



Kaunas University of Technology

School of Economics and Business

Implications of Virtual Reality on Team Creativity in Organizations: An Explorative Analysis

Master's Final Degree Project

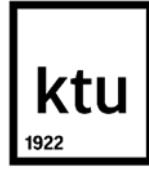
Dialina Kotlerova

Project author

Prof. Monika Petraitė

Supervisor

Kaunas, 2023



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Innovation Management and Entrepreneurship (6211LX031)

Dialina Kotlerova

Project author

Prof. Monika Petraitė

Supervisor

Assoc. Prof. Jurga Duobienė

Reviewer

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Dialina Kotlerova

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Summary

This study investigates the multidimensional, complex, and dynamic nature of team creativity in immersive Virtual Reality (VR) by conducting an extensive experiment with teams in an organizational setting. The study aims to improve the practical use of VR in organizations and establish critical links between the dynamic process of team creativity and its influencing variables. To achieve this, a conceptual model was developed, which includes variables for team creativity, and a creativity process was selected from a set of divergent and convergent thinking activities for the experiment based on theoretical foundations and implications.

The empirical findings suggest, that the advanced immersiveness of the state-of-the-art VR technology used in the experiment shapes individual behavior and team dynamics by stimulating psychological safety, a sense of liberation, playfulness, and openness, particularly in the prototyping phase of the creativity process. This promotes imagination, that is needed for novel and unusual ideas. However, it is essential to consider input variables such as team characteristics, technology-relevant team skills, individual health issues, task complexity, and the specifics of the VR app when designing experiences in immersive VR. The study also finds that 3D drawing can foster a creative and innovative mindset, empathy, and team building, making it suitable for visual tasks such as prototyping.

The final results include a theoretically and empirically validated conceptual model, implications for the use of VR in research and practice, as well as a designed and conducted experiment in a virtual environment, which can be replicated for further research.

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Santrauka

Šis tyrimas tiria daugiamatį, sudėtingą ir dinamišką komandos kūrybiškumo pobūdį įtraukiančioje virtualioje realybėje (VR), atliekant komandų kūrybiškumo valdymo eksperimentą organizacinėje aplinkoje. Tyrimu siekiama pagerinti praktinį VR panaudojimą organizacijose ir nustatyti kritinius ryšius tarp dinamiško komandos kūrybiškumo proceso ir jį įtakojančių kintamųjų. Tam buvo sukurtas konceptualus modelis, apimantis komandos kūrybiškumo kintamuosius, o eksperimentui iš divergentinio ir konvergentinio mąstymo veiklų rinkinio parinktas kūrybiškumo procesas, paremtas teoriniais pagrindais ir pasekmėmis.

Empirinės išvados rodo, kad eksperimente naudotos pažangiausios VR technologijos įtraukimas formuoja individualų elgesį ir komandos dinamiką, skatindamos psichologinį saugumą, išlaisvinimo, žaismingumo ir atvirumo jausmą, ypač prototipų kūrimo fazėje ir taip praturtina kūrybiškumo procesą, nes stimuliuoja vaizduotę, kurios reikia naujoms ir neįprastoms idėjoms. Tačiau, kuriant įtraukiančios VR patirtį, būtina atsižvelgti į įvesties kintamuosius, pvz., komandos charakteristikas, su technologijomis susijusius komandos įgūdžius, individualias sveikatos problemas, užduočių sudėtingumą ir VR programos specifiką. Tyrime taip pat nustatyta, kad 3D piešimas gali paskatinti kūrybišką ir novatorišką mąstymą, empatiją ir komandos formavimą, todėl jis tinkamas vizualinėms užduotims, tokioms kaip prototipų kūrimas.

Galutiniai rezultatai apima teoriškai ir empiriškai patvirtintą koncepcinį modelį, VR panaudojimo tyrime ir praktikoje pasekmes, taip pat suprojektuotą ir atliktą eksperimentą virtualioje aplinkoje, kurį galima atkartoti tolesniems tyrimams.

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List of abbreviations

Abbreviations:

Assoc. prof. – associate professor;

DSRM – Design Science Research Methodology;

Fig. – Figure

HMW – How Might We Question;

IPO – Input-Process-Output framework;

IS – Information Systems;

IT – Information Technology;

Prof. – professor.

PxTxS – Person x Task x Situation;

VR – Virtual Reality;

VUCA – volatility, uncertainty, complexity and ambiguity.

Introduction

In recent years, the technological landscape of applications has undergone rapid changes due to global events and advancements in technology, leading to significant changes in organizational work processes, such as team creativity (fuzzy front-end) and organizational innovation. With the technological progress and growing consumer market, immersive Virtual Reality (VR) could be the next technology to revolutionize the way collaboration and creativity are approached. Thus, organizations need to recognize the implications of this technology for their business early on and apply them appropriately to maintain a competitive advantage and establish technology-relevant skills.

Relevance:

Due to the COVID-19 pandemic, creativity and innovation processes have shifted to digital platforms, requiring teams to adapt to virtual work environments and use digital creativity tools and techniques. In today's volatile, uncertain, complex, and ambiguous (VUCA) world, companies face complex challenges and must manage their fuzzy front-end to solve the challenges within this new digital work environment. Therefore, it is important for companies to manage team creativity and organizational innovation in different digital scenarios, and to test relevant technologies early on to gain competitive advantages in the market and foster creative, innovative and technological skills within the company, which are crucial to solve future challenges. Immersive VR is the next technological disruption for collaborative work environments and has already shown potential for enhancing creativity, offering potential for a comprehensive analysis of the technology.

Problem Analysis:

In recent years, VR has made rapid technological advances. Major tech companies are currently investing in integrating the technology, including headsets and apps for collaboration, ideation and prototyping, into everyday business operations. However, there is a lack of practical experience for an efficient integration of VR into innovation projects in organizations. At the same time, there are initial studies from various research directions that show a positive effect on creativity through immersive VR, resulting in a growing demand for its use in business settings and an increase in technology investments and VR research. Despite these developments, previous research has primarily focused on students in academic settings and has explored only specific aspects of creativity. To address this research gap, this study aims to investigate the managerial and theoretical implications of bringing teams in the state of creative flow within the immersive virtual environment in a business challenge. Through this investigation, the study seeks to contribute to the closing of this research gap by bringing theory and practice together.

Object of research: How do immersive Virtual Reality shape the creative flow of teams to effectively solve a business challenge, and how can the experience be managed through targeted design of the working session in Virtual Reality?

Research aim: Improve practical use of Virtual Reality in organizations while establishing critical links between dynamic process of team creativity and its influencing variables.

Research objectives:

1. To review the status quo of VR in organizations and establish research and practice gaps.
2. To create a conceptual model including variables and design the selected creativity process for analyzing team creativity in VR based on theoretical foundations and existing implications of creativity, team creativity and immersive VR.
3. To design the VR app MultiBrush based experiment in an organizational environment in order to reveal creative team's behaviours as well as positive and negative factors influencing the output in the virtual environment.
4. To validate the conceptual model and its variables and empirically derive recommendations for the use of VR in organizations as well as managerial and theoretical implications.

Research methodology and structure of the thesis:

This thesis follows the Design Science Research Methodology (DSRM) by Peffers et al. (2007) in the research field of Information Systems (IS). In chapter 1 of this study, a problem analysis is conducted, which leads to a review of the current state of VR in organizations and identifies gaps in research and practice. Chapter 2 then explores the theoretical foundations of creativity, team creativity, and immersive VR. The chapter synthesizes relevant aspects and creates a conceptual model and the relevant creativity process steps for the experiment. In chapter 3, the research methodologies and their design such as ex ante questionnaires, a VR app-based experiment with two teams, and semi-structured ex post interviews with the participants are described. In chapter 4 the findings of the ex ante questionnaire, the notes from participants and observers of the experiment, and insights from individual interviews are analyzed. Finally, chapter 5 evaluates and discusses the main findings, validates the conceptual model, provides recommendations, implications as well as limitations and avenues for future research and practice. The conclusion reflects on the research objectives and the most important findings of the exploratory analysis of team creativity in VR in organizations.

The core of this study is the design and execution of the VR-based experiment for exploratively and systematically analyzing the experiences of the participants in VR. Six business experts from Deloitte Greenhouse Berlin were selected for the experiment via ex ante questionnaires to enable the experiences collected to be contextualized within the business domain and subsequently derive implications for organizations. Data was collected through the notes from three observers and six participants during the experiment as well as the conduction of six ex post semi-structured interviews with all six business experts after the experiment. An interview guideline was prepared based on the theoretical findings, which follows the structure from both, the conceptual model and the creativity process, designed for the experiment. The VR headset used in this experiment is Meta Quest 2, the VR app is the 3D drawing tool MultiBrush, and the challenge is a real business case from Deloitte Greenhouse Berlin.

1. Problem Analysis

1.1. Organizational Ambitions for Creativity and Innovation in the volatil, uncertain, complex and ambiguous World

Creatio ex nihilo – the creation out of nothing. Originally, creativity as a divine ability was associated with the early Christian theology of Creator, the Creator God. For a long time thereafter, the creative power was reserved for only a few chosen ones, mainly artists, musicians, and designers. With the slogan "Power to the imagination" of the 1968 movement¹, creativity has gained increasing importance in other areas such as art education. With the democratization of the term, creativity now refers to the individual human ability to create something new (Freund, 2021). Nowadays, creativity is not directly associated with artistic creations such as Salvador Dalí's surrealist or Van Gogh's impressionistic works. Additionally, creativity is the pedagogical creation - for the development of individual personality, the therapeutic creation - to stimulate imagination, the political creation - for the effective organization of the community, and lastly, the economic creation - for the competitive advantage through innovation (Bröckling, n.d.). Creativity thus depends on the context it is assessed (Sternberg, 2018).

From the organizational point of view, creativity is considered as the exploration of new and useful ideas, while innovation is understood as the successful exploitation of selected ideas (Amabile, 1996). Therefore, creativity must be understood as an essential element that leads organizations towards innovation and is generally considered as a driving force for the modern economic system (Somech & Drach-Zahavy, 2013). Organizations with creative skills have the potential to explore new areas, fulfill new or existing consumer needs through innovative business models, products, and services, and thereby be able to take new paths to achieve competitive advantages in the market (Boly et al., 2014; Smailhodžić & Berberović, 2021). From an economic perspective, innovation is also a driving force for the modern economic system. For example, the European Commission conducts a comparative analysis of the strengths and challenges of all European Union countries in its European Innovation Scoreboard in order to assess innovative performance and better promote the potential of individual countries (European Commission, 2023).

In the present-day context, creativity and innovation have become critical business attributes. The contemporary socio-economic landscape is marked by a volatile, uncertain, complex, and ambiguous environment (Cousins, 2018a; Worley & Jules, 2020). In the so-called VUCA world, conditions are rapidly changing and unpredictable, requiring companies to adapt in a timely, effective, and sustainable manner to gain a competitive advantage – an ability referred to as organizational agility (Worley et al., 2014). While the business environment has always been dynamic due to competitors and market forces, the complexity of the VUCA environment has intensified with Industry 4.0 (Gupta & Jauhar, 2023). Nowadays, rapid technological change, economic instability, geopolitical tensions, and environmental concerns have made it challenging for companies to plan and make decisions, requiring them to respond quickly to changing circumstances, take risks, and adopt an innovative approach to problem-solving (Dewit et al., 2016; Smailhodžić & Berberović, 2021). These characteristics are particularly evident in companies that effectively manage innovative dynamic capabilities (Teece, 2007). Innovation and thus creativity are organizational responses to problems through novel solutions (Cromptley & Oppert, 2018).

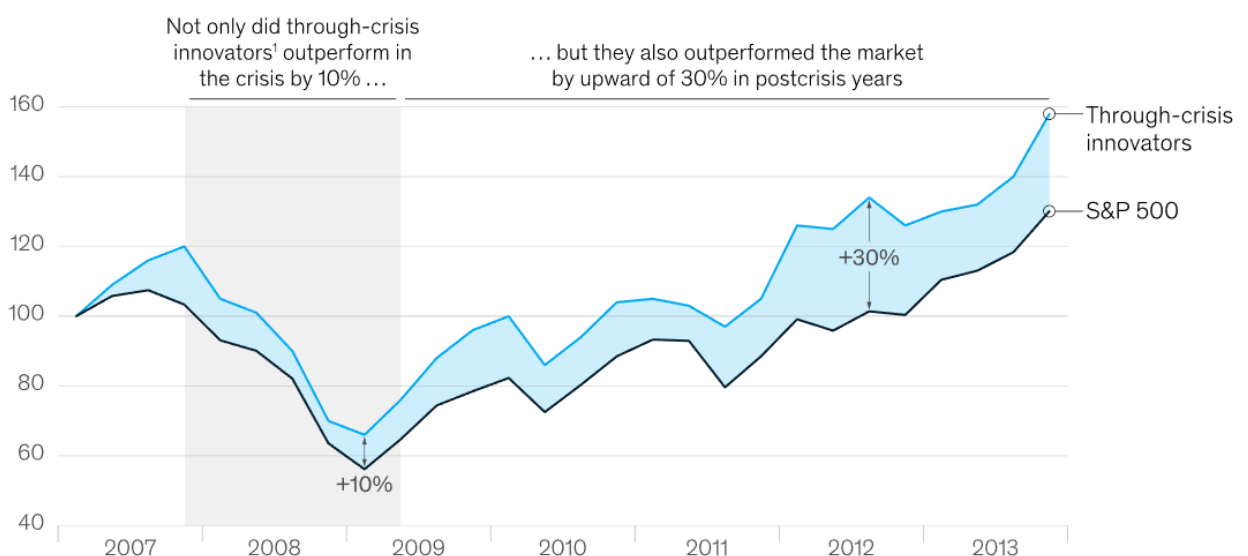
¹ Refers to the student movement for cultural revolution in West Germany in 1968.

One of the most notable examples of today's dynamic VUCA environment is the sudden outbreak of the COVID-19 pandemic in 2020. The global pandemic affected economies and societies worldwide by possessing them with challenges on an unprecedented scale such as disrupted supply chains, rapid switch to remote work, shifting of demand in different industries as well as implementation of health and safety due to governmental regulations (Gupta & Jauhar, 2023; Khlystova et al., 2022; Worley & Jules, 2020). As a result, organizations of all sizes, industries, and locations that demonstrated the ability to navigate uncertainty by generating new and practical ideas and implementing them quickly and efficiently without disrupting ongoing productivity and daily operations were the ones that gained a competitive advantage and survived the crisis.

The positive long-term impact of investments in innovation, including creativity, during times of crisis is demonstrated in a study conducted by McKinsey (2020). The study found that organizations, which sustained their innovation efforts during the 2009 financial crisis emerged stronger and achieved accelerated growth in the subsequent three to five years, outperforming the market average by over 30% (see Fig.1) (Bar Am et al., 2020).

History suggests that companies that invest in innovation through a crisis outperform peers during the recovery.

Normalized market capitalization, index (Q1 2007 = 100)



¹Identified as companies on the *Fast Company* World's 50 Most Innovative Companies list for ≥2 years through a crisis, normalized to 2007.

McKinsey
& Company

Figure 1: Market Performance of Companies during and after Crisis (McKinsey, 2020)

Especially in crisis situations, individuals are called upon to "think creatively" and "out of the box," as unforeseen challenges in the VUCA world do not offer a uniform and obvious solution, but rather various possibilities of ideas when divergent thinking is applied (Brooks et al., 2019). To succeed in unknown and ever-changing situations, a diverse set of skills, encompassing cognitive and meta-cognitive abilities such as creative thinking, social and emotional skills such as collaboration, as well as practical and physical skills such as utilizing new technology devices are anticipated to be highly

sought-after abilities in the future (Organisation for Economic Co-operation and Development (OECD), 2018).

As creativity and innovation are considered crucial core competencies from an organizational perspective, research has focused on the business sector in recent years. While earlier studies focused on product invention, recent studies explore creative management methods to enhance innovation and employee efficiency and productivity (Tromp & Sternberg, 2022). Therefore, the goal of creativity research is often to comprehend the thinking processes, personal traits, motivation, and emotions that lead to innovative products (Amabile, 1983; Glăveanu, 2013; Lubart, 2017). Additionally, the research aims to unveil the management practices that encourage these factors, including individual risk-taking and openness (Cropley & Cropley, 2012) as well as the various levels of interdependence that affect creative performance and innovation capacity (Kazanjian et al., 2000). However, with increasing networking, globalization, and digitization, the complexity of challenges grows, which can only be solved with multi-disciplinary teams (Chompunuch et al., 2019). Moreover, team creativity has greater potential than individual creativity, making it a crucial area of investigation in this master's thesis (Paulus & Yang, 2000). Hence, this study will examine team creativity, drawing upon research findings from different fields on individual and collaborative creativity.

While fostering creativity and innovation in teams to efficiently solve problems is a challenging task for companies, managing it in the constantly evolving realm of disruptive technological influences and virtual environments adds another level of complexity. As a result, companies must learn how to encourage team creativity and organizational innovation under constantly changing technological conditions.

1.2. Relevance for creative, innovative, and technological Skills in the Digital Age

The outbreak of the COVID-19 pandemic in 2020, as previously mentioned, was the biggest catalyst for digital transformation in organizations worldwide (Abidi et al., 2022). To comply with new political regulations for the economy and society, companies were forced to find new and sustainable solutions for transitioning their daily operations from on-site to virtual formats. As a result of rapid advancements in various technologies supporting telework, almost all processes, including innovation, have become increasingly digitized. Even in the post-COVID era, businesses continue to utilize digital tools to manage work processes across on-site, virtual, and hybrid work formats.

One of the most significant changes has been the digitization of the communication and collaboration within teams. Collaborative Information Technology (IT) tools, such as Zoom, Slack, and Teams, enable remote teams worldwide to stay connected through video conferencing, instant messaging, and collaboration software. Furthermore, online project management software, such as Asana or Trello, has facilitated teams in maintaining productivity levels while working remotely. This new way of working has also disrupted creativity and innovation processes. Online whiteboard tools, such as Mural and Miro, provide businesses with a broader toolset than in physical space to brainstorm collectively, create virtual prototypes, test new ideas, and receive real-time feedback. Consequently, businesses can quickly iterate and refine their ideas based on customer feedback, which is crucial in today's fast-paced business environment.

In the new digital era, the way people communicate, collaborate, and work is constantly evolving (Rogers, 2016). Various technologies such as connectivity, information and communication technologies, and big data have been already dominating our working world (Bharadwaj et al., 2013). However, according to Gartner (2023), the future of work could be disrupted by further emerging technologies and trends such as Metaverse, Digital Twins and Blockchain (see fig. 2) (Nguyen, 2023).

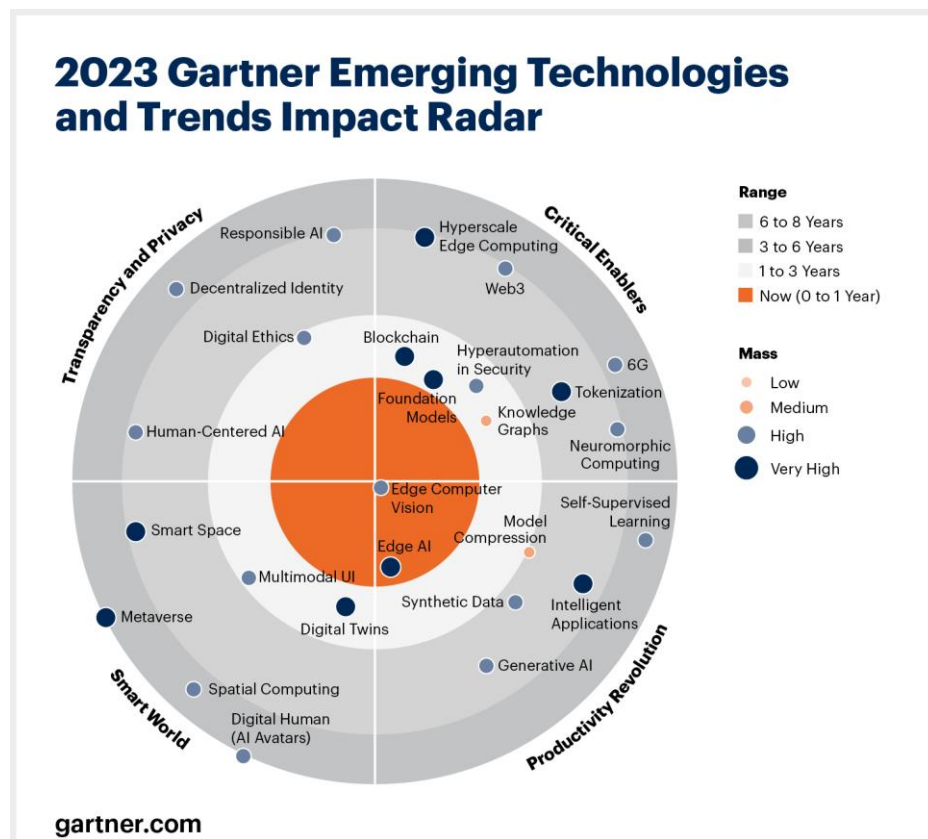


Figure 2: Gartner's Emerging Technologies and Trends Impact Radar 2023 (Gartner, 2023)

Consequently, companies are increasingly pressured to adopt these technologies and adapt their business models to the new requirements of the digital age, in order to meet the changing needs and demands of their stakeholders (Gupta & Jauhar, 2023; Teece, 2007). Further, companies need to possess their competitiveness in the market, as the competitors' density has intensified due to traditional and digital companies competing with each other from different industries in different markets (Popescu, 2022). Therefore, Design Thinking as an innovation and human-centered concept gained much popularity in science and business in the 21st century as it combines the development of dynamic capabilities and organizational learning in a constantly changing technological environment (Cousins, 2018b).

Technological competencies and other tech-relevant skills are additional essential characteristics for companies in the future. Insights from the digital transformation of many companies during the COVID-19 crisis have highlighted the differences between digitalized and less digitalized companies, thereby widening the digital gap. In a study by Calvino et al. (2022) on the Digital Gap, specifically in Italy, published by the OECD, it was found, that companies with a stronger digital presence suffered fewer losses in revenue and were less likely to become insolvent. Moreover, these companies

were able to switch to remote work more easily and invest more in digitization and personnel development than their less digitalized competitors. Hence, companies need to constantly adopt and incorporate technologies into their businesses to gain a competitive advantage in the market, remain resilient in the case of changing market conditions in the VUCA world, and provide customers with unique experiences through cutting-edge technologies such as the new technological trend of immersive VR (Gupta & Jauhar, 2023; Joshi et al., 2010).

Creativity and innovation play an increasingly important role in creating added value for companies, especially in the context of the digital business world (Lee et al., 2021). However, to maintain the firms' performance through creative capabilities and innovative competencies is not enough. In this new digital and complex age, the development of a technological fitness for companies is key.

1.3. Business-readiness of Virtual Reality through technological Advancements

What exactly is meant by reality and what distorts the perception of reality? These philosophical questions were already addressed by Plato in antiquity with his allegory of the cave. In the allegory, the reality of the cave dwellers is deceived by a shadow world projected onto a cave wall by a fire. When one person discovers the true world outside the cave and tells the others about it, they cannot believe, that there is another world besides their shadow world. In Plato's allegory of the cave, people are trapped in their own projection of reality. Similarly, the perception of virtual reality can be perceived differently. The individual perception and differentiation of physical and virtual reality and illusion have been dealt with in numerous artistic and philosophical works, novels, and films, either as utopian or dystopian, mostly through futuristic technologies in the distant future. However, this future is not far off.

The idea of VR, as it is understood today, originated in the 1960s (Guerra-Tamez, 2023). VR is a technology, that generates an artificial digital environment, allowing users to experience an interactive computer-generated simulation, that can mimic the real world or create a fantastic one. This immersive experience of "being there" is created through multi-projected environments or VR headsets, such as Head-Mounted-Displays, that provide realistic visual and auditory feedback in a three-dimensional environment (Smutny, 2022). The origin of VR revolution dates back to the 20th century (see fig. 3). In reference to Plato's allegory of the cave, the University of Illinois at Chicago published one of the first VR models in 1992 under the name CAVE. VR CAVE is a walkable VR room with three to six wall surfaces replaced by displays for the presentation of 3D visual content, enabling the user to fully immerse in the virtual environment (Mandal, 2013). The market for VR headsets started shortly after in 1995 with the release of Forte VFX-1 and Nintendo's Virtual Boy. Nowadays, the VR headset market is dominated by a few companies, including the most well-known VR provider, Meta, formerly known as Oculus. With its latest models, Meta Quest 2 from 2020 and Meta Quest Pro from 2022, Meta has brought technologically more advanced VR models to the market in recent years, featuring clearer visuals, improved monitors, eye tracking, and natural facial expressions for better communication (Meta Quest Blog, 2022). The new technological performance of immersive VR headsets thus offers further application possibilities in various fields.

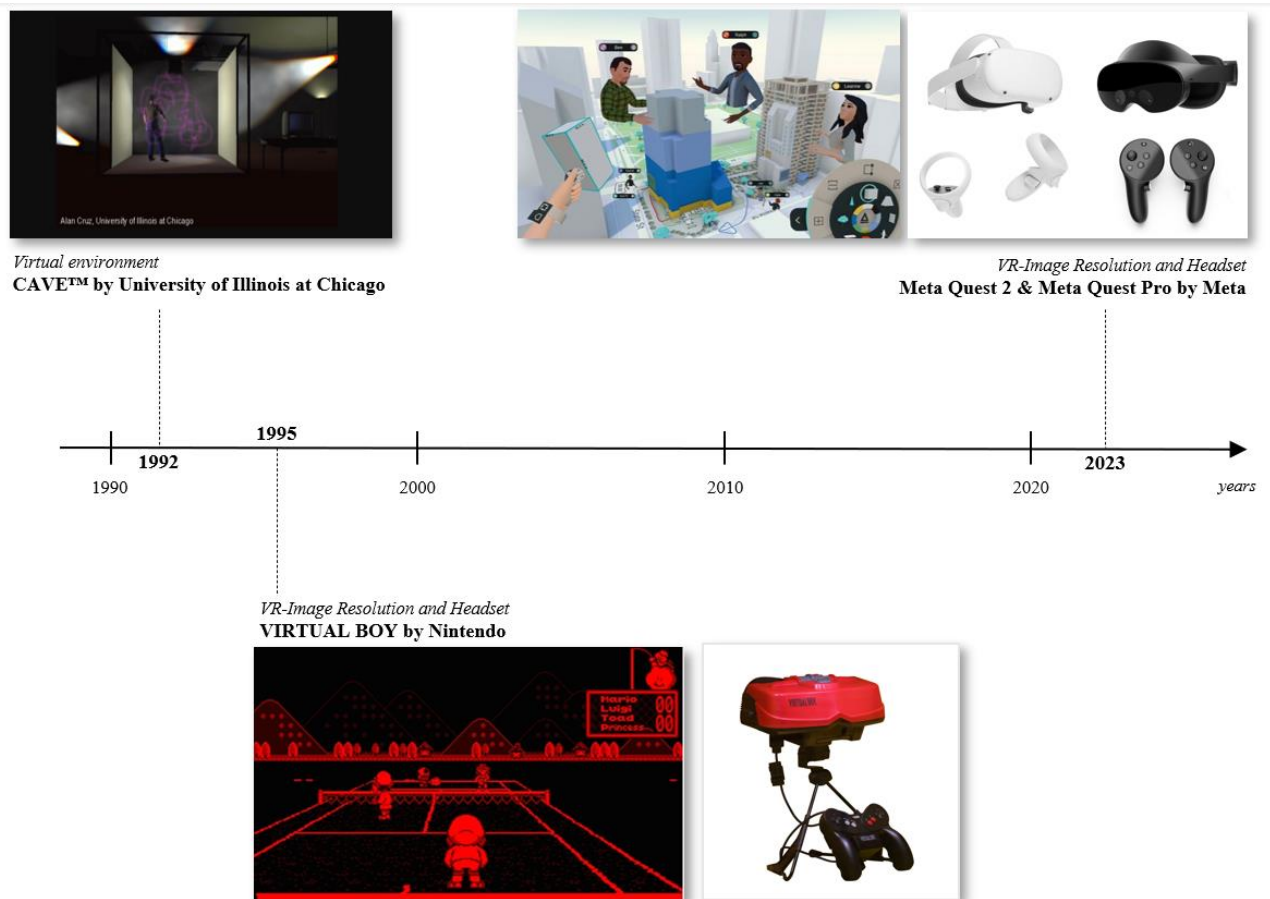


Figure 3: The Evolution of immersive Virtual Reality

As mentioned earlier, Metaverse has been identified as an emerging technology trend for the next few years in numerous studies (Gartner, 2022; Nguyen, 2023). Before ChatGPT, Metaverse was the most discussed tech trend of the future, creating a digital twin of the analog world in immersive and virtual spaces through virtual, mixed, and augmented reality. In the form of avatars, people can meet other avatars with their virtual identity and work together, engage in leisure activities such as playing or shopping, buy virtual real estate, and much more.

The hype around Metaverse is therefore considered a major catalyst for the development of the recently fast-growing VR market, as it is expected to experience significant growth in terms of revenue and device sales in 2023. According to Deloitte (2023), the global VR market is forecasted to generate \$7 billion in revenue, marking a 50% increase from the previous year (Esser, 2023). Of this revenue, 90% is expected to come from the sale of VR headsets, with an estimated 14 million VR headsets sold at an average price of \$450 in 2023, which represents a significantly affordable price for consumers and could drive consumption. While the predicted growth of the VR market is a global trend, it is also expected to occur in Germany. The results of Deloitte's Digital Consumer Trends Survey show, that there is an increase in the number of VR devices in Germany, indicating a potential market for VR technology. The projected growth of the VR market is promising, and the technology's potential applications are expected to expand beyond gaming to various industries.

