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Augmented Reality in Education and Learning

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Abstract: Technologies are changing and ever-growing. One of the newest developing technologies is augmented reality (AR), which can be applied to many existing technologies, such as computers, tablets, smartphones, and glasses. AR systems positively affect students' motivation and cognitive learning. They help to develop their spatial and psychomotor-cognitive skills. AR can provide hints and feedback visually, auditorily, or seasonally to improve students' experiences. Through these features, AR systems can be integrated into teachers' lecture notes. Thus, the abstract information to be taught can be conveyed to the students in a concrete way.

Using AR in the classroom can improve learning by helping educators create interactive classrooms that increase student engagement. AR technology can also be utilized through wearable components like glasses. Throughout this review paper on AR, the following aspects are discussed: research explored, theoretical foundations, applications in education, challenges, reactions, and implications. Several different types of AR devices and applications are discussed at length. An in-depth analysis is done on several studies that have implemented AR technology in an educational setting.

Keywords: *Augmented Reality, Learning and Development, Educator, Flow Theory, Just-in-Time Learning*

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Introduction:

In today's world, technology has become a crucial part of our lives. It has changed how people think and applies knowledge One of the newest developing technologies is augmented reality (AR), which can be applied to computers, tablets, and smartphones. AR affords the ability to overlay images, text, video, and audio components onto existing images or space. AR technology has gained a following in the educational market for its ability to bridge gaps and bring a more tangible approach to learning. Learner-centered activities are enhanced by the incorporation of virtual and real-world experiences. AR has the potential to change education to become more efficient in the same way that computers and Internet have [15].

Figure [1]

RESEARCH

Research conducted for this literature review focused on learning applications of AR. The initial search of K-12 applications was far too broad to provide a valuable synthesis. The keywords included learning applications, science or STEM focus, and augmented reality. Journals with a concentration in technology and education that held significance to AR within the classroom setting were sought. References were included that explained the concept of AR as well as studies that implemented AR. Most of the references for this analysis were published within the past five years; however, a few articles included were published as early as 2016.

THEORETICAL FOUNDATIONS

AR educational programs are learner-centered and related to learner interests. It allows learners to explore the world in an interactive way. Constructivism also encourages learners to work collaboratively, and AR provides learners the opportunity to do this in a traditional school setting as well as in distance education [07]. Dunleavy et al. (2009) believe that the engagement of the learner as well as their identity as a learner is formed by participating in collaborative groups and communities. Constructivism has also changed the role of the educator to become a facilitator, where the responsibility to organize, synthesize, and analyze content information is in the hands of the learner (DeLucia et al., 2012).

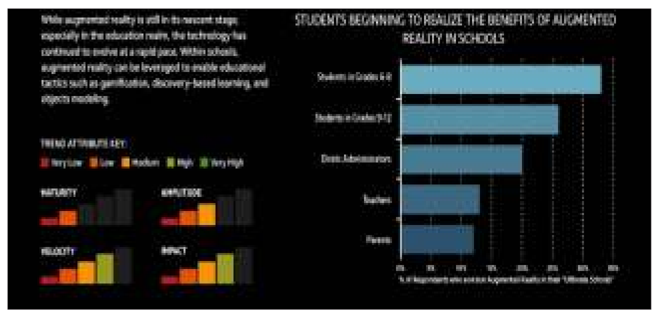

Figure: 2 [5]

Flow theory describes how people who are engaged in meaningful activities are more likely to stay focused. Bressler and Bodzin (2013) investigated a science gaming experience in relation to flow experience. Their study had a mean flow experience score of 82.4%, which indicates that the average learner experienced flow throughout the science mystery game that they played on a smartphone. This particular type of AR, as well as various others, connects their real-world surroundings to learning in a new and engaging way.

IMPLEMENTING AR IN LEARNING

AR allows flexibility in use that is attractive to education. AR technology can be utilized through a variety of mediums including desktops, mobile devices, smartphones, and Google/apple glass. The technology is portable and adaptable to a variety of scenarios. AR can be used to enhance content and instruction within the traditional classroom, supplement instruction in the special education classroom, extend content into the world outside the classroom, and be combined with other technologies to enrich their individual applications.

Traditional Classroom Uses

This is often seen foremost in the traditional classroom. Due to budget restraints or constraints on time, the means to teach learners in scenarios that allow them to learn by doing can be a challenge. Desktop AR allows learners to combine both real and computer-generated images. Lordache and Pribeanu (2009) used desktop AR that combined a screen, glasses, headphones, and a pointing device that allowed learners to conduct a hands-on exploration of a real object, in this case, a flat torso, with superimposed virtual images. Computer images could show the process, but the pointing device allowed learners to guide their learning [7].

Classrooms can shift from the traditional lecture-style setting to one that is more lab and learner-oriented. A case study conducted with a visual arts class noted that allowing learners to freely explore a room that was set up with webcams and desktops encouraged more activity while the learners perceived that they were more motivated to learn (Serio et al., 2013).

Instead of receiving information via images and lecture, learners had access to multimodal representations including text, audio, video, and 3D models.

