Augmented Reality: 3D Holograms for Engaged Learning

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Abstract

Augmented Reality (AR) offers a unique immersive experience by combining three-dimensional hologram objects overlaid on the real-world environment. The virtual image objects can be manipulated by expanding/contracting the size of the object, changing the position or location, or viewing it from any angle. AR instruction development should begin with an analysis of the learners who will be using the devices, to yield information for selecting an appropriate instructional design strategy to foster optimal learning. The instructional design strategy selected needs to facilitate effective teaching and learning practices with the goal of improving outcomes and meeting objectives. Well-designed instruction can then provide a productive learning environment for AR to increase academic success. The interactive and engaging nature of the medium provides a strong motivator for learning. Augmented reality can be used for teaching and learning across all fields of study in higher education and the eventual workplace. 3D images can impart significant content information to bring to life complex and normally difficult abstract concepts to yield understanding with increased learning acquisition. This article examines the research literature, challenges, benefits, and educational strategies for integrating augmented reality effectively.

Keywords: *Augmented Reality (AR), Head Mounted Displays (HMD), Heads Up Display (HUD), Holograms, Virtual Reality (VR).*

Introduction

Augmented Reality (AR) overlays three-dimensional digital hologram objects over the real-world environment. Some AR devices allow the digital objects to be manipulated by expanding the size of the object, changing the position or location, and viewing it from any angle above, below, or 360 degrees around it. Augmented reality can provide a productive learning environment for increasing academic success when well designed and aligned to learning goals. In addition, social, cognitive and emotional improvements have been found when the learning environment is realistic or authentic [18]. Augmented reality can increase engagement by materializing complex abstract concepts for easier comprehension [4]. New original objects can be made or one can purchase pre-made objects. directed towards the objectives within any field of study. The authentic environment provides more opportunities to learn directly on location without traveling. The 3D objects allow learners to see inside of objects as well [11].

The 3D objects viewed can be defined and driven by the instructor or learner. The personalized content selected for viewing can relate to the learning task at hand. The objects can be retrieved and examined from pre-made three-dimensional objects. Sometimes, objects can be modified from basic shapes provided in the application, or existing code can be modified, or original code can be written to create completely new original 3D objects. Free resources can be located or some require a fee. Highly complex layered 3D objects can take a great deal of time to create, as a result they are often costly to buy.

The AR head gear has a clear shield to be able to view the actual environment. After opening the 3D object, it appears as being layered on top of the actual environment. The viewer can walk around the object to look under and over it, and sometimes even look inside of the object depending on how the 3D object was built. Augmented reality is truly a new way to see the world through digital enhancement. An excellent goal for augmented reality is to focus on creating and delivering meaningful, compelling experiences to enhance learning [13].

One limitation with some AR devices is the need to be tethered to a powerful PC gaming laptop or computer by way of a HDMI cable. Switching to a Wi-Fi set up allows for freedom of movement. Even with these limitations, augmented reality is continuing to have skyrocketing sales as evidenced by the major

tech companies such as Apple, Facebook, Google, Intel and Microsoft, who are investing in AR's future to bring it to a mass audience [13].

Background

Challenges

In a recent Forbes community voice article by Mike Silagadze [15], he reports on challenges facing the implementation and use of augmented reality in higher education. He cites ongoing problems with reduced college funding, declining enrollments, and students being financially stretched, making the purchase of costly new and emerging technologies extremely difficult. The costs of these technologies need to be reduced while increasing mobility for a modern age to push development for quality educational experiences. The instructional design needs to be appropriately aligned with objectives using engaging experiences in order to capitalize on optimal learning to deliver real value to learners.

Zachary Jason from Harvard writes about how learners are becoming bored with sterile routines lacking intriguing open-ended research challenges yielding no creative thought processes and a lack of memorable learning experiences. Learning is not going to happen until learners are first engaged then connected with student goals [10].

As with any technology, issues can arise. Examples include: limited Internet connections, lag time, crashes, projecting to a display screen, live virtual conferencing, and headgear tethered with wires limiting freedom of movement.