As there is currently no dominant design for VR headsets, big technology companies such as Meta, Google, Sony and Apple are investing in the development of their own VR headsets. For example,

Facebook has positioned itself clearly in the market with its conviction of a future for consumers and organizations in immersive VR, partly through its name change to Meta in 2021 and partly through investments in the acquisition of Oculus in 2014 and the VR multi-player app Within in 2023 (Wege & Gentner, 2022). First forecasts also suggest, that the tech giant Apple plans to release its own VR glasses in 2023, which will likely further fuel the competition for the dominant design of VR headsets.

The investments of large corporations in technology development have produced an unprecedented level of VR technology, resulting in various new applications for the VR app store in recent years. Numerous new application possibilities, also for use in the organizational context, have thus been created. Although currently the main area of application of VR is gaming (Smutny, 2022), companies such as Meta are working together with companies like Microsoft, Zoom, and Adobe to mobilize immersive VR for the digital workplace of the future. The workplace, which has already been digitized due to COVID-19 using Microsoft Teams and Zoom, could therefore create a different kind of productivity through recently released VR apps for collaboration and creativity. Examples of these are:

- Gravity Sketch in 2019, a 3D design and collaboration tool
- Arthur in 2021 a virtual office space for collaboration
- Spatial in 2020, a creativity through interactive 3D environment
- MultiBrush in 2022, a multiplayer drawing and painting tool

The latter application is examined in more detail in this paper. Although the combination of immersive VR, collaborative and creative apps, and the world of work could create new opportunities for collaboration and creativity processes within a team, the implications of the technologies for this application area have yet to be explored.

1.4. Scientific Relevance and Research Gap for Team Creativity and Virtual Reality

The development of the VR headset has produced a series of studies in research examining the mature technology of VR hardware and software in various use cases and application fields in different research directions. Thus, studies have been published on the application possibilities of VR, in education (Guerra-Tamez, 2023) and art therapy (Ying-Chun & Chwen-Liang, 2018) alone in the last two years. Although numerous other fields are exploring the possibilities of VR technology for different use cases, there are simultaneously only a few studies examining the possibilities in the organizational context. In fact, the connection of team creativity with immersive VR in organizations still has potential in research (Chang et al., 2022; Houzangbe et al., 2022).

Numerous studies have demonstrated, that VR can serve as a tool to stimulate individuals' creativity and imagination (Yang et al., 2018) as well as on motivations (Huang et al., 2021) through different levels of immersion and sensory experiences. VR can also promote specific process steps of the creativity and innovation process such as learning experiences (Guerra-Tamez, 2023) ideation (Fleury et al., 2021; Toumi et al., 2021), creative writing (Fleury et al., 2021), design activities and sketch of Design Thinking performances (Chang et al., 2022; Fleury et al., 2021; Vogel et al., 2021), sketching (Houzangbe et al., 2022) and prototyping during design thinking performances (Chang et al., 2022; Vogel et al., 2021).

The aim of this study is to investigate how VR shapes the collaborative creativity processes. An exploratory analysis will be conducted on a selection of variables, that may affect team creativity in virtual environment. The findings from the tested existing and newly introduced variables will have implications for companies seeking to design and adapt VR experiences for creative processes.

The mentioned existing research studies explore the creative potential in virtual spaces. However, these studies were conducted using older VR headset models. With the immense technological leap made by Meta Quest 2 and Meta Quest Pro in the last three years, which offer users an immersion experience at a whole new level, and with further applications specifically designed for businesses released in the app store, new studies are needed, that apply the current state of the art technology. In addition, previous studies on creativity in immersive VR only illuminated individual aspects of creativity, such as focusing on divergent thinking, avatars, or individual creativity performance from a psychological and educational perspective. However, to assess the suitability of the technology for the use in an organizational context, creativity must be considered as a holistic concept, that can be influenced by numerous factors but also fits into an innovation process where interdisciplinary teams collaborate and produce outcome properties, that enable idea implementation in terms of innovation (Brem et al., 2016). Moreover, the technology needs further insights generated from theory and practice due to the emerging interest in VR from organizations (Heuer & Rupert-Kruse, 2015). Therefore, this study develops a multidimensional conceptual model and creativity process for the experiment, that examines the implications on two organizationally relevant topics: team creativity and immersive VR.

2. Theoretical background

Various types of creativity exist in an entrepreneurial context, including individual, collaborative (team creativity), and organizational creativity. Due to the interdependency between individual and team creativity, individual components must be considered first to derive an understanding of creativity between several people. Therefore, the first sub-chapter focuses on the clarification of the foundations of individual creativity, and the second sub-chapter on the development of the concept for team creativity for the explorative analysis, followed by the transition of the concept to the immersive VR in the third sub-chapter.

2.1. Theoretical Foundations of Creativity in Organizations

The following sub-chapters aim to provide clear definition for creativity and the distinction to innovation as well as verify the concepts of individual creativity for key factors relevant for analyzing team creativity.

2.1.1. Definition of Creativity and its Role within the Innovation Process

For decades, creativity in organizations has received significant attention from scientists and practitioners as a research field, as it holds practical implications for managing innovation in organizations (Amabile, 1996; Cropley & Oppert, 2018). However, there is often a lack of clear distinction between creativity and innovation in literature, as both have similar key factors. In fact, there are two distinct ways to distinguish creativity and innovation. Firstly, creativity can be understood as a starting point for organizational innovation (Amabile, 1996,1998; West, 2002). According to this logic, creativity represents the generation of ideas, and innovation represents the implementation of these ideas. Creativity is therefore positioned before the innovation process and serves as a foundation for innovation but is not sufficient on its own (Amabile, 1996). Secondly, creativity can be considered as a subprocess within the overall innovation process. Innovation comprises two distinct stages: the generation of ideas and their subsequent implementation for business use. Table 1 presents different terms and process steps, that exist for creativity and innovation in literature.

This master's thesis follows the general consensus, that creativity in the organizational context refers to the fuzzy front-end. In order to commercialize new products, processes, and services from a business perspective, the creativity phase must pave the way towards the generation of ideas, that are usable and applicable for the exploitation or new product development phase. Therefore, creativity in the organizational context must be considered in terms of innovation.

Creativity refers to the human ability to generate ideas, that are original and applicable. The initial definition of this concept was put forward by Amabile in 1996, laying the foundation for research on creativity in organizations (Amabile, 1996). While researchers have examined creativity as a construct from different perspectives, they have not deviated from the core definition in their studies (Hülshager et al., 2009; Reiter-Palmon et al., 2012; Somech & Drach-Zahavy, 2013; West et al., 2004). The definition combines three essential components, on which research in this field is based: firstly, creativity in the research context is seen as a human performance, encompassing emotions, characteristic traits, personality, expertise, and experience, that enable a *person* to think creatively

(Amabile, 1983). Secondly, the cognitive and operational *process* of generating ideas, and lastly, the characteristics of the *output*, whether it is a product, process or service, have been identified as crucial elements for making creativity and its situational efficiency measurable. Despite the unanimity of researchers in the definition of the concept, the nature of creativity is seen as complex, multidimensional, and interdisciplinary (Cropley & Cropley, 2012; Glăveanu et al., 2020).

Therefore, this master's thesis builds on findings from studies in various research fields such as psychology, education, art, and engineering, in addition to business. The individual variables influencing creativity will be examined in detail in the next chapters.

Table 1: Role of Creativity within the Innovation Process

	Author, Year	Stages		
		Creativity	Innovation	
Creativity is a starting point for organizational innovation.	Amabile 1996, 1998	Idea Generation	Idea Implementation	
	West, 2002	Creativity	Innovation Implementation	
		Innnovation		
		Creativity		
Creativity is a subprocess of the whole innovation process.	Roberts, 1988	Invention	Exploitation	
	Koen et al., 2002	Fuzzy Front-End	New Product Development	Commercialization
	Boeddrich, 2004	Fuzzy Front-End	Multi Project Management	
	Cropley & Cropley, 2018	Fuzzy Front-End	Exploitation	

2.1.2. The multi-dimensional Perspective on Creativity

Creativity is a multidimensional construct which has been explored by researchers for decades from various perspectives. The insights from different research fields either from psychological, educational or business perspective, have shown, that creativity in general emerges from an interplay of components depending on the situation and circumstances. Therefore, due to the fact, that various theories address distinct facets of creativity, they are not easily comparable (Sternberg, 2018). As those components can either foster or hinder individuals to generate creative ideas, it is beneficial for practitioners to be aware of the corner stones of creativity and their interdependencies as well as the possibilities and its consequences of consciously orchestrating them. To overcome the complexity of the topic, insights of different research streams have been systemized, and condensed to creativity models by scientists. This chapter examines the most prominent creativity models in research and their evolution highlighting the ongoing process of exploring, validating, and challenging the understanding of creativity until today.

Among various creativity models, the initial and most formative model in literature is the 4P model published in 1961 by M. Rhodes, which anchored creativity around four components: Person, Process, Product and Press (Rhodes, 1961). Several studies incorporated either all four or only single components such as person or process for further research examination and development of the model (Cropley & Cropley, 2012). Over the years, multiple efforts have been made to expand the model (see Table 2) (Tang & Gruszka, 2017). For instance, Glăveanu's (2013) 5A framework builds upon the foundation of the 4P model and expands it by adding interdependencies from Person to Actor, Process to Action, Product to Artifact, and Press to Audience and Affordance.

Another well-known model in creativity research is Lubart's (2017) 7C framework, which includes the following elements: Creators, Creating, Collaborations, Contexts, Creations, Consumption, and Curricula. Although this model does not directly relate to the 4P and 5A models, their core elements are found as a common denominator: Creators correspond to Person (4P) and Actors (5A), Creating corresponds to Process (4P) and Action (5A), Collaborations and Contexts correspond to Press (4P) and Audience and Affordances (5A), and Creations correspond to Product (4P) and Artifact (5A). Consumption can be understood as a further element towards product development, and Curricula as an extension of creativity in the educational sense. In assessing creativity, not all but individual components of the models are combined to evaluate creativity performance.

Table 2: Creativity Models

4P's Creativity by Rhodes, 1961	5A's of Creativity by Glăveanu, 2013	7C's of Creativity by Lubart, 2017
Person	Actor	Creator
Process	Action	Creating
Product	Artifact	Creations
		Consumption
Press	Audience	Collaboration
	Affordances	Context
		Curricula

The various models in the literature indicate, that there is no consensus regarding the nomenclature or the number of components, despite overlapping content. The expansion of models from four to five and from five to seven elements over decades demonstrates once again the multidimensional and complex nature of creativity, especially when the context and interdependencies from and to an individual play a role in assessing creativity.

Given the importance attributed to these models in creativity research, individual elements from all models are picked up in this study. The four core aspects of Rhodes' (1961) 4P model have the greatest common denominator among all creativity models (see table 2). Therefore, the foundations of creativity along the four dimensions of Person, Process, Product, and Press are unpacked in the following chapters.

2.1.2.1. Person

The individual is the starting point of numerous studies in creativity research since the generation of creative ideas are considered as a person's achievement (Tang & Gruszka, 2017). As previously mentioned, creativity was initially treated as an inherent trait of individuals, and that only a few are privileged to possess it. However, nowadays' research considers the cognitive and emotional characteristics of a person, which enable an individual to think and act creatively. The range of aspects here is broad varying from specific individual characteristics and personality traits, to skills, experience, and motivation (Amabile, 1983; Hennessey, 2019; Sternberg, 2018; Tromp & Sternberg, 2022).

A significant part of understanding the person's ability to generate original, novel and (business-) relevant ideas is not only about accumulating the knowledge about all previously mentioned individual aspects, but also bringing them into context (Chompunuch et al., 2019). In his 5A framework, Glăveanu (2013) thus expanded the terminology of Rhode's creativity component Person to Actor. By doing so, Glăveanu (2013) highlights the aspect of zooming out of the individual and refocus on the situation, in which the individual gets creative as well as on the interdependencies of the societal system, in which the person acts and reacts to.

Skills – In one of the most prominent models on individual creativity, the componential theory by Amabile (1983) encompasses three aspects: creativity-relevant processes, skills in the domain and intrinsic motivation. The first aspect refers to all personality characteristics, traits and the cognitive style, such as having the cognitive flexibility to solve problems. The second aspect, the domain relevant skills, comprises the knowledge, expertise, technical skills, experience, and educational background in order to solve the task in the respective domain.

Intrinsic motivation – The third and last aspect, the individual motivation, considers interest, enjoyment, satisfaction to solve the challenge. As a situational component, the intrinsic motivation greatly influences the idea generation process (Amabile & Pratt, 2016). In the situation of facing a specific challenge or problem, a person is intrinsically more motivated to get creative in order to solve the task when domain-relevant skills and personal task interest are available (Amabile, 1983). Extrinsic motivation on the contrary is strongly dependent on the environmental context such as leadership, business environment and hierarchies (Hennessey, 2019). Those are deliberately examined by other researchers as by Rhodes' fourth component Press (see chapter 2.1.2.4.).

Mood – The mood of a person has also been explored as another situational variable for creativity in research by Kaufmann (2003) and Baas, De Dreu and Nijstad (2008). Creative ideas thus do not necessarily arise when a person is in a good mood or has positive feelings. Rather, it is an interplay of the hedonic tone, level of activation and the effect on focus.

Attitude towards creativity – In addition to the social and situational context such as group dynamic, task, place or time, there is another influential and, according to various researchers, the most important variable: the individual attitude towards creativity. This includes, on the one hand, the mindset, which can be trained like a muscle and on the other hand, the creative confidence, which can emerge through personal development and the strengthening of the mindset (Kaufman & Sternberg, 2021).

Table 3: Key Aspects of Individual Creativity

Category	Subcategory	References
Skills	Domain-relevant skills	Amabile, 1983
	Creativity-relevant skills	
Intrinsic motivation	Task & Situation dependend	Amabile, 1983; Hennessey, 2019
Mood	Interplay of the hedonic tone	Kaufman, 2003; Baas, DeDreu and Mijstad, 2008
	Level of activation	
	Effect on focus	
Attitude towards Creativity	Creative Mindset	Niu and Sternberg, 2003; Baas, 2019; Glăveanu et al., 2019; Kaufman & Sternberg, 2021
	Creative Confidence (e.g risk-raking, open for change)	

People are neither born with a creative mindset, nor can they consistently produce creative ideas at the same level (Kelley & Kelley, 2013). Sternberg (2018) argues, that it depends on the basic creative attitude a person has in order to find new ways to overcome challenges. Intrinsic motivation also plays an important role here as for the creative process and the outcome to be useful, novel and efficient, the creative attitude must not only be an inherent characteristic of a person but also be actively applied (Hennessey, 2019). Furthermore, people with a creative mindset are assigned special character traits. For example, they usually face changes with confidence, they are open to trying new things and are more risk-taking (Amabile & Pratt, 2016). One of these steps includes the recommendation of encouraging confidence and risk taking. Kelley & Kelley (2013, p. 14) believe that “Creative confidence is like a muscle – it can be strengthened and nurtured through effort and experience”. The fluid state of the individual's creativity potential is highlighted here again with terms such as effort, experience, and individual personal development. Accordingly, a person with less experience with creativity techniques in general and specifically in the task-related area can show significantly less creative self-confidence than a person with more experience and expertise. These variables can shape both, the process and outcome and are thus important indicators for both individual and collaborative team creativity.

However, since mood and attitude are fluid components, domain-relevant and creativity-relevant skills and intrinsic motivation (see table 3) are considered for the explorative analysis in this study.

2.1.2.2. Process

The understanding of how to define the creative process has evolved in recent decades (Botella & Lubart, 2019; Guilford, 1950; Lubart, 2001). The definition has been enriched and evaluated differently, similar to the concept of *person* through insights from various research streams. The creative process refers to a series of ideas and activities, that result in the creation of unique and fitting works. Two levels of the creative process are differentiated: the micro and the macro level. The *micro* level includes all mechanisms, that make the creativity process possible, such as divergent and convergent thinking, while the *macro* level encompasses all major phases of the creative process, that pursue the goal of idea generation (Botella et al., 2018; Botella & Lubart, 2019).

As this master's thesis deals with team creativity in the business context, the findings from the literature on the individual will be taken into consideration in order to conceptualize and systematically analyze the creative processes in a complex construct and numerous other influencing factors.

From a psychological perspective, Guilford (1950) focused on the thought processes of individuals in his research on creativity. Building on this, Rhodes (1961) viewed the creative process in educational research as cognitive mechanisms for generating ideas. Specifically, topics such as motivation, learning, and thinking were examined in relation to education, but with a focus on the internal processes of an individual. According to Glăveanu's (2013) perspective, the creative process is a combination of psychological and behavior-based components, that originate from the individual, but can be controlled in a situational and context-dependent manner. Glăveanu refers to the coordination of internal cognitive and external visible behaviors in a person as Action, which is relevant for idea generation. This perspective is also reflected in Lubart's research on creativity, but focuses primarily on the goal of creating something new and desirable (Botella & Lubart, 2019; Lubart, 2001, 2017). Therefore, the definition of the creative process is derived as a sequence of actions, thoughts, and processes undertaken by the creator to achieve the desired outcome. Accordingly, Lubart consciously refers to this component of his 7C framework (2017) as Creating, but also points out, that this is a heuristic model.

In this master's thesis, creative thinking and action are considered as observation criteria to gain insights from a creative process.

a.) Micro Level

Divergent and convergent thinking involve examining creativity mechanisms on a micro level (Guilford, 1967; McCrae, 1987). The ideas or solutions arise from the underlying problem and do not prioritize the individual. Divergent thinking refers to the ability to generate multiple diverse ideas or solutions for an open-ended problem or challenge. Conversely, convergent thinking involves the ability to focus on a few essential ideas or even a single relevant idea from the many different ideas or solutions generated. To visually illustrate divergent and convergent thinking, the Double Diamond Model from Design Thinking will be presented in chapter 2.2.3..

A diamond represents a thinking process: the divergent thinking process is depicted by the first, opening part of the diamond, while the convergent process is represented by the second, closing part. Initially, starting from a problem or task, the creative thinking process is stimulated to expand, to consider the problem from different perspectives, and to let ideas flow freely, in order to generate a quantity of ideas. Subsequently, a selection is made from the breadth of ideas, for example, using criteria or project-based decision structures in the business world, to create an applicable, original, feasible, and relevant idea by the end of the creativity process. The final step is particularly important in the business context, as from the moment the creativity process ends with an idea, the implementation phase of the innovation process begins (see chapter 2.1.1.).

Although creativity research has particularly focused on divergent thinking, the process of expanding ideas, and there are numerous studies on how to stimulate this type of thinking, divergent thinking cannot occur without convergent thinking (Ulrich, 2015; Voigt & Bergener, 2013). Moreover, there may be no clear boundary between the two processes at some points in the process, and iterative interaction between the two is necessary (West, 2002). The interaction between both thinking processes is crucial for driving them forward, especially for innovation purposes.

For this reason, this master's thesis examines both divergent and convergent thinking during a creativity process.

b.) Macro Level

Creativity is not a linear process. Idea generation should be viewed as a sequence of process steps involving divergent and convergent thinking to solve a problem, task or challenge (Botella & Lubart, 2019; Lubart, 2001). The creative process lacks a universally accepted set of stages, as authors disagree on the process names, number, and sequence of the stages. For example, Wallas' (1926) four-stage model includes preparation, incubation, illumination, and verification, whereas Cropley and Cropley (2012) expanded the model to seven phases: preparation, activation, generation, illumination, verification, communication, and validation. According to the key innovation process by Boeddrich (2004), the Fuzzy Front End consists of the Generation, Collection, Adoption, Clustering, Screening, Selection and Improvement of Ideas, followed by the Decisions on Innovation Projects, which are then Implemented in the second phase of the Innovation process. The success of an innovation project, thus, depends on the sustainable flow of ideas (see fig. 4) (Boeddrich, 2004).

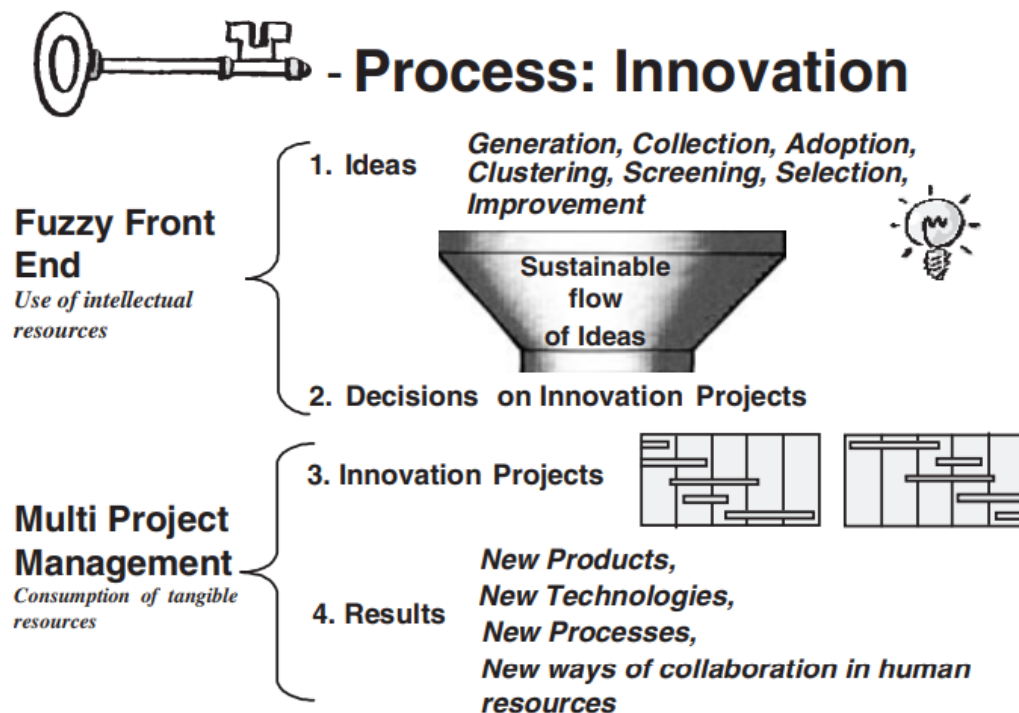


Figure 4: Main Stages of the Innovation Process as the Key Process (Boeddrich, 2004)

In business environments, iterative cycles are typically used between different creativity phases, always with the goal of aligning the produced ideas and decisions with the task at hand. This ensures, that the focused idea at the end, such as a rough prototype for the exploitation phase of the entire innovation process, is feasible, implementable, meaningful, and relevant. In Design Thinking, the constant back and forth between specific process steps is even desirable to ensure, that every action aligns with the challenge and user needs during the innovation process (Gerken et al., 2022).

To ensure these characteristics in the outcome, in addition to the actual idea generation and development phase, steps such as organize, evaluate, and select are identified as fundamental process

steps in creativity research (Cropley & Cropley, 2012; Nemiro, 2002; Voigt & Bergener, 2013). These steps are fundamental in that they give structure to the creations and filter the quantity of ideas through an idea funnel to focus on the essential results. Although creativity research has increasingly focused on the idea-generating part and its efficiency, creativity cannot be reduced solely to the momentum of idea creation. In fact, it goes beyond that to the ability of individuals to navigate through numerous possibilities towards a practical solution.

This is another argument for why both divergent and convergent thinking must be examined to understand creativity. For this reason, process steps requiring both modes of thinking are selected for the experiment.

2.1.2.3. Product

Contrary to the numerous discussions on creativity models and theories, researchers generally agree, that the production of new and appropriate ideas and products forms the basis of creativity (Amabile, 1996; Walia, 2019). It does not necessarily have to be a physical product; the maturity level can range from an idea, a prototype to a mature solution. The important thing is that the outcome fulfills certain qualities that are recurrently referred to as synonyms in the literature. These include novelty and usefulness (Cropley & Oppert, 2018), originality and effectiveness (Runco & Jaeger, 2012), problem-solving (Amabile & Pratt, 2016; Hennessey & Amabile, 2010), appropriateness to the task (Amabile, 2012), and high quality (Sternberg & Lubart, 1995) or fluency and originality (Bourgeois-Bougrine et al., 2019).

The mentioned characteristics are important indicators for assessing whether an idea or a product is sufficiently developed for further innovation development and implementation in terms of exploitation (Hennessey & Amabile, 2010). Therefore, Glăveanu (Glăveanu, 2013) expanded the concept of Product to Artifact in his 5A framework by adding the aspect of evaluation. However, the question remains, what person has the capabilities and what capabilities are needed for assessing the creativity potential of an idea.

The creative process involves people's individual interpretations of an idea's novelty and usefulness, which are based on experiences, communication, and knowledge (Walia, 2019). Although the individual perception is important to stimulate the creative process, it may be subjective and therefore often difficult to measure and observe. Therefore, creativity is often judged based on perceptions rather than actuality, and it is unclear whether rejected ideas are not creative per se. According to Amabile (2012, p. 3) „a response or product is creative to the extent, that it is seen as creative by people familiar with the domain, in which it was produced”.

In order to stimulate divergent thinking, the task must be open-ended (heuristic) and not offer a single correct and obvious solution (Amabile, 2012). Complex tasks often arise in the corporate world due to larger projects and unforeseeable events. Therefore, experts decide, whether the generated ideas and products solve the given task and challenge. In the business context, for example, more experienced team members, such as managers, would decide on the quality of the output (Zu et al., 2019). The innovation model Design Thinking, which is used in organizations (see chapter 2.2.3.), lists the three components of viability, feasibility, and desirability as benchmarks for the quality of an idea or product (Chasanidou et al., 2015).

Therefore, in this master's thesis, the product is considered as an idea, that is evaluated by the characteristic's applicability and novelty for further implementation in the context of innovation by experts.

2.1.2.4. Press

Unlike the other three dimensions of the 4P model, press represents an external variable for individual creativity performance. It refers to the interplay between a person and its environment and describes thereby the physical and social conditions, that either support or constrain a person generating ideas and products, that are novel and useful (Rhodes, 1961). Although the environment, in which creativity takes place can impact the creative person or process, it does not directly shape the outcome.

Four levels of social domains have been identified as influencing factors on creativity by Ford (1996) including groups and subunits, organizations, institutional environments, and markets. A social domain occurs during an interaction between an individual's actions and specific touchpoint of the domain. Here, intra- and interconnections between domains can arise, such as between different groups or organizations, or within a domain such as organizational resources or market opportunities (Tang & Gruszka, 2017).

Since this master's thesis focuses on exploring creativity in the business context, the mechanisms at the team level and those at the organizational level, albeit indirectly, are being specifically targeted.

2.2. Theoretical Foundations of Team Creativity

The following sub-chapters aim to provide an understanding of team creativity and its role within the innovation process as well as distill relevant key factors along the Input-Process-Output (IPO) framework, that are relevant for designing the exploratory analysis for team creativity.

2.2.1. Understanding the Dynamic and Complex Nature of Team Creativity

Well-functioning innovation processes, that consistently and rapidly develop new products, technologies, and processes are indicators of successful structure and management practices, as well as a good work environment and capable employees for organizations (S. Bharadwaj & Menon, 2000). Therefore, companies are constantly striving to understand the individual process steps along the innovation process and their success factors in order to better manage and constantly optimize them (Crompton & Oppert, 2018; Hülsheger et al., 2009). Creative teams can be an effective approach for accomplishing intricate creative ideas and resolving complex problems (Jiang & Zhang, 2014; Somech & Drach-Zahavy, 2013).

In the entrepreneurial context, the promise of success in product or idea development depends on how well multiple individuals collaborate. Rarely is the individual performance of a person required, as in project management, for example. When several people collaborate together, they are either referred to as groups or teams. Few studies use both terms interchangeably. Some studies on group creativity examine small groups in controlled settings (e.g. West, 2002). Teams differ from groups in that they have a long-term relationship, a shared goal, and members are not randomly assigned (Paulus et al., 2012). Therefore most of the studies in the organizational context explore team creativity and its underlying collaborative processes, that are important to achieve novel and applicable outcomes

(Amabile, 1996; Cropley & Oppert, 2018; Jiang & Zhang, 2014; Reiter-Palmon et al., 2012; Somech & Drach-Zahavy, 2013).

Team creativity refers to the fuzzy front-end process of generating novel and applicable ideas within a collaboration of individuals. To explore the creativity process of multiple individuals and the resulting outcome, each individual must be perceived as a variable that can potentially influence the process and outcome. However, team creativity is not simply the aggregation of creativity of the individual team members (Hargadon & Bechky, 2006). As the literature review in the previous chapter has shown, individual creativity is a multidimensional construct due to influencing factors such as expertise, creativity skills, and motivation (Amabile, 1996). The collaborative component adds further complexity to this already multidimensional construct of creativity. For the analysis of team creativity, additional individuals act as multipliers, and group dynamics unlock further interactions and influencing factors on team creativity. Therefore, team creativity is researched from various perspectives and with different variables.

In the classical creativity models of Rhodes (1961), Glăveanu (2013) and Lubart (2017), the aspect of the team component was touched upon. In the 4P model, creativity is represented by Press, in Amabile's theory by the surrounding environment. In the 5A framework, Press has been expanded to the terms Actor, Audience, and Affordances, and in the 7C framework, the reference to several collaborating individuals is mentioned through the elements of collaborations and contexts (see chapter 2.1.2.). The 4Ps framework helps to reject the idea, that creativity, either on its own or as the beginning of innovation, is vague, ambiguous, and thus, impossible to control. However, the 4Ps model offers a static explanation of creativity, implying a fixed set of conditions, that foster the emergence of novel and effective ideas, which may create confusion due to the discrepancy between the static nature of creativity and the dynamic nature of innovation and problem-solving. To address this discrepancy and refute the vagueness of the creative front-end of innovation, a dynamic model is required, that depicts the influence of Person, Process, Press, and Product across the innovation stages, allowing organizations to manage the innovation process more effectively and critically assess the creative front-end of innovation (Cropley & Oppert, 2018).

