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Augmented Reality in K-12 Education

Lisabeth J. Leighton
Old Dominion University

Helen Crompton
Old Dominion University, crompton@odu.edu

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Chapter 14
Augmented Reality in K-12 Education

Lisabeth J. Leighton
Old Dominion University, USA

Helen Crompton
Old Dominion University, USA

ABSTRACT

Today the world revolves around technology in daily tasks. Society uses technology to communicate, trade, for business, politics, and to education. Through education, Augmented Reality (AR) takes on a new purpose. AR enables students to reach a higher level of education, and teachers to efficiently engage students to see real-world situations. The use of technology in classrooms is currently on the rise; but how are teachers using AR within their classrooms to engage and education children? This chapter discusses literature and research supporting the AR affordances in K-12 Education.

INTRODUCTION

In a society where our daily lives revolve around an ever-changing digital world, new methods of learning have been created using technology. We use technology daily to communicate, collaborate, entertain, invent, design, and teach (Kidd & Crompton, 2015). Over the last few years, the educational system has integrated various digital tools and technologies into classrooms for students and teachers in the United States at an accelerating rate (Bower, Howe, McCredie, Robinson, & Grover, 2013). Teachers are able to utilize different digital tools to help students not only think critically in the classroom, but also take information and apply it outside of the classroom (Baharti, 2014). Augmented Reality (AR) is one of the digital tools being integrated into classrooms. AR is defined as a technology applied to digital devices to link together the reality and virtual worlds by adding a virtual overlay to real world scenarios (Bower et al.,). These digital tools allow teachers and students to formulate, explain, learn, and let their creativity take their education to new levels. Through traditional teaching, this opportunity would not be possible for students. The use of AR in a classroom enables students to reach higher levels of thinking by connecting to real-world experiences (Bower et al., 2013). Although AR is available to many educators,

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there are problems in using and applying it in the classroom (Demski, 2013). Teachers are still mainly relying on older methods of teaching to instruct students, as they lack training in how to use and integrate these digital tools into teaching and learning (Antonioli, Blake, & Sparks, 2014). Technology is often the tool selected to support didactic teaching in the use of slide presentations (Demski, 2013). Teachers also face obstacles, such as a lack of support from administration, a lack of personal experience with the technologies, and a fear of digital malfunctions (Spencer, 2012). There are a great many affordances in using AR in K-12 learning and with support these tools can be best used to support teaching and learning.

The purpose of this chapter is to articulate the affordances of using AR in K-12 classrooms. This is thematic review of the literature to understand what themes have developed from the published literature. This chapter begins with a definition of AR. This is followed by the unpacking of four trends in how AR can support teaching and learning. These affordances are that AR supports; authentic learning, contextualized learning, student-centered learning and enables students to better visualize subject content. Finally, the projected future path of AR is revealed to show where AR may benefit future students.

What is Augmented Reality?

Augmented Reality (AR) blends physical and digital worlds together in real time by using 3D technologies (Kidd & Crompton, 2015). Ionitescu and Radu (2015) articulated this further as they defined AR as "adding computer-generated content upon the real, physical objects in the world around us, by displaying overlays of information and digital content connected to physical objects and locations" (p. 105). This means that images on a piece of paper or our view of the environment can be enhanced with the addition of digital images, video, sound. This relatively new and still emerging technology can be applied to web-enabled devices such as tablets and iPads, smartphones, television, movies, desktop computers, and laptops. One common example of AR on television in the U.S. is when viewers watch sports, such as American football, and colored lines appear to explain what is happening in the game. Viewers see a blue line to symbolize the line of scrimmage, and a yellow line symbolizing the line for a first down. If you are present at the football game, there are no colored lines indicating the placements (Joan, 2015). These lines represent a basic AR technology by using an overlaid image on top of a preexisting real world object.