Some drawbacks found with the use of AR include attention tunneling, usability, ineffective integration, and learner differences [14]. Attention tunneling can cause some learners to overlook important information presented in AR due to the higher levels of sensory input competing for attention. Sometimes this can result in more effort to focus on the learning tasks.

Usability and perceptual difficulties can be encountered when using the head mounted display [2]. In addition, learner differences and physical abilities need to be considered with equipment selections. With the increase in global connections the need to use virtual conferencing with AR is becoming increasingly important. At this time, not all platforms have this option available. Ineffective classroom integration of AR technology can negatively impact the learning experience. In addition, the lack of inquiry, discovery based, instruction can negatively impact the AR learning experience. Sometimes higher achieving students have difficulty when the AR experience did not provide sufficient new information and challenges.

Benefits

Some of the benefits cited in the literature with the use of AR are; increased content understanding, learning spatial structures and functions with the use of 3D hologram objects, some even using transparent layers of objects for multi-depth views, language associations, long-term memory retention by providing a concrete way to conceptualize abstract concepts using more detailed mental representations, physical task performance, and improved collaborations [14].

One research study, when comparing traditional media to AR learners, found better short-term memory and long-term memory gains when tested one week later [17]. When looking at memory retention, at the time of training no significant difference has been found in short-term memory. However, increased long-term memory has often been found with AR. In addition, increased test scores are found when using AR over traditional media. When overlaying diagrams on top of the real-world it has been found to help in transferring knowledge to solve authentic work tasks.

Learning language or symbolic associations through images can increase reading and writing scores when compared to traditional media. It works best with average to low achieving learners, as it may not provide sufficient new information to satisfy advanced learners. Perhaps changing the learning task to inquiry based may increase the challenge and engagement for all learners. With the more open-ended format, learners can excel beyond restricted assignments. Learners may then have the freedom to explore and discover beyond expectations.

When working to improve physical task performance, AR has proven to be effective since the learning simulates the actual authentic work task. Tasks can be performed with greater accuracy, faster, and with a higher transfer rate. Improved collaboration is found when implementing AR to solve spatial problems, as it allows learners to create shared meanings from the shared visual displays. Improved motivation is

found when using AR in regards to increased learner satisfaction, novelty, and willingness to devote more time to tasks even when it is more challenging. AR use tends to increase motivation, creativity, and discovery learning when well implemented.

Learning

The literature cites many examples of using augmented reality in education in the areas of Biology, Anatomy, Astronomy, Chemistry, Math, Geometry, and Physics. Especially difficult to understand abstract concepts can be illustrated visually in three dimensions; such as the solar system, molecules, atoms, and the human body. It is a great way to demonstrate changes over time, and show a sequence of events. Augmented reality is so valuable in education because, in addition to its ability to visualize difficult to understand concepts, it can also be used to construct information, develop cognitive thinking skills, experience meaningful authentic hands-on learning, increase affective experiences, gain practice with emerging technologies, and ultimately increasing long lasting student success [6-7].

One study found augmented reality supports integrating the real world with the learning environment to be able to visualize abstract and complicated objects [18]. Reaching students at any level contributes to reductions in concept errors, and increases perceptions of complicated learning objects. Augmented reality then provides positive contributions at the cognitive level by enabling logical learning, creating experiment observations, understanding theoretic knowledge, and activating visual knowledge. In addition, motivation increases through interest and curiosity fostering a positive attitude towards learning.

However, if learners experience technical problems, communication issues, eye problems, or a lack of technology knowledge and experience, they can form negative reactions. This points to the need to be prepared, ensure equipment is working, and make sure directions are clear, using an inquiry-based instructional approach to increase learner success.

Instructional Design Strategies

Instructional design first begins with an analysis of the learners. The instructional design strategy is selected to enhance and facilitate instruction and learning, to improve results, and to meet objectives based on proven learning theories. Three instructional strategies aligning well with augmented reality are - using discovery, authentic experiential learning, and engaging motivational immersion.

