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RESEARCH LITERATURE 2023 UPDATE

Virtual and Augmented Reality Technologies

In the fall of 2020, a collaboration among the Michigan Association of Administrators of Special Education (MAASE), the Michigan Council for Exceptional Children (MCEC), Great Lakes Reality Labs (GLRL), and Public Policy Associates (PPA) launched MI TRANSITION TO INDEPENDENCE (MITTIN) to develop innovative digital content supported by curriculum resources to bridge gaps between the classroom and the outside world. This work has included a life-skills library of virtual experiences in educational settings, including home and school. The project provides resources for teachers of students with disabilities to learn and practice authentic life-skill tasks in safe, controlled environments. MITTIN's tools also support at-home learning.

A March 2021 PPA brief identified a growing body of literature related to the use of virtual reality (VR) and augmented reality (AR) technologies in education, including a smaller sub-set of work in special education settings. This initial review was later updated by PPA in May 2022 to assess the status of research tracking the progress in AR/VR technologies and their rapidly spreading use in education. The second brief concluded that "[t]he findings within this update reinforce the top-line conclusions stated earlier that both AR and VR technology can positively affect student learning and skill acquisition, benefitting both regular and special education students [endnote and references omitted]." Since technology and follow-on research continue to advance, a second annual update is now warranted.

More recent research results point in the same direction as the prior literature update. Instructional strategies and interventions employing immersive technologies in education can improve general and special student affective engagement and skill acquisition. But the expanding body of research not only deepens and broadens the evidence base underpinning continuities in overall outcomes, but it also focuses and elaborates particular research trends as well (e.g., Chang et al., 2022; Kapetanaki et al., 2022; Li et al., 2022; Jiakai Zhang et al., 2022).[1]

Some earlier research by Garzon and colleagues (2019), for example, found a medium effect of AR on learning based on the advantages, affordances, and challenges of using the technology in education (see also Akcayir and Akcayir, 2017; Grazon and Acevedo, 2019). Similarly, a systematic review of studies occurring in special education settings had determined that, although further research was needed, "AR is an effective tool to use [in] education of SSN [students with special needs]." (Yenioglu et al., 2021, p. 120).

[1] Due to the sheer volume of individual studies in the field, which are published in various modes at various times, a literature review like the instant one must as a practical matter rely principally on systematic reviews and meta-analyses.

Furthermore, the advantages for use in special education encompassed:

1. The experience of challenging real-life situations and environments, including those that are conceptual, increases learning opportunities
2. The differentiation of knowledge and skills can meet individual needs and characteristics
3. Increases in the motivation to practice and learn, while enhancing the enjoyment of the learning experience (Veniole et al., 2021; see also systematic reviews by Berenguer et al., 2020 and Khowaja et al., 2020; and meta-analyses by Baragash et al., 2020 and Baragash et al., 2022)

More recent studies confirm such prior work while also extending and adding more nuance to it. Thus, Jiakai Zhang et al. (2022) reviewed and conducted a meta-analysis of 20 years of research in AR-supported K-12 instruction. The researchers examined study contexts and design, technologies used, and effectiveness achieved. Their eight summary findings concluded that "[o]verall, AR usage has a large effect on learning outcomes, with discipline, scaffolding, and rounds of practice as the significant moderators" (Jiakai Zhang et al., 2022, p. 13).

Ideal Application in K-12 Education

Based on their extensive results, moreover, Jiakai Zhang and colleagues (2022, p. 13) posited five keys to "an ideal AR application for [the] K-12 context." These features include:

1. Portability to be implemented in various learning contexts
2. Flexibility to facilitate learning in diverse domains
3. High interactivity to promote student-centered learning and hands-on practice
4. High fidelity to support content delivery and display
5. Sustainability featured by low cost and increased convenience and accessibility

After meta-analyzing ten years of quasi-experimental studies involving how AR instruction affected learning outcomes, Chang et al. (2022) found an overall medium effect due to educational advantages of the technology that closely mirrored those identified in prior research (Yenioglu et al., 2021 [summarized above]; see Baragash et al., 2020; Baragash et al., 2022; Berenguer et al., 2020; Khowaja et al., 2020). Chang's research team (2022) in addition identified several specific factors by which positive effects varied, including AR intervention duration, content matter or subject area, students' educational level, co-occurring instructional strategies, and the nature of the visualization (e.g., two or three dimensions, cognitive load).

Immersive Technologies

The literature on immersive technologies in special education also reports predominantly positive results, but with additional continuities and across a wider range of research characteristics (e.g., Kapetanaki et al., 2022; Montoya-Rodriguez et al., 2022; Bailey et al., 2022; Jiakai Zhang et al., 2022). While the more recent literature, like that previously published, adduces support for AR, it now includes analyses of a number of VR studies.[2]

[2] A strict definitional distinction between AR and VR technologies can be elusive, at least at the technological edge (see Carreon, Smith, and Rao, 2020; Carreon et al., 2020). Still, differences are commonly recognized, and can be compared, based on equipment, purpose, and the qualitative nature of the user experience (see, e.g., Akcayir and Akcayir, 2017; Bailey et al., 2022; Khowaja et al., 2020).

