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Beyond Media Comparison: Investigating *When* and *How* Learning with Augmented and Virtual Reality Works

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Editorial
Beyond Media Comparison: Investigating When and How Learning with Augmented and Virtual Reality Works

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At first glance, the imagery on the cover of a psychology journal dedicated to the subject of learning with augmented reality (AR) and virtual reality (VR) may seem odd, as it features apples and oranges. However, the choice of image is highly relevant given the main topic of this issue of Digital Psychology – comparative research designs where conditions cannot be accurately compared; the classic example of comparing apples to oranges (e.g. Castro-Alonso et al., 2016).

Although this problem has been widely recognized and extensively debated in educational (technology) research for over forty years (e.g. Clark, 1983; Kerres & Buchner, 2022; Lockee et al., 1999; Reigeluth & Honebein, 2023; Warnick & Burbules, 2007), there is currently a need for action specifically for research on teaching and learning with AR and VR.

This became apparent through our research on AR as an educational technology (Buchner et al., 2022; Buchner & Kerres, 2023): Our systematic and critical reviews found that the research landscape is dominated by media comparisons and that theoretical assumptions are primarily used to justify these comparisons. For instance, learning with AR is primarily linked to the Cognitive Theory of Multimedia Learning or Cognitive Load Theory, but the control conditions did not differ in design principles pertaining to these theories. However, varying the design principles would be necessary to explore if the principles are also relevant when learning with AR (Buchner et al., 2022; Krüger & Bodemer, 2022). Furthermore, as research continues to demonstrate that AR can boost learners' motivation (e.g. Bacca et al., 2019), theory-based investigations considering this effect are needed. Such inquiry should incorporate other theories of digital learning like the Cognitive Affective Theory of Learning with Media (Park et al., 2014) or the Cognitive Affective Social Theory of Learning in Digital Environments (Schneider et al., 2021). Also, effects on learning outcomes beyond the cognitive domain merit more attention.

Similar findings have been reported in previous literature reflecting on research methodologies applied in educational VR studies. For instance, Parong and Mayer (2018) as well as Makransky and Petersen (2021), Glaser and Schmidt (2022), and more recently Lawson and Martella (2023) refer to the problem of media comparisons in IVR research. Specifically, the imbalance of experimental conditions is problematic. For instance, comparing a highly interactive VR application with the passive viewing of a video is, in fact, to compare two distinct learning activities, rather than to assess the learning impact of one form of media presentation versus another. Lawson and Martella (2023, p. 6) describe such obviously inferior control groups as strawman conditions.

It is evident that, four decades after the "Great Media Debate" (Sickel, 2019), there is again a requirement for a thorough, scientific discussion about research methods and study designs – here with a focus on educational AR and VR research. The aim of this special issue in the Digital Psychology journal is to contribute to this discussion.

All submissions were subject to a rigorous double-blind peer review process. The reviewers, including Peter Honebein, Stefan Siegel, Miriam Mulders, Jorge Bacca Acosta, and David Fernes, are greatly appreciated for their work.

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Following the review process, two manuscripts have been selected for publication in the special issue.

In the first contribution, an invited letter, Noah Glaser and Stephanie Moore provide an overview of the debate on the issues of media comparisons. They further elaborate on the challenges that these comparisons pose specifically for research on learning with AR/VR. Glaser and Moore (p. 5) argue that the significance of AR/VR for learning lies in the linking of media affordances with specific learning objectives. To support this claim, they cite studies on the development and testing of VR applications for autistic learners (e.g. Schmidt et al., 2023; Schmidt & Glaser, 2021). To move beyond media comparisons, the authors call for more meaningful research in the field of educational AR/VR. Such research should be characterized by Learner-Centeredness, Iterative Design and Refinement, and Integration of Pedagogy and Technology (p. 5).

The second contribution is a letter by Miriam Mulders. The paper first overviews research designs applied in educational technology research, followed by a critical reflection. Mulders notes that simplistic media comparison studies are unable to consider the complexity of learning. In exploring alternative research methods, including moderators and mediators as variables in experimental designs may facilitate a visualization of the complex learning process through AR/VR and also invalidate the unidirectional assumption of medium impact on learning outcomes. Further, according to Mulders (p. 9) it must be considered that establishing an adequate control condition in educational AR/VR research might be impossible. This accounts for learning situations, which are either too dangerous or too costly to conduct in real life. The letter concludes by highlighting that the complex research and analysis designs described in the article, for an example see Mulders (2023), can provide more meaningful information for both educational theory and practice compared to simple media comparison study designs.