Special Learning Uses

Because of the variety of tools that can be overlaid in an augmented environment, learners with physical disabilities can benefit from the potential learning aides that could be incorporated. Something as simple as overlaying audio for those with visual impairments or text for those with hearing disabilities can be effective tools when considering disability access (Forsyth, 2011). Head-mounted displays (HMD) can provide a hands-free device to project the overlay visuals to a learner and adjust the images based on the orientation of the learner while other devices enable learners to interact with the environment via voice recognition, gesture recognition, gaze tracking, and speech recognition [8]. Bringing this technology to the classroom has the potential to allow for differentiated instruction and enrichment of the learning experience of learners with special needs. Evaluation trials conducted by Arvantis et al. (2009) showed that using wearable AR technology with learners who had physical disabilities produced, *interestingly comparable results with able-bodied users, (p. 250) in terms of wearability and pedagogy.*

Outside the Classroom

Mobile applications can extend the traditional classroom beyond the physical walls. Annetta, Burton, Frazier, Cheng, and Chmiel (2018) reported that the percentage of 12 to 17-year-olds who have their own mobile device is 75%, compared to 45% in 2004, and regardless of a learner's socio-economic status, the number of learners carrying their own mobile devices is growing exponentially every year. Camera phones and smartphones allow users to gather information in a variety of locations. QR codes and GPS coordinates can be used to track and guide the movement of the learners. Although several researchers chose to take learners off-campus and conduct investigations in a field trip setting, others chose to remain within the grounds of the school [09].

An important point to note from this research is that GPS will not work inside buildings. Therefore, any indoor activity would need to be conducted without location-based AR technology.

CHALLENGES

Training

Training is an important aspect of AR. Most educational AR systems are single-use prototypes for specific projects, so it is difficult to generalize evaluation results (Billinghurst & Dunser, 2012, p. 61). Educators did not feel confident when setting up or implementing the program. In addition, educators who are normally lecture-focused had a hard time letting go and allowing learners to explore the learning environment on their own.

Training should be provided for educators to learn a hands-off approach with their learners and show them how this way of teaching will foster an effective learning environment. The fear of not knowing what is on each learner's device can be elevated according to the authors through the process of allowing the learners more control over their learning [10].

Technical Problems

Dunleavy et al. (2009) showed that the GPS failed 15-30% during the study. A GPS error refers to either the software of the GPS itself or incorrect setup. This was considered the "most significant" malfunction. Other malfunctions identified in this study were the ability of the devices to be effectively used outdoors. The glare from the sun as well as the noisy environment could impair the learning of the learners.

There are several different kinds of devices that can be used when implementing AR in the classroom. Glasses, hand-held devices, and headwear are ways for the user to see computer-generated images imprinted on their reality.

Acquiring devices that are calibration-free or auto-calibrated can be beneficial to the user as to avoid malfunction and user frustration.

Learner Issues

One issue identified in Dunleavy et al. (2009) determined that some AR situations can be dangerous. In this particular *Alien Contact!* scenario, learners must look at their handheld devices to participate. When engaging in activities outdoors the learners are unable to work on their devices and watch where they are going simultaneously. Therefore, learners were found to be wandering into roadways and needed to be redirected to safety by educators [11].

REACTIONS

Learners

Overall, learners reacted positively to using AR technology both in and outside of the classroom.

Learners also reported that learning in an AR environment is more stimulating and appealing than viewing a traditional slide presentation (i.e., Microsoft PowerPoint, SmartNotebook) because they preferred the audio, video, and feeling as if they were part of the 3D model that was transposed into real physical space (Serio et al., 2013).

Educators

Educators may feel alarmed as if AR will "overtake" their classrooms; it seems that once learners experience this type of learning, they will not go back to their previous ways of learning. However, Annetta et al. (2012) expressed that AR can be an activity to engage learners in future units and discussions. Billinghurst and Dunser (2012) believe that AR is a new form of face-to-face instruction, as learners share the learning experience. Educators have reported learners taking responsibility and ownership of their learning (Kamarainen et al., 2013). Therefore, educators using AR technology are becoming facilitators to their learners.

IMPLICATIONS FOR RESEARCH

The importance of this literature review is that it not only showcases the current trends in AR technology but also focus on the increased research and potential further application in the educational setting. Several components remain to be explored. When using AR outside of the classroom, educators and learners are able to use this as a tool for physical activity (Dunleavy et al., 2009). Linking learning with exercise and activity in an educational way can improve the perception that technology creates a non-interactive environment (NAEYC & Fred Rogers Center, 2012) [14].

Another is that the amount of visual information that can be displayed on the screen can be overwhelming to learners. Studies should further explore the effects AR has on cognitive load in the brain and how much information should be displayed before it turns from a beneficial device into a distracting device (Bressler & Bodzin, 2013; Van Krevelen & Poelman, 2010).

CONCLUSION

AR has already begun to help learners learn more efficiently as well as increase their knowledge retention (Sinha B & Sahay S, 2020). However, before AR becomes mainstream in education, like desktops, laptops, tablets, and even cell phones have become, special consideration must be taken into account on the usability, cost, power usage, visual appearance, and the like, in order for content AR simulations activities to become part of the regular academic curriculum (Van Krevelen & Poelman, 2010). AR has proved to be an engaging way for learners to participate in their learning. This new technology allows the learning to be learner-centered and creates opportunities for collaboration that fosters a deeper understanding of the content. AR is on the way to becoming an important part of education, and its use will continue to grow.

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