Two methods are used in AR, which are: Marker-based, which uses symbols or codes to create a digital image, and location-based, which uses GPS to pinpoint the user's location globally (Bharti, 2014). Virtual objects present in AR can include an assortment of texts, videos, audios, 3D models, animations, and images that are superimposed in the viewer's environment (Bower et al., 2013). Bower et al. listed basic hardware requirements for creating and viewing AR. These are a camera for video and image taking, computer storage space, a powerful computer processor, and a computer program to allow interaction between real and virtual objects. AR has progressively developed as a popular tool for use in real world applications.

AR Technologies and K-12 Education

AR is viewed via mobile devices such as tablets and mobile phones. There are various AR headsets available, such as the Oculus Rift, HTC Vive, VR One, Poppy3D, and Google Cardboard. Two of the most recent AR headsets that have advanced AR capabilities are the HoloLens and Meta 2.

Hololens is an advanced holographic computer providing the user a mixed reality experience that allows them to interact with the real world and digital content. Hololens has more computing power than the average laptop and as it does not have any wires, external cameras or a phone or PC connection needed, the user is completely untethered and able to move freely. The sensors in the Hololens capture the persons' activities as well as the surrounding environment as the high definition lenses with the optical projection system allows the user to view the holographic images projected over the real-world.

A hologram is a visual light created 2D or 3D object that is placed in the real world without any mass. These holographic images are placed on top of real world surroundings that only the individual wearing the HoloLens can see (Statt, 2015). For example, when using the HoloLens headset, the wearer could bring a holographic image of building plans on top of a clearing where the future building will be built. If several individuals are wearing the HoloLens, they are all able to see the same hologram when wirelessly connected to the same file or program. Unlike a virtual reality headset where the user can visit a location out of reach, the HoloLens allows users to overlay 3D images from anything, so long as it comes from a computer program (Statt, 2015). Statt (2015) also points out that while using the HoloLens, wearers are still able to move and communicate with people and their surrounding environment, unlike virtual headsets where the image hinders vision of the surrounding environment.

There is also a camera on the outside of the HoloLens that overlooks the area surrounding the operator. This feature allows for video chatting with others who can interact with your HoloLens by drawing images on their digital device that will appear in your vision (Statt, 2015). Statt (2015) was able to experiment with the HoloLens by rewiring a light switch while another individual coached him through the process by drawing images and arrows on a separate tablet that showed up on his HoloLens. In the future, HoloLens may be able to help businesses and companies interact and develop connections, help customers with numerous problems, create product designs, impact surgeries and the medical field, or assist in instructive settings.

In a university in North America, Microsoft HoloLens is using the device to see human anatomy in 3D verses 2D on a computer or in a book. Teachers and students are able to manipulate the human body for investigation verses using a cadaver. Simulations are created for students that enables them to fail and practice with the HoloLens, because in the real world medical students have little room for mistakes on human life. HoloLens transforms a student's learning environment to change how they see the world. The future of teaching and learning could be changed dramatically through HoloLens.

Similar to Holo Lens, Meta 2 is a wearable glasses set that allows the wearer to freely manipulate 3D objects projected in front of them from the AR lens. The lens projects 3D objects in front of the wearer who can manipulate the image through hand movements (Catanzariti, 2016). Meta creators are currently working on their second model to include a headset larger than Microsoft's HoloLens, which will the wearer to have an increased field of vision. An advantage to a wider lens decreases confusion and space limitations for the user. In addition of the wider lens, the Meta 2 will also feature a higher resolution display and can also be used with both PC and Mac systems. Unlike HoloLens, Meta glasses will have a heightened mapping space. This means that the location tracker within the headset will be to closely pinpoint the wearer's positioning within his or her environment. This heightened feature will be able to automatically add images to the user's environment based on where they are located. The Meta Vision AR lens will also be able to help decrease the billions of dollars and hundreds of lives lost as a result of human error (Meta, 2014). Meta glasses will allow medical students and doctors practice different scenarios to eliminate human error in future situations. Meta creators are also working towards creating interaction between wearers in different locations by using AR as means of communication

(Catanzariti, 2016). Meta Vision's AR glasses will drastically change how we communicate and interact with one another in the future.