Recent research on dynamic creativity has led to the development of the Person x Task x Situation (PxTxS) Framework (Tromp & Sternberg, 2022). This framework suggests, that creativity is influenced by the interplay of three variables: individuals, such as their individual influences, tasks, such as the topic field, and situations, such as environmental conditions and context. Using the Venn diagram model, the analysis can be approached from different perspectives, depending, on which component is being focused on. For instance, individual creativity potential can be influenced by the nature and content of the task, psychological safety, cognitive flexibility, a creativity-supportive environment, and temporal and spatial context. Simultaneously, the situation can be adjusted to the team's constellation, the presence of leadership, hierarchical levels, organizational rewards, and the type of task. Finally, group-level creativity levels can be explained based on the task, by taking into account individual preferences and the context, in which people are creatively stimulated. Tromp & Sternberg (2022) emphasize, that the PxTxS framework does not replace other creativity models but complements them by connecting the three components and accounting for their complexity, interdependencies, and dynamics.

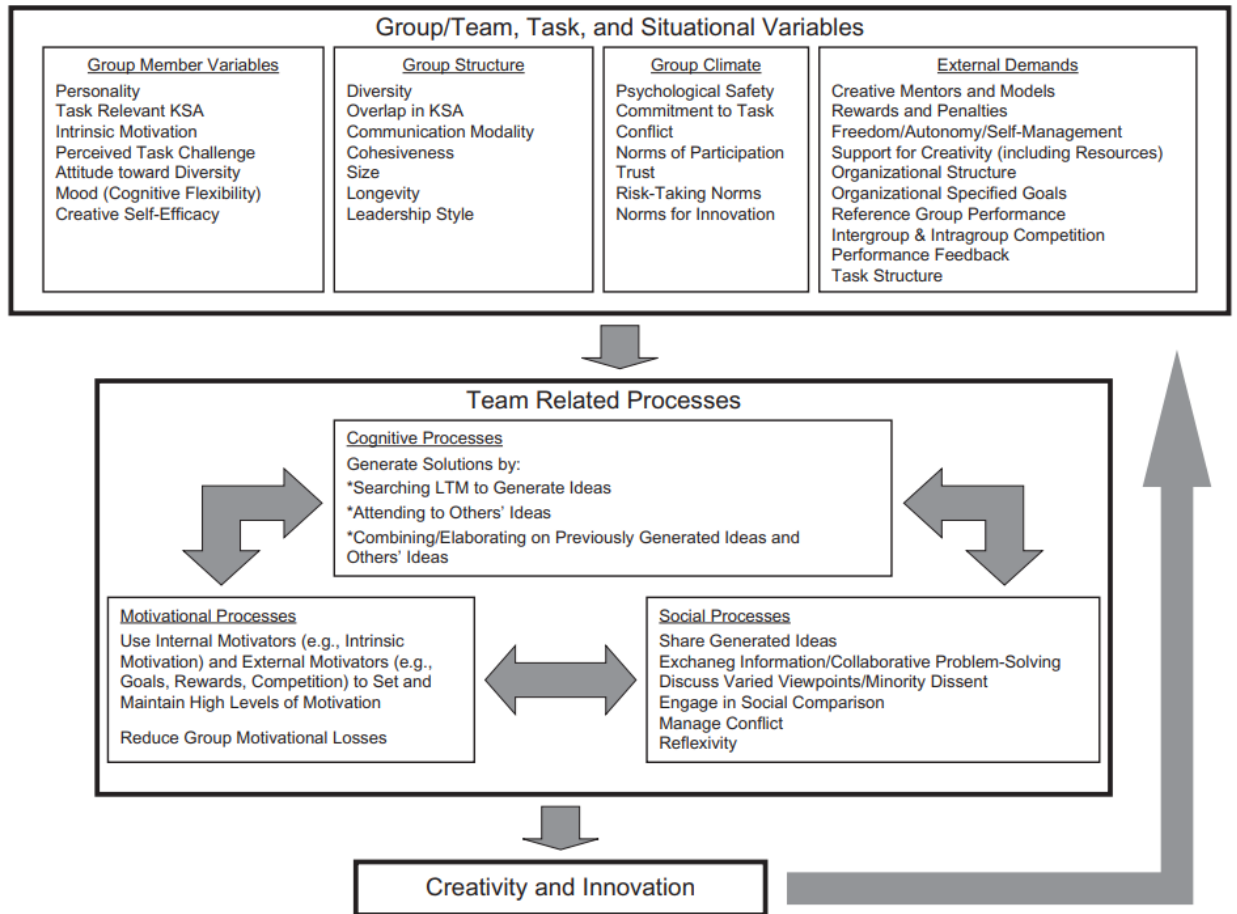


Figure 5: A Model of collaborative Creativity (Paulus et al., 2012)

The origins of the PxTxS framework can be traced back to the model of collaborative creativity (see fig. 5). According to Paulus et al. (2012), there are group, task, and situational variables, that affect team-related processes, which in turn influence creativity and innovation. At the same time, creative outputs can have an impact on task and situational variables. The complexity as well as direct and indirect directions of influence from variables to processes and output are further evidence of the dynamic and complex nature of team creativity. Lastly, according to Jiang and Zhang (2014), to explore team creativity the following characteristics need to be considered: Integrity – the collective efforts of the team, dynamic – the entire creative process and nonlinearity – the integration of different variables.

In the following chapters, the dynamic and complex nature of team creativity is analyzed by a selected set of variables along the IPO framework.

2.2.2. Team Creativity Variables along the Input-Process-Output Framework

The master's thesis relies on the IPO framework by Hackmann (1987), a common model for team creativity analysis (Hülshager et al., 2009; Reiter-Palmon et al., 2012). This framework primarily examines the factors, that contribute to team creativity. Moreover, the framework provides a basis for a more in-depth analysis, also from an organizational perspective, in order to examine the interactions between the various factors. For instance, conclusions can be drawn from the process and output with

respect to the input factors (Paulus et al., 2012). The IPO framework is a multidimensional analytical construct and thus, well-suited for understanding and managing team creativity.

Various researchers have investigated the team creativity variables, with some focusing on similar variables while others having different foci, as shown in table 4. Hülshager et al. (2009) made a distinction between team creativity input and process variables, which is adopted for the categorization according to the IPO framework and extended to include the team creativity output variables.

Table 4: Team Creativity Variables Comparison

Category	Hülshager et al., 2009	Paulus et al., 2012	Reiter-Palmon et al., 2012
Team creativity input variables			
Team Size	X	X	
Team Diversity	X	X	X
Team creativity process variables			
Psychological safety	X	X	X
Task Orientation	X	X	X
Conflict	X	X	X
Cohesion	X	X	X
Communication	X		X
Support	X		X
Collaboration			X
Leadership		X	
Vision	X		

2.2.2.1. Team Creativity Input Variables

The following input variables are selected with regard to the relevance for the exploratory analysis of team creativity:

Team size – As the team size increases, it is more likely, that poorer performance will result. This phenomenon, known as the Ringelmann Effect, creates a lower commitment among team members towards the outcome as team size increases (Ringelmann, 1913). The interaction and coordination among team members are impeded by the increased number of people, leading to issues such as lower participation levels, less support for innovation, and less emphasis on quality. Decreased team performance, in turn, can hinder the idea generation process, leading to negative impacts on team creativity. To enable effective and comprehensive sharing of information and ideas between team members, the group size should be limited to as few individuals as possible, regardless of the complexity of the task (Paulus et al., 2012). In their comprehensive study on Design Thinking in organizations, Gerken et al. (2022) also advise, that an ideal group size should not exceed 10 individuals. *Therefore, in this experiment, teams consisting of three individuals are considered.*

Team diversity – In organizations, especially in the context of innovation and creativity, team diversity is considered an entrepreneurial strength. With increasing task complexity, the diverse knowledge and experience of team members can be beneficial for problem-solving. This change in perspective also allows for increased variability in creative performance (Taylor & Greve, 2006). High team diversity is particularly advantageous when the individual characteristics of team members match the requirements of the task and complement each other with complementary expertise, enabling successful completion of complex industry projects (Fiore, 2008). A match in the team's domain-relevant and creativity-relevant skills, as well as intrinsic motivation according to Amabile (1983), is therefore a good indicator of successful creativity performance. Studies indicate, that employee's creativity is positively associated with overall job performance (Y. Gong et al., 2009). The more intrinsically motivated a person is through e.g. interest or enjoyment, to fulfill a task, the more likely the person achieves a higher creative performance level (Amabile, 1996). On the other hand, the social and work environment such as everyday's attitude and behaviors from colleagues or the organizational characteristics such as culture, mindset, or other managerial practices can either facilitate or impede individual and team creativity (Baer, 2012). However, the more complex the task, the more helpful a balanced demographic diversity can be (Paulus et al., 2012). This is because characteristics such as age, gender, and origin can influence communication, interaction, and social cohesion during the team's creativity process (Mannix & Neale, 2005). Furthermore, a study by Hülshager et al. (2009) shows, that job-relevant diversity in a team has a slightly positive impact on innovation compared to background diversity. The duration of team membership can also affect psychological safety (Paulus et al., 2016).

In their study on Revised Dynamic Componential Model, Amabile & Pratt (2016) affirmed the need for a model, that conveys the dynamic nature of creativity. The initial componential theory by Amabile (1983) considers creativity-relevant processes, skills in the task domain and the intrinsic motivation by an individual or team to do the task as premises for eliciting creativity (see chapter 2.1.2.1.). The new theory builds on the initial model by adding future iterations in the form of feedback loops within the process as well as the stronger interdependencies between the organizational innovation and individual and group creativity. Accordingly, individual creativity and organizational innovation are interconnected as the creative inputs from individuals and teams serve as the catalyst for innovation within an organization by enriching the skills in innovation management, the resources in the task domain and the overall motivation to innovate (Amabile & Pratt, 2016). Consequently, company's resources need to be able to get managed by existing skills in the task domain of an individual or team. Further, the team composition must be better understood in order to facilitate efficient collaborative processes, which can be consciously managed through team size and diversity to enhance idea generation by multiple individuals (Paulus et al., 2012).

2.2.2.2. Team Creativity Process Variables

The following process variables are selected with regard to the relevance for the exploratory analysis of team creativity:

Psychological safety – Work environments with psychological safety encourage creativity and innovation (Edmondson, 1999). This is because psychological safety is a collective perception among team members, that setbacks and mistakes are permissible and regarded as prospects for advancement and learning, without any adverse consequences. In such settings, setbacks lead to

enhanced intrinsic motivation and learning of domain-relevant skills, especially when feedback culture is perceived as part of the shared mindset among team members (Amabile & Pratt, 2016; Reiter-Palmon et al., 2012). To jointly endure uncertainties and overcome failure as a team, individuals need to have the cognitive flexibility to endure ambivalent emotions and be open to risk-taking. Here, psychological safety and trust are relevant as well. In addition, those aspects can be supported by the organizational culture and shared beliefs, that again encourage teams to find a creative solution for a challenge.

Task orientation – Task orientation, or climate for excellence, refers to a collective dedication to accomplishing exceptional task performance with respect to a common goal or result (West, 1990). Teams, which prioritize task orientation aim to attain superior levels of performance and engage in shared monitoring, feedback, and periodic evaluation of ideas and performance. Task orientation encompasses task reflexivity, which entails reflecting on the team's objectives, strategies, and processes, and appraising each other's work to improve team efficacy and outcomes (Hülshager et al., 2009). Further, team creativity can be increased by ensuring, that the relevance of the task is transparent, and the challenge aligns with the goals and purpose of the company (Amabile & Pratt, 2016). In the context of innovation, task orientation needs to incorporate the new development of products and services with some degree of novelty and applicability (Reiter-Palmon et al., 2012).

Communication – Communication as a crucial factor in promoting creativity and innovation within teams (Paulus et al., 2012; Reiter-Palmon et al., 2012). Team members who are creatively working together in a physical space can rely on verbal and nonverbal communication through facial expressions and gestures. The different levels of communication can create psychological safety and, therefore, a better creative performance of the team with greater likelihood. Further, effective communication enables team members to share information, ideas, artifacts and knowledge, which is essential for generating new ideas. High-quality communication is especially important for addressing complex problems, that require the exchange and discussion of ideas, as well as the sharing of past experiences. In addition, communication plays a critical role in the plan execution phase, as team members need to monitor and provide constructive feedback to one another to ensure the successful implementation of new ideas (Hülshager et al., 2009).

2.2.2.3. Team Creativity Output Variables

The following output variables are selected from the 4P framework (see chapter 2.1.2.3.) with regard to the relevance for the exploratory analysis of team creativity:

Applicability – In terms of innovation, the result of the team creativity process must be useful and desirable for further implementation in practice.

Novelty – The selected idea must be new and yet desired by the target audience in order to provide added value.

2.2.3. Team Creativity – A Dynamic Creativity Process within Design Thinking

Team creativity is a dynamic and complex phenomenon, as discussed in chapter 2.2.1, due to various influencing factors and variables, as elaborated in chapter 2.2.2, as well as dependencies and relationships through the collaboration component. However, this complexity hinders the efficient execution of a creativity and innovation process on micro and macro level, as the sequence of process steps from the Fuzzy Front-End to exploitation can be iterative and nonlinear, requiring both divergent and convergent thinking interchangeably.

In the early stages of the innovation process, organizations attempt to generate a sustainable flow of ideas and reduce the high quantity of ideas to a few qualitative ones in the Fuzzy Front-End (Boeddrich, 2004). According to Amabile & Pratt (2016), the innovation process involves team creativity at a late stage, rather than at the beginning, and is thus considered more of a “fuzzy middle part” than a “fuzzy front end”. However, there are instances when the innovation process begins with unexpected discoveries by individuals and teams, making the “front end” label applicable. Nevertheless, at the end of the sustainable flow, the idea characteristics must be applicable and novel according to the definition of creativity, so that the filtered ideas can be transferred to the innovation project phase.

Design Thinking is a systemic approach, that aims to bring value to complex environments, in which organizations operate (Gerken et al., 2022). Due to its successful application in practice for decades, companies and project teams utilize this approach to generate relevant ideas for the challenge despite uncertainties from the Fuzzy Front-End.

Therefore, in this study, Design Thinking serves as the basis for the design of the exploratory analysis of team creativity in organizations.

2.2.3.1. Design Thinking

Design Thinking is a framework, that navigates leaders, innovators, designers and any other practitioner alike through the process of developing innovations by creating deep empathy for human needs, values and interests, solving complex challenges with creative techniques and thus, develop solutions, which are desirable by the end-users (Brown, 2008). The focus on human-centricity allows Design Thinkers to integrate the internal motivators and emotional aspects into the innovation process (Stewart et al., 2020).

In the past years, companies have discovered the opportunities and benefits of the application of Design Thinking, which draw further attention from businesses for this innovation model. Design Thinking as a human-centered and creative approach has not only solved complex, previously intractable challenges and yielded promising results but also is applicable in a wide range of industries (Beckman & Barry, 2007; Buchanan, 1992).

Design Thinking as a human-centered innovation approach has been re-interpreted several times, which has consequently led to multiple definitions with different approaches, that exists nowadays in scientific and business context (Kimbell, 2011). This is due to the nature of Design Thinking being on the one hand a systematic and on the other hand a broad-minded, highly flexible approach for the development of innovations (Sato, 2009). Therefore, Design Thinking embraces a constant evolution

of the established models such as the 3I model by IDEO or the Double Diamond model by the British Design Council in the recent years (Tschimmel, 2012). *The latter Design Thinking model is introduced to understand the main process steps on mirco and macro level.*

2.2.3.2. The Macro and Micro Level of the Double Diamond Model

The Double Diamond model within the operational context was published in 2004 by the British Design Council (Design Council, 2022). This Design Thinking framework navigates innovators from the starting point “Don’t know” or “Could be” to the innovation solution “Do know” or “Should be” (similar to the Fuzzy Front-End). An exemplary illustration can be found in figure 6 (Nessler, 2016).

The micro level of the Double Diamond model accentuates the two thought processes both in their nomenclature and in their depiction through diamonds. The initial part of a diamond, which opens up space, illustrates divergent thinking, whereas the concluding part of a diamond, which closes space, illustrates convergent thinking. This implies, that creativity, as it relates to innovation, necessitates the utilization of both thought processes. Innovative ideas generated through divergent thinking can only come to fruition within a company by means of subsequent convergent thinking. Consequently, both thinking processes are necessary for an exploratory analysis of team creativity.

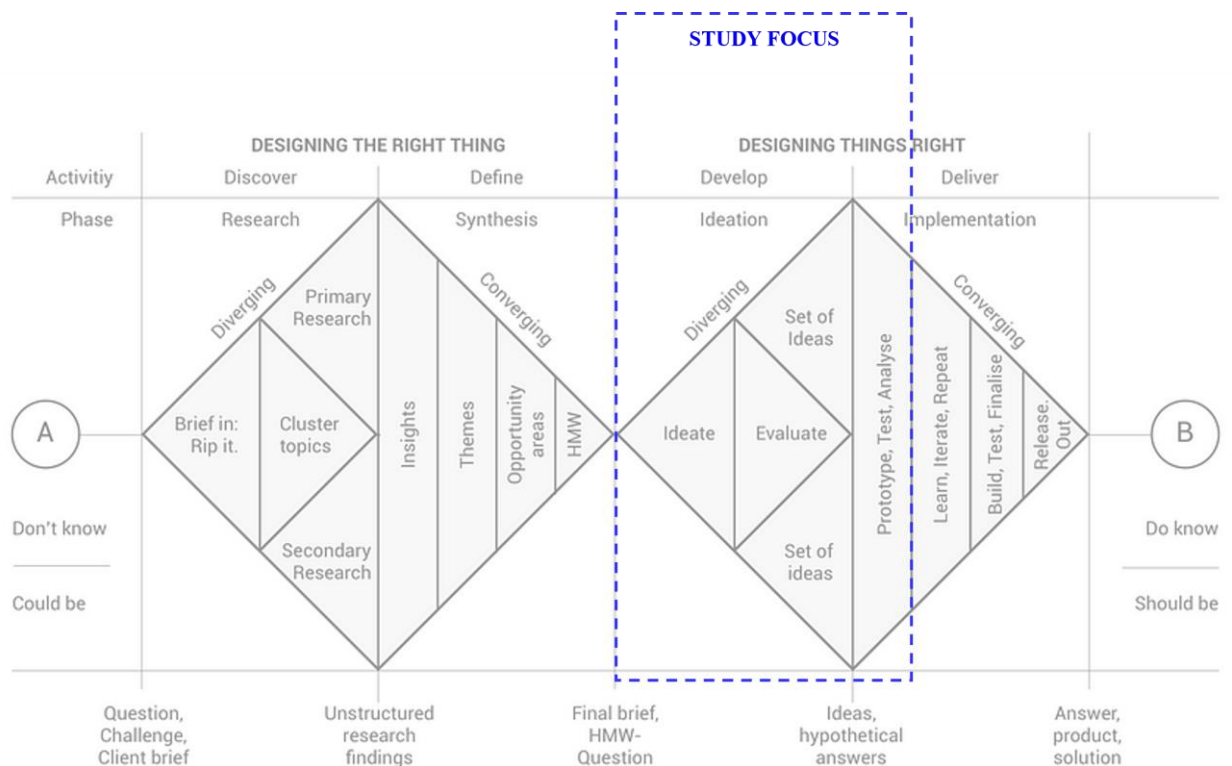


Figure 6: Double Diamond V.2 according to Nessler, 2016 (adopted and edited by author)

The macro level of the Double Diamond model consists of four main phases, which incorporate further subprocesses: (1) Discover, (2) Define, (3) Develop and (4) Deliver. The first diamond starts with the *Discover* phase, which is all about interacting with those people related to the challenge to comprehend their needs and concludes with the *Define* phase by refining the recently obtained insights from the exchange to reinterpret the challenge and establish a clear problem statement, also

known as How Might We (HMW) question. The latter lays the foundation for the second diamond, as it leads the innovators into the *Develop* phase to find ideas to the previously identified problem statement and prototype the solution. In the final phase, the *Deliver* phase, the created solutions are tested with the stakeholders to obtain feedback for optimization (Ball, 2022). Due to their characteristics, the process steps of the first diamond are clustered to the so-called “Problem space”, whereas the process steps of the second diamond belong to the “Solution space”.

This study focuses on the second diamond, the Solution Space, to examine the process steps of idea generation (Ideation), idea selection, and idea combination (Prototyping) through an exploratory analysis. A HMW question will serve as the starting point for the workshop.

2.2.3.3. Creativity Techniques and Creativity Support Tools for the Process

Design Thinking practices are designed to incorporate creativity techniques as an essential aspect of the process to encourage teams to collaborate and be creative. One of the most well-known creativity techniques is brainstorming, which was developed by Osborn (1953, rev. 1957, 1963) to support the idea generation process. Brainstorming is part of a broader method known as Creative Problem Solving, which provides a set of guidelines for effective brainstorming, including avoiding judgement and emphasizing quantity over quality. Modern brainstorming techniques involve the variation of silent and group brainstorming, brainwriting, mind mapping, as well as artistic methods such as sketching (Herring et al., 2009; Tschimmel, 2012).

Moreover, technology-based tools are being increasingly utilized to enhance individual and collaborative creativity in various ways, such as through inspiration, idea generation, and socialization (Shneiderman, 2007). Recently, immersive VR has emerged as a potential Creativity Support Tool, which has opened new opportunities for exploring its potential in fostering creativity and innovation. Studies on brainwaves have suggested that VR applications can enhance cognitive reflection, heart flow, and thereby, creativity (Yang et al., 2018). Further studies on creative 3D sketching (Houzangbe et al., 2022), design creativity and design thinking (Chang et al., 2022) and prototyping (Vogel et al., 2021) have indicated the need for broader exploration in this area, especially in the business context.

Hence, the following chapter examines the team creativity in VR.

2.3. Team Creativity in Virtual Reality in Organizations

The following sub-chapters aim to provide an understanding of the concept of VR and its indications for the team creativity variables and the process for the subsequent exploratory analysis.

2.3.1. Definition of Virtual Reality

As the disruptive nature of VR becomes increasingly apparent in the business and working world, there is potential for another digital transformation to the virtual world after COVID-19. Therefore, insights into the potential applications of VR along the creativity and innovation process, as well as information about the requirements for efficient idea generation, selection, and prototyping development, are particularly important for companies.

VR is a flexible term that has evolved over the years with the continuous optimization of hardware and software, leading to new features, applications, and possibilities of the technology (Rubio-Tamayo et al., 2017; Stanney, 1995). VR research is guided by the current level of technological maturity in the market, resulting in a differentiated understanding of the VR concept in the literature. Zheng et al. (1998, p. 1) define VR as "an advanced, human-computer interface that simulates a realistic environment". Bowman and McMahan (2007, p. 36) add the human factor component by stating that the goal of VR is to "let the user experience a computer-generated world as if it were real - producing a sense of presence, or 'being there,' in the user's mind". According to Wohlgenannt et al. (2020, p. 457), "VR leverages immersive technologies to simulate interactive virtual environments or virtual worlds, with which users become subjectively involved and in which they feel physically present".

Furthermore, different types of reality exist in the technological world (Wohlgenannt et al., 2020), which are described in the following and illustrated in figure 7. The terms *Mixed Reality*, *Augmented Reality* and *Augmented Virtuality* are often used interchangeably with VR. Essentially, the level of immersiveness is classified based on the extent to which the technology interacts with our physical world and conveys the level of immersion. *Augmented Reality* connects digital and physical information in real-time, while *Augmented Virtuality* involves mapping real-world media onto virtual objects. Both types of reality are considered subsets of *Mixed Reality*, which merges the virtual and real worlds. VR, on the other hand, creates a fully artificial environment and thus a fully different type of Immersion. *Extended Reality* encompasses all real and virtual environments and interactions created by computer technology and wearables.

The nature of VR is described by three core features: immersion, presence, and interactivity, which are further explained in the following:

Immersion is the extent, to which a VR system can provide sensory fidelity and illusions (Slater et al., 2022; Slater & Sanchez-Vives, 2016). Whether a technology is immersive or not depends on the performance of hardware and software, and how strongly they integrate and occupy the person in the virtual 3D world. In general, three different levels of immersion are distinguished (Mandal, 2013):

- *Non-Immersive*, also known as Desktop VR, involves a user interacting with a virtual environment through a computer screen but does not fully provide an immersed experience.
- *Semi-Immersive systems*, also called Fish Tank VR, are an improved version of Desktop VR, that support the feeling of "being there", but the multi-sensory experience lacks due to the use of a monitor sensory.
- *Immersive VR* is the most advanced type of VR, which offers complete immersion through a Head-Mounted Display with stereoscopic views, which allows users to interact with a real-time three-dimensional environment, providing the illusion of being present in a computer-generated world. Here, the technology employs input devices, that simulate sensory input channels like hand- and body-trackers and audio.

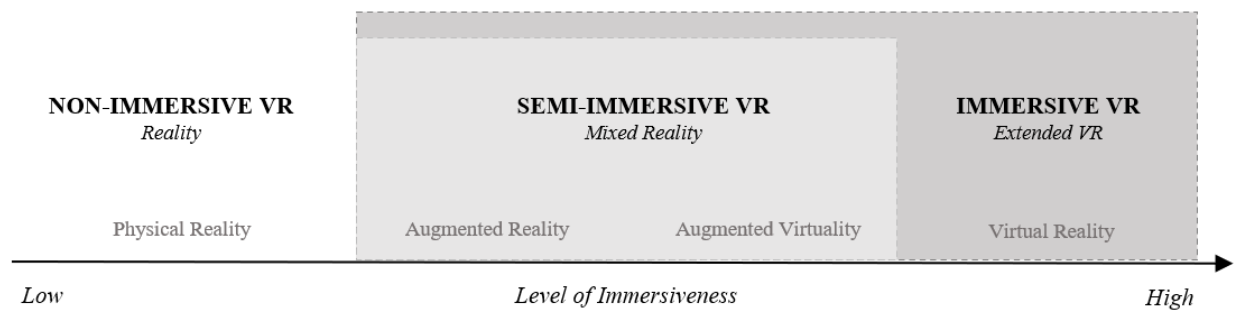


Figure 7: VR classification according to Wohlgenannt et al., 2020, p. 457 (adopted and edited by author)

However, the varying combination and technological maturity of different technological components such as systems' rendering software and display technology result in differing levels of immersion as they shape the quality and type of immersive VR experience for the user. These are in particular: the size of visual field, display size and resolution, stereoscopy, head tracking, realism of lighting, frame rate and refresh rate (Bowman & McMahan, 2007). According to Slater (2009, 2018) immersion is considered to be an objective perception. However, there are studies, that explore immersion based on subjective factors such as cognitive and emotional involvement, as well as technological capabilities such as inclusiveness and surrounding.

Non-immersive VR poses a paradox in the literature. The question arises on how VR can be considered non-immersive, when immersion is uniformly regarded as a core characteristic of VR, especially when immersion is considered as an artificial environment the monitor is no longer visible (Pimentel & Teixeira, 1993). These and many other discussions can be found in VR research (Wohlgenannt et al., 2020) - in part because the constant change in the state of technology requires a continuous shift in perspective and an adjustment of the definition of the term.

In the past decades, there has been a notable increase in accessibility and a significant advancement in graphics and computing power. Presently, it is feasible to obtain a state-of-the-art VR setup, that features a stereo head-mounted display with a broad field of view, six degrees of freedom head tracking, and even hands and feet tracking, all for an affordable price (Slater, 2018).

The development of technology is also reflected in research: Due to limitations in computational power and user-friendly environment design software in the past, the virtual environments used in previous research on visual realism were not truly visually realistic. This may have contributed to the inconsistent results found and the lack of a clear conclusion in this area of study (Toczek, 2016). For example, according to current literature, VR has three essential properties: immersion, presence, and interaction, and these concepts are consistent throughout the different technology's development stages in the past years. However, as the quality of VR technology has improved, the perception of the implications and definition of immersive VR changes accordingly.

Although the focus of the master's thesis is on immersive VR, it should be noted, that there is still significant potential for the technology to evolve in the coming years. Therefore, this study needs to be considered as a current overview of research from recent years, which incorporates the state-of-the-art technology currently available on the market.

Presence is the feeling of physically being in a different place from one's actual location (Mandal, 2013; Rubio-Tamayo et al., 2017; Wohlgenannt et al., 2020). Contrary to the objective perspective of immersion, it refers to person- and context-dependent subjective perception of "being there" in a VR system (Slater, 2018). Accordingly, individuals might perceive presence differently in a virtual world, depending on the technological components as mentioned before such as display settings as well as image and audio quality or the stimulation of further sensors such as smell. By increasing levels of immersion, presence can also be attained, which reinforces the aforementioned paradox of VR being non-immersive. The literature on VR presence contains the term "telepresence" in this context (Steuer, 1992). The idea of telepresence involves the use of virtual reality systems for the remote manipulation of physical objects in a real but remote environment. *Therefore, the interest in this master's thesis is also to understand the subjective experience that users have in a specific immersive application.*

Interactivity involves the possibility of entering and engaging with different realities such as manipulating objects or interacting with other persons in real-time (Walsh & Pawlowski, 2002). Recent developments in immersive VR have improved interaction with computer-based environments by providing a multi-sensory experience, such as through the use of head-mounted displays, and by creating and representing individuals through avatars (Slater et al., 2022). This enables multiple individuals to communicate, interact, and collaborate simultaneously, regardless of their physical location. *This study further explores how the team interacts with each other within the virtual world.*

2.3.2. Team Creativity in immersive Virtual Reality

2.3.2.1. Imagination

Another field of immersive VR is imagination (Graessler & Taplick, 2019). Through an advanced immersive technological environment, the user not only feels present in the artificial world (*presence*) but can also interact, collaborate, and work within it (*interaction*). These three components allow for a new perspective shift, stimulating imagination and promoting creativity. Moreover, new technologies like VR have a positive impact on intrinsic motivation, which acts as a booster for idea generation. Therefore, VR holds great potential as a technology tool for creativity enhancement (Chang et al., 2022; Houzangbe et al., 2022). However, to fully realize the potential of VR, it is essential to ensure, that the technology and VR applications support the creativity process and do not hinder it. For this purpose, specific requirements for the system must be considered, and the compatibility of the application and creativity technique must match. This study builds on the previously known implications from the research and examines the requirements and conditions of VR to implement creativity in the company using the technology.