Both contributions provide a critical reflection together with solutions to (possibly) overcome the media comparison problem. These solutions must be discussed within the research community to determine potential consequences for study designs.

The discussion generated by this special issue may aid in reducing the number of studies comparing AR/VR with so-called traditional media or teaching, and instead concentrate on learning, as suggested more broadly for technology-enhanced learning and teaching by Kirschner (2015).

This will require conducting theory-based studies on learning with AR and VR, including possible influencing factors in more complex study designs, exploring the interplay of media affordances and learning in iterative research approaches, and taking a closer look at the effects of how AR/VR affects multiple learning outcomes.

Josef Buchner
Guest Editor

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Conflict of interest

JB declares no conflict of interest

Invited Letter

Redefining Immersive Technology Research: Beyond Media Comparisons to Holistic Learning Approaches

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Highlights

(1) Media comparison studies on AR and VR raise questions about research methods and relevance, tracing back to historical and philosophical debates.
(2) The rise of immersive technologies like AR and VR complicates the evaluation of their educational efficacy, challenging traditional media comparison paradigms.
(3) A shift from technocentric research to understanding AR and VR's unique learning affordances is essential, emphasizing collaboration for transformative educational experiences.

Keywords: media comparison studies, virtual reality, augmented reality, media debate

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1 The Ongoing Debate of Media Comparison Studies in Instructional Design

The continued emphasis and publications on media comparison studies in the field of educational technology and instructional design is both surprising and puzzling. Historically, these studies have endeavored to gauge the effectiveness of one medium over another in the realm of learning. Examples include contrasting learning through video with virtual reality (e.g., Meyer et al., 2019), comparing face-to-face instruction to online environments (e.g., Levenber & Caspi, 2010), or evaluating comprehension differences between e-book readers and physical books (e.g., Schwabe et al., 2021). While such studies have been historically commonplace, one cannot help but question: In an age defined by rapid technological and pedagogical shifts, why is there a lingering attachment to a research methodology that is "plagued with … design issues" (Lockee et al., 1999, p. 33). It's time we prioritize more holistic research paradigms that address some of the significant shortcomings of media comparison studies.

2 Historical Context and Philosophical Underpinnings

The debate surrounding the utility and relevance of media comparison studies is multifaceted. For some, it's a matter of academic rigor and the pursuit of empirical evidence. For others, it's about understanding the historical and philosophical underpinnings of the field. Those deeply entrenched in instructional design and educational technology history recognize this debate isn't new but a continuation of discussions that have long shaped research and practice in the field. This history, spanning over a century, is filled with bold assertions, such as Edison's 1913 proclamation that films would soon supplant textbooks in classrooms (Reiser, 2001). Notable contributors to this ongoing dialogue include Grabowski (1989), Levie & Dickie (1973), Lockee et al. (2001), and Schultz (1988). As we delve deeper into the annals of this debate, a few pivotal moments and figures stand out, setting the stage for the foundational arguments in the field.

The seminal debate between Richard Clark (1983) and Robert Kozma (1991) serves as a touchstone in the ongoing discourse about the influence of media on learning, a topic that educators have explored since Thorndike's (1912) recommendation of pictures as instructional aids. Clark argued that media are mere vehicles for instruction, devoid of any direct influence on learning. Drawing on a meta-analysis of media comparison studies (e.g., Mielke, 1968), Clark concluded that media do not directly influence learning, famously likening media to delivery trucks, stating they "deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition" (1983, p. 445) Clark's stance was that the choice of medium might influence the cost or extent of distributing instruction, but only the content can influ-

ence achievement. He also presented rival hypotheses to explain instances where learner gains were observed, such as novelty effects for new media or differences in instructional methods.