The emergence of two branches investigating contrasting technologies suggests comparisons among varying treatment factors such as degree of immersion, frequency, and duration (Cheng and Bololia, 2023; see also, e.g., Chang et al., 2022; Montoya-Rodriguez et al., 2022), as well as among practical considerations such as accessibility, usability, and cost identified in earlier studies, all given the technology of the time (e.g., Akcayir and Akcayir, 2017; Yenioglu et al., 2021; compare Bailey et al., 2022; Lorenzo et al., 2022; Lorenzo et al., 2023). However, as Bailey and colleagues (2022) point out, limitations in study design, methodology, and reporting can make meaningful comparisons problematic.

Interventions

With respect to AR interventions, Kapetanaki and colleagues (2022) in a systematic review of 14 studies of AR in special education between 2014 and 2022 describe such characteristics as the special education needs addressed, types of technology used, and the advantages and limitations of application in special education. The researchers found that "augmented reality plays an important role in the learning of students with special needs by improving the acquisition of skills and knowledge through an interactive environment tailored to their characteristics" (Kapetanaki et al., 2022, p. 1; see also Lorenzo et al., 2022).

The body of research into VR-supported interventions is growing, although it so far seems more limited in application and less robust in results. Zhang et al. (2022), for instance, review the theoretical and pedagogical supports for VR interventions for students with autism spectrum disorder (ASD); they likewise discuss the advantages of VR in ASD research and therapy.

The researchers' more cautious conclusion is that VR applications hold "significant potential and considerable achievements have been recorded in terms of improving ASD individuals' social communication abilities. However, there are technology- and design-related limitations that remain to be addressed...." (Minyue Zhang et al., 2022, p. 19; see also, p. 25). They further note that the "effectiveness of the [VR] intervention depends largely on how accurately it targets the specific vulnerabilities of the ASD participant…." (Zhang et al., 2022, p. 23; see also Li et al., 2022; Montoya-Rodriguez et al., 2022).

Bailey et al. (2022) review studies involving the application of AR and VR for a range of participants with intellectual disabilities including but not limited to ASD. Like Zhang's team, these researchers concluded that most studies' participants could access the relevant VR/AR systems and that those systems fostered some effective interventions. Although few adverse effects of access were reported, participant learning outcomes varied across technologies and contexts.

Individuals

A second continuity across studies is a primary focus on individuals, in particular children, with autism or ASD and the related development of social communication, interaction, and related skills like emotional recognition (compare, e.g., Cheng and Bololia, 2023; Lorenzo et al., 2022; Lorenzo et al., 2023 with Berenguer et al., 2020; Khowaja et al., 2020; Yenioglu et al., 2021). This research continuity might be explained by a combination of two factors: the prevalence of ASD within the population of relevant research subjects and how the functional strengths of immersive technologies might better fit or address individual ASD participant characteristics and needs (Berenguer et al., 2020; Minyue Zhang et al., 2022).

However, these factors—a high proportion of study subjects with ASD and the technology's fitness for the disability with its heterogeneous symptomatology—adversely affect the generalizability of research findings within ASD sub-populations and among different skills, let alone among broader special education populations (Bailey et al., 2022; Cheng and Bololia, 2023; Khowaja et al., 2020; Montoya-Rodrigues et al., 2022).

Despite the continuity, the scope of some research has widened in two respects: participant ages and special needs (see Kapetanaki et al., 2022). As noted above, for instance, Bailey et al. (2022) reviewed studies involving children, adolescents, and adults with communication disabilities and neurodevelopmental disorders, along with ASD (see also Montoya-Rodriguez et al., 2022). Li et al. (2022) examined the application of VR in special education teacher training and to students with physical, developmental, behavioral-emotional, and sensory impairment disabilities (see also Jdaitawi and Kan'an's 2022 review of research on AR effectiveness with special-needs students in higher education).

A final continuity between the literature discussed in this update and that of prior reviews is found in researcher concerns for the relatively low quality and rigor of many studies (Bailey et al., 2022; Berenguer et al., 2020 Kapetanaki et al., 2022). This is sometimes attributable to methodological limitations, such as small sample sizes, sample gender imbalances,[3] and the lack of viable comparison groups and/or weak outcome measures (Cheng and Bololia, 2023; Kapetanaki et al., 2022). In addition to the validity threats cited above around evidence from mainly ASD-focused research, other studies fail for inadequate research designs and reporting (Bailey et al., 2022).

Conclusion

PPA's last literature review update noted much of the progress and many of the shortcomings of the immersive technology research at the time. This update reflects further progress within the same research continuities and challenges. While Montoya-Rodriguez and colleagues (2022, p. 17) aptly conclude that "this research field is far from consolidated," this fact in itself may incentivize further, future improvements in the research base, quality, and applicability to benefit wider ranges of teachers and students.

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[3] The dearth of female subjects in many studies may be another artifact on the over-representation in studies of (predominantly male) individuals with ASD (Montoya-Rodriguez et al., 2022).

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