision of Sufficient, Rich, and Appropriate Resources	($DP_{rev.}4$) Fostering Human Contact, Social Presence, and Interaction	($DP_{rev.}6$) Balancing Group and Individual Work
	($DP_{rev.}2$) Anticipating and Addressing Technical Problems	($DP_{rev.}5$) Effective Communication and Visualization	($DP_{rev.}7$) Task and Time Management
	($DP_{rev.}3$) Adaptation to Process, Person, and Context		

Provision of Sufficient, Rich, and Appropriate Resources

Creativity in virtual collaboration was facilitated by the availability of rich and sufficient resources, as mentioned by 16 respondents. Participants made appreciative statements that it helped that there are "[…] more resources online accessible". Furthermore, they acknowledged that "[…] the whiteboard and the ability to write notes and insert pictures helped [to be creative], which was furthered by the fact that we could communicate it vocally." They further referred to the ease of use as "[…] the data transfer is a lot easier [and the] integration of creative IT tools [such as photoshop] is a lot simpler.", and that they could "[…] easily post your words with nice templates". On the other hand, participants witnessed "[…] distraction from work, e.g., browsing through the internet" and "[…] time consumption due to different links". These statements underline that the virtual environment should provide the group with user-friendly tools, methods, and information materials that offer the group alternative ways of working (Borjas & Gebbing, 2021; Cropley, 2006; Dul, 2019). Therefore, when selecting tools, it is mandatory to consider both their usefulness and ease of use (Davis, 1989).

Within the design thinking workshop, sufficient, rich, and appropriate resources can be provided via the following mechanisms: (1) A separated group space on a digital whiteboard facilitates easy access to the resources. (2) The group had access to a knowledge library with links to ample information, pre-tested ICT tools, and creativity techniques. (3) The selection of resources based on expert recommendations. (4) Labels indicated which resources are helpful for which kind of user (e.g., novice, expert, etc.) and in which stage of the creative process it should be applied (e.g., adapted to the 6 phases of the design thinking).

Anticipating and Addressing Technical Problems

Nine workshop participants indicated technical problems and connectivity issues as the most restricting factor in creative collaboration. Moreover, technical issues seemed to negatively overshadow the virtual collaboration experience: "I can't say anything that [the use of a virtual whiteboard] Miro hindered my creativity because the technical problems during the course might be the main factor that I have these feelings." Further, we found evidence that dealing with novel technologies created a cognitive overload that blocked creative thinking, as expressed in the following statement from a study participant:

> We were unfamiliar with the platform Mural, so my problem was that while I was trying to understand the platform, I was also expected to brainstorm ideas for our discussions. If we were familiar with the platform, things would have been easy, and we could have focused more on our group work.

If not handled correctly, technical failures lead to technostress and negative impacts on group motivation and effectiveness (Chandra et al., 2019; Gerdiken et al., 2021). In line with current literature, the creative setting must be functional, prevent technical errors, or offer accessible alternatives and solutions (Dul, 2019). The resources provided should be adapted to the level of technical experience and task characteristics (Biskjaer et al., 2020). When technical issues arise during the creative process, actively promote a positive attitude and tolerance for ambiguity and dealing with frustration (Borjas & Gebbing, 2021). This might help to keep a positive, conducive mood and prevent creativity blocks (Baas et al., 2008).

The following DFs are suggested to prevent the negative impacts of technical failure: (1) Before a workshop, the technical prerequisites must be assessed, including the level of technical expertise and which technologies have been used before and are already familiar, (2) Tools should be chosen adapted to the users' prior technical knowledge. (3) A training session should precede the actual task, allowing the group to achieve a common level of technical understanding. The training session can also be conducted playfully, connecting the technical introduction to an icebreaker or team-building activity. (4) Time buffers and

alternative solutions should be prepared to anticipate technical difficulties proactively. (5) A moderated metacommunication dialogue can address how the group will handle technical issues and ensure a positive attitude that promotes tolerance for ambiguity.

