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-

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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

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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).

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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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