2.3.2.2. MultiBrush – an immersive Virtual Reality Art Tool

For this study, an 3D art app has been chosen to explore the potential of team creativity in immersive VR as drawing is a common creativity technique for ideation or prototyping in innovation processes (Rubio-Tamayo et al., 2017). Several publications in VR research have already investigated the influences and application possibilities of the VR app Tilt Brush by Google from different perspectives such as education (So & Lu, 2019), communication (Rubio-Tamayo et al., 2017) and art

therapy (Ying-Chun & Chwen-Liang, 2018). However, in this study, the counterpart of Google's Tilt Brush, called MultiBrush has been used as a multiplayer adaption of Google's app allowing collaboration within teams additionally to the exact similar features and tools. Therefore, the insights gained from the literature deploying Google's Tilt Brush will be considered for the respective theoretical implications on team creativity in immersive VR.

One of the main characteristics of those two immersive VR art apps is, that they allow users to draw in 3D space, which presents a completely different experience to traditional 2D drawing. With 24 types of brushstrokes, the app offers a variety of intensity, shading, and texture effects, allowing for a range of creative and unique expression. Additionally, the ability to adjust effects and brush size using a virtual handheld palette offers users a greater level of control over their creations. Further the creations can be viewed by walking around or through them stimulating immersiveness of the tool as well as presence, interactivity and imagination of the team members (Chittenden, 2018).

Moreover, the immersive experience is provided by the VR headset, that ties the individual directly to the space and substance of the painting, resulting in a continuum from painting-to-viewing space via the point of gaze. However, there is a tendency among new users to draw flat images or even start writing on the app, possibly due to unfamiliarity with VR or the brushstroke's appearance. Additionally, the virtual space, in which Google's Tilt Brush and MultiBrush operates enables users to work collaboratively with others in real-time on the same creations, regardless of their physical location, making it a suitable tool for remote teams. Another valuable asset, that supports collaboration and communication in virtual worlds is the possibility of creating customizable and individual avatars, that are capable of expressing gestures and emotions (Brown et al., 2011).

The advanced immersiveness of the tools could potentially not only stimulate the subjective feeling of presence but also ease virtual interactivity and thus, foster the imagination and inspiration, that enables teams to get creative in a VR space (Chang et al., 2022). As the 3D art tools received favorable reviews, with Disney animator Glen Keane citing its usefulness in expressing emotions, *this study explores the potential and usefulness of such as a VR art tool with MultiBrush for team creativity in organizations.*

2.3.3. Input, Process and Output Variables for the Conceptual Model

As mentioned in chapter 2.2.2., there are variables, that could potentially occur during and influence the team creativity process. When considering the possibility of several individuals undergoing the creativity process within an immersive VR context as opposed to a physical setting, there is a question regarding the experiences the participants encounter in this synthetic environment and how these experiences may impact established variables.

Therefore, for the development of the conceptual model for team creativity in immersive VR, the following team creativity input, process, and output variables are selected based on their significance for the exploratory analysis of the topic. This selection is made by reevaluating the variables presented in the chapters 2.2.1., 2.2.2. and 2.2.3. in the context of theoretical indications from immersive VR, and by incorporating new variables derived from the theoretical literature review.

2.3.3.1. Team Creativity Input Variables in immersive Virtual Reality

Team size – Similarly to the physical setting (see chapter 2.2.2.1.), a team configuration comprising the minimum number of individuals and consisting of three team members per group, could potentially ease the collaboration process by reducing the need for coordinating diverse individuals.

Team diversity – From an organizational Design Thinking perspective, it is recommended to assemble a multidisciplinary team consisting of various experts, including individuals with backgrounds in design, IT, and business, as well as individuals with diverse personality traits (Gerken et al., 2022). Given that the environment is virtual, in addition to domain-relevant and creativity-relevant skills, technology-relevant skills such as affinity for and experience with technologies must also be present in the team to be able to quickly transfer newly discovered possibilities of the tool to its usage in order to efficiently solve the problem. Furthermore, a team of solution-oriented individuals could be particularly promising for good creativity performance, as all participants are confronted with many uncertainties from the unfamiliar environment to an unknown challenge and a somewhat different type of creativity technique. Knowledge in the respective VR app and facilitator skills could also help with the efficient process implementation in the VR world. Participants selected for the experiment should have already had some experience with VR headset and show a basic interest in an extended and deepened experience with the tool. This ensures from the beginning, that the participants have a high intrinsic motivation and therefore the right mindset, such as openness towards uncertainties and risk-taking. Additionally, studies have shown that immersion and presence, even during the creativity process within the 3D world, can influence the emotional state and thus intrinsic motivation (Guerra-Tamez, 2023). On the one hand, this can have a positive effect on the individual, such as through exclamations of "Wow" or "How cool" or through a creative flow. On the other hand, it can have negative effects, if the possibilities of the tool seem overwhelming. In the first case, it could further boost intrinsic motivation, while in the second case it could rather flatten it.

2.3.3.2. Team Creativity Process Variables in immersive Virtual Reality

a.) Collaboration

Psychological safety – Psychological safety is a crucial aspect of any relationship involving two or more individuals and is thus a crucial aspect for collaborative processes (Barczak et al., 2010). In a team setting, trust is defined as the level of confidence, that team members have in each other, based on the expectation, that they will behave as anticipated. It refers to the level of confidence, that a person has in the words, actions, and decisions of others, which enables them to act accordingly (McAllister, 1995). A familiar and trustworthy setting for participants thus is not only relevant in the physical space, but especially in the new and virtual work environment (Chae, 2016; Dincă et al., 2023) and could potentially result in uncertainties in the execution. Therefore, it is interesting to explore, how team members overcome uncertainties and fully engage in the creativity process despite the unfamiliar environment.

Task orientation – Immersion has been found to be associated with the emergence of inventive ideas, and VR has specific features, such as avatars, co-presence, media richness, and simulation capabilities, that can enhance the results of creative tasks (Alahuhta et al., 2014). Bourgeois-Bougrine et al. (2020) have also recently investigated the impact of Multi-User Virtual Environments on

creativity, discovering, that they foster a sense of liberation, that encourages risk-taking, mental flexibility, and divergent thinking among individuals, regardless of their creative potential. Furthermore, the study demonstrated, that users were able to engage in collaborative ideation and create original and useful artifacts. Another study indicates, that the creativity, flow, and attention of users in VR environments is higher than in the traditional environment (Lu et al., 2022). As these characteristics are important for the team creativity output for innovation purposes, this study examines, if similar outcomes can be observed in MultiBrush, which offers a large number of different brushes and tools.

Learning curve – Developing learning skills through collaboration is a variable used to understand students learning experiences in non-immersive VR (Dincă et al., 2023). However, the theme of learning as a process variable for team creativity may be potentially relevant for a team in new and unfamiliar immersive VR environment such as MultiBrush in this case as well (Brown et al., 2011).

b.) Communication

Sharing of information, knowledge, and ideas (verbal communication) – Sharing of information, knowledge and ideas is an important variable for team creativity in the physical space (Drach-Zahavy & Somech, 2001). To achieve a shared learning curve in an unfamiliar virtual work environment within the team with the new tool, knowledge sharing becomes more important due to the new environment and the different technology-relevant skills. Physical proximity, verbal, and nonverbal communication facilitate this process. The provision of real-time interaction and immediate feedback through communication tools, as well as the ability to be able to express ideas openly is also a relevant aspect for team creativity (Dewit et al., 2020; Owens et al., 2009)

Avatars (non-verbal communication) – With the advancement of online communication technology, avatars are now able to communicate nonverbal cues and expressions, such as body language and facial expressions (Brown et al., 2011). The use of avatars is likely to facilitate communication for the participants (Brown et al., 2011; Gong et al., 2022; Graessler & Taplick, 2019; Slater & Sanchez-Vives, 2016). Research has explored, how the design of avatars affects creative performance, revealing, that users who represent themselves as inventors with their avatars generated significantly more novel ideas compared to those, who used avatars with uncreative appearances (Guegan et al., 2016). In a study regarding the creativity potential in Multi-User Virtual Environments, Bourgeois-Bougrine et al. (2018) suggested, that future studies should use creative avatars instead of neutral ones to foster feelings of openness among users.

Perceived proximity – The concept of proximity has been shown to have a positive impact on communication and interactions among team members in past studies (Chae, 2016; Hoegl & Proserpio, 2004). However, physical distance can be a challenge in virtual collaboration, where team members are geographically dispersed. To address this challenge, recent research has proposed the concept of perceived proximity (Wilson et al., 2008) as a model for understanding, how team members can feel close to each other even when physically distant. This psychological or perceived proximity has been identified as a crucial factor in the performance of virtual teams (Cha et al., 2014) and might be thus a relevant topic for team creativity in immersive VR (Chae, 2016). Given that team members interact in a computer-mediated communication environment with limited face-to-face contact and initial information about each other, the establishment of trust and the management of

perceived proximity are crucial. These factors are particularly important in the context of creativity, which is a social process, that arises from interactions among individuals and must take these variables into account.

c.) Effects on body & mind

Cognitive overload – The use of 3D virtual environments in VR spaces has drawbacks due to the increased cognitive load resulting from the use of extraneous data and graphics, that are unfamiliar to the user. This cognitive overload can surpass the capacity of working memory and have a negative impact on knowledge acquisition (Hui et al., 2022; Paas et al., 2004). However, as of the year of the experiment (2023), the graphics card technology has advanced further, so this may not have a strong influence on the findings. The overwhelming factor could instead arise from the fact, that the MultiBrush application offers a large number of different brushes and tools, which could present a creative block or affect the creative flow of users who have never worked with it before.

Technology-induced stress can potentially arise due to the IT complexity from technology systems and affect the worker's job satisfaction (Suh & Lee, 2017). As the user's are exposed to a new level of technology experience during a creativity process and could potentially lead to technostress.

Motion sickness – Immersive VR experiences can sometimes cause motion sickness particularly in those who are prone to it (Petrykowski et al., 2019; Slater & Sanchez-Vives, 2016; Wohlgenannt et al., 2020). This can occur due to unnatural gestures such as teleporting (Vogel et al., 2021). As the common and negative side effect of VR experiences involves usually feeling dizzy, disoriented or other symptoms such as discomfort in the stomach, Vogel et al., (2021), for example, used the Simulator Sickness Questionnaire by Kennedy et al. (1993) for his study to examine the Design Thinking practice in VR, which measures Nausea, Oculomotor and Disorientation. Nonetheless, with the continuous evolution of VR technology, solutions to these issues may be developed in the near future (Wohlgenannt et al., 2020).

To prevent or reduce the risk of motion sickness and nausea in virtual reality experiences, it is important to take breaks and limit the amount of time spent in VR. Therefore, breaks are included after each process step as well as the time was limited to minimum in the experiment.

2.3.3.3. Team Creativity Output Variables in immersive Virtual Reality

Considering that the utilization of immersive VR technology may cause participants to feel overwhelmed by the plethora of tools, suffer from cognitive overload or nausea, it is vital for proficient team members to contemplate, whether MultiBrush is a viable tool in terms of usability within a corporate context, with regard to the output. Furthermore, the ramifications of immersive VR on product characteristics ought to be taken into consideration. It is a question whether the outcomes can be used for further integration into the innovation process.

Applicability – The use of immersive VR may overwhelm participants with too many tools or cause nausea. However, if the tool is able to provide the feeling, that the product is transferable and suitable for further innovation, it can ultimately enhance the perceived value of the result. Therefore, the usefulness and usability of the product needs to be assessed by the team members in order to draw conclusion regarding the further implementation process (Houzangbe et al., 2022).

Novelty – VR has a noteworthy and positive influence on the originality and novelty for the creative design output (Chang et al., 2022; Houzangbe et al., 2022). Immersion is one way, in which VR can support novelty. Through immersion people can experience a sense of presence, which allows them to feel like they are actually in the environment, and this can stimulate creative thinking. This should also motivate the users to the exploration of different options and try out new things, that could potentially lead to new novel outcomes (Cherry & Latulipe, 2014; Dewit et al., 2020; Lattemann et al., 2017; Rubio-Tamayo et al., 2017). In the case of MultiBrush, the multitude of the available brushes, colours and effects can also open up the possibility of representing abstract or non-figurative ideas, such as data or metaphors.

Results worth effort – An additional aspect, that is considered as a relevant variable for the usefulness of the VR art tool for team creativity in organizations is Results worth effort. This aspect reveals, if the technology is perceived by the team members as a supporting or rather hindering tool to meet the goals of the challenge and put that in relation with the team efforts during the creativity process (Cherry & Latulipe, 2014; Dewit et al., 2020; Lattemann et al., 2017; Vogel et al., 2021).

2.3.4. The Conceptual Model and Creativity Process for Team Creativity in Virtual Reality

The foundations of team creativity of the previous chapters provide the basis selection on relevant variables along the IPO framework for creating the conceptual model (see fig. 8) and designing the creativity process (see fig. 9) in the virtual environment for the experiment, both providing an extract of the dynamic, complex, and multidimensional nature of team creativity for the experiment and subsequent explorative analysis.

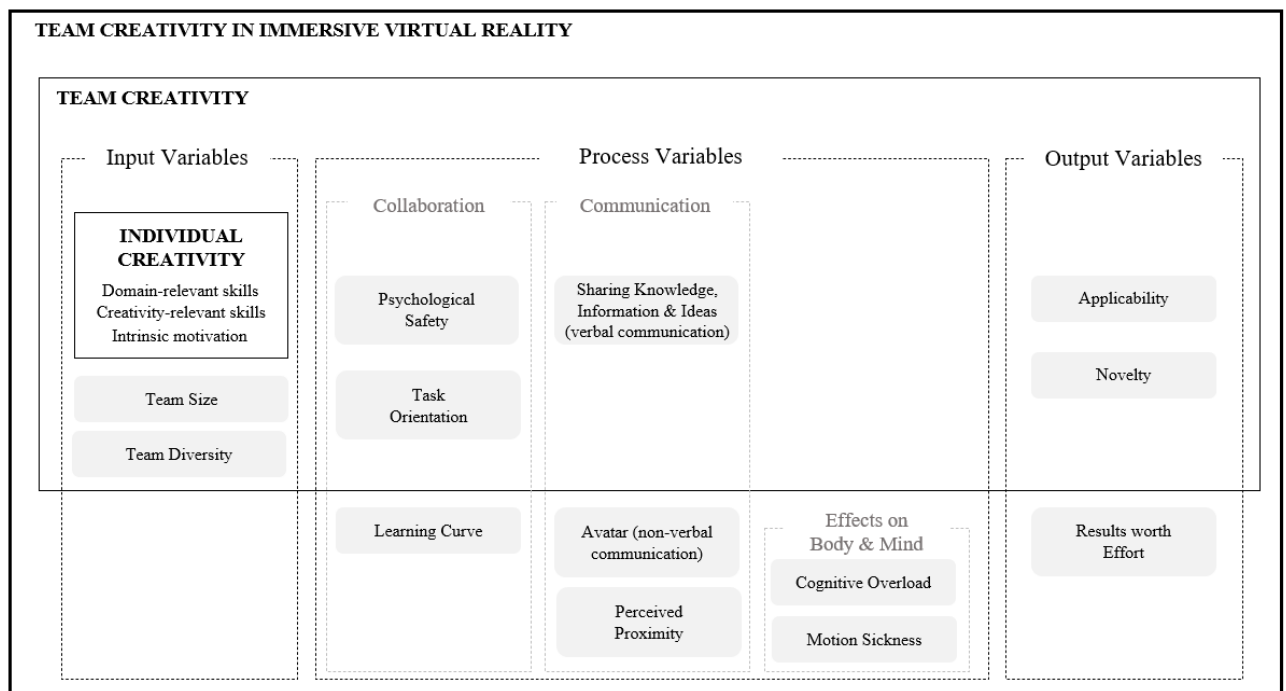


Figure 8: Conceptual Model for Team Creativity in Virtual Reality

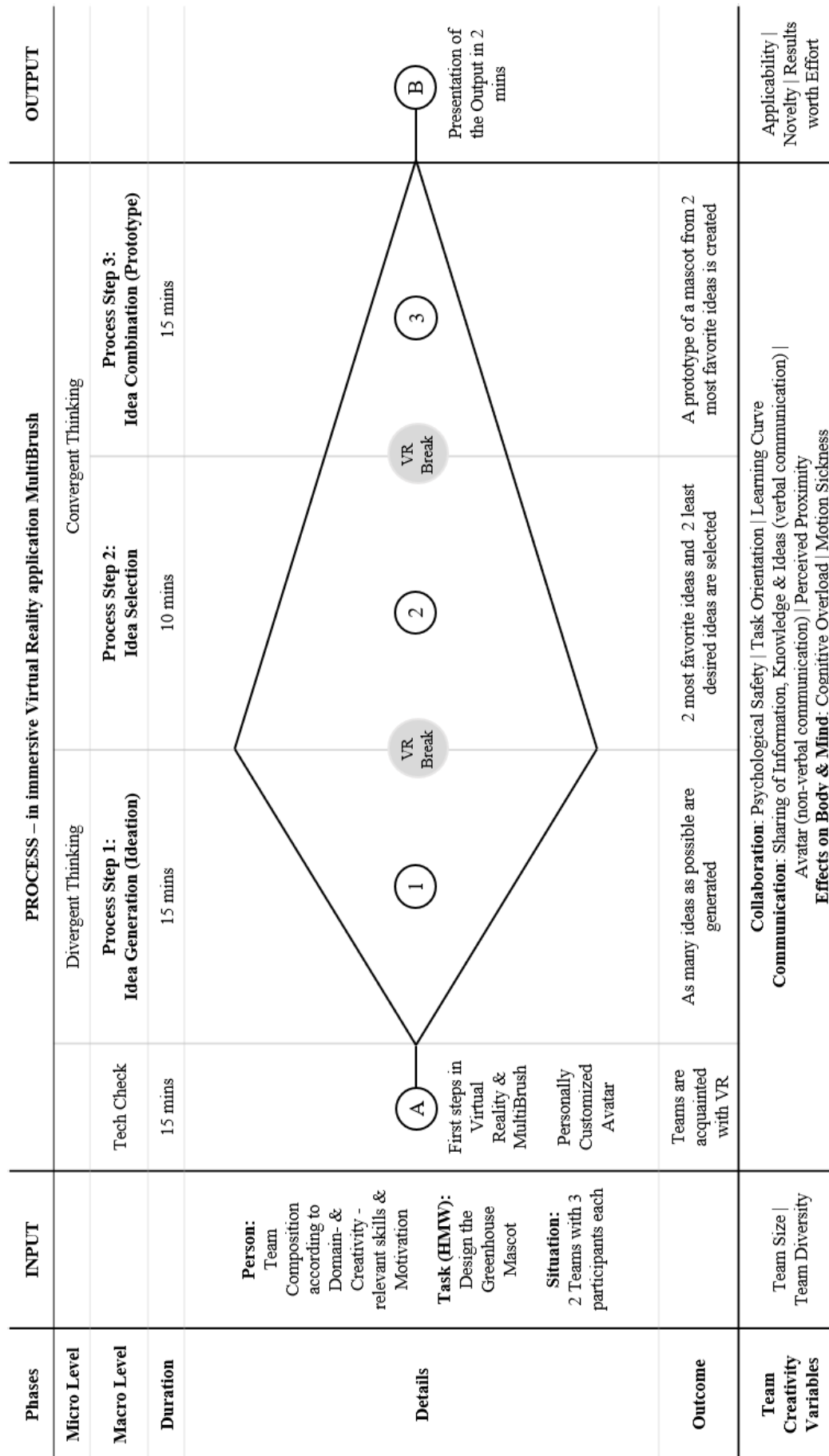


Figure 9: Design of the Creativity Process for the Experiment

3. Research Methodology

The subsequent text proposes a research methodology for the explorative analysis of the implications of team creativity in immersive VR.

3.1. Research Interest and Research Question

As outlined in the previous chapters, immersive VR is experiencing a resurgence in both practical application and research. Team creativity and innovation have been a relevant field of research for several years, with numerous theories and studies examining it from various perspectives. Since the first studies proved, that immersive VR can have a positive effect on creativity, there has been an increasing demand from the business world, as well as advancements in technology and creativity-promoting VR research. This has created an opportunity for new insights to emerge from the intersection of VR and team creativity in organizations. Previous research on team creativity and innovation in immersive VR has mainly been conducted in academic settings with students and investigated certain aspects of creativity and innovation (Chang et al., 2022; Guerra-Tamez, 2023; Houzangbe et al., 2022). Furthermore, numerous quantitatively conducted studies have highlighted the open nature of the research field, which makes qualitative research particularly desirable for professionalizing VR. Therefore, this study aims to close this research gap by adopting an exploratory research approach and bringing theory and practice together to understand, how VR shapes the collaborative creativity process.

The following sub-chapters illustrate how the research approach was designed to explore a complex and dynamic construct such as team creativity in the virtual environment. The following questions formed the basis for the subsequent analysis:

1. What are the relevant process steps for investigating collaborative creativity processes? Which steps are suitable for exploring creativity processes to address the research question?
2. What should be the technical, spatial, and organizational workshop setting to enable teams to fully focus on the creative process and minimize potential distractions? How can the researcher and the observers be incorporated in the workshop to explore both, the virtual and physical environment?
3. How can relevant data be obtained and analyzed to distill observations and results from the workshop and interviews and derive implications?

3.2. Qualitative Research Design

The combination of the dynamic and complex nature of individual and team creativity (see chapter 2.2.1.) along with the complex system of computer-generated 3D environment (Liu & Fan, 2017) creates an opportunity to explore the intersection of these fields. Therefore, for this thesis, a systematic qualitative research methodology has been chosen, which offers a distinct research approach due to the open nature of team creativity in immersive VR, particularly in an organizational context.

Design Science Research Methodology (DSRM) has been recognized as an important and legitimate research paradigm in the field of Information Systems (IS) (Hevner et al., 2004). With its origins rooted in Design Thinking principles, DSRM is a research methodology, that seeks to find

technological solutions to address known organizational problems by creating and evaluating IT artifacts in an iterative and systematic manner (Hevner et al., 2004; Peffers et al., 2007). As some exploratory studies on immersive technology applications for Augmented Reality and VR have considered DSRM as a methodology for further research in the past years (Romano et al., 2021; Vasilevski & Birt, 2021), this methodology has also been selected as a suitable research construct for this study. The iteration of the research methodology also fits with the constantly changing construct of team creativity, as the person and technology depended input is constantly varying. Further, this methodology was also selected in order to provide a foundation for future research on the concept and its implications for other technologies or further advancements of the same technology, Therefore, the main objectives of this study are to derive implications for future studies in science as well as for the application in organizations according to the IS Research Framework by Hevner et al. (2004) (see fig. 10):

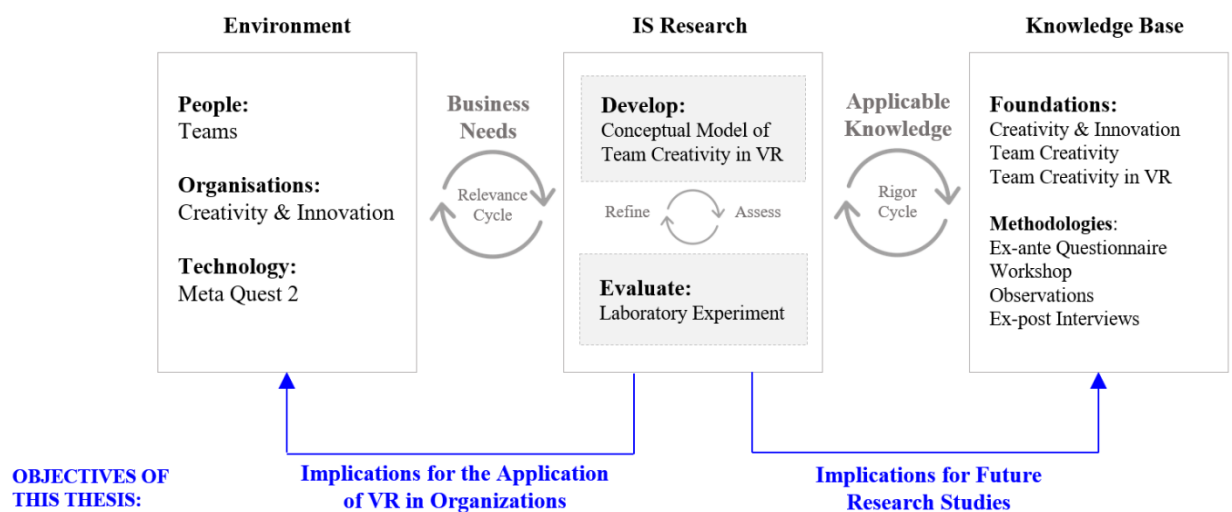


Figure 10: Applied IS Research Framework by Hevner et al., 2004 (adopted and created by author)

This thesis examines the artifact of collaborative creative flow in immersive VR by following the six phases of Peffers et al. (2007) methodology for the DSRM Research Framework: The problem analysis is conducted in chapter 1, which results in the review of the status quo of VR in organizations and establishment of research and practice gaps. Chapter 2 examines theoretical foundations and existing implications of creativity, team creativity, and VR, and synthesizes the key aspects, that are relevant for creating a conceptual model including variables and selection of the creativity process steps for the subsequent experiment. This model is enriched through research methodologies in the design and development phase in chapter 3. These included the ex ante questionnaires, a VR app MultiBrush based experiment with two teams and six semi-structured ex post interviews with the participants of the experiment. The demonstration phase is presented through the findings of the ex ante questionnaire in chapter 4.1, the recapture of the experiment based on the notes from the participants and observers in chapter 4.2., and the insights of the individual interviews in chapter 4.3. Subsequently, the evaluation phase in chapter 5 distills and discuss the main findings from the previous chapter, leading to the validation of the conceptual model, recommendations and implications for research and practice, followed by the conclusion of the exploratory analysis of team creativity in VR in organizations. Communication will be ensured by publishing the results in the

academic context and through the researcher's dissemination of the findings in practice. Due to the limited scope of the study, a process iteration of the experiment with other teams for further validation of the findings is not included in this thesis.

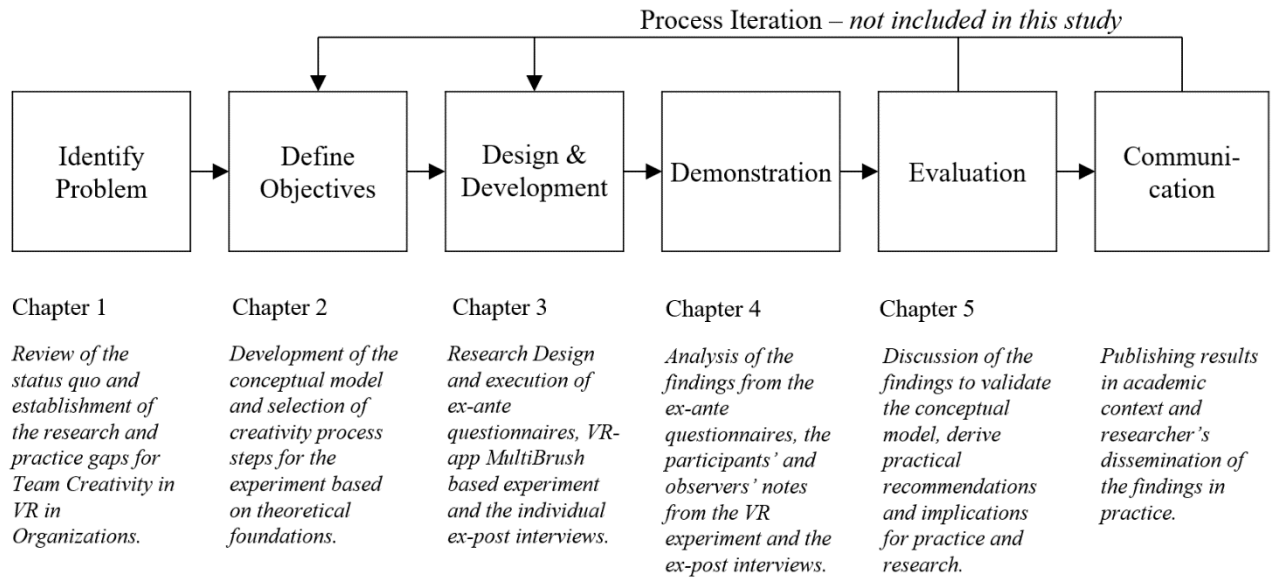


Figure 11: Research Process according to Peffers et al., 2007 (adopted and edited by author)

As workshops commonly serve as a means for developing and evaluating artifacts, the experiment in question constitutes a workshop, which was conducted entirely employing immersive VR technology. This workshop was designed as a classically controlled laboratory experiment (Thoring et al., 2020), with the VR setting and procedures structured in a way, that would allow participants to completely focus on the creativity process. Prior research implications from previous studies were utilized in designing the experiment. Following the workshop, individual interviews were conducted with all participants, forming the foundation for the subsequent evaluation.