Adaptation to Process, Person, and Context

Seven participants mentioned adapting the work mode to the groups' and individuals' needs and preferences as a decisive prerequisite. Participants expressed positive experiences with the flexibility of the virtual workspace: "I was able to work and "move" across different websites more freely" and the autonomy as "[…] low spatial commitment must be taken to participate". Further, they noted that the additional "[…] integration of creative IT tools (such as Photoshop) is a lot simpler". As the exemplary statements reveal, adaptation is an abstract principle that plays a role in many other DPs, whether it is effective communication (Maaravi et al., 2021), selecting the right technologies (Dennis et al., 2008), or the support of the creative process (Furmanek & Daurer, 2019). The goal is thus to provide a customized user experience rather than a one-size-fits-all solution (Ahmad et al., 2020). The accessible functionalities should not over- or under-challenge the technical and creative previous experiences (Nakamura & Csikszentmihalyi, 2014). The design must thus consider different parameters, such as personality differences, group composition, and work context (Gebbing et al., 2022). It is important to note that adaptation can occur in two ways (Schlimbach et al., 2022): explicitly, through an individual's choice to select between several options, also referred to as adaptability, or implicitly, through an automatized analysis of user behavior, also referred to as adaptivity. Explicitly addressing group members' previous experiences and expertise can provide a basis for metacommunication and a personalized work environment (Craig, 2016).

The following DFs allow creative virtual collaboration to adapt to the user needs: (1) The individual and group preferences can be assessed in a questionnaire before the actual group work. (2) A customizable interface that distinguishes between "novice," "advanced," and "professional" allows the group to choose the complexity they need explicitly. (3) Instant reflections should be planned, and the group members should be encouraged to express themselves freely and try new ways.

Fostering Human Contact, Social Presence and Interaction

Ten respondents mentioned human contact and interaction as the second most dominant influencing factors on creativity in virtual environments. Participants said that to create a bond between team members; it helped if they "[…] turned on cameras; talk[ed] about private topics [and] shared personal experiences". They also embraced targeted activities such as "[…] team building at the beginning of a project, music, and fun".

However, some of the participants made it clear that they preferred in-person collaboration and believed that virtual collaboration could not match the same level of interaction quality: "I think we may have lost a little bit of team connection from the lack of in-person interactions, and perhaps it is a little bit harder to express your ideas creatively only with the use of technology." Statements that participants were "[…] holding back ideas [and] members [were] waiting for approval to determine if something is a good idea" conveyed the adverse effects of the virtual collaboration setting on interpersonal communication. These answers confirmed that human contact, social presence, and connectedness are essential needs, but it occurs less naturally in the digital space (Kock, 2005). In this context, social presence refers to the feeling of connectedness among a group of people, even when they are not in the same physical location (Bulu, 2012). Furthermore, creative virtual collaboration requires psychological safety to comfortably share ideas and express oneself (Amabile et al., 1996; Newman et al., 2017). Therefore, a particular emphasis on social presence and psychological safety is necessary for convergent processes that involve an open feedback culture on the quality of ideas (Cropley, 2006). The aim of this revised DP is thus to increase perceptions of

social- and co-presence to increase psychological safety among the group members (Bulu, 2012; Newman et al., 2017). Research has shown that playfulness (Meske et al., 2017) and open metacommunication (Craig, 2016) positively impact group cohesion and perception of social presence.

In conclusion, human contact, social presence, and interaction can be fostered through the following two DFs: (1) Encouraging informal conversations through game-based activities or icebreakers. (2) Facilitating metacommunication and reflection on the group's work through standardized, open group evaluations after different milestones (e.g., workdays, process phases, task completion).

Effective Communication and Visualization

Despite the use of identical communication channels across all groups, there was significant disagreement regarding the efficacy of communication: “In between, it really helped using MS Teams and Mural simultaneously because we had an enhanced interaction. Nonetheless, the interaction was hindered when the internet connection was not stable or we did not receive direct feedback from one of the team members”.

Again, some students perceived video conferencing as too constrained and voiced that “[…] the communication would be better in person,” indicating a clear preference for face-to-face interaction: “It is a different environment. Since it is easier to communicate in a non-virtual setting, that is slightly a disadvantage for incentivizing creativity as a team”; “I felt the need for face-to-face contact.”

However, survey participants noted that visualizations and the use of digital whiteboards could enhance virtual collaboration by improving clarity, connectivity, and creativity, as expressed in the following statement from a study participant:

> The virtual setting helped with creativity because by using the platforms, personally, I was able to map out my thoughts easier and in fun ways, which then led me to make connections easier. In addition, by using the different features offered in Miro, all of us had an easier time thinking of the challenge and potential solutions since all of us were present in the same document.