In contrast, Kozma (1991) posited that unique symbol systems and processing capabilities of different media can complement learner characteristics to promote achievement. This stance emphasizes the intertwined relationship between medium and method and asserts that certain media attributes could foster unique cognitive processes in learners (Kozma, 1991). The debate didn't end there. Clark (1994) remained steadfast in his belief, challenging the idea of media attributes enhancing learning and emphasizing the replaceability of media. He maintained that it's the methods, not the medium, that influence learning. Kozma (1994), in the same year, reframed his argument, suggesting that the real question might be about the future potential of media to influence learning, given the rapid technological advancements introducing new symbol systems and processing capabilities.

Amidst this backdrop, Jonnassen and colleagues (1994) offered a new perspective that shifted the focus from the binary nature of the debate. Instead of viewing the issue through the lens of the media's direct influence on learning, they brought in the concept of complexity theory. They argued that learning environments are multifaceted, with numerous interacting variables and that trying to isolate the impact of a single factor, such as media, amidst this complexity might be an oversimplification. This perspective emphasized the need to understand the myriad of factors at play and how they interact, rather than attempting to attribute learning outcomes to a single variable. This perspective challenged researchers to embrace the inherent complexity of instructional design and recognize learning as a multifaceted phenomenon influenced by numerous factors. Importantly, this perspective underscores the idea that because learning is so complex, media comparison studies, which often fail to account for these myriad variables, are inherently flawed. This complexity can readily be seen, for example, in online and blended learning research where Means et al. (2014) identified nine dimensions with 33 variables across the literature.

3 The Challenge of Immersive Technologies and Media Comparisons

The advent of immersive technologies, such as virtual reality (VR), simulations, games, augmented reality, and more, has introduced a new layer of complexity to the educational landscape (Kimmons, 2020). These technologies, with their potential for creating deeply immersive and interactive learning experiences, challenge our traditional notions of media (Dede, 2009). However, the literature often fails to capture the nuanced differences and the multifaceted nature of these technologies (e.g, Glaser & Schmidt, 2022).

For instance, the term VR is frequently misused and misunderstood in academic literature (Girvan, 2018). It's a term that can encompass a wide range of experiences, from desktop-based 3D interfaces like *Second Life* to 360-degree videos, both in and out of headsets. There are CAVE projector systems, fully immersive 3D worlds experienced through headsets, and a myriad of combinations of software and hardware that fall under the VR umbrella (Bamodu & Ye, 2013). The same is true for other immersive technologies including, but not limited to augmented reality technologies (Edwards-Stewart et al., 2016). Yet, many researchers tend to paint all these diverse experiences with the same broad brush, leading to overgeneralizations (see Glaser & Schmidt, 2022 for examples). Such generalizations are not just academic oversights; they have real-world implications. When a study labels a system as VR, even when it doesn't align with contemporary definitions or when the technology has evolved significantly since the study's publication, it can mislead practitioners and educators. They might adopt or invest in technologies based on outdated or misinterpreted research findings, leading to suboptimal learning experiences for students.

4 Why does it matter?

Consider the example of VR surgery simulations. Some are desktop-based, where a medical student operates via a keyboard and mouse. This leads to an intriguing question: Which surgeon would you rather have operate on you? One who trained for the surgery using a desktop-based system or one who trained using a fully immersive VR system, designed in alignment with the learning needs, offering full congruency of motion and interaction fidelity? At first glance, the preference might lean towards the latter. However, the essence of this illustration isn't to champion one technology over another, but to underscore the importance of aligning a technology's affordances with the learning objectives. The emphasis here is on the thoughtful selection of tools that best serve the learning goals. If a technology, regardless of its sophistication, doesn't resonate with the learning objectives (precise motor skills should not be simplified to a press of a button on a keyboard), its integration might not yield the desired outcomes. The question of whether VR 'works' transcends a mere evaluation of the technology's efficacy. It delves into the realm of how the design of the VR experience can be tailored to support the learner and the intended learning outcomes (see Schmidt & Glaser, 2021).