Meta is currently working with the Royal Ontario Museum and Decimal Lab, a company working on bringing historical articles to life through AR glasses. The app will allow museum visitors to borrow a Meta headset and use AR in addition to the preexisting museum exhibits without any physical contact to the exhibits (Friberg, 2015). Teachers and their students would be able to take class field trips to museums with AR glasses to help students grasp different concepts and view historical battles or speeches as if they were present. Another Meta app, anARtomy, allows the operator to view the muscular and skeletal systems layered on top of their own body or another person in front of the AR headset. Meta's upcoming apps will allow students to manipulate different atoms and combine them to make new compounds and elements (Friberg, 2015). As Antonioli et al. (2014) stated in their research, students retain more material when they are doing, and Meta's glasses headset will provide those opportunities for students.

Affordances for Teaching and Learning

In a review of the literature, four trends were revealed in how AR can be used to extend and enhance teaching and learning. These affordances are the ability to support authentic learning, contextualized learning, student-centered learning visualize subject content. While these are highly interconnected, these have been separated to delineate each of these aspects.

Authentic Learning

Brown, Collins, and Duguid (1989) defined authentic activities as ''the ordinary practices of the culture'' (p. 34) AR technologies today are used to assist learning in a variety of different occupations. For authentic learning, Reeves, Herrington, and Oliver (2004) posited that the learning environments should include authentic tasks that:

- Have real-world relevance;
- Are ill-defined and include a number of sub-tasks;
- Are complex and require students to undertake complex investigations;
- Provide opportunities for students to investigate the tasks from different perspectives;
- Provide collaborative and reflective opportunities;
- Integrate across different subject areas;
- Include integrated assessment; and
- Allow competing answers or solutions.

AR is a tool that can be used to meet each of these criteria. It is versatile in that it can be used across subject areas and it has real-world relevance as it has the student directly connected with actual tasks that a person would do in the real world. For these reasons, AR has become a leading technology in various fields, such as surgery (Van Krevelen and Poelman, 2010). Doctors are able to utilize AR to work with patients to visualize the body system and discuss 3D imaging reports together (Yuen, Yaoyuneyong, & Johnson, 2011). AR aids surgeons with navigation and positioning during surgery (Yuen et al., 2011)). In the car industry, BMW and Volkswagen have already incorporated AR into their assembly lines (Van Krevelen and Poelman, 2010). Airlines use AR to superimpose information in real time to show the location of the plane and flight information for passengers through tablets on the plane (Bower et al., 2013) and the military uses AR that allows pilots to view instructions, maps, and enemy locations on a screen in front of them (Yuen et al., 2011).

AR allows teachers to enhance students' educational experience by allowing students to interact with 3D objects in their environment. Research findings show that students who use AR while learning content, were more likely to retain the information and construct real-world applications of the material, verses students who learned in a more traditional instruction method (Yuen et al., 2011). Seeing the added digital layer in their environment through the lens is relatively simple, but what incites the higher-level thinking is when the students are able to apply the knowledge of what they saw with the AR to the real world after the AR is removed. Through the technology, students are able to learn in a real-world situation, and develop 21st century skills required for a society that is technology enriched (Dede, 2008).

Student-Centered Learning

Student-centered learning is an educational philosophy that puts students in the center of the learning process. Using this approach, students play an active role in their learning using their own learning styles and strategies (Çubukcu, 2012). This strategy has become popular in the past 30 years as it improves skills such as critical thinking, problem-solving, and reflective thinking (Çubukcu, 2012). AR has the students seeing and experiencing what the subject content is rather than hearing about it described, often in a decontextualized manner, through a lecture approach. Pedagogical potentials are endless as a result of the multi-sensory experience permitted through AR (Kidd & Crompton, 2015).