The *aim of the workshop* was to explore participants' behaviour, dialogues, and interactions for participants to experience and get insights throughout the sequence of theory-selected creative process steps in the VR application MultiBrush, in teams. Subsequently, *the aim of the ex post expert interview* was to get insights on the perceived experiences, self-observations, and suggestions as experts in an interview for applying the learned techniques in organizational settings.

This Research Design is guided by the five general principles for evaluations of DSR workshops proposed by Thoring et al. (2020):

Table 5: Thorings' (2020) General Principles (adopted and edited by author)

Thorings' (2020) General principles	Ensured by
1. Focus Definition	Evaluating the Artifact of Team Creativity in immersive VR in Organizations.
2. Role Allocation	1 Resarcher/ Facilitator 3 Observer for Notetaking of Participants' Behavior, Dialogues and Interactions 6 Participants (3 per Team) for Participation during the Workshop, Notetaking of Perceptions, Feelings and Opinions and Ex post Interviews

Thorings' (2020) General principles	Ensured by
3. Triangulation	Four methods have been combined to validate the qualitative data (see appendix 1): <u>During the Workshop</u> : Observation & Notes from all Observers & Participants; Screenshots (Photography) and <u>After the Workshop</u> : Ex post Expert Interviews
4. Transparency	All relevant methods, details and results of the experiment are described and included in this Master's Thesis for the potential replicability for future research.
5. Reflection	see chapter 5.5.

3.2.1. Ex Ante Questionnaire – Data Sampling

Six participants from the Deloitte Greenhouse Berlin team were selected for this study. Deloitte Greenhouse Berlin is part of the global auditing and consulting network, Deloitte Touche Tohmatsu Limited, and supports its clients with innovative workshop and lab experiences. Greenhouse Labs are immersive and collaborative experiences tailored to address adaptive business challenges. To design and facilitate these experiences, the team at Deloitte Greenhouse makes use of a full range of interdisciplinary backgrounds, such as in Design Thinking, behavioural science, psychology, and management to engage participants intellectually, physically, and emotionally, allowing new ways of thinking and engaging with problems.

The Deloitte Greenhouse team members were selected for the study for several reasons. Firstly, the team is committed to providing innovative workshop and lab experiences for their clients and thus is keen to explore new ways of incorporating VR in team workshops. Secondly, at the time of the study, the researcher was part of the team and familiar with the experience and expert level of the other team member in designing workshop experiences from practice and hence had prior information about who brings the necessary experiences to draw informed conclusions when comparing the virtual experience with commonly used creativity processes in the physical world. Thirdly, the challenge, which is selected for this study, is a real project at Deloitte Greenhouse Berlin, enabling the participants to evaluate the output regarding further implementation. Therefore, it is important to select participants for the experiment based on their experience and a certain level of expertise in the creativity and innovation field.

To allocate the two teams with three participants each, an ex ante questionnaire was sent to the six participants via Google Forms to assess their suitability for domain-relevant skills, creativity-relevant skills, internal motivation (see chapter 2.1.2.1. and appendix 1), as well as their experience with VR (see appendix 2). Only those participants were selected, who had prior experience with immersive VR for more than 20 minutes without experiencing any physical or psychological strain.

3.2.2. The Experiment – Research Setting, Data Collection and Evaluation

The experiment was conducted at the venue of Deloitte Greenhouse Berlin. Despite the possibility of spatially segregating participants during the experiment to facilitate the use of audio features in VR headsets, a conscious decision was made to gather all participants in one physical location. This was necessary because the observers had to monitor the movements and voices of all participants in the physical space and observe the transmission of the virtual world to take notes on the Mural board. It

was not possible to be in the virtual space and scribe in the physical world simultaneously. Thus, the complete immersive experience was intentionally relinquished in favor of research observation.

The researcher in her role as facilitator was also present simultaneously in both, the same physical space as the observers and participants as well as in the VR space to observe the teams' activities from a distance and a viewpoint, that allowed the observers in the physical space to monitor the activities of the working group on a large external screen via live video transmission from the virtual space. However, only the observers in the physical space were able to take notes as the researcher had to wear the VR headset, during the experiment (see fig. 12). Moreover, Deloitte Greenhouse Berlin has a broad technological infrastructure with numerous state-of-the-art VR headsets, that were used during the workshop. The technology and environment setting were also suitable for a research experiment. The technology used for the participants was Meta Quest 2, while the researcher used Meta Quest Pro as there only one headset of this model was available at this time at Deloitte.

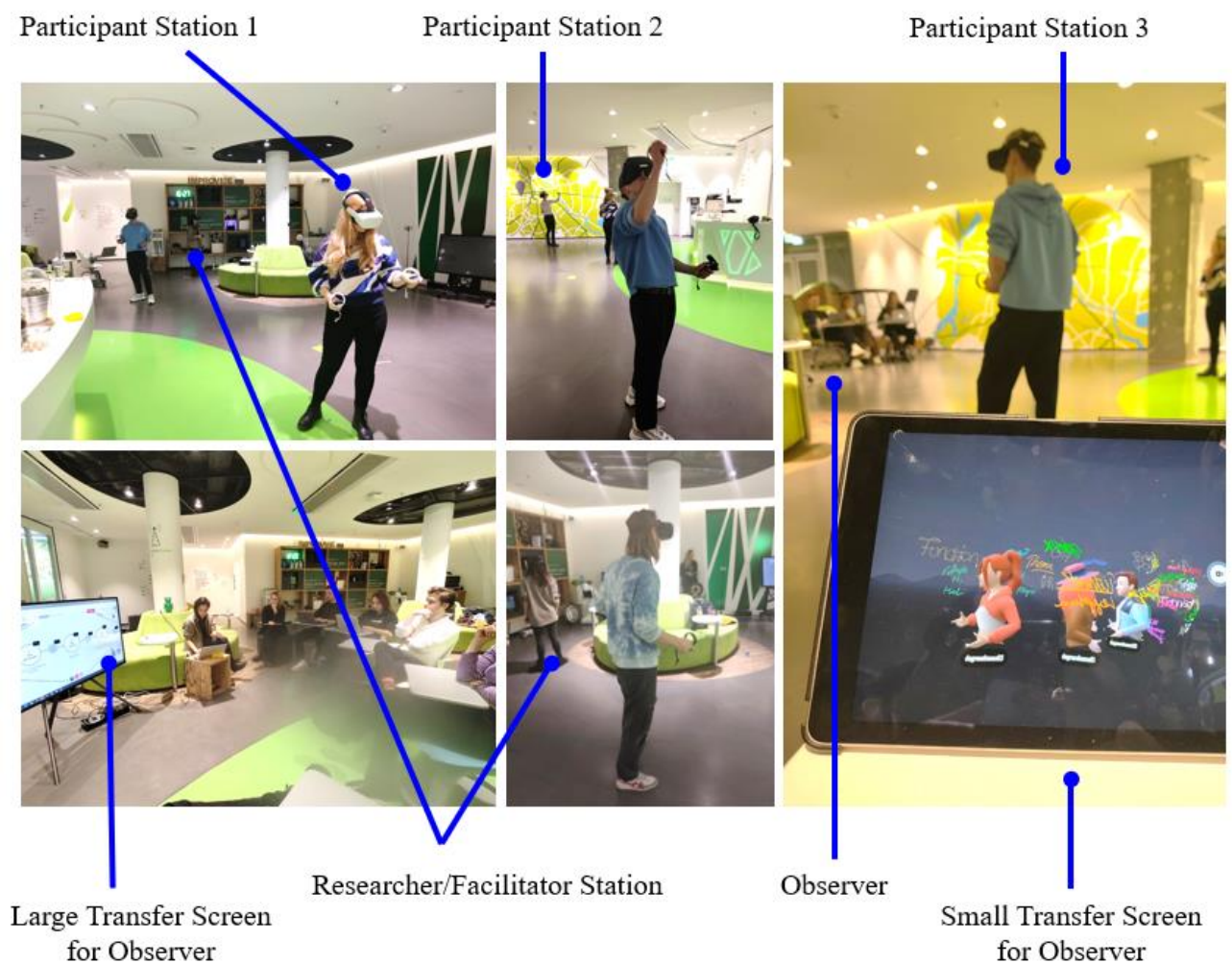


Figure 12: Experiment Setting

Regarding the procedure, the experiment was conducted on a single day during the weekend and outside of working hours. This choice was made to utilize the available space at Deloitte Greenhouse Berlin and ensure participants could fully focus on the experiment without distractions from their everyday work environments, such as emails or appointments. The same agenda was followed for both groups. Initially, the researcher provided an introduction to the context and presented the challenge of designing a Greenhouse Mascot, which was formulated as a HMW question. The task

was intentionally designed to allow team members to create a prototype based on their own perspectives as potential users of the product. Consequently, the need to develop a persona, as commonly done in Design Thinking, was eliminated. Furthermore, the objective was to make use of and further develop the results beyond the scope of the experiment.

The VR experiment commenced with participants positioning themselves using controllers and entering an immersive VR environment via a VR headset. During a so-called tech check, participants were given 10-15 minutes to create their own avatars, with which they could identify and be recognized by others, and to familiarize themselves with the MultiBrush tools. The researcher also created an avatar. Tasks were only given once participants were in the immersive VR environment. In process step 1, idea generation (ideation), participants had 15 minutes to generate as many ideas as possible. In process step 2, idea selection (selection), participants had 10 minutes to choose their two most favorite and two least desired ideas. For the final process step 3, idea combination (prototype), participants were asked to draw a mascot from their two favorite ideas within 15 minutes (see fig. 9).

A 10-minutes VR break was inserted between each process step, during which participants could take off the headsets to refresh themselves, and additionally record their initial thoughts and emotions on a pre-designed template (see appendix 3) in Mural, a collaborative online whiteboard, using their laptops. The breaks were also included in the process to allow participants to digest the experience they just made in the virtual environment. After the complete working session in VR, a participant from each group briefly presented their prototype to highlight the essential characteristics. Furthermore, on the same Muralboard, the notes of the three observers were recorded using a specific observer template (see appendix 3). Three observers were necessary to keep an eye on all participants to track the team dynamics. In addition, screenshots were taken by the researcher in MultiBrush to document the progress of the process (see fig. 13 and 14).

After the experiment, the researcher analyzed the notes taken by the participants regarding their feelings, opinions, and ideas, as well as the observations made by the observers regarding the behaviors, movements, and actions of the participants. This analysis was conducted using clustering techniques on the Muralboard, both at the team level and at the individual participant level. The purpose of clustering was to identify potential themes that emerged from the notes of both the participants and observers, and to address them during the individual ex post expert interviews when these themes were mentioned. The screenshots captured by the researcher and facilitator using the VR headset during the experiment were transferred to the desktop and assigned to each group. From each team, two screenshots were selected to be shown during the interviews: a group picture of the avatars and a screenshot of the outcome, which was the 3D drawing of the Deloitte Greenhouse Berlin mascot.

3.2.3. Ex Post Interviews – Research Setting, Data Collection and Analysis

The ex post interviews were conducted as semi-structured expert interviews (see appendix 4) with the participants from the teams (see table 6), with a general outline of the interview guide developed based on the journey of the conceptual model and indications by Harrell and Bradley (2009). Initially, participants were asked to reflect on their experiences, during which they could already set initial content accents. They were then asked to compare their experiences with different process steps to their experiences with creativity processes in the physical world. Selected screenshots were presented

to gauge emotional responses and obtain expert opinions on the output and potential implementation in the future. Finally, expert opinions were solicited for specific recommendations on the application of VR, and participants were given the opportunity to provide additional comments on any topics not previously discussed.

During the entire data collection process, ethical principles were upheld. Participants were provided with information on the background, topic, and research approach prior to the experiment and interviews. To ensure privacy and confidentiality, all data obtained from secondary sources, Mural notes, and semi-structured interviews were anonymized before transcription. Codes were assigned to participants to protect their identity.

Table 6: Overview interviews

Team Number	Code	Gender	Professional Background	Working Experience	Interview Duration
1	G1R1	Male	Communication Design, Design Thinking	5 years	40:22 min
1	G1R2	Female	Leadership & Organizational Change	3 years	31:09 min
1	G1R3	Male	Media Technology	>10 years	40:07 min
2	G2R1	Female	Team & Leadership Development, Culture	6 years	40:18 min
2	G2R2	Male	Design Thinking	7 months	35:30 min
2	G2R3	Female	Innovation, Design Thinking	11 years	35:35 min

The semi-structured interviews were transcribed in a readable format according to the suggestions of Mayring (2014), and the MAXQDA software was used for qualitative content analysis. Each individual interview and teams are analyzed separately before being compared to other results. During the coding process, a deductive-inductive category application based on the team creativity variables developed in the theoretical section was conducted (Mayring, 2000). The mix of deductive-inductive category formation was deliberately chosen as on the hand a coding structure based on the proposed concept model to enable an efficient content analysis and later derivation of implications for such a dynamic and complex research object as team creativity in immersive VR. On the other hand, the application of inductive categorization allows for flexibility in the event, that new categories arise from the interview data, that may need to be taken into account for subsequent analysis, especially for the creation of new categories for the application areas for MultiBrush. Additionally, observers' and participants' notes, as well as experiment screenshots, were used to support statements from the interview where appropriate and relevant (see appendix 1).

Communication during the workshop and ex post expert interviews were conducted in German, the language of communication at Deloitte Greenhouse Berlin, to avoid potential misunderstanding problems, that could affect the experiment. All relevant quotes cited in the work were translated into English.

4. Findings of the Empirical Research of the Conceptual Model

4.1. Team Composition based on the Ex ante Questionnaire

The following section presents the composition of the teams based on domain-relevant and creativity-relevant skills, as well as their motivation for participating in the workshop. These factors serve as the foundation for and a better understanding of the results of the experiment and subsequent individual interviews.

a.) Team 1

G1R1 has a background in Communication Design and Design Thinking. In this field he has 5 years of work experience. He draws his creativity-relevant skills from different techniques such as Crazy 8, Star Fish, and Music Walking. To implement the generated ideas, he uses Rapid Prototyping. His motivation for participating in the workshop is to learn new methods for virtual dialogue. He also has previous experience with VR.

G1R2's focus in the Deloitte Greenhouse Berlin is on Leadership and Organizational Change, and she has been working in this field for three years. She indicated in the questionnaire, that her creativity-relevant skills include the team creativity techniques of World Café, 1-2-4-all, and Crazy Eight. To further develop ideas generated through these creativity techniques, she uses "consolidation of ideas and group voting." Her motivation for participating in the workshop was, that she finds the topic very interesting and wants to learn how to integrate these technologies more into the Greenhouse labs. She also has previous experience with VR.

G1R3's area of focus in the Deloitte Greenhouse Berlin centers on the field of Media Technology, in which he has accumulated more than a decade of experience. Unlike the other five participants, he is not affiliated with the Design and Facilitation workshop in the Greenhouse. With regards to his creativity-relevant skills, he cites classic brainstorming activities. To refine the ideas generated, he evaluates their feasibility and iteratively tests them. His participation in the workshop is motivated by a desire to acquire novel perspectives and experiences, that can be applied to his professional work. Sebastian also brings prior experience with VR to the table.

b.) Team 2

G2R1 is focused on Team & Leadership Development, Culture, Diversity, and Inclusion in the Greenhouse, and has approximately six years of experience in this field. Her creativity-relevant skills involve Free Brainstorming, Brainstorming in Clusters, Creating Personas, and Discussion. To implement the ideas, she employs techniques such as Clustering, Prioritization, and Challenge-Task Match. Her intrinsic motivation for participating in the workshop is to explore new possibilities and methods for herself, her team, and the workshops and labs they prepare. She expects to gain a deeper understanding of how VR can be used and to enjoy the process. She also has prior experience with VR.

G2R2's focus in the Greenhouse is on Design Thinking, which he has been pursuing for the past seven months. He derives his creativity-relevant skills from various brainstorming techniques used in design thinking contexts, primarily employing digital collaboration tools such as Miro. To further develop ideas, he frequently employs different prototyping techniques. Regarding his motivation for participating in the workshop, he stated his interest in the topic, as it is work-related, and he wishes

to explore the possibilities of VR in the labs and workshops. Additionally, he has prior experience with VR.

G2R3's focus in the Greenhouse is on Innovation, particularly in the realm of Design Thinking. She has amassed 11 years of professional experience in this field. She draws upon a variety of creativity-relevant skills, such as diverse brainstorming methods, Mind Map, Drawing, Prototyping, Improvisation Session Dancing, and Sport Exercises as team creativity techniques to generate ideas. To further develop ideas, she builds upon or enhances existing concepts. As for her motivation for participating in the workshop, she expressed an interest in the topic and a desire to learn about new tools, exercises, and how people interact in novel environments. Additionally, she possesses prior experience with VR.

4.2. Recapture of the main Activities of each Team during the Experiment

The following sub-chapter is a recapture of the most important topics and process steps of the experiment, that has been extracted based on the notes taken by the observers and participants on the Muralboard as well as on the screenshots from the researcher (see fig. 13 and 14).

a.) Process Step 1: Ideate

In the first process step of the workshop, participants in each team assumed their roles, resulting in the development of a specific team dynamic. In Team 1, G1R1 assumed the role of a facilitator and was praised for executing it effectively. An observer noted, that *"G1R1 has taken on the role of facilitator right away, carried out well"* (G1R3_Muralboard). This was also apparent in the observer notes, where G1R1 was seen connecting words and writing while G1R2 and G1R3 brainstormed but did not write (OBS1_Muralboard). In Team 2, there was no clear division of roles, as G2R2 suggested silent brainstorming and G2R1 took on the role of clustering ideas (OBS3_Muralboard).

Both teams began with a silent brainstorming session, where each member brainstormed independently before presenting their ideas to the group. In Team 1, G1R1 proposed the silent brainstorming approach, and other participants agreed. They engaged in group brainstorming with stimulating questions from G1R2, such as *"We should think again why one sympathizes with a mascot?"* and *"What are particularly adaptable animals?"* (OBS3_Muralboard). G1R1 also marked important aspects with stars, as noted by an observer: *„G1R1 underlines a word, puts stars on it"* (OBS1_Muralboard). In Team 2, G2R2 also suggested a silent brainstorming approach, followed by a Gallery Walk (see fig. 14, G2P1), where they moved from station to station and exchanged their ideas on the appearance, skills, and color of the Greenhouse Mascot from the silent brainstorming process (OBS3_Muralboard). They remained focused during the brainstorming session and critically questioned the ideas and process to solve the task. For example, G2R3 directed the conversation: *„We have to ask ourselves, what the mascot should represent"* (OBS3_Muralboard). G2R2 also suggested to focus on developing more concrete ideas (OBS3_Muralboard).

Both groups primarily wrote instead of drawing (see fig.13, G1P1). On the Muralboard, participants from Team 1 commented on this phase as follows: *"We write more than we draw"* (G1R1_Muralboard), *"The three-dimensionality is confusing when writing; I would prefer a 2D view for an overview and faster comprehension."* (G1R2_Muralboard), *"We have only written so far."* (G1R3_Muralboard). A similar comment can be found on the Muralboard section from Team 2: *"Writing in 3D makes it more difficult to read things than in a 2D representation."*

(G2R1_Muralboard). However, one participant noticed, that *"written ideas worked as starters"* (G2R3_Muralboard).

There was some confusion about how some tools worked, and much explanation was necessary, including the discovery and use of the teleport function. One observer noted that *"G1R3 explains Teleport"* (OBS1_Muralboard). However, the technical experience sometimes took precedence over the actual challenge, as noted by a participant from Team 2: *"After a while, it was super exciting but also more about the technical experience sometimes than the actual challenge"* (G2R2_Muralboard). There was also a lot of talk about movement because participants often got in each other's way. For example, one participant said, *"Hey, somehow you're in my way"* (OBS1_Muralboard). In Team 2, many questions arose due to the need to become more familiar with the technology, which took away from concentrating on the content, as one participant observed: *"Since you first have to get familiar with the technology, it steals time away from concentrating on the content"* (G2R1_Muralboard).

b.) Process Step 2: Select

In the second process step, both teams went through the process of reviewing the previous results by conducting a brief assessment. They marked the good and bad results together and then G1R1 from Team 1 and G2R1 from Team 2 wrote the results separately again in an organized and clear way (OBS3_Muralboard) (see fig 13, G2R2 and fig.14, G2P2). The clustering and handwriting proved to be a challenge for both groups, as indicated by the comments: *"Readability of handwriting still a challenge"* (G1R2_Muralboard), *"no clustering/rearranging of sketches possible (might be challenging with more ideas/more complex topics), but team still coordinated by talking to each other"* (G2R3_Muralboard), *"It would have helped if we could move and cluster things"* (G2R1_Muralboard). Despite the challenge, the participants expressed satisfaction with the results: *"had a lot of fun, discovered new tools"* (G1R2_Muralboard), *"way more calm, focused, therefore satisfied after this session and happy with the result"* (G2R2_Muralboard), *"excited, that I could visually implement the glitter ideas we had"* (G2R3_Muralboard).

Team 1 was able to include a brief mini-challenge at the end of the second process step, in which they engaged in painting for the first time. In the remaining time, Team 2 also experimented to some extent with the tools (OBS1_Muralboard).

c.) Process Step 3: Prototype

In the third and final step of the process, both teams first reviewed their previous results and quickly agreed on an animal. Team 1 chose an octopus (see fig.13, G1P3), while Team 2 chose a unicorn (see fig.14, G2P3). Team 1 immediately began collaboratively drawing the animal, while in Team 2, G2R1 started drawing first, and then the other team members joined in the collaborative drawing process. As a result, in both teams, the prototype was created through the simultaneous drawing of all team members (OBS1_Muralboard). Finally, Avatar team pictures were taken of the team members and the prototype (see fig. 13 and 14).

As a result of both teams starting to paint in 3D for the first time in the process, many positive comments were noted by the participants about the emotions and the process itself. For example, G1R1 left a comment on the Muralboard, stating that *"I found it very inspiring, open and extremely collaborative,"* while G2R2 noted that they were *"very happy about the end result."* G2R1 noted

down that "the added value of the different color and visual effect options was particularly great here." However, some critical comments were also made, such as G2R3's statement that "coordinating to draw in 3D within a group is certainly challenging."

Nonetheless, the process generated many ideas, including "Cool, you can create bubbles here, so it looks like there's water everywhere" (OBS3_Muralboard), "I'm going to draw a fluffy octopus" (OBS1_Muralboard), "I'll try to add some electricity" (OBS3_Muralboard), and "Look, there are rainbows" (OBS2_Muralboard). One participant also commented, that "people dare to think crazier than in normal brainstorming sessions" (G1R2_Muralboard). At the same time, both teams aligned their results with the challenge, with Team 1 posing the question "What is Dotti's mission?" (OBS3_Muralboard) and Team 2 checking "5 minutes before the end, to what extent the previously established characteristics are represented." (OBS3_Muralboard).

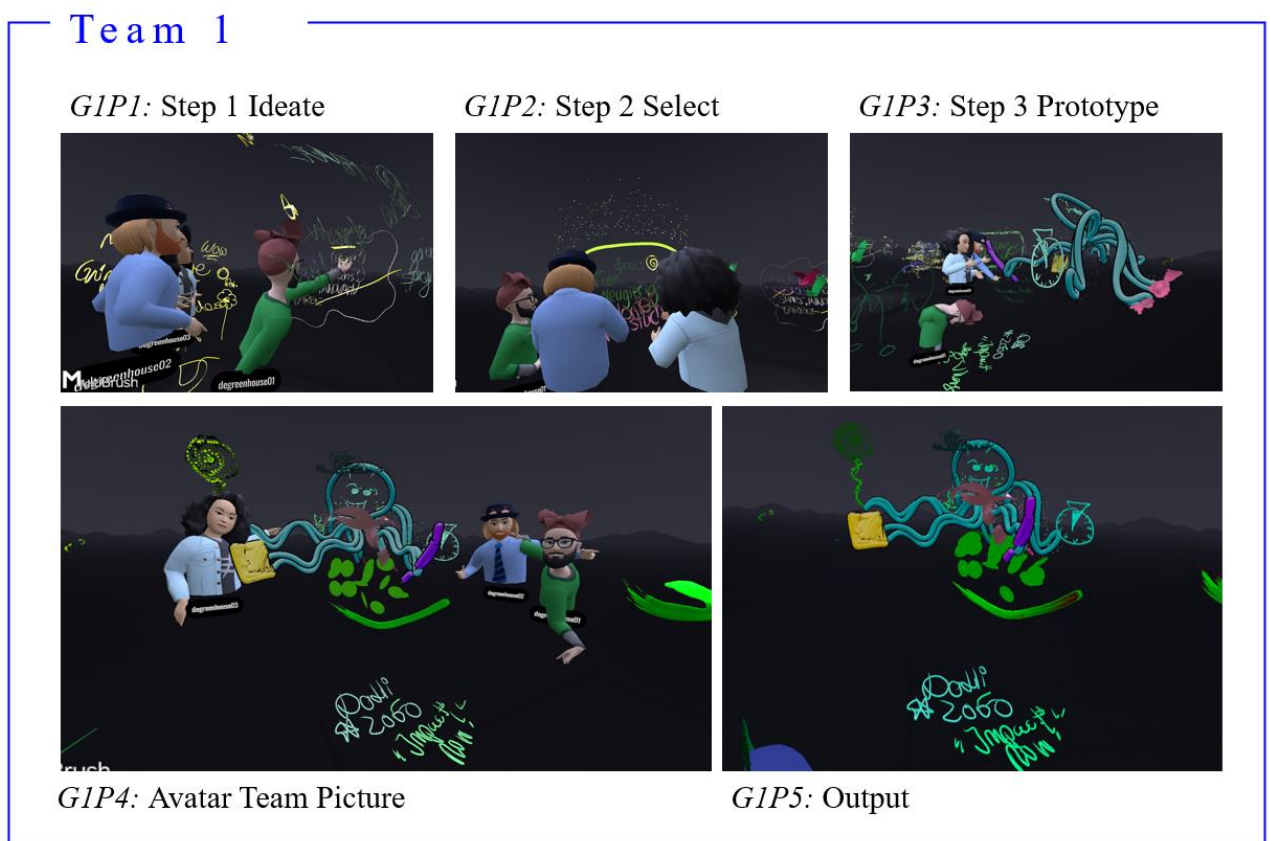


Figure 13: Screenshots of the Experiment in VR_Team 1

Team 2

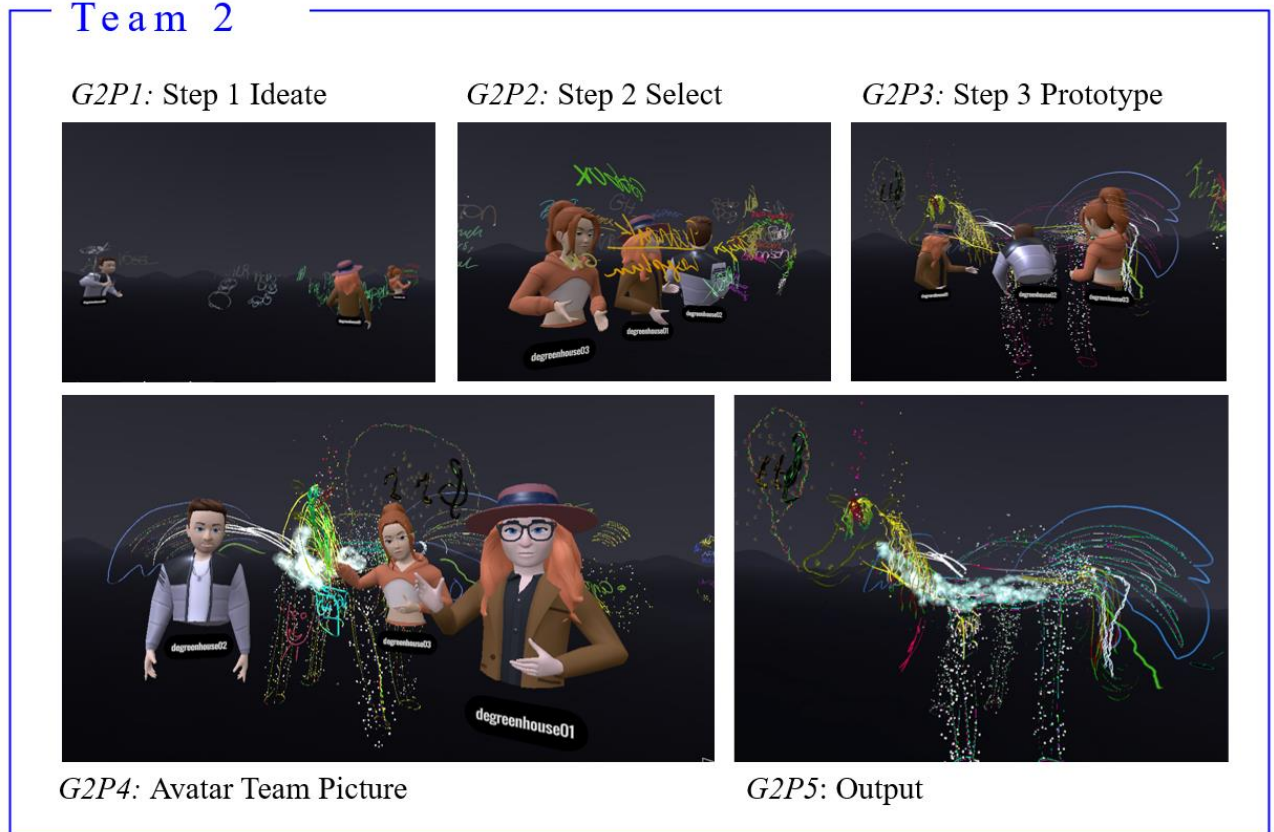


Figure 14: Screenshots of the Experiment in VR_Team 2

4.3. Comparative Analysis of the Conceptual Model based on the Ex post Interviews

The selected interview quotes for the comparative analysis of the team creativity variables and application areas can be found in the tables in the appendices 5-8.