ICT should support communication and visualization in alignment with the task and requirements (Candy, 1997; Furmanek & Daurer, 2019). Rich, visual communication becomes increasingly influential in convergent tasks, such as sharing ideas, discussing, combining, and evaluating different solutions, decision-making, planning, and prototyping (Dennis et al., 2008; Furmanek & Daurer, 2019). Divergent tasks such as brainstorming and research benefit from less direct communication, as separated individuals generate a greater number of ideas (Maaravi et al., 2021). Consequently, communication channels should be constrained to enhance ideation (Biskjaer et al., 2020; Pilcicki et al., 2021).

The following DFs support communication and visualizations: (1) Videoconferencing enables high synchronicity and visual richness. (2) The use of digital whiteboards supports visualization and collaborative work. (3) Electronic brainstorming requires participants to independently generate ideas before coming together to discuss and evaluate their ideas. (4) A chat function that can be muted allows team members to connect during individual work more unobtrusively, as it does not disrupt the workflow.

Balancing Group and Individual Work

The topic that generated the most contentious reactions was the one that dealt with the importance of striking a balance between independent work time and active participation and

responsibility within a group work environment, as reflected in the responses of seven participants. Participants with a positive experience noted that spurred creativity to be "[…] working on our own at first" and that through virtual collaboration, "[…] everyone was working on their side and still you are in touch". Participants who had a rather negative group experience reported a lack of communication, which made it "[…] easier for unenthusiastic teammates to avoid work or confrontation." Some participants perceived the virtual setting as less anonymous and reported feeling a high pressure to perform, as expressed in the following statement from a study participant:

> I don't like being observed during brainstorming and group work constantly. Being able to see every change is done by participants/teachers on Miro honestly stressed me a lot because I felt like I needed to add something for the sake of the group work, but it reduced and undermined the thinking /learning process of the course itself. People have different perceptions of learning, and some people need to understand the content analytically before starting spreading ideas all over a whiteboard and group work.

Finding the right balance between togetherness and individual work is challenging in creative teams (Nemiro, 2002). The ideal environment should simultaneously hold everyone accountable and allow each group member to develop their creative potential in their own way (Amabile et al., 1996; Ivcevic & Hoffmann, 2019). Differences in individual preferences for visibility can create conflicts, as quieter group members are often perceived as contributing less. Group work can block creativity when participants feel observed or judged and disengage with the group (Gebbing et al., 2021; Rosenberg, 2009). On the other hand, people feel less inhibited when they perceive themselves as anonymous (Hite et al., 2014). However, the selection of ideas benefits from integrating different perspectives and ideas (Cropley, 2006). Information sharing is necessary to get the complete picture and find the best solution (Mesmer-Magnus & DeChurch, 2009). The objective is to select the suitable work mode and technology depending on what is best for the creative process (Furmanek & Daurer, 2019).

The following DFs allow to coordinate of group work and individual work in creative virtual collaboration: (1) The creative process should distinguish between divergent tasks that can be executed in individual work, such as research and idea generation, and convergent tasks that require each group members participation, such as idea sharing, selection and presentation. (2) A code of conduct is necessary to ensure accountability, including guidelines on when team members should actively participate and when individual work is appropriate. In preparation, the group should openly discuss individual preferences for more or less visibility to avoid conflicts. (3) Visualization of contributions on a digital whiteboard allows for holding quiet team members accountable.

Task and Time Management

Seven respondents highlighted the increased flexibility and autonomy in task and time management as an advantage for creative collaboration. Participants stated that "[Virtual collaboration] did help as there was no redundant work done. Everything was done in a timely and organized manner, so every idea was pinned down and helped to deliver the end result". The independence of the participants was positively emphasized, which allowed tasks to be distributed and thus processed more effectively. The respondents stressed the importance of reliability and task ownership to ensure a successful group outcome.

On the other hand, the initial adjustment period required to accommodate differences in work styles and experience was identified as a potential obstacle to effective time management. Although most groups quickly familiarized themselves with the virtual work environment, some experienced time-consuming challenges adapting to the new work mode.