Furthermore, when researchers conduct media comparison studies involving immersive technologies, they often overlook or fail to report critical design considerations and contextual details. The unique affordances of XR systems, both in terms of software and hardware, play a pivotal role in the learning experience. Yet, many studies don't detail how these affordances are being intentionally designed for and aligned with specific learning goals. This omission is a significant gap, as the intentional design of technology to leverage its unique affordances is crucial for optimizing learning outcomes. In essence, while immersive technologies hold immense promise for revolutionizing

education, the current state of research often falls short. To truly harness the potential of these technologies, researchers need to adopt a more nuanced, detailed, and critical approach, moving beyond overgeneralizations and towards a deeper understanding of the intricate interplay between technology, design, and learning (see Glaser & Schmidt, 2021).

This understanding brings to light an urgent need for clarity and precision in how researchers present their methodologies and findings. Addressing this challenge means being meticulous in the Methods sections of their papers. Researchers should clearly define the type of media being used, avoiding umbrella terms without specific qualifiers. Comprehensive details about the hardware and software configurations are paramount. For instance, when referencing VR, it's essential to specify whether it's a CAVE projector system, a headset-based experience, or a desktop interface. The description should also capture how users interact with the media, detailing whether the VR experience is passive or interactive. Aligning terms or definitions with current academic and industry standards is crucial, and proper citations that outline the term are necessary. If a term's meaning has evolved, specifying the version or iteration being referred to becomes essential. Adhering to these guidelines ensures that findings are contextualized accurately, paving the way for the academic community and practitioners to make informed decisions.

5 A Call for Meaningful Research

The persistence of media comparison studies in the face of their evident limitations (see Buchner & Kerres, 2023 for a critical review of augmented reality in education research) begs the question: If not these studies, then what should be our research focus? The answer lies not in the abandonment of research but in its evolution (Reeves & Lin, 2020). We must transition from a narrow, technocentric approach that seeks to merely "prove" the efficacy of a medium to a more holistic perspective that aims to 'improve' learning experiences by harnessing the unique affordances of different media (Reigeluth & Honebein, 2023).

In this context, "meaningful research" can be defined as research that not only evaluates the efficacy of educational tools and methods but also seeks to understand and enhance the learning experience in a comprehensive manner (Reigeluth & Honebein, 2023). While perhaps not fully comprehensive, we believe that three defining characteristics of meaningful research are:

1. **Learner-Centeredness**: Meaningful research prioritizes the needs, preferences, and contexts of learners. It goes beyond mere technological evaluations to understand how learners interact with, perceive, and benefit from educational interventions.
2. **Iterative Design and Refinement:** Instead of static, one-off studies, meaningful research embraces an iterative approach. It acknowledges that educational tools and methods can and should be refined based on feedback, results, and changing contexts.
3. **Integration of Pedagogy and Technology:** Rather than isolating technology from pedagogy, meaningful research examines how the two can be synergistically combined. It explores how technological affordances can be leveraged to support and enhance pedagogical goals.

Accomplishing meaningful research in this area involves recognizing and harnessing the unique affordances of different media, as highlighted in the thought experiment between Reigeluth and Honebein (2023). For instance, the motion inherent in video might be particularly effective for teaching tasks that involve movement. Similarly, as previously discussed, consider the example of VR surgery simulations. The distinction between a desktop-based system and a fully immersive VR system isn't merely about the technology itself but how it's designed and applied. The real inquiry should be about how the design of the VR experience supports the learner and the intended learning outcomes. This perspective underscores the importance of media affordances and their alignment with specific learning objectives. This shift necessitates a deeper understanding of the intricate dance between technology and pedagogy. It's not enough to ask if one medium is "better" than another. Instead, we should be asking how we can design learning experiences that leverage the strengths of each medium to meet specific learning objectives. It's about recognizing the potential of technology, not as an end unto itself to be studied but as an important variable in addressing complex learning problems and needs (Reeves & Lin, 2020).

For a comprehensive understanding of this methodology in action, readers are directed to the 'Virtuoso VR' intervention, specifically tailored for autistic adults. This intervention's depth and efficacy have been meticulously explored in a series of studies, notably by Schmidt and colleagues (Schmidt et al., 2019; Schmidt & Glaser, 2021a, 2021b; Schmidt et al., 2023). These studies predominantly employed a design-based research (DBR) approach. DBR is pivotal as it emphasizes iterative design, real-world testing, and continuous refinement based on empirical evidence (McKenney & Reeves, 2020). This approach inherently aligns with our earlier discussions about the importance of selecting tools that best serve learning goals. By focusing on the real-world application and continuous improvement of interventions, DBR ensures that the chosen technology or medium is not only effective but also evolves in response to learners' needs and feedback. The insights and findings from this approach, which inherently prioritizes the alignment of technology's affordances with learning objectives, have been further elaborated upon by Glaser and associates (Glaser et al., 2021, 2022).