When properly used in the classroom, the benefits are exceedingly constructive. Wu et al. (2013) found that AR helped students develop skills and knowledge, as well as facilitate skill acquisition. Teachers noticed a difference in student's abilities to retain and connect material to the real world after using AR in their lessons (Wu et al., 2013). Joan (2015) states, "the importance of AR is to implement novel technology to enhance learning approaches in education" (p. 11). As a result of AR technologies, students can become active participants in their education and have teachers incorporate more student-centered teaching methods (Kidd & Crompton, 2015). The potential in AR for learning to be engaging, motivating, collaborative, and authentic is remarkably high when used appropriately and accurately.

To reach the top of Bloom's Taxonomy hierarchy, students could learn to design and create their own AR programs to help them learn subject content. When simply using AR to reinforce or teach material, lower order-thinking skills, like application and comprehension, are supported (Bower et al., 2013). By having students designing AR programs, this will enable students to reach higher order thinking by analyzing, evaluating and creating (Bower et al.). Creation of AR programs supports the best practice of learning by doing. Programs, such as ZooBurst and MagicBook, allow students to create visual 3D interactive AR pop-up books using a handheld device (Kidd & Crompton, 2015). In a recent study conducted by Antonioli, Blake, and Sparks (2014), they found that AR had a positive impact on the way students were learning by increasing knowledge retention. Antonioli et al. (2014) discovered that the children had a high level of engagement while using the book apps on a handheld device. The use of AR allows students to reach both high level of engagement and creativity to increase their educational experience.

Researchers have conducted experiments to measure whether using AR in the classroom increases students' learning. Estapa and Nadolny (2015) conducted a study that measured the effects of student achievement and motivation through an AR enriched math lesson. They developed a lesson on dimensional analysis by having students calculate unit conversion and dimensional analysis with multi-step problems for a Mexico spring break trip. The marker-based AR used an interactive print document for students to manipulate with a mobile device. Another group of students completed the same project with their mobile devices, but did not have an interactive print document to use. In their results, Estapa and Nadolny (2015) found that students in both groups increased their overall achievement, but those with the AR interactive print document exhibited higher motivation throughout the study.

Two emerging practices with AR include educational games and lab experiments. Currently, AR game systems are already available such as the 'Nintendo 3Ds' and AR apps like 'Star Chart', which allows users to map out the stars at that time and location (Joan, 2015). These AR educational games allow students to organize and collect data within the game that help develop 21st century skills (Wu, Lee, Chang, & Liang, 2013). Two AR games include ARSoccer and Alien Contact. Alien Contact was developed to help students with math, language arts, and science literacy through a hand-held game that allowed students to collaborate with one another (Antonioli, 2014). Virtual soccer balls are controlled in ARSoccer through user kicking motions (Bower et al., 2013). Yuen et al. (2011), noticed that games involving AR exhibited stress-relieving capabilities when used for either educational or entertainment purposes. Manipulations of objects and symbols through these games and labs also allow students who struggle with certain phenomena to grasp material in a different method.

Contextualized Learning

Contextualized learning is learning that is directly connected to the real-world context in which is occurs. Baker, Hope, and Karandjeff (2009) postulate that context is important as it "helps students recognize the purpose and value of basic skills development to their academic or career advancement – enhancing the learning process and facilitating students' mastery of material" (p. 3). The contextualized approach stems from constructivist theory where learning is based on experience and individuals construct their own knowledge through these experiences (Rathburn, 2015). This philosophy has been developed over the years by a number of prominent scholars including John Dewey, Paulo Freire, Lev Vygotsky, Jean Piaget, and David Kolb.

It is important to note that authentic learning is one type of contextualized learning as it involves the student taking part in a real-world task. What makes contextualized learning broader in scope is that students do not have to be learning through an activity a person would undertake in a professional situation. It can just be learning while interacting or just connecting to a real-world phenomenon. Often, students are required to learn from decontextualized materials that provide little to no meaning to the students. For example, we ask students to learn about the concept of angle by showing them joined lines on a page. Students often struggle as they try to remember that these lines are supposed to have another meaning. By contextualizing those angles and pointing them out in a real world setting, students are more likely to remember as the concept of angle has been connected with a context they are familiar with. They can better understand why angles are important as they see them on buildings and playground materials. Students themselves also report a significant preference for problems that are relatable (Premadasa & Bhatia, 2013).