Interestingly, most respondents seemed to equal “efficiency” to creativity, even though efficiently completing a task does not necessarily mean they entirely fulfilled their creative potential. For example, only one participant made this distinction and said, “[…] online setting increases efficiency and concentration, but I haven't seen any change in my creative way of thinking”.

These unanticipated disruptions might cause time pressure and frustration and block creativity (Amabile et al., 1996; Dul, 2019). Therefore, rather than attempting to avoid distractions, planning and reacting flexibly could be advantageous to the creative outcome, as it encourages disruptive thinking and incubation (Ritter & Dijksterhuis, 2014).

Traditional task and time management tools include goal setting and planning, task management, and performance monitoring and evaluation (Achtziger & Gollwitzer, 2009). A salient feature of creative tasks is the inability to generate novel ideas instantaneously. These tasks often lack a predetermined timeline and require flexibility and agility, allowing ideas to incubate and change over time (Brenner et al., 2016; Ritter & Dijksterhuis, 2014). In design thinking, agile processes, iterations, and early prototyping and testing play a critical role in incrementally developing a new idea (Brenner et al., 2016). In practice, creative activity is often somewhat constrained, e.g., by financial resources, project deadlines, and personnel. In this case, having a clearly defined process and allocating time effectively can ensure that all participants are aligned toward the same goal and that the process stays on track within the given boundary conditions.

Hence, the goal is to provide groups with adequate methodologies and tools to manage their tasks and time effectively yet allow flexibility and autonomy to facilitate a flow of creative ideas (Lund & Wiese, 2021; Nakamura & Csikszentmihalyi, 2014). The following DFs were applied in the virtual design thinking environment to support task and time management: (1) Goal setting helps to establish the framework for the group's collaboration. (2) Documenting the progress of the creative process through a visual progress bar enables effective tracking and provides clear orientation and clarity (3) To accommodate the individual circumstances of the group context, the approach to task completion should be flexible; for instance, by adopting an agile methodology.

Discussion

The user-centered findings on creative virtual collaboration presented in this research provide valuable insights into the challenges and opportunities of collaborating on creative projects in a virtual environment. This study explored the experiences of student groups who engaged in design thinking workshops to develop innovative solutions to practical challenges. The implementation and evaluation of DPs in the specific application context of an online design thinking workshop shed light on the relevance and blind spots of the conceptually derived DPs (Gebbing et al., 2022). The DPs were revised and specified based on the comments from the survey. As a result, seven DPs were identified, some of which replicated prior findings, while others presented new insights that had not been previously considered.

First $DP_{rev.}1$ requires sufficient, rich, and appropriate resources, remaining the most defining characteristic of the virtual space (Dul, 2019). The participants recognized that digital whiteboards are a useful collaboration tool, video conferencing expanded their reach for interview partners, and the internet provided abundant resources. However, seeking inspiration from the physical world and encouraging off-screen activities are also recommended (Borjas & Gebbing, 2021).

Second, $DP_{rev.}2$ focused on anticipating and addressing technical problems. Although virtual collaboration can bridge geographical dispersion, it is crucial to consider that the quality of

technology infrastructure may vary significantly in globally distributed teams, e.g., between European or Asia-Pacific regions, which impacts the availability and effectiveness of virtual collaboration tools. Furthermore, most groups faced technical difficulties at some point during their collaboration, leading to the realization that preventing such issues should not be the primary focus. Instead, the focus should shift towards maintaining a positive attitude, resilience, and the avoidance of negative technostress (Gerdiken et al., 2021), as well as providing strategies for mitigating and finding quick fixes or alternative solutions.

Further, $DP_{rev.}3$ reflected the need to adapt to the virtual environment, specifying that it should consider specific requirements of the creative process, individual differences, and context. The results suggest mixed positive and negative feelings toward creative online collaboration, and different users perceive the same environment differently. For instance, creative virtual collaboration could be different in the Asia Pacific region due to variations in cultural norms and values, language barriers, technological infrastructure, and work styles. In some Asian cultures, a consensus is highly valued in collaboration, which can hinder the expression of unpopular ideas and promote groupthink (Kakar & Kakar, 2018). Using ICT to separate group members during ideation may facilitate the creation of innovative ideas (Maaravi et al., 2021). A creative environment cannot consist of a one-fits-all solution but requires adaptation and individualization. Future developments in ICT should react to emotions, preferences, and individual differences (Jonell, 2019; Schlimbach et al., 2022).