6 Final Thoughts

As we venture into this new research paradigm, we must be wary of falling into old traps. Examples of these traps include over-reliance on novelty effects, where the initial excitement of a new technology boosts engagement but doesn't lead to sustained learning (Miguel-Alonso et al., 2023); the assumption that more technologically advanced tools automatically equate to better learning outcomes; and the tendency to implement technology without adequate training or support for educators, leading to suboptimal usage (Emre, 2019). The allure of new technologies can be seductive, leading researchers to make grand technocentric claims about their potential. But as history has shown, from Edison's films to modern VR, technology alone is not a panacea. Its true value lies in how it's integrated into the broader educational ecosystem, informed by sound pedagogical principles and tailored to the unique needs and contexts of learners.

In this light, the call for meaningful research is also a call for collaboration. Instructional designers, educators, technologists, and learners must come together, pooling their expertise to co-create learning experiences that are not just effective but also meaningful, engaging, and transformative. It's about moving beyond the binary of "this versus that" and embracing a more integrative, synergistic approach to educational research and practice.

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Statements and declarations

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Confounding in Educational Research: A Critical Overview of Research Approaches Investigating Virtual and Augmented Reality

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Highlights

(1) Media comparison studies are often confounded because relevant factors of the learning scenario are not considered.
(2) Media comparison studies would be more meaningful if the conditions during investigations were standardized, and additional moderator and mediator variables were incorporated into the experimental design.
(3) Other research approaches, e.g., value added studies, may offer insights relevant to educational practice.

Keywords: Virtual Reality, Augmented Reality, Media Comparison, Confounding, Research Approaches

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1 Introduction

Despite considerable evidence in research that Virtual and Augmented Reality (VR/AR) enhances learning (e.g., Arici et al., 2019; Radianti et al., 2020), an argument is presented that most of this research is confounded. Wherever VR and AR are used to deliver competencies and are at the same time compared to conventional educational presentation forms, any resulting change in learning or performance may be attributed to the uncontrolled effects, e.g., of different instructional methods or content, if these are not controlled systematically. Typically, those studies, known as media comparison studies (e.g., Mayer, 2019), are focusing on the question *if* learning with VR or AR works and *if* it is better compared other presentations, and do not examine *when* and *how* learning with VR and AR works (e.g., Buchner & Kerres, 2023; Makransky & Petersen, 2021).

Within this comment, the research question to be addressed is which research approaches are currently examining the effectiveness of VR/AR learning applications. Thus, the aim is to give an overview of different types of research approaches, including media comparison studies, and discuss their relevance for educational research. The comment concludes by summarizing the findings for future research with VR and AR and providing recommendations.

2 Types of Media Comparison Studies

Based on a theoretical background, the definition of research questions and hypotheses, and the operationalization of research constructs, educational researchers aim to use several research approaches to conduct investigations, collect, analyze, and synthesize data with reference back to their questions and hypotheses. Regardless of whether a researcher chooses qualitative or quantitative research methods, there are different research approaches in the field of educational technologies. Clark (2014) suggests four approaches to educational research. For VR and AR, further research approaches are distinguished (see Table 1).

3 Limitations of Media Comparison Studies

Media comparison studies are prevalent. A systematic review analyzing studies using AR from high-quality journals revealed that 80% of the studies compare AR to another medium or technology (Buchner & Kerres, 2023). However, in media comparison studies, there is often a risk that relevant parameters of the learning setting are not considered. Contrary, theoretical models that describe learning with AR and VR are complex in design and consider multicausal relationships (e.g., Dengel & Mägdefrau, 2020; Makransky & Petersen, 2021; Mulders et al., 2020). The effects of learning environments, teacher behavior, instruc-

Table 1. Overview of research approaches towards AR/VR.