4.3.1. Team Creativity Input Variables

Team size – One participant suggests that a group size of two or three individuals in a virtual room can be optimal for creativity, as "[...] it could work very well as a back-to-back exercise with two people." Therefore „[...] with more than three people, it will probably become difficult to collect results and navigate the space“. (G1R3_Interview, Pos.52). However, concerns arise with larger group sizes, as navigating the space and collecting results may become difficult. As another participant expressed, " [...] we were three people in the room now. [...] When could it possibly become difficult if too many people start drawing or writing on it?" (G2R1_Interview, Pos.48).

Team diversity – Team diversity was perceived positively by the participants, who acknowledged the different backgrounds and skills of the team members as a contributing factor to the team's success. One participant stated, "Considering that we all come from different backgrounds, [...] I think that we have actually achieved a pretty good result." (G1R1_Interview, Pos.25). A facilitation role within the team was also crucial, with one participant highlighting the importance of having a moderator, stating, "For example, G1R1 quickly took on the role of moderator. [...] That was very helpful for me." (G1R2_Interview, Pos.17). Another participant notes, that the perfect skill

combination consists of moderation, creative and tech skills of the team members, saying, *"It was a perfect combination because, as I said, I perceived G1R1 as the moderating part who was also extremely fast and creative. G2R2 was the same, visually very strong. [...], in the third process, she also took on the role well. I saw myself more in this technical role again."* (G1R3_Interview, Pos.34). Drawing skills were also mentioned as important, specifically for prototyping, with one participant stating, *"Although it is still challenging, we were lucky that G2R1 can draw so well."* (G2R3_Interview, Pos.14).

The familiarity of the team environment was also highlighted, with one participant expressing his liking of his colleagues and the familiarity of the environment, saying, *"I really like all of my colleagues and it was already such a familiar environment."* (G1R3_Interview, Pos.33). This familiarity was seen as an advantage, with one participant saying, *"I think that working together on Multibrush with people who are completely strangers to me, with whom I have never worked before and whom I do not know personally, [...] would be more difficult for me than working with people I know."* (G2R2_Interview, Pos.54).

Task – Task is a new created team creativity input variable, as it is a crucial aspect for the team's creative process according to the participants' statements. In fact, they suggest, that *"it doesn't even have to be a very complex challenge in terms of content."* (G1R2_Interview, Pos.40). This sentiment was echoed by another participant, who mentioned, that the task in the experiment *"wasn't that demanding"* and therefore they *"didn't need to come up with the perfect solution,"* (G1R1_Interview, Pos.9) allowing them to make quick decisions. Furthermore, participants stressed the importance of choosing the appropriate tool, that matches the level of challenge and vice versa, as one participant stated, *"I always try to choose the tool that will hopefully bring me the best possible result. That's why I wouldn't just use VR because it's VR, or just draw because I can hold a pen better. Instead, I look at what I actually want to do and what I want to achieve."* (G2R3_Interview, Pos.47). In the case of MultiBrush, the task in the experiment was suitable for the team creativity process, *„especially if you want to visualize something, build prototypes, or do design sprints [...]"* (G1R3_Interview, Pos.53).

The timing of the task is also a critical aspect for designing a team creativity process, as one participant said, *"I would plan short sessions, just as you did. Rather, several sessions in a row than one long session. This way, it is divided, and people have breaks in between to recover."* (G2R3_Interview, Pos.60). Additionally, another participant suggested to avoid *"massive time pressure"* (G2R2_Interview, Pos.55).

Room set-up – The room set-up is the second team creativity input variable, that have been newly added by the author as the participants highlighted the importance of having a clear and organized room set-up in the virtual environment to have a guideline through the work process. One participant expressed the need for a structure by saying *"It would have been really helpful for me if there had been some sort of blank gallery walk."* (G1R2_Interview, Pos.10). Another participant suggested *„[...] whether that be through floor markings or pre-drawn frames, so that the initial process could be roughly represented in the virtual space."* (G2R2_Interview, Pos.50). According to another participant, *„this boundless freedom and unlimited possibilities, if played as an advantage, could actually be a hindrance or limitation when one needs to work in an incredibly organized or structured manner."* (G1R3_Interview, Pos.56).

Tool training – Tool training has been identified as an additional new team creativity input variable as it has been identified as an important success factor for team members, who aim to work efficiently and effectively in the virtual space by being familiar with the tool. Either it is a short tool onboarding, *“so that one knows exactly how each tool works.”* (G1R3_Interview, Pos.53) or a comprehensive training as suggested by another participant, saying *“I would also suggest conducting a comprehensive training session in this space, [...] so that everyone can get comfortable and understand the functions of the tools.”* (G2R2_Interview, Pos.50).

4.3.2. Team Creativity Process Variables

4.3.2.1. Collaboration

Psychological safety – The participants' experiences suggest, that due to the freedom, movement, playfulness and familiar working environment, the new way of psychological safety within MultiBrush can foster a collaborative and creative environment and development of novel ideas and outcomes. Immersive VR allows for a freer creativity flow such as expression, without the fear of failure as one participant stating, *“It does not claim to be perfect, simply due to the movement and everything else, but you feel much freer than when you have to bring it onto white paper or into two-dimensionality, which can be more difficult.”* (G1R1_Interview, Pos.14). Another participant mentioned, that the tool created a playful setting – *“A setting where we can try things out and everyone also has some desire to step out of their role and let loose.”* (G1R2_Interview, Pos.18). This relaxed atmosphere was further enhanced by the fact, that the participants were already familiar with each other, as one participant stated, that *“I really like all my colleagues and it was already a familiar environment. [...] I also immediately recognized them in the virtual space. We can also hear each other, so it was actually like working in a familiar environment.”* (G1R3_Interview, Pos.33).

Additionally, the familiarity with colleagues allowed for a comfortable working environment, especially in the prototyping phase. One participant expressed initial concerns about drawing simultaneously a prototype with the other team members, but in the end enjoyed the collaborative process. The selected quote highlights the thought process of the participant: *„Most of all, I was wondering what the other two were doing during that time? Because if we all worked on it together, it would look terrible in the end. [...] But when we started doing it, suddenly everyone had their place and contribution to work on it together. [...] I ended up enjoying creating something together.* (G2R1_Interview, Pos.48). As a result, the group was able to work together without worrying about minor issues, such as *„I can't read that' or 'How do we organize that now?‘*. According to another team member's statement: *„Instead, we decided to work together on something and see what comes out in the end. I may have used a different color or done something else, but it's really cool how it turned out. We were also surprised by what the others did.”* (G2R3_Interview, Pos.19).

Task orientation – Task orientation has been mentioned with respect to different process phases. The aspects thus have to be differentiated accordingly. In the ideation phase, two main things were mentioned: Firstly, the facilitating role was positively associated with the task orientation by a participant saying that *“G1R1, I would say, took on a bit of the facilitating leadership role, also in the task, and did a good job leading us through it.”* (G1R3_Interview, Pos.5). Secondly, MultiBrush is not suitable for creativity techniques such as Brainstorming within the ideation phase in business as explained by a participant: *„That was very unusual and unnecessarily complicated things. Actually,*

a brainstorming session is a quick process and we got hung up on reading it. [...] We had a small brainstorming session with just a few points that we collected. It was still manageable to remember them all. But if there were more ideas and we couldn't properly organize them, [...] such as moving things around, sorting them, or giving them headings, it would become difficult. (G2R3_Interview, Pos.9). Although the teams were able to opt for a more manageable approach of collecting a few key points, this situation demonstrates, that the idea generation process was rather hindered than enhanced in this immersive VR app.

In the select phase, both teams assessed their collaborative process as efficient, saying *“I think we quickly found some common ground and agreed on what we chose. [...] But even in that step, we wrote it down, checked it, and marked it exactly.”* (G1R3_Interview, Pos.13) and *„We quickly agreed on points or questioned them again. It went well and progressed quickly.* (G2R3_Interview, Pos.27). In the prototype phase, one participant also perceived the decision process as efficient, noticing, that *“then we had the last 15 minutes, where we had to prototype and knew: Now we have to make decisions, done. Then we quickly drew our Dottie².”* (G1R1_Interview, Pos.15). This was due to the fact, that *„the tool worked better already, because it was about visualizing things“* (G2R3_Interview, Pos.14).

Although the participants enjoyed experimenting with the different brushes and features of MultiBrush, there are two distinct opinions on whether it supported to remain task-oriented at this stage as one participant states *“[...] we didn't focus on one purpose, but due to the numerous possibilities [...], we also included numerous features in the prototype.* (G2R2_Interview, Pos.30). On the contrary, another participant commented: *„I had the feeling that we had fun trying out these different features and seeing what else was there. At least in our case, experimenting like that also served our end result. That's why I thought it worked well.* (G2R1_Interview, Pos.19).

Learning curve – The participants' quotes suggest, that they experienced a positive learning curve in adapting to the new virtual environment. As one participant remarked, *“considering we used a completely new environment, a new tool, it was surprisingly good and fast.”* (G1R3_Interview, Pos.54). Another participant also highlighted the improvement in collaboration *„in each round - also with the technology.”* (G2R3_Interview, Pos.16). Despite the uncertainty of cognitive overload and nauseous effects, the tool *„[...] actually has great potential for bringing people together.”* (G1R2_Interview, Pos.42). The participants were able to develop a skillset by trying out and practicing their MultiBrush skills and by doing so, they *„[...] became more and more creative and confident over time.”* (G2R2_Interview, Pos.56). However, this did not require much lead time as noted by one participant, saying *„I was really amazed at how quickly we [...] actually got used to it. That's why I thought it was pretty cool, especially for this fast type of work.”* (G1R1_Interview, Pos.25). Another participant also observed success moments within the team during the learning process: *„I also had the feeling that from one session to the next, we got better and faster at using the tool. This led to faster feelings of success because certain things were already much more automatic the second time around.”* (G2R3_Interview, Pos.60). One of those success moments as a team was *„at the end of the second phase“* as, according to a participant, *„it was the first time we used these features that can be used to make things move or change color in the room, even as we were writing things down.”* (G2R1_Interview, Pos.7).

² Dottie refers to the name of the prototype of Team 1.

4.3.2.2. Communication

Avatar (non-verbal communication) – Avatars, that were customized in the Tech Check-in phase by the participants, had an impact on their experience during the creativity process. As one participant noted, *"So for creativity, you only had these characters, which also didn't have facial expressions, and at the same time only the different brushes."* (G2R2_Interview, Pos.7). This limited their ability to express themselves creatively. Another participant found the ability to create their own avatar exciting and inspiring, saying *"What was also funny and exciting for me was that you could create your own avatar. [...] For example, he created a pretty funny character, with attributes that I found funny and then made everything he did funny too."* (G1R2_Interview, Pos.17). Nevertheless, this could also become distracting and hinder concentration. Another participant mentioned, that they focused less on people and saw the avatars more as representatives, stating *"I actually looked at people less, these avatars were more like representatives: Where are you standing? They didn't have any gestures or facial expressions in that sense."* (G1R1_Interview, Pos.38).

Contrary to that statement, one participant noted, that verbalizing actions helped to understand the activities of the other team members in the virtual environment, saying *"G1R1 actually verbalized what he was doing and working on the whole time, that reminds me now again. For me, there was actually no disconnect between text and image, which may not be the right term for it. But what his avatar was doing, I could make sense of because I could also hear him speak and could better contextualize it. With G1R3, I often didn't know exactly what he was doing. What is he looking at now? What is he actually thinking? What is he working on?"* (G1R2_Interview, Pos.20). However, it was challenging to understand what others, represented as Avatars, were doing or looking at without visual cues. Another explains the challenge as follows *"[...] we had a visual anchoring of things here. That means we had things that we looked at together. I just didn't see practically what you were looking at."* (G2R1_Interview, Pos.56). That aspect was also noted on the Muralboard during the experiment, stating *„It's kind of weird not being able to see the facial expressions of others or what they're currently doing, what they're looking at specifically."* (G2R1_Muralboard).

Sharing of information, knowledge, and ideas (verbal communication) – Expanding on the preceding subject of nonverbal communication via avatars, the participants frequently raised and emphasized the significance of open communication and active listening, given its novel implications within the VR realm. As one participant stated, *"a communication level was missing for creativity in teams"* (G2R2_Interview, Pos.7) without pre-defined roles or integrated communication. In the virtual space, precise communication was necessary, as another participant noted, *"[...] it wouldn't be possible in a normal workshop setting to come to such a result without an explanation. but in the virtual space, it is all the more important that you name even the most obvious things very precisely."* (G1R2_Interview, Pos.21). The same participant concludes further *„This lack of orientation in the space needs to be compensated for by a lot of communication."* (G1R2_Interview, Pos.48). Despite the lack of visual cues in the virtual space, they were able to communicate effectively through voice. *"We all had the same visual experience. So it's not like we didn't use the digital or virtual space at all. We simply worked with our voices,"* (G2R2_Interview, Pos.25) noted a participant. Another participant, who noticed to focus more on the voice, recognized, that he *„wouldn't say that it was bad not to feel someone's facial expressions and gestures."* (G1R1_Interview, Pos.28). Moreover, a participant from Team 2 noticed the increased use of verbal communication during the ideation phase

by stating that „[...] we weren't quite satisfied with the technology, so the three of us automatically avoided using the technology properly. Instead, we spoke more.“ (G2R3_Interview, Pos.10).

Besides the verbal communication, there was another and fast way to share ideas immediately. According to the participant, *"this is the case in a drawing process like this, when you have a thought that is similar to brainstorming. In that moment, it counts that you put it out there and bring it up again. That was an option through this environment, through this tool, to do it simultaneously."* (G1R3_Interview, Pos.20).

Perceived proximity – Perceived proximity is a process variable, that appears in VR with immersion and presence. The participants highlighted several aspects that indicate, how they perceived the proximity to their team members in the virtual environment. One participant underscored the importance of visibility, stating, *“that's why it was also very nice, and for me, the two of them were always clearly visible in the 3D space.”* (G1R3_Interview, Pos.5).

What makes the VR experiences so unusual compared to non-virtual collaboration in the physical space is the navigation and movement through the teleport function. For example, maintaining a suitable physical distance from other participants while working collaboratively presented challenges, as another participant noted, *"What made it a bit challenging, though, was that we had to keep moving back and forth to get closer to the other person and do it well. Balancing not standing on or in the person or standing directly in front of their eyes."* (G2R3_Interview, Pos.7).

Moreover, the participants perceived a discrepancy between their perceived proximity to team members in the virtual space and their actual proximity in the physical space. One participant explained her experience as followed: *"You have to first try to find your way in the virtual space and also understand where my fellow players are. They don't necessarily stand as far away from me as their voices sound. In this case, we were all in the same room. G1R3 was physically further away from me, for example, but in the virtual space, he was very close to me."* (G1R2_Interview, Pos.7). Another participant observed, that *„We didn't have microphones and spoke at live volume. We still stood far apart from each other, and I found it easier to listen closely, probably also from the brain's perspective, when my avatar was physically closer to the person, even though it wasn't necessary.“* (G2R3_Interview, Pos.8). Further, the participant acknowledged the positive side effect, that *„Through this, I felt like we were working together more closely when our avatars also came physically closer together.“* (G2R3_Interview, Pos.8).

4.3.2.3. Effects on body and mind

In the context of the process variable effects on body and mind, the author has made the decision to consolidate the subcategories of cognitive overload and motion sickness, which were initially proposed in chapter 2.3.3.2.. This decision is attributed to the fact, that this variable negatively impacted only one participant. She noted the cognitive overload after the allotted working time, stating *"my energy was also a bit depleted. I don't think I could have worked much longer or more complex."* (G1R2_Interview, Pos.37). Further comments during her interview demonstrate the severe and harmful effects on her experience in VR: *"I have noticed that it is quite interesting that the cognitive capacity is strongly demanded and that it takes a lot of energy."* (G1R2_Interview, Pos.4) and *„What I remember most is that at one point it was physically very exhausting for me, [...]“*

(G1R2_Interview, Pos.5). However, another participant noted on the Muralboard, that during the Ideation phase „*things appeared to close and narrowed when working jointly on it which caused a bit of claustrophobic feeling within this endless space*“ (G2R3_Muralboard). In contrast, two participants mentioned, that they feel comfortable in VR, either because their body naturally adjusted well to it or due to previous extensive experience, with one participant noting “*I always find it impressive how quickly one gets used to such an environment, both physically and mentally.* (G1R1_Interview, Pos.5) and the other participant stating “*I mean, I've worn a VR headset before. I'm probably somewhat used to it.*“ (G1R3_Interview, Pos.15).

4.3.3. Team Creativity Output Variables

Applicability – The applicability of the output has been assessed by the participants based on various aspects. Initially, the result of the creative process was deemed to be a satisfactory foundation, even though some things are missing. As one participant mentioned, “*At least we now have a mascot there. Some things are still missing, [...] but at least having a shared idea of what it could look like is already helpful.*” (G2R1_Interview, Pos.32). Other participants expressed interest in further developing the prototype, for instance, by holding an analog follow-up workshop, as one participant suggested: “*I would have added an analog workshop part after this session to continue working on the parts that were developed.*” (G1R2_Interview, Pos.34). Another participant suggested focusing on enhancing the mascot's specific characteristics, stating that “*The prototype is great in its basic idea. Perhaps the specific characteristics [...] should be highlighted and these characteristics should be focused on again. [...] Nevertheless, I think that the colorful aspect is something that fits very well with such a business-unusual context.*” (G2R2_Interview, Pos.38). One participant suggested the possibility of creating a high-resolution prototype, saying that “*For the very short time, it was an acceptable result that could be filled with content - why and what it represents. Potentially, a high-resolution prototype could even be developed.*” (G2R3_Interview, Pos.35). Ultimately, testing and evaluating the output in various contexts would help determine its effectiveness. As one participant remarked, “*Something like this could actually be tested and evaluated to see if it works in the analog space, on the avatar, mirrored in the greenhouse, only takes place virtually, or if it is included in printed materials like a logo.*” (G2R3_Interview, Pos.38).

Novelty – The novelty of the output lies in the sense of freedom, that comes from realizing, that the world is not real, but rather a digital realm, where anything is possible, even brilliant ideas, as one participant noted: “*And just the feeling alone that this world is not real, but rather some kind of digital world where anything is possible, makes one much freer, or indeed more unrestricted, to live wild ideas. [...] And often, it's only through crazy ideas that brilliant ideas come about.*” (G1R1_Interview, Pos.19). Another participant echoed this sentiment, stating that the ideas for the creation of the prototype would not have been possible without the digital medium: “*To elaborate on this, I'm sure that this octopus wouldn't have been created on a normal, real drawing board.*” (G1R3_Interview, Pos.16). This is due to the fact, the digital medium allowed for unexpected and creative ideas to emerge, which are not restricted to the physical world, as one participant observed: “*If we had created the prototype on the wall in real life, I don't think we would have come up with the idea that soap bubbles had to rise or something like that.*” (G2R1_Interview, Pos.37). Working collaboratively in VR also contributed to the creativity of the output, as one participant noted: “*In any case, one is creatively influenced by what one has and achieves more than if one had to build something new all*

alone. One would probably have less confidence or imagination." (G2R3_Interview, Pos.16). The final outcome of the collaborative effort was described by another participant as a proud team moment, by stating that *"Just such a collaborative work, that afterwards you stood proudly in front of this object, like a work of art."* (G1R3_Interview, Pos.41).

Results worth effort – Through the use of different drawing tools available in MultiBrush, the teams were able to quickly visualize a prototype in a way that met their expectations. As one participant noted, *"Just through this space and these different brushes, [...], we were able to quickly visualize a prototype the way we wanted it to be. I think it's actually easier than doing it on paper."* (G1R1_Interview, Pos.23). Drawing in 3D was found to be easier than using traditional paper-based methods and may even help to reduce the demand for perfectionism, while emphasizing the importance of creativity and experimentation, especially in the prototyping phase. As another participant pointed out, *"Maybe it even takes a bit of the demand for perfectionism away, as I already mentioned with painting and prototyping. Maybe it actually puts more focus on doing and creativity than on perfection. But I would say that at least for prototyping, I already see added value from the tool."* (G2R1_Interview, Pos.35).

On the contrary, two other participants from each group assessed the results as less efficient when using MultiBrush. Despite the added value, that the drawing 3D app provided, there is still doubt whether the team *"[...] actually got the maximum out of what our prototype could have been [...]."*, stated one participant (G2R3_Interview, Pos.17). Another participant attributed the lower efficiency to a higher fun factor in VR, suggesting that, *"My theory would be that the fun factor was simply higher there. [...] But I don't think the creativity of the result was necessarily much more exciting than the result we would have gotten otherwise."* (G1R2_Interview, Pos.5).

4.3.4. Application Areas for MultiBrush

4.3.4.1. Output-driven tasks

Visualization – When it comes to application areas, MultiBrush can be particularly useful for visual tasks, as one participant noted: *"I would actually use it more for visual things. Where you want to draw something or visually represent something to a group."* (G1R2_Interview, Pos.61). This could be particularly applicable, when dimensions and size relationships are important, as noted by a participant: *"But at least for everything that is of a size comparable to the human body, it can certainly be used well."* (G2R3_Interview, Pos.61).

Prototyping and testing – In the interviews, MultiBrush was repeatedly recommended as a suitable tool for both prototyping and as a potential tool for testing a prototype. The following selected statements from the Design Thinking experts in both groups serve as examples:

- *„But if you only refer to the tool, [...] then I would say that it works extremely well in the last two phases of Design Thinking.“* (G1R1_Interview, Pos.62),
- *„[...] prototyping or testing, showing people what you have, I find it extremely powerful, I have to say.“* (G1R1_Interview, Pos.72),
- *„I could imagine it for simple prototypes. [...] Of course, if you know that it should be an object and have people who can draw well, [...]“* (G2R3_Interview, Pos.45).

Another participant even suggests unlocking specific feelings and emotions in people during prototyping through the immersiveness of MultiBrush and VR in general, using storytelling. The participant explains it as follows: *„That would also be exciting for prototypes or certain things, that you can convey the feeling to people, which otherwise you can only achieve with a lot of role-playing. Imagine being able to tell a story, putting them in there and suddenly they have the feeling. That is a completely different level that otherwise could not be achieved so easily.“* (G2R3_Interview, Pos.52).

Ideation & Problem Analysis – As useful as MultiBrush can be for the above mentioned application fields, it is not suitable *„for collecting ideas or analyzing problems.“* (G2R3_Interview, Pos.61). The Design Thinking expert continues: *"As a possibility for ideation, I didn't find it very helpful. More hindering and delaying."* (G2R3_Interview, Pos.45). Another participant emphasized the unsuitability of MultiBrush for problem analysis: *„[...] for example, if a team is supposed to work on problem-solving. [...] Maybe even for topics that cannot be easily represented visually. To cope with complexity, I would probably only work with text, less with images.“* (G1R2_Interview, Pos.39).

4.3.4.2. Human-centered tasks

Creativity and innovation mindset – MultiBrush supports individuals in various ways to adopt a more creative and innovative mindset. One participant suggested, that MultiBrush could alleviate individuals' fear of stepping out of their comfort zone, stating, *"So, as I said, for small exploratory things, to bring in a different context and get people out of their comfort zone a bit. For people who are mainly afraid of prototyping or afraid to visualize, I can imagine it relatively well because you don't have the worry of the blank page."* (G1R1_Interview, Pos.72). MultiBrush could also serve as a tool *"to get into the mode of thinking out of the box together [...]."* (G1R2_Interview, Pos.44). Furthermore, the virtual environment of MultiBrush could be particularly stimulating for a creative mindset, *"if not everyone were present in the physical room or if, for example, we had a completely uncreative environment."* (G2R2_Interview, Pos.49).

Warm-up & energizer – As mentioned in chapter 4.3.3, VR can provide psychological safety through a playful and relaxed setting. Therefore, one participant sees MultiBrush as a potential tool for warm-ups and energizers for groups. She suggests, that *„I could imagine this very well as a warmup or energizer, in a context where the outcome is not that important. [...] More as a playful element and maybe also for getting to know each other. [...] One can first show with the avatar how one would like to present oneself, [...] with all kinds of attributes.“* (G1R2_Interview, Pos.44).

Team building – Overall, MultiBrush and VR can be seen as potential tools for all team-building activities, allowing teams to face challenges together in a relaxed environment. The participant shares her thoughts on this: *„I could imagine it well in the context of getting to know each other better as a team and building trust. I think it can be quite exciting as a trust-building exercise because everyone has to let go of any etiquette or behavior they might have, as everyone feels awkward and insecure. [...] In the sense of, "We're all facing the same problem right now, that we're in a setting we don't know. How can we support each other and tackle this together to have a great experience?" It has great potential for that, also because it's a bit crazy. You feel like you're in a video game or at least not in a work setting.“* (G1R2_Interview, Pos.42).

5. Discussion

5.1. Validation of the Conceptual Model of Team Creativity in Virtual Reality

In the following the implications, particularly from the experiment for team creativity in organizations, are derived discussed in the following chapter.

5.1.1. Team Creativity Input Variables

The input variables, that have been identified in this study play a crucial role for understanding the requirements of designing team creativity experiences in immersive VR. The *team size* consisting of three participants did not hinder the creative process during the experiment. However, there were concerns about increased complexity and potential disruptions with larger groups. Similar to the the Ringelmann Effect (1913) in the physical space, this suggests, that smaller groups may be more beneficial for team creativity performance in immersive VR, given the current state of technology. *Team diversity* was frequently mentioned, with diverse strengths noted among team members. In Team 1, the leadership and facilitation skills of G1R1, combined with the drawing skills of G1R2 and the tech skills of G1R3, were particularly beneficial for the team's creativity performance and efficiency, whereas in Team 2, decisions were made collaboratively and no specific roles emerged, highlighting the advantage of having individuals with varying knowledge and experience. All participants were intrinsically motivated to participate in the experiment, which led to a collective effort and a positive outcome.

Three new variables were identified: *Task*, *Room Set-up*, and *Tool Onboarding*. These were inductively formed based on the participants' feedback, highlighting their importance in facilitating collaboration in an unfamiliar virtual environment. Although task and room set-up are also important in the physical world for facilitating creativity, these variables appear to be even more critical in immersive VR environments. Task has already been embedded as a variable in the PxTxS model by Tromp and Sternberg (2022). However, in this study, task is expanded to include the understanding, that the task should be compatible with the VR app and vice versa. Tool onboarding is less important in the physical world, but it may require greater attention in virtual environments based on the team members' experiences.

5.1.2. Team Creativity Process Variables

a) Collaboration

The *psychological safety* of participants in an unfamiliar virtual environment was maintained due to several factors. Firstly, the freedom of movement and flexibility, as well as the avatars and playful setting, contributed to their sense of safety. Moreover, it was viewed positively, that the participants engaged in the new creative experience in VR with a familiar group of colleagues, rather than strangers. These observations and results indicate, that the participants were able to adapt quickly to the unfamiliar work environment and overcome challenges, demonstrating a high degree of risk-taking and openness. Despite the novelty of the situation, the participants felt secure in expressing their opinions and engaging in collaborative work. Simultaneously painting the prototype generated a sense of psychological safety, leading to creative ideas and a more balanced team dynamic. The reasons for this could be rooted in the deeply ingrained psychological safety at the individual, team-level, and organizational level. However, the importance of psychological safety for team creativity

performance is evident both in the physical and virtual worlds, which is stimulated by immersive VR, confirming the findings from previous studies, e.g. Chae (2016).

With regard to *task orientation*, both teams critically questioned multiple times during the experiment, whether their results and processes were significant to answer the task at hand. This likely led to their satisfaction with the final mascot designs. Despite the numerous tools and technical hurdles in MultiBrush, team members did not get distracted from the main task. This can be attributed to their profession as facilitators who are experienced in efficiently leading groups through a process in physical or non-immersive spaces. The different needs of participants in terms of a freer or more structured creativity flow for task completion were particularly noticeable. Some participants felt a sense of freedom due to the range of tools, playful nature, and infinite virtual space, which enabled them to develop creative, new, and unconventional ideas, especially during the prototyping phase, when they painted and unleashed their out-of-the-box thinking. For example, Team 1 created an eight-armed fluffy octopus, and Team 2 gave colors and brushes a new meaning and metaphors, similar to the creativity and innovation technique such as Lego® Serious Play® (Vogel et al., 2020). Other participants preferred a structured approach to navigate the wide range of possibilities in the VR app through visual anchor points to enable efficient process execution. However, the free and structured creativity flow do not need to be contradictory in implementation, as different needs may be attributed to different working and learning styles, that could be supported by orientation aids such as instructions and assistance. The scaffolding methodology from the pedagogical-psychological context can be used to support individuals in independently completing tasks and has been proven to do so in technology-enhanced learning environments (Sharma & Hannafin, 2007). However, not all participants need to have a structured flow. Another way to support efficient process execution could be a special role within or outside the team. In Team 1, for example, the facilitator role was clearly taken over by G1R1, which was perceived positively by other team members. Some form of guidance could potentially have also helped Team 2, as one participant expressed a desire for more guidance or structure. It can be concluded that depending on one's familiarity with the virtual environment, a facilitator or leadership role may be necessary to guide inexperienced team members through the process. Additionally, the person, who took on the facilitator role in Team 1 had a generally positive attitude towards technology.