$DP_{rev.}4$ emphasized fostering human contact, social presence, and interaction. One of the issues often voiced by participants was the difficulty of balancing the benefits of a flexible, autonomous work environment with the demand for accountability and an equal contribution from group members. Participants reported that it was more challenging to understand whether silent group members were still contributing or disengaged. Social loafing is the term used to describe the phenomenon where certain team members rely on the efforts of more vital members, resulting in reduced individual effort (Chen et al., 2014).

Success in group endeavors requires a joint effort from all participants, and a lack of motivation or engagement from any individual can hinder progress (Chen et al., 2014). In practice, however, we observed that a constantly high level of motivation is an ideal condition rather than the rule. Further research could explore the potential effects of automated tracking of speech contributions or desktop activities on group dynamics. Introducing such a mechanism would likely enhance accountability among group members and could serve as an external incentive. However, there is a concern that this type of monitoring may go against the principles of freedom and autonomy essential for promoting workplace creativity (Dul, 2019).

$DP_{rev.}5$ highlights effective visual communication as an essential enhancement of verbal communication. Participants reported that virtual collaboration tools, such as video conferencing, instant messenger, and virtual whiteboards, enabled effective communication and visualization, making ideas more transparent and easier to combine. However, they said it was essential to establish clear communication rules and workflows to ensure everyone was working towards the same goal.

Metacommunication can be a practical methodological approach to address negative group dynamics, especially for virtual teams with diverse personalities and limited prior knowledge of each other. Metacommunication involves reflecting on how individuals communicate and identifying ways to improve collaboration to achieve shared goals (Craig, 2016). Previous studies on creative virtual teams have shown that building a shared mental model or a common understanding of purpose and goals within the group facilitates the creative process and leads to innovative outcomes (Mathieu et al., 2000; Redlich et al., 2017). By building mutual understanding, respecting individual differences, and reflecting on communication patterns, groups can create a psychologically safe environment that supports a free flow of

creative ideas, information sharing, and an open feedback culture (Lechner & Tobias Mortlock, 2022; Newman et al., 2017)

$DP_{rev.}6$ addressed the need to balance group and individual work. On the one hand, this finding confirms research on electronic brainstorming, outlining the benefits of group separation in idea generation (Maaravi et al., 2021). Further, our study shows the importance of individual work to support personality differences and allow quieter members to gather their thoughts.

Finally, $DP_{rev.}7$ replicated the particular prerequisites of creative tasks concerning a flexible but structured task and time management in accordance with a creative process which often requires taking a step back, iteration, or incubation (Ritter & Dijksterhuis, 2014). It is noteworthy that some participants in the study equaled time and task "efficiency" with "creativity" when assessing the success of their creative virtual collaboration. This association may be explained by the specific task and context of innovation management, which often entails time and budget constraints. Thus, while many respondents found online interaction time-efficient and effective for completing tasks, other participants felt that virtual creative group work was inefficient regarding communication, human contact, and social interaction.

Some participants clearly stated that they prefer face-to-face interaction over virtual communication for creative collaboration. This discourse reveals an interesting research gap regarding the relationship between efficiency and creativity in innovative group collaborations. Hybrid approaches, for example, aim to combine the advantages of virtual and physical collaboration. Further research could explore whether creative hybrid collaboration is a valuable alternative to entirely virtual or physical collaboration.

While this study offers valuable insights into the DPs for creative virtual collaboration in online design thinking workshops, some limitations should be acknowledged. The first constraint is that the DPs were applied within a particular innovation methodology, namely design thinking, resulting in context-specific insights. Second, the study was conducted with students. Future studies with more diverse target groups, such as managers, creative professionals, and artists, may provide further insights into how to accommodate the needs and values of different users. Finally, due to the specific application context, the generalizability of the findings may be limited, and further research should replicate these findings in different creative settings.