Research approach	Description with an AR or VR example
Evaluative approach	VR/AR vs. no VR/AR: Students explore a VR/AR simulation and rate its efficacy (before and) after the exploration. There is no control group. *Example:* The effectiveness of a VR simulation on behavior in emergency situations (e.g., fire) is evaluated by aspiring paramedics.
Media comparison approach (type 1)	VR/AR vs. conventional presentation: Randomly assigned students learn something using either an VR/AR simulation or a conventional presentation form. *Example:* Aspiring paramedics learn how to behave in emergency situations (e.g., fire). Half of them receive a written manual, the other half use a VR simulation.
Media comparison approach (type 2)	VR/AR technology 1 vs. VR/AR technology 2: Randomly assigned students learn something using either the VR/AR technology form 1 or the VR/AR technology form 2. *Example:* Aspiring paramedics learn how to behave in emergency situations (e.g., fire). Half of them use the 360° application on a laptop, the other half use Head-Mounted Displays to explore a VR simulation.
Value added approach	VR/AR without generative learning activities vs. VR/AR with generative learning activities: Before, during or after a VR/AR experience, half of the randomly assigned students perform an additional learning activity, the other half perform no activity. *Example:* Half of the students will be given an assignment to create a to-do list after exploring a VR training for emergency situations, the other half will not be given an assignment.
Interactional approach	VR/AR target group 1 vs. VR/AR target group 2: A VR/AR simulation is used with different target groups. *Example:* VR training for emergency situations (e.g., fire) is explored by trainees either at the beginning or end of paramedic training.
Unique affordance approach	VR/AR vs. no VR/AR: Students explore a VR/AR simulation and rate its efficacy. There is no control group. Conventional presentation forms are not available. *Example:* The effectiveness of a VR simulation on behavior in emergency situations (e.g., fire) is evaluated by aspiring paramedics. Conventional teaching methods (e.g., a real large-scale fire in a controlled setting) cannot be used to present the situation, because it is too dangerous and expensive.

tional methods etc. are explained theoretically. However, media comparison studies fail to operationalize this complexity into an appropriate empirical design.

In addition, media comparison studies run the risk of confounding: To be able to clearly attribute learning effects to the manipulation of the media presentation, the other conditions must be kept equal during the investigation. Often, however, the conditions during an investigation differ not only with respect to the medial presentation, but also with respect to the instructional methods, the teacher, or the content. For example, a VR environment in which a single aspiring paramedic learns how to behave in case of fire differs from a group work of several trainees in which the behavioral steps in case of fire are to be put in the correct order, not only regarding the medial presentation, but obviously also regarding the social setting. Hence, differences in learning are not clearly caused by the manipulation of the media presentation but may also be due to the different social setting.

Laboratory studies make it easier to standardize conditions during an investigation and usually eliminate confounding variables, but they have limited generalizability and are not close to educational practice. Field studies are prevalent in educational research but make it nearly impossible to keep all conditions the same except for the manipulation of media presentation. Whether laboratory or field research, it is recommended that experimental conditions be standardized as much as possible in media comparison studies (Shaughnessy et al., 2000).

One way to reflect the complexity of learning scenarios more adequately than it happen in media comparison studies is to integrate moderator and mediator variables into the experimental design (as suggested in several theoretical models towards VR and AR, e.g., Makransky & Petersen, 2021). Regarding VR and AR, possible mediators are latent processes that happen during a VR or AR experience. One of these processes may be the feeling of presence (Mikropoulos, 2006), another one cognitive load (Makransky & Petersen, 2021). Moderating effects can be expected, for example, from the learners' prior knowledge (Taçgın, 2020). Figure 1 shows how experimental designs, known from media comparison studies, can be supplemented with moderating and mediating variables.

