Augmented Reality as a Visual and Spatial Learning Tool in Technology Education

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Potential exists for AR to be incorporated in not only STEM education, but across all disciplines.

Improvement in instructional practices through dynamic means of delivery remains a central consideration to technology educators. To help accomplish this, we must constantly utilize contemporary and cutting-edge technological applications in attempts to provide a more beneficial learning experience for students. These technologies must simultaneously relate to course concepts while engaging and exciting students about technology. An emerging technology that has the potential to both engage and excite is augmented reality (AR).

A leading expert in the field of AR, Ronald T. Azuma, has defined AR as allowing “the user to see the real world, with virtual objects superimposed upon or composited with the real world (p. 355).” The purpose of AR is to enhance an individual’s physical and visual environments. This is accomplished by superimposing a three-dimensional (3-D) virtual image onto a real-world object or environment. The viewer then has the ability to merge his or her physical environment to a predesigned virtual environment.

The importance of this technology lies in the fact that AR devices can superimpose a virtual overlay of data and experiences onto a real-world context. The viewer can then see the overlaid information through a simple viewing device such as a camera or monitor. Based on this, AR could become the fundamental user interface of the 21st century (Kroeker, 2010). AR can be incorporated into a variety of technologies, ranging from head-mounted displays to simple mobile devices, allowing for an almost endless number of applications for users and designers.

Initially, AR could be incorporated into the classroom as a supplemental learning tool. This would allow teachers and students to gain familiarity with the technology and allow more research to be conducted. In the long run, AR could bring experiential and location-based learning to students by supplementing their surroundings (Educause, 2005).

In the technology education classroom, AR would provide a rich contextual view for teachers to use as an educational resource for modeling objects in engineering design. AR’s ability to create a 3-D image could become essential in design technology and engineering (see Figure 1). In math, for example, AR could be used to enhance a student’s knowledge of 3-D geometry by actually creating a 3-D image for the student to view (Kaufmann & Schmalstieg, 2003). This same technique could be used in drafting or computer-aided design. It also keeps the students engaged and excited in the learning process (Villano, 2008). For example, an animation
class could use AR to establish an object’s spatial relationship to other components or the environment. A teacher could demonstrate an experiment using AR without exhausting materials, allowing the process to be repeated until students exhibit mastery.

There are several different AR software packages available for use in the classroom (e.g., ARSights). These types of software work with a variety of universal formats with ease of use. A teacher can easily download any AR software and print a marker to be used as a symbol for AR object recognition. Once installed, a teacher can access models through 3-D modeling software (e.g., Google Earth, Google 3D Warehouse, Google SketchUp). All of these applications are compatible with most AR software and are relatively easy to use. For example, there is a link on the ARSights webpage that allows for simple AR viewing of historic landmarks through Google Earth. Images from Google 3D Warehouse can be downloaded in Google SketchUp for viewing.

For teaching purposes, applications like Google SketchUp provide flexibility and multiple potential benefits in the classroom. Models can be created or imported through other software. There are plug-ins connecting AR to modeling software that allow for seamless integration. The potential benefits of AR in the classroom are endless, but the focus of our initiative was to take 3-D design and determine how AR can be used to enhance student visual skills. The use of AR in the classroom addresses Design Standards 8, 9, and 10 of Standards of Technology Literacy (ITEA/ITEEA, 2000/2002/2007). AR can meet Design Standard 8 by having students develop an understanding of attributes of design through manipulation and viewing the intricacy of models from multiple perspectives. For Design Standard 9, students can develop an understanding of the engineering design process; this can be met by evaluating the components and relationships through spatial analysis. By adding depth to an object, AR can provide instant analysis, detect errors, and troubleshoot to meet requirements for Design Standard 10 where students “develop an understanding of the role of troubleshooting, research and development, invention and innovation, and experimentation in problem solving.” All of these examples provide additional resources for teachers to engage students and create a richer learning experience.