Discovery learning tends to be problem based where learners discover knowledge during the learning process. Scaffolding assists learners with keeping on track while staying focused on the learning goals. When applied to augmented reality research, it can mean providing assistance to learners through the generation of guiding research questions, planning, designing the experiment, visualizing the data presented, monitoring progress, and organizing and interpreting the results [9]. One research study evaluated augmented reality using inquiry-based learning activities applying the five-step design criteria of: 1) ask, 2) investigate, 3) create, 4) share, and 5) reflect [3]. It is through exploration, learners test out their hypothesis, which in turn encourages further study [16]. Inquiry based-learning provides a student-centered platform for learners to hypothesize, explore, validate, categorize, integrate, evaluate, assimilate, explain, and collaborate to proactively develop deeper high-level learning and self-responsibility. The knowledge gained can then be applied to new situations [5].

Authentic experiential learning offers a stronger sense of presence and a stronger connection to real-world learning. Augmented Reality is an excellent tool to enhance a user's perception of and interaction with the real world [1]. The highly immersive nature of augmented reality is due to its stronger visual impact and interactive ability with 3D visuals. Augmented reality offers highly interactive digital experiences to fully engage user's senses [14]. Learning using well integrated, organized, relevant materials, while simulating actual field conditions is found to improve learning performance [12]. Real-world perception reduces the cognitive load while providing more meaningful cues for constructing elaborate knowledge by using both sight, touch, and sometimes audio. Experiential learning provides a concrete experience to serve as the basis for observation and reflection to formulate new theories to test. Contextual learning, or learning in context, includes learning related to new concepts through something familiar, learn by doing, applying concepts, collaboration, and transferring knowledge to new situations [16].

Over time we see an increasing sense of tactile experiences made possible through various sensors for object manipulation. AR provides physical visual interactions by allowing users to move around, over,

and below virtual objects within a real environment. Over time, increased audio capabilities and tactile experiences are anticipated.

Augmented Reality offers a unique participant immersion, engagement, or motivation by providing a bridge between a real-world environment overlaid with three-dimensional interactive objects, all at the same time. Due to the highly interactive nature of the AR medium it can be a strong motivator for learners. An immersive environment can keep learners engaged at a constant level [12]. Increasing motivation and confidence can then improve learning outcomes. Through increased engagement and time on task, better cognitive connections are possible.

AR knowledge acquisition requires learners to be engaged in learning tasks for maximizing learning. The focus needs to be on learning rather than the excitement of working with new technologies. For learners' new to understanding three-dimensional visualizations, additional support may be needed. To ensure overall project success, thought needs to be given to how the research will be set up, providing learners with clear directions, training, practice, and ongoing support. The scaffolding assists all learners and especially those with low self-regulation ability. When these items are well in place with learner centered inquiry-based learning goals and objectives, it can have a huge impact on outcomes-based learning. Effective learning strategies are one of the most critical factors for improving achievement.

Conclusion

Reviewing the literature describing the use of augmented reality demonstrates how with the proper alignment between inquiry-based discovery, authentic experiential learning, and engaging motivational immersion, the teaching and learning can be used to leverage knowledge acquisition. When well planned, designed, aligned to the content, well supported, and implemented the 3D holographic objects, can generate high-level knowledge, with learners willing to spend more time on tasks, resulting in improved learning outcomes. The use of visual aids has been shown to be an effective teaching method, with studies showing an increase in memory retention. AR can set up so learners can work independently or in groups to increase knowledge acquisition [8].

Since the whole concept is in its infancy, there are still technology challenges needing improvements to take augmented reality to the next level for a seamless intuitive experience. A massive increase in the number of 3D educational hologram objects need to be created, then shared for free or at a reasonable price to extend the use and applications. The addition of audio, and natural intuitive physical haptic interaction sensors needs to be expanded. The hardware needs to be more user-friendly and flexible for use with the diverse learner populations. The software needs to be well supported with quality tutorials and expanded features specifically targeting the needs for teaching and learning. The software programs used to create and edit 3D hologram image objects need to be simplified and be more intuitive for learners to actually use. The ability to live virtual conference and share AR easily on a global scale needs to be included, especially considering the increase in online teaching and learning. The design of inquiry-based learning needs to be a priority when designing augmented reality instruction so learners can excel beyond expectations.

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