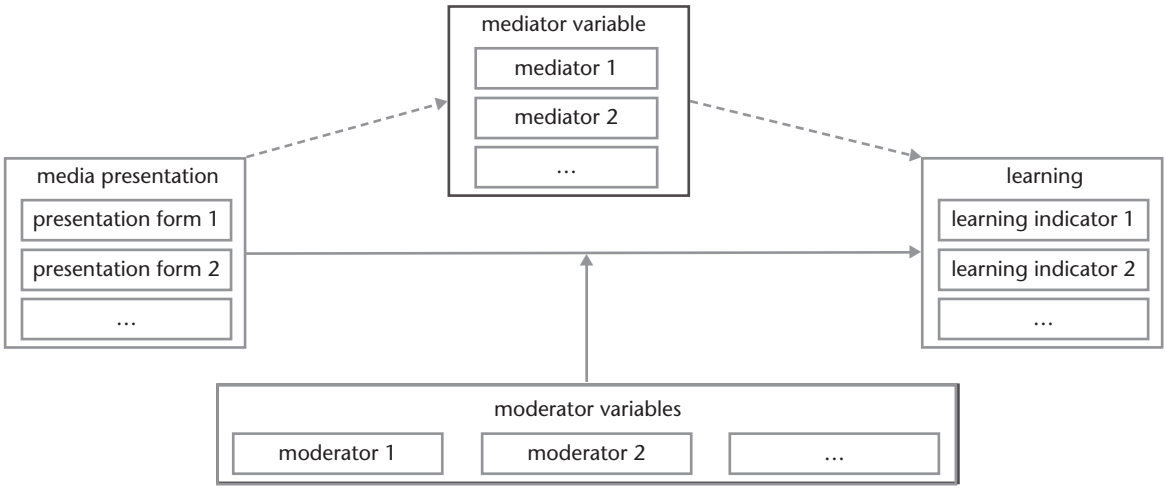

Figure 1. An experimental design beyond media comparisons (based on Mulders, 2023).

Due to the criticism of media comparison studies, other research approaches seem beneficial. Using value added and interactional approaches, further independent variables are integrated into the experimental design and are manipulated systematically (see Figure 2). Such approaches can provide recommendations relevant to educational practice. Klingenberg et al. (2022), for example, investigated the effectiveness of additional learning activities, as segmentation or summarization after a VR experience. Results indicated that, compared to the control condition, adding segmentation or summarization leads to better transfer, but not to acquiring more factual knowledge.

4 Conclusion

Taken together, VR and AR are two contemporary technologies arousing great interest in educational research and practice. However, a perspective focused solely on the technology fails to provide evidence of the effects of VR and AR. Hence, other research approaches are needed to test the potential and limits of the use of VR and AR in educational settings. More complex research approaches are indicated that go beyond the unidirectional effects of media presentation forms. For example, the studies by Parong and Mayer (2021), Petersen et al. (2022) as

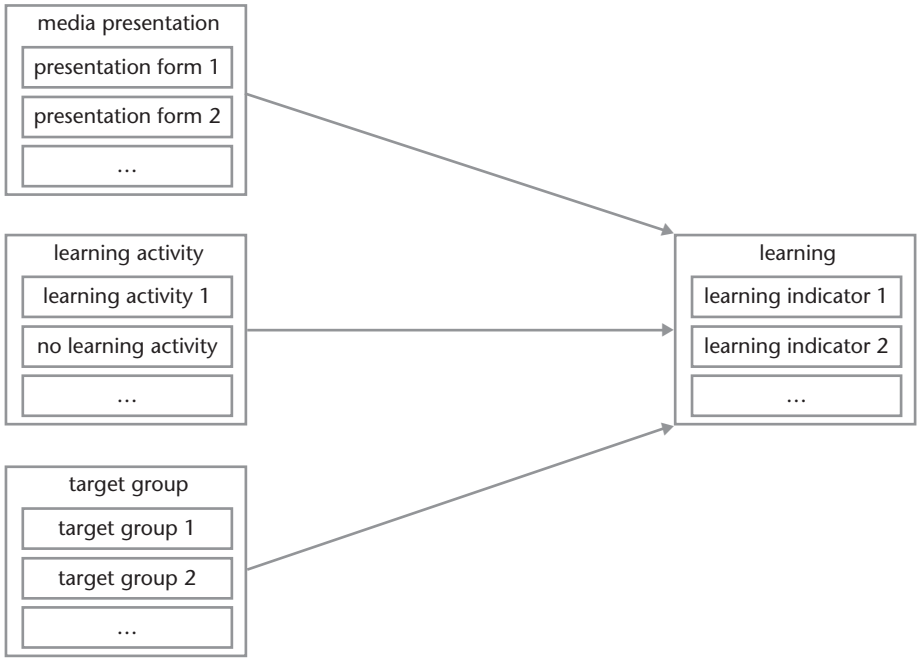

Figure 2. An experimental design beyond media comparisons.