AR can provide classroom benefits while improving upon student visual and spatial skills. Although there is no genuine consensus on what constitutes visual and spatial skills, in 1994 Maier (as cited in Sorby, 1999) proposed that spatial perception, spatial visualization, mental rotations, spatial relations, and spatial orientation are the components that form spatial skills of a visual nature. Spatial perception refers to the observed magnitude and/or proximity of an object in relation to an individual, where spatial visualization denotes the ability to perceive and mentally negotiate objects or models (Park et al., 2008). Similarly, mental rotation ability suggests that, through cognitive visualization, a revolved perceptual structure of an object or model is enabled. Spatial relation refers to the proximity of an object in reference to an associative or relative object. Common to spatial perception and spatial relation, spatial orientation suggests the immediacy of an object in material or simulated space in relation to the individual. Samsudin, Rafi, & Hanif (2011) identify that the development of spatial visualization, mental rotation, and spatial relation and orientation abilities may be environmental or experiential, suggesting that the use of multisensory applications can be influential. Sorby (1999) further identifies that providing students with hand-held models is useful in the development of spatial skills. Models that students can simultaneously touch and see enhance information acquisition that cannot be experienced through the visual alone. Even though simulated, AR provides these dual sensory experiences that permit deeper understandings. Through the use of AR, many new potential student benefits targeting visual and spatial application exist.

Skill developments aside, there are also numerous classroom benefits for technology education teachers. First, AR allows teachers to incorporate new technology in the classroom. Second, AR allows greater detail, explanation, and clarity
of examples through the establishment of visual and spatial relationships. Third, this approach can be an effective tool for providing accommodation resources to students with disabilities. Finally, AR presents opportunities for further educational engagement and process/competency reiteration for at-risk learners as well as the general noncategorical student populace. AR appeals to the constructivist approach of learning by allowing teachers to use hands-on approaches through interaction and manipulation of models. For example, students can interact with famous structures such as the Eiffel Tower by accessing Google Earth through ARSights. Applications and advantages considering the cost associated with the software is relatively inexpensive.

The end product is a supplemental teaching aid that allows students the ability to visualize complex and intricate virtual models (see Figure 2 for projected AR model). The possibility exists for AR to provide a more holistic approach to technology education. Students will no longer view concepts and ideas in an isolated set of facts or procedures (Squire & Klopfer, 2007). Instead they will be able to determine spatial and visual relationships. AR will allow students to take a more active role in their education (Villano, 2008). AR can also be great for discovery-based learning, allowing students to be creative, take risks, and make mistakes without consequences. A student can design a product in a solid modeling application, analyze it using AR, and make corrections before creating it with a computer numerical control machine or three-dimensional (3-D) printer.

The potential is there for AR to become a major component of training and development. Manufacturing can benefit greatly from the use of AR. Assembly workers can be guided through every step of the process through the use of interactive visual instructions that superimpose an image onto the object (Ennakr, Domingues, Benchikh, Otmane, Mallem, 2009). AR can also greatly improve the accuracy and ability of doctors in the medical field. Azuma (1997) believes this will occur through the use of virtual tutorials to guide a surgeon through a procedure, 3-D datasets that can be overlaid on patients, and the instantaneous provision of vital statistics (p. 358). This will increase accuracy and improve efficacy by simplifying the process.

The future presents many educational entry points and possibilities for AR. For example, the mobile phone industry has become a driving force behind the implementation of Mobile AR (Giles, 2009). From a user standpoint, all that is necessary is a GPS device, a camera, and a compass. Manufacturers are also now including AR applications on most smart phones, leading to rapid experimentation and evolution within the field of AR (Educause, 2005). Classrooms no longer need to be stationary, and learning can occur anywhere. Students could use their mobile phones for learning while exploring their communities.

The growing popularity of video games within education can have a positive effect on the growth of AR within education. The video game industry is constantly pushing the boundaries of technology, making the video game industry a driving force behind AR (Blecken & Davis, 2009). The fusion of AR and video game design is still a few years away, but it can already be seen in concept games such as “ARQuake.” In the future, AR can be an important component of video game design and included within the curriculum.

In conclusion, AR is an emerging technology that necessitates strong consideration as a learning tool in the implementation of technology education curricula. Potential exists for AR to be incorporated in not only Science, Technology, Engineering, and Mathematics (STEM) education, but across all disciplines. AR can aid in design by allowing students to construct interactive objects, create visual models to accompany math problems, and examine engineering problems from multiple perspectives (see Figure 3 for rotated model). Smart phones and video games will be two technologies that allow for additional pathways to incorporate AR into technology education.
Finally, AR presents distinct advantages to traditional means of conveying engineering design graphics’ associated content and applications. Dynamic and realistic models in visualized settings provide motivation to learn based on uniqueness of presentation while providing authentic and realistic perspectives to virtual modeling. The development and infusion trajectory of AR presents current and future educational possibilities for technology education and other STEM disciplines alike.

References


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