Overall, these findings contribute to the practical and scientific understanding of creative virtual collaboration. The identified DPs reflect a user-centered approach to support virtual teams in creative collaboration, which differs from the traditional focus on enhancing creative outcomes such as idea quantity and quality (Voigt & Bergener, 2013). The user-centered approach prioritizes the social component, improving the overall experience, satisfaction, and technology acceptance. The results, therefore, contribute to the literature on DP development by providing an additional perspective on DP development. Integrating a user-centered with an outcome-oriented perspective can result in a more balanced approach to technology design and development. The results, therefore, have also practical relevance for professionals and educators who aim to foster creative virtual collaboration in their teams.

Conclusion

Digital transformation is changing the collaboration processes in ASEAN and other rapidly digitalizing countries. Co-creation and innovation processes are now more flexible and location-independent, but virtual collaboration still poses challenges, such as technical difficulties and limited social presence. To address these challenges, a study was conducted to identify Design Principles (DPs) and Design Features (DFs) from a user perspective, representing creativity drivers that effectively support creative virtual collaboration. The study identified seven fundamental Design Principles (DPs) that should be prioritized in designing user-centered creative virtual collaboration, including providing sufficient resources, technical problem-solving, adaptation to context, social interaction, communication tools, group and individual work balance, and flexible task management. Additionally, the study offers specific design features, including virtual whiteboards, social games, and metacommunication, to enhance the virtual collaboration experience.

The main challenges identified were the difficulty of building psychological safety and rapport in a virtual environment, a sense of social presence, connection, and shared purpose when working remotely, making communicating effectively and collaborating on creative tasks more challenging. The study identified the need for training and guidance to enhance team members' awareness and ability to mitigate negative team dynamics. It also highlighted the significance of adapting the richness of communication to the respective phase of the creative process. Additionally, the study identified a research gap concerning the balance between individual autonomy and the ability to hold group members accountable for their contributions, suggesting that future developments of ICT should focus on adapting to personal and group-specific preferences.

Overall, this study provides valuable insights into the challenges and opportunities of creative virtual collaboration. Participants reported that virtual collaboration allowed them to access a wider pool of resources and expertise, as they were not limited by geographic location. Additionally, the virtual collaboration provided greater flexibility and autonomy, allowing team members to work in a way that best suited their preferences and schedules. The study emphasizes the importance of adapting technology and collaboration processes to individual, cultural, and procedural differences to ensure the success of virtual workshops. By understanding these challenges and implementing strategies to address them, organizations and teams can leverage the benefits of virtual collaboration while minimizing the potential drawbacks.

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Appendix

Exemplary Coding Scheme			
	Which aspects of the virtual collaboration…	Exemplary response of a participant	Code
Q1	… help your personal and your group's creative performance?	The data transfer is a lot easier. Integrating creative IT tools (such as Photoshop) is much simpler.	
Q2	…hindered your personal and your group's creative performance?	Lack of communication. easier for unenthusiastic teammates to avoid work or confrontation.	
	Gender		F
	Age		23
	Second Order Theme	**First Order Codes**	
Functionality	Rich and appropriate resources	Completeness, Perceived usefulness, ease of use of available tools & info	p
	Distraction	Too many features, unclear design	
	Technical problems	Connectivity Issues, bugs	
	Adaptation	Select and add tools as needed	p
	other / comments		
Process	Divergent processes	Idea generation, brainstorming, research	
	Convergent processes	Idea evaluation, selection, decision-making	
	Task & time management	Task distribution, workload	
	Supervision	Availability of coaching advice, guidance	
	Efficiency/ Productivity	Progress	
	other / comments		
Affordances	Freedom and self-expression	Autonomy, adaptation to personal needs	
	Stimulation and inspiration	Sources for new ideas, encouragement	
	Passion / intrinsic motivation	Task enjoyment, engagement, flow	
	other / comments		
Collaboration	Social presence and Interaction	Human contact, group perception, connectedness	
	Psychological safety/sense of security	Feedback culture, fear of critique, openness	
	Anonymity / Work in isolation	Individual work	
	Accountability: work together	Contribution of others to the group outcome	n
	Visualization	Use of tools for illustrating or structuring ideas,	
	Effective communication	Reaching other group members, intrusiveness	n
	other / comments		
Mood	Attention span / Concentration	Signs of fatigue, mental load, technostress	
	Stress and Ambiguity	Conflict, frustration, and creativity blocks	
	positive activation	Mood, atmosphere, group attitude	
	other / comments		

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