The *learning curve* developed throughout all three process steps. Due to the fact that the experience with MultiBrush and collaboration in an immersive VR environment was new for all participants, everyone had to become familiar with the tool first. Despite the process times being limited to a maximum of 15 minutes, the teams were able to quickly familiarize themselves with MultiBrush. Participants reported feeling more comfortable with MultiBrush and the new VR environment as the process progressed and observed progress in their application of the tool from one process step to the next. Although there were some technical challenges and uncertainties in working with MultiBrush, the learning curve did not significantly disrupt the creative flow, probably because the participants were able to adapt to the new technology. Assistance for the learning process using the scaffolding method, human-guided process execution, or a detailed onboarding process in the VR app could be particularly helpful for individuals, who have never worked in VR and have low technological competence. Furthermore, the experiment showed, that the shared learning curve was necessary in the ideation and selection phase for participants to build the necessary confidence and new knowledge in MultiBrush to better engage with the tools during the prototyping phase. Moreover, the experience

in immersive VR could ease the access to this technology, if the working session is properly designed from the outset.

b) Communication

The results from the process steps suggest, that the foundation for verbal communication, *sharing information, knowledge, and ideas* was successful in VR. In some instances, teams relied solely on verbal communication when unable to cluster ideas and made decisions through discussion on the audio channel. This approach was perceived as highly efficient and not distinct from that of the physical world. The participants engaged in live communication rather than through the VR headsets, which only minimally affected the immersive nature of the VR experience. Additionally, there were no discernible limitations in terms of real-time interaction, immediate feedback, or the expression of ideas in either written or verbal form. An important insight garnered from the experiment is, that when non-verbal communication, such as through avatars in VR, cannot be portrayed, an alternate mode of communication is necessary. The absence of gestures and facial expressions requires participants to expend extra effort to articulate their actions, locations, and gaze during communication, in order for their teammates to follow their visual cues.

In the tech check-in phase, participants personally created *avatars*, which contributed to creating a relaxed atmosphere in the teams and allowed participants to orient themselves to the body language of other avatars during collaboration. Despite technological advancements, however, avatars were unable to accurately replicate gestures and facial expressions, and thus impeded the non-verbal communication. The absence of non-verbal communication needs to be compensated with more verbal communication due to the limitation of the current status of technology. However, this issue could potentially be solved with future technological advancements.

Regarding *physical proximity*, the experiment took place with all participants being in the same location, which allowed team members to hear each other live. However, this also had drawbacks, such as the fact, that the proximity to a team member's avatar in the virtual world did not match the proximity of their voice in the physical world. It would be interesting to explore, whether the collaborative creativity process could work over physical distance, and whether theoretical concepts could be confirmed through a geographically dispersed team (Wilson et al., 2008; Chae, 2016).

c) Effects on Body and Mind

One participant out of the six in the VR experiment experienced adverse effects on their creative process as a result of well-known drawbacks of the technology, including cognitive overload and motion sickness, as reported in previous studies (Hui et al., 2022; Petrykowski et al., 2019). To simplify the analysis, this variable was classified under a broader category. However, this does not suggest, that this issue is irrelevant or has minimal significance. On the contrary, it is essential to consider this variable since a team's success is viewed as being unified (Jiang & Zhang, 2014), and a team member's limitations due to adverse effects on their physical and mental state during the creative process have an impact on the team's overall performance. Despite experiencing negative effects, the participant acted professionally and continued with the experiment. Moreover, the claim is, that individuals who do not feel comfortable in VR should also receive inclusive treatment. This implies, that the well-being and any pre-existing health issues of team members should be assessed before engaging in VR, and the necessary steps taken accordingly. Additionally, it is crucial to develop the required sensitivity to recognize immediately when a participant is uncomfortable in VR, and to switch to analogue working, take more breaks, and work in small process steps. The latter step is

especially important since the participant in question denied experiencing any health issues in VR during the initial assessment but experienced cognitive overload and motion sickness during the experiment. Thus, effects on body and mind needs to be considered similar to mood and attitude (see chapter 2.1.2.1.) as a fluid variable of individual creativity potential.

To facilitate an efficient experience for a team and achieve relevant results, it is crucial to take into account the peculiarities of the virtual environment in collaborative processes in immersive VR. Nonetheless, these variables can only be managed to a certain degree prior to the process, as they heavily rely on situational circumstances, which are subject to the dynamic conditions occurring during the creativity process.

5.1.3. Team Creativity Output Variables

The prototypes developed in the workshop were assessed based on their *applicability* for further development. Overall, the prototypes were considered a good starting point for further work on the topic. The participants evaluated the prototypes as useful, as they would be suitable for further validation of their properties in additional iteration workshops. Furthermore, they were also seen as usable for direct implementation, such as for a digital or analog mascot. Thus, the applicability of the prototypes was considered achieved, either completely or with reservations for further iteration cycles.

The second assessment criteria for team creativity is *novelty*. The VR environment fostered creative, innovative, and unconventional ideas, positively affecting the participants' creativity performance. The prototypes developed in the workshop were perceived as more novel than those that might have been produced in a physical environment. This may be attributed to the relaxed, playful setting and psychological safety provided by the VR environment. The participants felt free to explore and experiment with ideas, leading to prototypes, that were innovative and unique.

Regarding the third assessment criteria, *results worth effort*, the process of developing prototypes in VR was enjoyable and fun, and the outcomes were considered worth the effort. However, it is essential to note, that in a business context, the challenge's goal and complexity, the available time frame, the participants' experience in VR, and the suitability of the respective VR for the application area needs to be well balanced to achieve novelty and applicability of the ideas and thus the success of creativity and innovation projects in immersive VR.

The three output variables provide a good assessment framework for determining the relevance of the team creativity output resulting from divergent and convergent process steps for further elaboration. Thus, the experiment design has, to some extent, supported team creativity in VR.

5.1.4. Application Areas for MultiBrush

The application areas were derived inductively, despite theoretical indications, that immersive VR is suitable for ideation purposes (Fleury et al., 2021), but not specifically in the context of MultiBrush and a creativity workshop in a business environment. There is theoretical evidence suggesting, that immersive VR is suitable for *ideation* purposes. However, in the business context ideation needs to be done fast, usually with quick brainstorming techniques, that allows to generate as many ideas as

possible. Following this line of thought, MultiBrush as a 3D sketching tool is not suitable for brainstorming activities. This could be due to the fact, that sketching is generally unsuitable for rapid brainstorming in a business context. Thus, it is important to distinguish the insights and expert opinions on the application areas as relating specifically to MultiBrush, and not to immersive VR in general. In light of this, a 3D painting app like MultiBrush is not particularly conducive to ideation sessions in a corporate context, where the tasks and processes are output-driven. Business experts from Deloitte Greenhouse Berlin suggest, that ideation involves rapid brainstorming to generate as many ideas as possible, followed by clustering for evaluation and selection. However, MultiBrush hinders quick idea generation and does not allow for clustering. As such, challenges involving large data sets, such as ideation and the analysis of complex issues, are not recommended for MultiBrush. Instead, the app is well-suited to *visual* representations, *prototyping*, and *testing*, particularly in the second diamond of Design Thinking. Furthermore, 3D painting, especially during the prototyping phase, have been associated as a suitable tool for the development of soft skills for individuals and teams. The playful and inspiring setting of MultiBrush can help individuals overcome their fear of expressing creativity, try new things, practice risk-taking and openness to technology, and step out of their comfort zone. The features of MultiBrush are viewed as favorable for human-centered tasks, such as fostering a *creativity and innovation mindset*, serving as a *warm-up and energizer*, and applying it for *team building* activities.

Team creativity is a dynamic and complex process, especially in a virtual environment, where new and unfamiliar variables come into play. Further research and testing are needed to better understand the interdependencies between the variables accurately, as the field of study is still in its early stages. In this context, the IPO framework, which helps to structure variables in the corporate setting, can be particularly useful. The selected variables for team creativity and team creativity in immersive VR have been successful in the conducted experiment, and the immersive environment has even introduced new variables to the proces, which are depicted in the revised conceptual model:

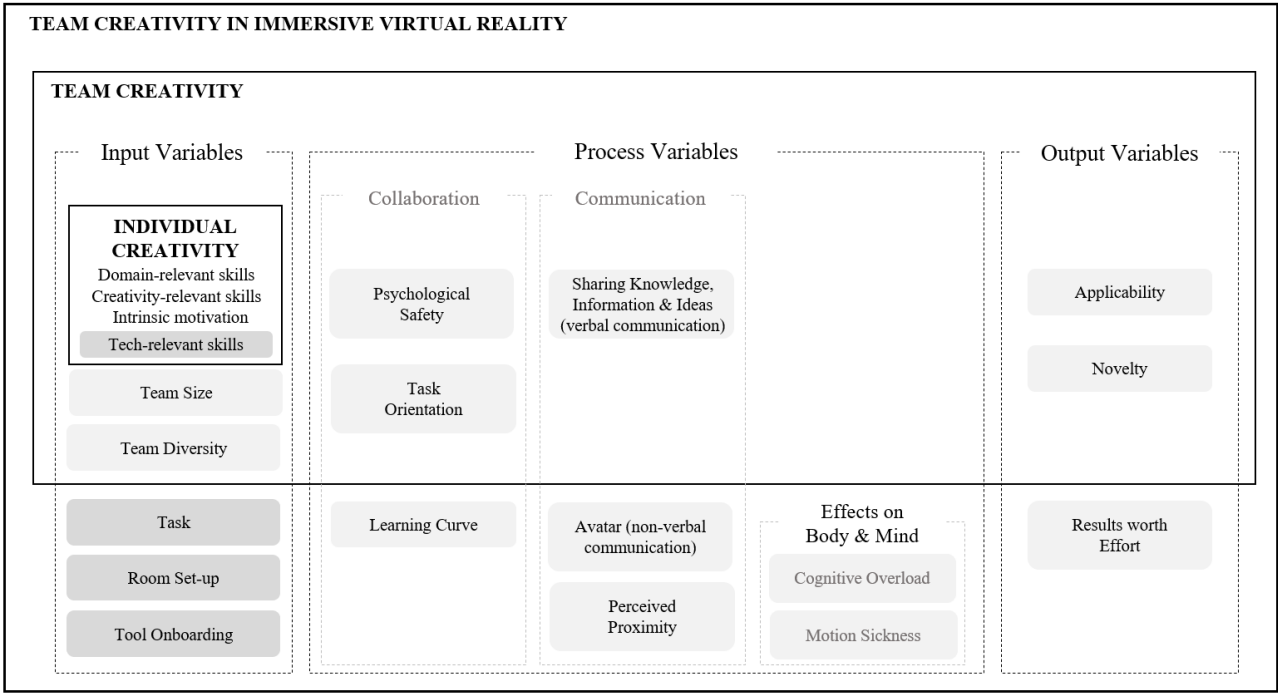


Figure 15: Revised Conceptual Model for Team Creativity in immersive Virtual Reality

5.2. Recommendations for designing Team Creativity Processes in Virtual Reality

An actionable model with recommendations is required to assist teams in organizations in efficiently designing a VR working session using insights obtained from the team creativity input, process and output variables and implementing it in practical application areas, regardless of the VR app chosen. The subsequent model, presented in this chapter, was developed based on the study's findings as a recommendation for organizations. The key components, that shape the team's immersive VR experience in organizations are Team, Task, and Technology. The primary objective of the model is to enable teams to attain a state of creative flow while dealing with a task. The secondary objective is to ensure, that technology functions as an enabler for Team and Task and should never be the primary focus of designing creativity processes.

Task-Technology Match: Prior to designing a working session for teams in VR, it is crucial to determine the type of task, that will be tackled within the creativity and innovation process. Is it an output-driven or human-centered task, and which VR app is suitable or unsuitable for the task, are the main questions here to answer. Based on this, an initial VR app selection can be made, that is conducive to collaborative teamwork. Figure 16 displays exemplary application areas for MultiBrush and needs to be expanded with information on other VR apps through future research.

		MultiBrush	VR App X
1. Output-driven Tasks	1.1. Research & Inspiration	●	
	1.2. Synthesis & Analysis	✕	
	1.3. Ideation	✕	
	1.4. Prototyping	✓	
	1.5. Testing	●	
2. Human-centered Tasks	2.1. Warm-up/ Energizer	✓	
	2.2. Team building	✓	
	2.3. Creativity and Innovation Mindset	✓	

Tool suitability: ✕ Low ● Medium ✓ High

Figure 16: Task-Technology Match

Task-Team Match: Subsequently, the Task-Team Matrix assesses the complexity of the task and the team's tech-relevant skills to obtain a clear understanding of how to design the team creativity input variables for the VR working session.

High task complexity arises, when a large amount of data needs to be analyzed or when there are tense and problematic team dynamics. In the quadrants affected by this, more structured creativity flow needs to be incorporated into the process in terms of scaffolding (see chapter 5.1.2.), such as breaking down the process into smaller steps, using templates with instructions and detailed tasks, providing

visual anchors for the process flow, shortening the timing of process steps, and increasing the number of breaks. Dealing with high task complexity requires significantly more preparation time and effort for the VR working session in advance. Therefore, if the task is under time pressure, the use of VR must be critically evaluated.

On the other hand, *low task complexity* exists, when the task is open-ended, the team has already developed a specific implementation plan in the physical world, or the team is seeking a playful setting without a specific output from the outset. In the corresponding two quadrants, less structured flow can be given to provide a free creativity flow in advance in terms of the room set-up, process, and subtasks. However, hints and ideas for the teams can still be helpful in efficiently completing the task according to the scaffolding method.

To assess the tech-relevant team skills, the fitness level of team members in the use of VR technology in general and the corresponding VR app must be determined. This includes experience with the technology, openness, risk-taking, motivation for technology, and known health issues, that may arise in combination with VR. It must be emphasized again, that the evaluation of the effects on body and mind must be done with special attention, as otherwise, the execution of a work process in VR within a team cannot be carried out.

Low tech-relevant team skills are evident when team members demonstrate uncertainty either with VR technology in general or with a specific VR application. In such cases, it becomes necessary for the team to have one or more individuals who can assume a guidance role and effectively navigate the VR process. Facilitators, leaders, and tech experts can fulfill this guidance role. Furthermore, it is advisable to consciously maintain a small team size and strive for a diverse team composition. For individuals with low-tech relevant skills, it is essential to provide them with a comprehensive tech onboarding process to ensure familiarity with the virtual environment.

High tech-relevant team skills, conversely, imply, that team members can quickly adapt to the work process despite the VR environment and have the ability to work autonomous. As a result, the team does not necessarily require a guidance role. The team size could exceed three individuals, while it is necessary to keep a diverse team composition. Additionally, the duration of tool onboarding can be adjusted based on specific requirements, potentially shortening the process.

By utilizing the task-team matrix (see fig. 17) to allocate task complexity and tech-relevant team skills, the team creativity input variables and process can be designed to achieve the aforementioned goals. However, in the organizational context, it is necessary to question, whether the selected VR app continues to facilitate the team's ability to solve the task in a creative flow, as well as whether adequate time and necessary resources are available for designing the working session. Additionally, it is imperative to determine, how the results of the team's VR work will be utilized for future process steps prior to implementation.

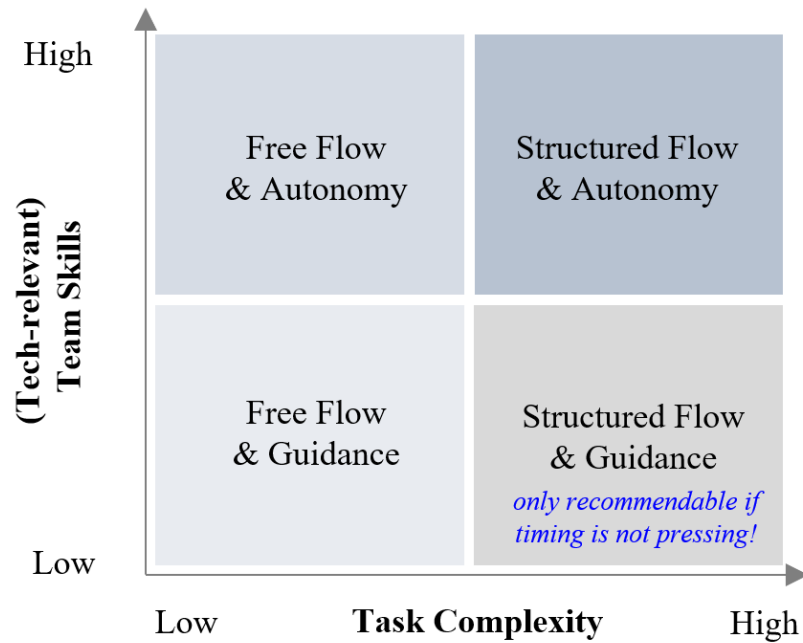


Figure 17: Task-Team Match

5.3. Managerial Implications

As discussed in previous chapters, VR has generated significant interest among businesses and companies due to advancements in technology and resulting opportunities. However, there is a dearth of universally accepted guidelines and orientation aids for teams on the effective utilization of VR within the innovation process, owing to the limited experience and routine usage in practice. Thus, the experiment in this study was deliberately designed application-oriented in immersive VR within an organizational context, incorporating experienced experts from the business field, to identify concrete implications for the use of immersive VR in team creativity and innovation. The implications are aimed at individuals in companies, who intend to explore new collaboration approaches in their teams using immersive VR, familiarize team members with the technology, and test the benefits of VR applications in their respective use cases.

Team creativity is a dynamic and complex construct in physical spaces, and its outcomes can be partially controlled by understanding various variables before, during, and after the creativity process. However, transitioning from the physical environment to immersive VR alters the effects of known variables on team creativity. Furthermore, new variables come into play and influence the process and outcomes. Hence, in order to successfully organize a collaborative working session in VR and lead the team towards their intended objective, it is essential to be aware of the variables and their implications within VR. Comparable to a physical environment, a small team size and a heterogeneous group with diverse competencies can yield favorable results. Along with relevant domain-specific and creativity-related skills, it is crucial to consider the technical expertise of team members for a proper setup and tool onboarding in the virtual space. The task, including the process approach, timing, and process steps, must also match the team's abilities and the capabilities of the selected VR app. The principle must be followed, that the technology always and without exception takes a secondary role in designing the collaborative working session and that these teams must be

enabled to enter a creative flow to be able to process a task in such a way, that the results can be used for further implementation purposes.

The four most important findings from the experiment for bringing teams into a state of creative flow in the virtual environment are: First, a balance must be taken into account between the free and structured creativity flow. On the one hand, the free creativity flow of the tool reinforces psychological safety within the teams and thus stimulates new ideas, on the other hand, there is a demand for a more structured creativity flow for efficient process implementation and more task orientation. Second, guidance in the form of facilitation, leadership, and technological experts must be taken into account for collaborative work according to the tech-relevant skills to navigate teams through an unfamiliar environment such as VR. Thirdly, verbal communication takes on a different and new meaning in the virtual environment, as avatars, according to current technology, do not adequately support nonverbal communication. However, this issue could be potentially solved with technological advancements in immersion. This can thus be rather understood as an appeal to the developers at the respective companies to consider the aspect of enhancing the communication experience in VR through better facial expressions of the avatars. Fourthly, awareness of the potential negative effects of VR on the body and mind of team members must be present, and sensitive handling is necessary both before and during a collaborative working session in VR. By adjusting input and process variables in advance, optimal conditions can be created to achieve applicable and, above all, novel output in VR, that is relevant for further steps along the innovation process. Nevertheless, the possibilities for transferring output from an immersive environment to a physical and non-immersive environment must also be considered.

MultiBrush is particularly suitable for prototyping and promoting creative and innovative mindsets and skill sets, but less suitable for ideation and complex matters. It should also be noted, that application areas may differ from one VR app to another, making it difficult to derive general implications for VR. Therefore, the 3T model was developed, which allows for action recommendations for designing a working session for team creativity and innovation in immersive VR based on a proper match of tech-relevant team skills (Team), task complexity (Task), and VR-tapp (Technology). This is generally applicable for the use of VR in organizations and provides recommendations on how to critically evaluate the application of VR in practice.

Overall, immersive VR offers new opportunities for team creativity and innovation, but also presents new challenges and requirements for companies, that want to use it effectively. By following the recommendations and insights from this study, companies can design and execute collaborative working sessions in VR, that leverage the team's skills and abilities, the technology's features and limitations, and the purpose and objectives of the use case. This can lead to applicable and novel outcomes, that can contribute to the innovation process and the business success.

5.4. Theoretical Implications

From a theoretical perspective, this study has contributed to a closer examination of the connection between team creativity and the current state of technology for immersive VR in an organizational context, thus providing a better understanding of the implications for theory and research. As previous key findings on immersive VR and creativity often come from studies, that employ a quantitative research design with students as research participants, a qualitative research design with business

experts was deliberately chosen for this study. This allowed the experts to directly apply their experiences from the creativity workshop in VR to the business context in the individual interviews, thus making meaningful statements for the use of VR and MultiBrush in organizations.

In addition, the exploratory analysis has opened up the research field of team creativity in VR in organizations in all directions. For this study, the basis for the investigation was the existing theory for individual and collaborative creativity in the sense of innovation. Due to the multidimensionality and dynamics of team creativity in the physical environment, a handful of carefully selected variables were examined in varying depth and superficiality for this study, out of numerous variables previously known. These variables can be reconfigured in future research studies depending on which aspects of team creativity are to be examined more closely.

The study found, that creativity and team creativity operate similarly dynamically, nonlinearly, and situationally in virtual and physical environments. The initially proposed conceptual model was revised with specific characteristics for VR derived from the experiment. Team size, team diversity, psychological safety, task orientation, sharing of information, knowledge and ideas, as well as novelty and applicability, were given new significance due to the virtual component, while additional VR-specific variables were created, such as task, tool onboarding, room set-up, learning curve, avatar, perceived proximity, effects on body and mind, and results worth effort.

Team creativity input variables, such as team size and team diversity, were considered crucial in determining team performance during the work process in the theory. What is new with immersive VR is the technical component, which until now has not been incorporated as an integral part of any creativity or team creativity model. As humans become increasingly digital, not only domain-relevant and creativity-relevant skills but also tech-relevant skills are thus required for creativity and innovation processes. These include technical fitness level, technical experience, openness to new technologies, as well as known effects on body and mind. The PxTxS framework by Tromp & Sternberg (2022) could also consider the tech component as it could have impacts on both the individual and the task and situation in general and thus significantly influence the creativity process.

To investigate how teams can achieve a sustainable and creative flow of ideas in immersive VR, the process must be created accordingly. Researchers must take into account, that both micro and macro level processes vary, making it impossible for the study to provide universal implications on how a creativity process should and will unfold. Nevertheless, exploring both divergent and convergent thinking is crucial in determining whether the output can be utilized for further innovation purposes. Moreover, in theory, similar to the application-oriented practice (see chapter 5.3.), understanding the different team creativity input, process, and output variables, as well as the application areas of the respective VR apps, is necessary to design research studies specifically aimed at investigating team creativity in the virtual environment, and not VR for team creativity.

The study suggests, that the creativity process designed led to ideas, that the participants evaluated as particularly novel and applicable for further practical implementation. Therefore, it can be concluded, that the workshop was appropriately designed and can be replicated for future research purposes as stated in the thesis.

Another important finding for research with the technology is the differentiation between the implications for immersive VR in general and the specific VR app used in the respective study. As MultiBrush was used in this study, the experts' recommended application areas were exclusively for

this app. Thus, experts considered ideation in the classic brainstorming sense in a business context as unsuitable for MultiBrush.

Although this study did not completely closed the research gap identified in the problem analysis, it contributed by opening up the possibility for further future research.

5.5. Limitations and Future Research

The study is subject to numerous limiting factors, that must be taken into consideration for future research on team creativity in VR. An essential limitation factor is the qualitative and exploratory nature of the research, which restricts the generalizability of the results (Queirós et al., 2017). Although the insights gained from the workshop and six individual interviews with experts allow for the identification of patterns and provide a sound foundation for further research in this field, additional and potentially long-term studies in a business context are necessary to validate the findings of this study.

The experiment itself also presents additional limitations. The workshop was conducted on-site, which precluded the testing of a fully immersive experience among geographically dispersed teams. Thus, for future studies to acquire more comprehensive insights, a more technologically complex environment with participants and observers would need to be considered. Additionally, all selected participants possessed domain-relevant and creativity-relevant skills, as well as high motivation to participate in the experiment. Therefore, future studies should also include participants with less VR and technology experience. Furthermore, due to the scope of the master's thesis, a selection of process steps and variables for the exploratory analysis was made, and the conceptual model for team creativity in VR was established. In the future, the defined input, process, and output variables, as well as additional ones, could be explored more deliberately and comprehensively.

Following the DSRM framework, it is necessary to conduct an iteration of the experiment to further test the validity of the results obtained in this study, as well as the variables identified in the validated conceptual model. Due to the limiting scope of the master's thesis, this iteration could be carried out in future studies by also addressing other aspects, that were not prioritized in this study.

The application possibilities of different VR apps throughout the innovation process also offer another area for future research. Long-term studies in a business context should investigate the applicability of VR apps and test the 3T model established in this study using comparative values. Additionally, the technology itself poses a limiting factor. Due to the rapid technological development of immersive VR headsets, the implications expressed in this study for team creativity in VR may not correspond to the most current state of the art in the future. Consequently, the findings must be viewed with consideration for the technological state of development. As a result, future research must be more agile and responsive to the latest state of technology.

Conclusions

1. Team creativity in immersive VR is as dynamic and complex as in the physical environment, thus requires more in-depth research on its influencing variables.

The emergence of new research fields in theory and practice for immersive VR is due to the increasing leaps in immersion of VR in recent years and current investments by companies in the future development of this technology. Although limited insights are available for both research and companies at the initial stages of their exploration of emerging technologies like immersive VR, particularly from an organizational standpoint, engaging with such technologies early on can enhance the competitive advantage of the company and foster the development of technological skills among employees. Furthermore, initial findings from studies suggest, that immersive VR has a creativity-enhancing effect. However, implications for creativity in the organizational context are scattered in the literature, and practical experience is still limited. Therefore, this study addresses this issue by designing an experiment with teams consisting of business experts in VR in an organizational setting. To achieve this, a conceptual model for team creativity and a creativity process for the experiment based on theory were developed. Team creativity is a multidimensional, complex, and dynamic construct, that poses challenges in both theoretical and practical understanding, even in the physical environment.

Different variables, components, and influencing factors are known from various studies and research directions. For the conceptual model and creativity process, the most relevant variables and process steps for the experiment were first selected to enable a systematic analysis of the creative flow of collaborating individuals in a virtual environment. The IPO framework was used to structure the variables, which also ensured the applicability and novelty of ideas for further implementation. The input, process, and output variables resulting from team creativity were examined for their implications in immersive VR and complemented by further variables, that could be relevant for the process flow and applicability and novelty of the outputs. The design of the creativity process for the experiment simulated a fuzzy front-end of an innovation process, incorporating process steps from divergent thinking, such as ideation, as well as convergent thinking, such as selection and prototyping.

With the wide selection of variables and process steps for team creativity in immersive VR, countless combinations for various foci can be set either with few in-depth or broader and multidimensional research studies. Furthermore, research must consider technological advances as the level of immersion of VR makes developmental leaps in the future, which can influence the experience of the users and, subsequently, the creativity variables and implications. This complicates research on the topic, but still leaves much potential for future research.

2. Team creativity input variables and the used VR app are relevant to consider for shaping the desired process and output.

The combination of the conceptual model, selected creativity process and the designed creativity workshop for the experiment has shown, that the advanced immersiveness of the state-of-the-art VR technology can stimulate the subjective sense of presence but also facilitate virtual interactivity, thereby promoting imagination and inspiration, that supports collaborative creativity process in the artificial environment. Previously known results from previous quantitative studies were indirectly confirmed in this study through this qualitative research design involving business experts. It was found, that immersion through VR headsets shapes individual behaviour and thus, the team creativity

dynamics. A sense of liberation, psychological safety, playfulness and openness were reflected by the participants, particularly in the prototyping phase. This could also be a side effect of the drawing tool as the movement of drawing in 3D supports the sense of freedom. This resulted in a greater flow of novel and unusual ideas, perceived to be higher than in traditional settings, whereas the applicability of the results would need further iteration in a further analog or digital workshop. Therefore, the results were worth their effort in MultiBrush under the condition of further iteration. However, the qualitative nature of this research methodology creates new opportunities for discussion when applying VR in organizations in the future and still needs to be validated through further research and practical use cases.

The key findings from the experiment on VR identify the key input, process, and output variables, indicating, that guidance in the form of leadership, facilitation roles, or tech experts is crucial in an uncertain setting with low tech-relevant skills. Moreover, the design of the immersive VR-based creative and collaborative working sessions can be a free flow, a structured flow, or a combination of both, depending on the input variables and the expected or set output. In communication through VR, verbal communication gains significantly more importance, as the current technology cannot fully replicate non-verbal communication such as facial expressions and gestures through avatars. However, this finding may become obsolete in the future due to advancements in immersion. During the process, individual persons may experience effects on their body and mind, regardless of whether health issues are known in advance or not. Therefore, awareness of this issue and sensitivity toward the affected team members are crucial to ensure, that the collaborative work is inclusive.

It is essential to differentiate these insights since they permit conclusions to be drawn regarding the use of immersive VR in organizations, while the application area of VR apps must be considered specifically. Using the 3D drawing app MultiBrush in this study allowed for specific insights regarding its suitability for visual tasks such as prototyping but less so for ideation and complex, analytical tasks. Since ideation in organizations should be quick, 3D drawing can be a hindrance. Nonetheless, 3D drawing can also foster a creative and innovative mindset, empathy, and team building.

3. Team creativity can to some extent be efficiently modified by considering tech-relevant skills, task complexity and the VR-App when designing the process.

Technical components are important to consider before designing experiences in immersive VR. The study highlights the need to consider input variables such as team size, diversity, as well as the technology-relevant skills such as technical fitness level, technical experience, openness to new technologies, and known effects on body and mind when investigating team creativity in immersive VR. Further the team characteristics need to be brought into relation with the task complexity.