Note. Interactions between the independent variables are not displayed in the presentation, nevertheless they are scientifically interesting to observe.

well as Johnson-Glenberg et al. (2021) exemplify how the integration of additional variables significantly enhances the validity of these studies. Such approaches make it possible to better describe the quality of learning experiences in VR and AR or to make practically relevant recommendations for the use of generative learning activities.

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Call for Papers

Exploring Virtual Nature: Immersion, Duration, and Therapeutic Applications

Guest Editor

Thiemo Knaust, M.Sc. (thiemo1knaust@bundeswehr.org)

Virtual natural environments have emerged as a promising avenue in the field of digital psychology, offering novel opportunities to harness the positive impact of nature on human well-being. While the restorative effects of nature are widely acknowledged, accessibility to real natural settings is often constrained. Virtual representations of natural environments, ranging from highly immersive 6DoF Head-Mounted Displays (HMDs) delivering computer-generated 3D nature videos to less immersive formats, have gained significant attention. From single-session interventions to more frequent and extended VR nature exposure, foundational research has made significant contributions to this field.

However, there remains a significant gap in understanding the utilization of virtual natural environments in clinical practice, especially for patients with stress-related mental health conditions. Furthermore, questions persist regarding the ideal level of immersion, the dose-response relationship, and the practical integration of these interventions within clinical settings.

In light of these considerations, we invite submissions for this special issue of Digital Psychology, which focuses on Virtual Natural Environments. This issue aims to systematically investigate the mood-enhancing and relaxation effects of virtual natural environments presented through varying levels of immersion, durations of exposure (single-use or extended), and their influence on both self-reported and psychophysiological parameters. We are particularly interested in research that investigates how clinical populations perceive immersive nature experiences, whether patients are inclined to utilize virtual nature, and the potential for integrating these interventions into therapeutic contexts.

Types of Papers

We seek original papers, Letters and Commentaries are also welcome. For eligible manuscript categories see the *Digital Psychology* author guidelines.

Topics of Interest Include (but are not limited to):

- Assessing mood-enhancing and relaxation effects of virtual natural environments.
- The impact of immersion levels on the user experience and therapeutic outcomes.
- Dose-response relationships in virtual nature interventions.
- Implementation potential in clinical practice.
- Preferences and perceptions of virtual natural environments among clinical populations.
- Innovative technologies and methodologies for delivering virtual natural environments.

Submission Guidelines

Authors are invited to submit original research papers, reviews, and innovative contributions related to the above topics. Papers should be submitted through the *Digital Psychology* website, clearly indicating that the submission is intended for the "Virtual Natural Environments" Special Issue in the Comments to the Editor field.

For detailed submission instructions and manuscript guidelines, please refer to the Digital Psychology submission guidelines.

Contact

For inquiries or further information, please contact the Guest Editor, Thiemo Knaust (thiemo1knaust@bundeswehr.org)

We look forward to receiving your submissions and exploring the transformative potential of virtual natural environments in the field of digital psychology.

Deadlines

Submission of Papers: June, 1st 2024
Expected Publication: October 2024

Publication Fee – Option for Open Access Publication

No publication fee is applicable for standard submissions to this Special Issue. However, authors have the option to request open-access publication of their accepted articles, for which a publication fee of € 349,- per article is applicable.

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Original articles include original empirical research, and are not to exceed 4.500 words including the reference list and a 250 word abstract. If the original article includes clinical trials (e.g. RCTs), it should be registered in an official trial register, authors should report the registration number and database. RCTs should follow CONSORT guidelines (incl. CONSORT checklist and flow diagram). See http://www.consort-statement.org for according guidelines and forms. An original article may be submitted in English or in German.

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Case studies may be considered for publication in Digital Psychology if they are unusually innovative and refer to the fields of Digital Psychology & Clinical Psychology. Case studies should not exceed 2.500 words. A case study should be submitted in English or in German.

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