The insights from the current study are bound to the current state of technology. The rapid development of VR technology therefore requires, that both research and practice must constantly stay up to date in order to be able to derive the implications of new levels of VR immersion in the future. To be able to express implications for the application of immersive VR in organizations, that are independent of the level of immersion, the 3T model consisting of Task, Team, and Tech was developed as a guide in this study. Its primary goal is to bring teams into a state of creative flow in order to tackle tasks such as developing applicable and novel ideas in VR. Thus, the working session and the corresponding input variables could be matched and designed according to task complexity,

tech-relevant team skills, with the right match of VR app and application area. In this context, the focus on the technology is secondary, as it aims to facilitate teams in effectively solving tasks in VR. From a research perspective, it is important that technology is more integrated into the models, as humans have become digital. The exploratory and qualitative research has provided a basis for numerous entry points for further studies. Overall, both companies and researchers must track the implications of VR technology and ideally apply it directly in order to adapt agilely to rapid technology leaps.

4. The use of immersive VR in organizations holds a lot of potential for science and in organizations, but still requires a high resource investment.

VR, and MultiBrush in particular, offers opportunities to work in completely new ways, experience creativity processes differently, and provide new perspectives on challenges through immersion. The findings of the study also show, that the current state of immersive VR offers potential for creativity-enhancing activities in an organizational context but also presents uncertainties and challenges, that need to be properly managed. Therefore, it is important for companies and researchers to further explore this technology and test various application areas. However, the use of immersive VR in companies currently requires significant resource investment, which poses challenges for many firms. Only those companies, that can afford to invest the necessary money and time to experiment with various VR apps, design workshops, and integrate the results of virtual projects into the real work environment can also draw on their experiences to integrate VR into their workday in the long run. This also applies to research in order to be able to quickly draw implications. It is important, that the use of VR in companies is carefully evaluated to ensure, that investments are meaningful and support creativity and innovation processes instead of hindering them. Only then can organizations venture into the virtual world from their analog cave.

5. A VR-based experiment is a unique challenge, that requires the consideration of both, virtual and physical environments in the research design.

The core of the study is the extensive designed VR app-based experiment, which allows to explore the collaborative creativity process both, virtually and physically. The experiment presents a unique challenge in that it requires combining physical and virtual environments in order to provide observers and participants with the ability to take analog notes. Additionally, collaborative work in immersive environments, like in practical settings, requires lead time and a complex setting. The design, execution, and balancing of virtual and physical elements must be carefully considered. The experiment had some limitations, such as being conducted at a physical location rather than remotely. As a result, the full potential of the technology's immersion level could not be tested. If the experiment were to take place remotely, an even more complex setting would be required, as participants would be left alone with the technology, or the research team, including observers and researchers, would need to be familiar enough with the technology to design research studies for geographically dispersed teams. Nonetheless, the design of the experiment achieved the objectives of this study and thus can be replicated for future research purposes.

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Appendices

Appendix 1. Goal-Method Selection for the Research Design

	Structure	Goal	Method	Tool
1. Before the Experiment	1.1. Sampling with Ex Ante Questionnaire	Participant's Domain-relevant skills; Creativity-relevant skills; Motivation	Questionnaire	Google Forms
	1.2. Team Division	Division of Participants in two Teams	Results are used from Ex ante Questionnaire	Excel
2. During the Experiment	2.1. Observers' Notes	Participants' Behavior, Dialogues & Interactions	Notes by Observers during the Experiment	Muralboard
	2.2. Participants' Notes	Participants' Perception, Feelings & Opinion	Notes by Participants in the VR Breaks	Muralboard
	2.3. Process Documentation	Experiment Process Documentation	Screenshots in MultiBrush by Researcher/Facilitator	MultiBrush
3. After the Experiment	3.1. Note Clustering	Preparation for the individual Interviews	Clustering	Muralboard
	3.2. Ex Post Expert Interviews	Participant's Perception, Feelings & Opinion	Semi-structured Expert Interviews with each Participant	Zoom
	3.3. Analysis of the Findings	Participants' Main Experiences	Inductive-deductive method by Mayring (2010)	MAXQDA

Appendix 2. Ex ante Questionnaire for Data Sampling

Section	Questions
1. Demographic Data	
1.1 Name	<i>What is your name?</i>
1.2 Age	<i>Please indicate your age</i>
1.3 Gender	<i>Please indicate your gender</i>
2. Content knowledge skills (Domain-relevant skills)	
2.1 Deloitte Experience	<i>How long do you work for Deloitte Greenhouse?</i>
2.2 Content Focus	<i>What is your position and main content focus in your job at Deloitte Greenhouse?</i>
2.3 Focus Area Experience	<i>How long do you already work in your focus area?</i>
3. Previous team creativity experience (Creativity-relevant skills)	
3.1 Creativity Technique	<i>Think of your last challenges at work, what team creativity techniques and methods have you used or experienced to generate a smany ideas as possible?</i>
3.2 Idea Implementation	<i>Think of you last challenges at work, how did you as a team use the various ides generated from the creativity techniques to focus on/ develop one idea further?</i>
4. Previous Virtual Reality experience (Domain-relevant skills)	
4.1 Context	<i>Have used Virtual Reality before? If yes, in what context have you used virtual glasses before the experiment – in both, private and business context?</i>
4.2 MultiBrush	<i>Have you worked with the VR app Tilt/Multi Brush befoe? If yes, for how long?</i>
4.3 Health Issues	<i>Do you have any health issued working in virtual reality longer than 15 minutes?</i>
5. Your motivation	
5.1. Motivation	<i>What is your motivation to participate in the experiment?</i>

Appendix 3. Workshop/ Experiment Templates for the Observers and Participants

Name Observer 1

Write down all activities, statements & emotions from the virtual team creativity exercises that you observe as unusual compared to non-virtual team creativity activity

optional

DOING

How did the team members solved the challenge? What was the process

- Gedanken/ Ideen austauschen
- Ideen kreieren
- Auf den Ideen anderer aufbauen
- "Started to share and create ideas in the first 10 mins of the task"
- First silent brainstorming afterwards sharing
- Clustering? Themed-oriented?
- Wie wurden Entscheidungen getroffen?
- Gab es Hindernisse, welche sie gehindert haben?
- Gibt es längere Pausen?

SAYING

What do they say/ comment while being in action (not in action) with the other team members?

- Wo finde ich denn...? Wo hast du das gefunden? Wie kann ich...?
- Hallo! Wink mal
- Ja und...! Ja aber...!
- Lasst doch, Schau mal,
- Wo siehst du das? Wo seid ihr?
- Oh nein, wir haben noch so wenig Zeit
- Ich könnte die ganze Zeit hier drin bleiben

FEELING

How do the team members communicate emotions? (e.g. smiling, non-verbal, gestures, etc)

- Wow, Boah, Cool, ...
- Das sind super aus!
- Hahaha (lautes Lachen)
- Ah nein! Argh! (wenn)
- Oh nein! (Zeit rennt...)
- Große Bewegungen/ viel laufen/ unterschiedliche Höhen

STEP 1: IDEA GENERATION



STEP 2: IDEA SELECTION



STEP 3: IDEA CONSOLIDATION



Name Participant 1

Write down all your thoughts & emotions from the virtual team creativity exercises that you experiences as unusual compared to non-virtual team creativity activity

THINKING

What are your initial thoughts (Impulsgeanken) during the team creativity activity in the virtual space?

- Kollaboration und Interaction mit anderen TM
- Konntest du deine Ideen und Gedanken teilen, sodass andere auf deinen Ideen?
- Hastest du das Gefühl, dass andere deine Ideen verstanden haben? Konntest du die Ideen/ Gedanken anderer verstehen?
- Gab es Hindernisse, welche dich daran gehindert haben, deine Ideen zu teilen und zu kreieren?
- Konntet ihr euch gegenseitig inspitieren und Wissen teilen?

Teamdynamik

- Konntet ihr euch gegenseitig motivieren?
- Wie hat sich die Teamarbeit für dich angefühlt?

Sonstiges

- Gab es etwas außergewöhnliches, was dir nur in der virtuellen Teamzusammenarbeit mit anderen aufgefallen ist?
- Wie habe ich Dinge anders wahrgenommen in der virtuellen Welt verglichen mit der nicht virtuellen?

FEELING

How did you feel during the team creativity activity? And is there any specific reason for the emotions?

- Energized bc of the movements & new experiences
- Overwhelmed by all the opportunities
- Happy bc I created a great idea with my team members
- Neutral bc it's not different
- Angry bc I couldn't create idea I had in mind

STEP 1: IDEA GENERATION



STEP 2: IDEA SELECTION



STEP 3: IDEA CONSOLIDATION



Appendix 4. Ex Post and semi-structured Interview Guideline translated to English

Section	Questions
1. Introduction	
Recap	Recap of the process steps of the experiment by the researcher.
2. Team Creativity (Input and Process Variables)	
Focal Areas of the Participants' Workshop Experiences	Please recall the scenario in which you and your team members went through the individual process steps to arrive at the creative ideas. Please describe how you experienced and perceived both the collaboration with your colleagues and the creativity process in virtual reality (specifically with Multi Brush). <i>Optional: Could you please provide concrete examples? Elaborate on specific moments that come to mind?</i> <i>If suitable, further topics extracted from the Observer' and/or Participants' notes are mentioned by the researcher.</i>
Differentiation of the Specifics in virtual and non-virtual Reality	What were the key differences in team creativity across all three process steps in the virtual world, compared to the non-virtual world? <i>Optional: Could you please provide concrete examples? Elaborate on specific moments that come to mind? What would have helped you in those moments?</i> <i>If suitable, further topics extracted from the Observer' and/or Participants' notes are mentioned by the researcher.</i>
Key Moment	When you think about your experience with team creativity in the virtual space, which one or more key moments come to mind? What contributed to those moments and what factors led to their success? <i>Optional: What factors led to their success?</i> <i>If suitable, further topics extracted from the Observer' and/or Participants' notes are mentioned by the researcher.</i>
3. Team Creativity (Output Variables) for Innovation	
Screenshots	Screenshots of the Prototype and the Avatar Team Picture are shown by the researcher.
First Association	What is the first thing that comes to mind when you see the screenshots?
Output Assessment	When you look at the end result - the prototype - and compare it to the challenge, what do you think <i>Optional: Could you please elaborate on why you are satisfied or unsatisfied with the result?</i>

Section	Questions
	<i>If suitable, further topics extracted from the Observer‘ and/or Participants‘ notes are mentioned by the researcher.</i>
Implementation	Imagine that you had to launch the project 'Design the Greenhouse Mascot' - how would you proceed? How would you utilize or process the results from the virtual world? <i>Optional: Would you validate the results? Would you recreate everything from scratch in the non-virtual world or continue designing in the virtual space?</i> <i>If suitable, further topics extracted from the Observer‘ and/or Participants‘ notes are mentioned by the researcher.</i>
4. Application Areas	
Application Areas	Suppose you were working creatively with others in Multi Brush, why would you do it and in what context could you envision it?
NO GO Application Areas	Suppose you were working creatively with others in Multi Brush, why would you NOT do it and in what context could you ABSOLUTELY NOT envision it?
5. Miscellaneous	
Further topics	Is there anything else that we have not discussed but is important to you? <i>If suitable, further topics extracted from the Observer‘ and/or Participants‘ notes are mentioned by the researcher.</i>

Appendix 5: Selected Interview Quotes for the Analysis of Team Creativity Input Variables

Team Creativity Input Variables	
Variables	Quote
Team Size	<i>[...] I think the group size is good. I even think two or three is fine. I believe that it could work very well as a back-to-back exercise with two people. I think that with more than three people, it will probably become difficult to collect results and navigate the space. (G1R3_Interview, Pos.52)</i>
	<i>[...] we were three people in the room now. [...] When could it possibly become difficult if too many people start drawing or writing on it? (G2R1_Interview, Pos.48)</i>
Team Diversity	<i>Considering that we all come from different backgrounds,[...] I think that we have actually achieved a pretty good result. (G1R1_Interview, Pos.25)</i>
	<i>For example, G1R1 quickly took on the role of moderator. [...] That was very helpful for me. (G1R2_Interview, Pos.17)</i>
	<i>It was a perfect combination because, as I said, I perceived G1R1 as the moderating part who was also extremely fast and creative. G2R2 was the same, visually very strong. As I said, in the third process, she also took on the role well. I saw myself more in this technical role again. (G1R3_Interview, Pos.34)</i>
	<i>Although it is still challenging, we were lucky that G2R1 can draw so well. (G2R3_Interview, Pos.14)</i>
	<i>I really like all of my colleagues and it was already such a familiar environment. (G1R3_Interview, Pos.33)</i>
	<i>I think that working together on Multibrush with people who are completely strangers to me, with whom I have never worked before and whom I do not know personally, [...] would be more difficult for me than working with people I know. (G2R2_Interview, Pos.54)</i>
NEW: Task	<i>[...] we were aware that the task wasn't that demanding and that we didn't need to come up with the perfect solution. The fact that it was more relaxed actually gave us the courage to make quick decisions. (G1R1_Interview, Pos.9)</i>
	<i>It doesn't even have to be a very complex challenge in terms of content. (G1R2_Interview, Pos.40)</i>
	<i>I always try to choose the tool that will hopefully bring me the best possible result. That's why I wouldn't just use VR because it's VR, or just draw because I can hold a pen better. Instead, I look at what I actually want to do and what I want to achieve. (G2R3_Interview, Pos.47)</i>
	<i>In fact, the task was great for that. Especially if you want to visualize something, build prototypes, or do design sprints [...]. (G1R3_Interview, Pos.53)</i>
	<i>Another context in which I couldn't imagine it would be under massive time pressure. (G2R2_Interview, Pos.55)</i>
	<i>I would plan short sessions, just as you did. Rather, several sessions in a row than one long session. This way, it is divided and people have breaks in between to recover. (G2R3_Interview, Pos.60)</i>
NEW: Room Set-up	<i>This boundless freedom and unlimited possibilities, if played as an advantage, could actually be a hindrance or limitation when one needs to work in an incredibly organized or structured manner. (G1R3_Interview, Pos.56)</i>
	<i>It would have been really helpful for me if there had been some sort of blank gallery walk. (G1R2_Interview, Pos.10)</i>
	<i>[...] whether that be through floor markings or pre-drawn frames, so that the initial process could be roughly represented in the virtual space. (G2R2_Interview, Pos.50)</i>
	<i>In this case, it would definitely be helpful [...] to have a tool onboarding again so that one knows exactly how each tool works. (G1R3_Interview, Pos.53)</i>

Team Creativity Input Variables	
Variables	Quote
NEW: Tool Training	<i>I would also suggest conducting a comprehensive training session in this space,[...] so that everyone can get comfortable and understand the functions of the tools. (G2R2_Interview, Pos.50)</i>

Appendix 6: Selected Interview Quotes for the Analysis of Team Creativity Process Variables

Team Creativity Process Variables	
Variables	Quote
Collaboration	
Psycho- logical Safety	<i>It does not claim to be perfect, simply due to the movement and everything else, but you feel much freer than when you have to bring it onto white paper or into two-dimensionality, which can be more difficult. (G1R1_Interview, Pos.14)</i>
	<i>It rather caused me to find a very relaxed approach with the others and somehow feel like we were in a playful setting. A setting where we can try things out and everyone also has some desire to step out of their role and let loose. (G1R2_Interview, Pos.18)</i>
	<i>I actually really like all my colleagues and it was already a familiar environment. [...] I also immediately recognized them in the virtual space. We can also hear each other, so it was actually like working in a familiar environment. (G1R3_Interview, Pos.33)</i>
	<i>We talked less about ‚I can’t read that?’ or ‚How do we organize that now?’ Instead, we decided to work together on something and see what comes out in the end. I may have used a different color or done something else, but it’s really cool how it turned out. We were also surprised by what the others did. (G2R3_Interview, Pos.19)</i>
	<i>Most of all, I was wondering what the other two were doing during that time? Because if we all worked on it together, it would look terrible in the end. [...] But when we started doing it, suddenly everyone had their place and contribution to work on it together. [...] I ended up enjoying creating something together. (G2R1_Interview, Pos.48)</i>
Task Orientation _Ideation	<i>G1R1, I would say, took on a bit of the facilitating leadership role, also in the task, and did a good job leading us through it. (G1R3_Interview, Pos.5)</i>
	<i>That was very unusual and unnecessarily complicated things. Actually, a brainstorming session is a quick process and we got hung up on reading it. [...] We had a small brainstorming session with just a few points that we collected. It was still manageable to remember them all. But if there were more ideas and we couldn't properly organize them, [...] such as moving things around, sorting them, or giving them headings, it would become difficult. (G2R3_Interview, Pos.9)</i>
Task Orientation _Select	<i>I think we quickly found some common ground and agreed on what we chose. [...] But even in that step, we wrote it down, checked it, and marked it exactly. (G1R3_Interview, Pos.13)</i>
	<i>We quickly agreed on points or questioned them again. It went well and progressed quickly. (G2R3_Interview, Pos.27)</i>
Task Orientation _Prototype	<i>Then we had the last 15 minutes, where we had to prototype and knew: "Now we have to make decisions, done and done." Then we quickly drew our Dottie. (G1R1_Interview, Pos.15)</i>
	<i>The tool worked better already, because it was about visualizing things. (G2R3_Interview, Pos.14)</i>
	<i>Just through this space and the various brushes that you can use, I think we succeeded very quickly in visualizing a prototype as we actually wanted it. I think it's actually easier than with a paper. (G1R1_Interview, Pos.23)</i>

Team Creativity Process Variables	
Variables	Quote
	<i>There are also tons of different brushes, strokes, colors, textures, and things like that that you can use. I had the feeling that we had fun trying out these different features and seeing what else was there. At least in our case, experimenting like that also served our end result. That's why I thought it worked well. (G2R1_Interview, Pos.19)</i>
	<i>But yes, we didn't focus on one purpose, but due to the numerous possibilities of Tilt Brush, we also included numerous features in the prototype. (G2R2_Interview, Pos.30)</i>
Learning Curve	<i>[...]and for that, it must be said that considering we used a completely new environment, a new tool, it was surprisingly good and fast. (G1R3_Interview, Pos.54)</i>
	<i>We also worked better together in each round - also with the technology. (G2R3_Interview, Pos.16)</i>
	<i>This uncertainty, as long as you don't feel completely nauseous or uncomfortable, actually has great potential for bringing people together. (G1R2_Interview, Pos.42)</i>
	<i>Otherwise, I think you just need a minute to try something out. [...] That's why we became more and more creative and confident over time. (G2R2_Interview, Pos.56)</i>
	<i>I was really amazed at how quickly we got the hang of it and actually got used to it. That's why I thought it was pretty cool, especially for this fast type of work. (G1R1_Interview, Pos.25)</i>
	<i>I also had the feeling that from one session to the next, we got better and faster at using the tool. This led to faster feelings of success because certain things were already much more automatic the second time around. (G2R3_Interview, Pos.60)</i>
	<i>At the end of the second phase, it was the first time we used these features that can be used to make things move or change color in the room, even as we were writing things down. (G2R1_Interview, Pos.7)</i>
Communication	
Avatar – non-verbal communication	<i>So for creativity, you only had these characters, which also didn't have facial expressions, and at the same time only the different brushes. (G2R2_Interview, Pos.7)</i>
	<i>What was also funny and exciting for me was that you could create your own avatar. [...] For example, he created a pretty funny character, with attributes that I found funny and then made everything he did funny too. Of course, this can quickly become ridiculous, so that you can no longer concentrate well, but it inspired me more. (G1R2_Interview, Pos.17)</i>
	<i>I actually looked at people less, these avatars were more like representatives: Where are you standing? They didn't have any gestures or facial expressions in that sense. (G1R1_Interview, Pos.38)</i>
	<i>G1R1 actually verbalized what he was doing and working on the whole time, that reminds me now again. For me, there was actually no disconnect between text and image, which may not be the right term for it. But what his avatar was doing, I could make sense of because I could also hear him speak and could better contextualize it. With G1R3, I often didn't know exactly what he was doing. What is he looking at now? What is he actually thinking? What is he working on? (G1R2_Interview, Pos.20)</i>
	<i>But we had a visual anchoring of things here. That means we had things that we looked at together. I just didn't see practically what you were looking at. (G2R1_Interview, Pos.56)</i>
	<i>It's kind of weird not being able to see the facial expressions of others or what they're currently doing, what they're looking at specifically. (G2R1_Muralboard)</i>
Sharing of Information, Knowledge & Ideas –	<i>But here too, I think that a communication level was missing for creativity in teams. [...] Or a bit more pre-defined roles or something like that, some kind of structure and continuity, or some kind of communication that would be integrated. (G2R2_Interview, Pos.7)</i>
	<i>It wouldn't be possible in a normal workshop setting to come to such a result without an explanation, but in the virtual space, it is all the more important that you name even the most obvious things very precisely. What am I doing right now? (G1R2_Interview, Pos.21)</i>

Team Creativity Process Variables	
Variables	Quote
verbal communication	<i>This lack of orientation in the space needs to be compensated for by a lot of communication. (G1R2_Interview, Pos.48)</i>
	<i>We all had the same visual experience. So it's not like we didn't use the digital or virtual space at all. We simply worked with our voices. (G2R2_Interview, Pos.25)</i>
	<i>I really listened closely to the voice and concentrated on it, which I didn't find too bad, actually. [...] I wouldn't say that it was bad not to feel someone's facial expressions and gestures. (G1R1_Interview, Pos.28)</i>
	<i>I noticed this very strongly, because we weren't quite satisfied with the technology, so the three of us automatically avoided using the technology properly. Instead, we spoke more. (G2R3_Interview, Pos.10)</i>
	<i>This is the case in a drawing process like this, when you have a thought that is similar to brainstorming. In that moment, it counts that you put it out there and bring it up again. That was an option through this environment, through this tool, to do it simultaneously. (G1R3_Interview, Pos.20)</i>
Perceived proximity	<i>That's why it was also very nice, and for me, the two of them were always clearly visible in the 3D space. (G1R3_Interview, Pos.5)</i>
	<i>What made it a bit challenging, though, was that we had to keep moving back and forth to get closer to the other person and do it well. Balancing not standing on or in the person or standing directly in front of their eyes. (G2R3_Interview, Pos.7)</i>
	<i>You have to first try to find your way in the virtual space and also understand where my fellow players are. They don't necessarily stand as far away from me as their voices sound. In this case, we were all in the same room. G1R3 was physically further away from me, for example, but in the virtual space, he was very close to me. (G1R2_Interview, Pos.7)</i>
	<i>We didn't have microphones and spoke at live volume. We still stood far apart from each other, and I found it easier to listen closely, probably also from the brain's perspective, when my avatar was physically closer to the person, even though it wasn't necessary. Through this, I felt like we were working together more closely when our avatars also came physically closer together. (G2R3_Interview, Pos.8)</i>
Effects on Body and Mind	
Effects on Body Mind (Cognitive Overload and Motion Sickness)	<i>After the given time, my energy was also a bit depleted. I don't think I could have worked much longer or more complex. (G1R2_Interview, Pos.37)</i>
	<i>I would describe myself as a very curious and open-minded person, but I have noticed that it is quite interesting that the cognitive capacity is strongly demanded and that it takes a lot of energy. (G1R2_Interview, Pos.4)</i>
	<i>What I remember most is that at one point it was physically very exhausting for me, [...] (G1R2_Interview, Pos.5)</i>
	<i>„Things appeared to close and narrowed when working jointly on it which caused a bit of claustrophobic feeling within this endless space“ (G2R3_Muralboard)</i>
	<i>I always find it impressive how quickly one gets used to such an environment, both physically and mentally. (G1R1_Interview, Pos.5)</i>
	<i>I mean, I've worn a VR headset before. I'm probably somewhat used to it. (G1R3_Interview, Pos.15)</i>

Appendix 7: Selected Interview Quotes for the Analysis of Team Creativity Output Variables

Team Creativity Output Variables	
Variables	Quote
Applicability	<i>At least we now have a mascot there. Some things are still missing, [...] but at least having a shared idea of what it could look like is already helpful. (G2R1_Interview, Pos.32)</i>
	<i>I would have added an analog workshop part after this session to continue working on the parts that were developed. (G1R2_Interview, Pos.34)</i>
	<i>The prototype is great in its basic idea. Perhaps the specific characteristics [...] should be highlighted and these characteristics should be focused on again. [...] Nevertheless, I think that the colorful aspect is something that fits very well with such a business-unusual context. (G2R2_Interview, Pos.38)</i>
	<i>For the very short time, it was an acceptable result that could be filled with content - why and what it represents. Potentially, a high-resolution prototype could even be developed. (G2R3_Interview, Pos.35)</i>
	<i>Something like this could actually be tested and evaluated to see if it works in the analog space, on the avatar, mirrored in the greenhouse, only takes place virtually, or if it is included in printed materials like a logo. (G2R3_Interview, Pos.38)</i>
Novelty	<i>And just the feeling alone that this world is not real, but rather some kind of digital world where anything is possible, makes one much freer, or indeed more unrestricted, to live wild ideas. [...] And often, it's only through crazy ideas that brilliant ideas come about. (G1R1_Interview, Pos.19)</i>
	<i>To elaborate on this, I'm sure that this octopus wouldn't have been created on a normal, real drawing board. (G1R3_Interview, Pos.16)</i>
	<i>If we had created the prototype on the wall in real life, I don't think we would have come up with the idea that soap bubbles had to rise or something like that. (G2R1_Interview, Pos.37)</i>
	<i>In any case, one is creatively influenced by what one has and achieves more than if one had to build something new all alone. One would probably have less confidence or imagination. (G2R3_Interview, Pos.16)</i>
	<i>Just such a collaborative work, that afterwards you stood proudly in front of this object, like a work of art. (G1R3_Interview, Pos.41)</i>
Results worth effort	<i>Just through this space and these different brushes, [...], we were able to quickly visualize a prototype the way we wanted it to be. I think it's actually easier than doing it on paper. (G1R1_Interview, Pos.23)</i>
	<i>Maybe it even takes a bit of the demand for perfectionism away, as I already mentioned with painting and prototyping. Maybe it actually puts more focus on doing and creativity than on perfection. But I would say that at least for prototyping, I already see added value from the tool. (G2R1_Interview, Pos.35)</i>
	<i>My theory would be that the fun factor was simply higher there. [...] But I don't think the creativity of the result was necessarily much more exciting than the result we would have gotten otherwise. (G1R2_Interview, Pos.5)</i>
	<i>But whether we actually got the maximum out of what our prototype could have been – I doubt it. (G2R3_Interview, Pos.17)</i>

Appendix 8: Selected Interview Quotes for the Analysis of Application Areas

Application Areas	
Variables	Quote
Output-driven Tasks	
Visualiza- tion	<i>I would actually use it more for visual things. Where you want to draw something or visually represent something to a group. (G1R2_Interview, Pos.61)</i>
	<i>But at least for everything that is of a size comparable to the human body, it can certainly be used well. (G2R3_Interview, Pos.61)</i>
Prototy- ping & Testing	<i>But if you only refer to the tool, [...] then I would say that it works extremely well in the last two phases of design thinking. (G1R1_Interview, Pos.62)</i>
	<i>[...] prototyping or testing, showing people what you have, I find it extremely powerful, I have to say. (G1R1_Interview, Pos.72)</i>
	<i>I could imagine it for simple prototypes. [...] Of course, if you know that it should be an object and have people who can draw well, [...] (G2R3_Interview, Pos.45)</i>
	<i>That would also be exciting for prototypes or certain things, that you can convey the feeling to people, which otherwise you can only achieve with a lot of role-playing. Imagine being able to tell a story, putting them in there and suddenly they have the feeling. That is a completely different level that otherwise could not be achieved so easily. (G2R3_Interview, Pos.52)</i>
Ideation & Problem Analysis	<i>But not for collecting ideas or analyzing problems. (G2R3_Interview, Pos.61)</i>
	<i>As a possibility for ideation, I didn't find it very helpful. More hindering and delaying. (G2R3_Interview, Pos.45)</i>
	<i>[...] for example, if a team is supposed to work on problem-solving. [...] Maybe even for topics that cannot be easily represented visually. To cope with complexity, I would probably only work with text, less with images. (G1R2_Interview, Pos.39)</i>
Human-centered Tasks	
Creativity and Innovation Mindset	<i>So, as I said, for small exploratory things, to bring in a different context and get people out of their comfort zone a bit. For people who are mainly afraid of prototyping or afraid to visualize, I can imagine it relatively well because you don't have the worry of the blank page. (G1R1_Interview, Pos.72)</i>
	<i>For working on content, as a small creative session, or perhaps to get into the mode of thinking out of the box together [...]. (G1R2_Interview, Pos.44)</i>
	<i>I would do it if not everyone were present in the physical room or if, for example, we had a completely uncreative environment. (G2R2_Interview, Pos.49)</i>
Warm-up & Energizer	<i>I could imagine this very well as a warmup or energizer, in a context where the outcome is not that important. [...] More as a playful element and maybe also for getting to know each other. [...] One can first show with the avatar how one would like to present oneself, [...] with all kinds of attributes. (G1R2_Interview, Pos.44)</i>
Team Building	<i>I could imagine it well in the context of getting to know each other better as a team and building trust. I think it can be quite exciting as a trust-building exercise because everyone has to let go of any etiquette or behavior they might have, as everyone feels awkward and insecure. [...] In the sense of, "We're all facing the same problem right now, that we're in a setting we don't know. How can we support each other and tackle this together to have a great experience?" It has great potential for that, also because it's a bit crazy. You feel like you're in a video game or at least not in a work setting. (G1R2_Interview, Pos.42)</i>