Chiang, Yang, and Hwang (2014), contextualized learning for one group of students as they measured the effects of AR being used in a Natural Science elementary class on student achievement. Students were separated into two different groups: AR based mobile learning, or inquiry-based mobile learning. The group of students in the AR learning approach classroom were encouraged to use GPS to pinpoint ecological locations and information. This is the contextualized group as students were able to understand where and the locations are geographically. The other group of students were placed in a classroom with a teacher using a traditional learning approach used with mobile devices. These students were not encouraged or permitted to use GPS and students only conducted independent research on the mobile device. The results showed that students in the AR based mobile learning group had increased skills such as attention, confidence, and retention beyond those who were grouped into the AR based mobile learning group that used inquiry-based mobile learning.

Visualization

Information visualization is to represent abstract information in a dynamic way that facilitates human interaction for exploring and understanding (Klerkx, Verbert, & Duval, 2014). Information visualized in this way makes use of the principles in Gestalt Theory in using human visual capacity as a powerful pattern-finding tool, to provide a vigorous means of making sense of the available data. Klerkx et al. (2014), describes how high quality learning materials such as texts, graphical illustrations, interactive demonstrations, tutorials, and audio and video presentations can be used for students to fully grasp and understand the meaning of a certain topic.

However, many representations provided in texts, tutorials and demonstrations depict prototypical examples that do not represent the diverse examples in the real-world (Crompton, Grant, & Shraim, in press). As AR is situated in the real-world the visual examples are varied and relevant. For example, in Crompton's (2015) study, fourth grade students learned about the mathematical classification of angle by using visualization supported by AR. In this empirical work, students looked for angles in the real world. Once an angle was identified, students used the Measure a Picture program on an iPad to view the real-world angle and use a dynamic protractor to measure that angle.

Programs for AR have been created to fit various subjects that allow the students to utilize visualization. LearnAR created curriculum activity packs for courses such as biology, chemistry, foreign languages, math, and English to support independent investigation for teachers and students in the classroom or at home (Yuen et al., 2011). Students learning a foreign language have the capacity to use AR simulation programs to help decipher tongue placement for correct pronunciation of words (Yuen et al., 2011). Teachers are even capable of assigning AR for homework by giving students an informational homework page that allows them to watch a video by scanning a page or QR code to use if assistance is required for completion (Bharti, 2015). Lee (2012) discusses the use of AR in biology classes to help students understand the human anatomy through computer-generated 3D models. Students are able to collaborate with one another on biological structures using these marker-based ARs (Lee, 2012). Other visual-based AR mobile apps, like AndAr and String, allow the user to take a photo of a tack on a bulletin board, and a 3D prism will appear on the screen to be manipulated by the user (Demski, 2013).

Using a handheld device with access to a camera, teachers can create mobile applications to be used alongside AR for students. For example, a quick response (QR) code application will help students in a biology class understand the human anatomy through computer-generated 3D models (Lee, 2012). Using the application, students can scan a QR code next to the definition of vascular arteries with their digital device camera that will enable them to see the inside of the body and locate vascular arteries that would not be visible without AR technology.

Future of Augmented Reality in Education

Although AR is not a new concept and is still in its infancy, it has immense potential for changing education (Billinghurst, 2002). Within the next few years, scholars postulate that AR will be widespread among college and university campuses (Yuen et al., 2011). Practices and activities involving AR are seemingly endless, and can be applied across subject areas. Currently in U.S. school systems, AR does not yet appear to be a popular tool among teachers. This is probably due to lack of funding or training on how to use AR effectively in the classroom and this will increase in the future. One explanation for Lee (2012) is the lack of financial support and awareness from both the government and academic community.

Dede (2008) suggests that due to the decrease in the cost of digital devices, AR will become more affordable for schools to purchase in the future and this could cause a rise in the use of AR. Furthermore, it is anticipated that further training will be available for teachers in the future. The increase in AR technology is not only expanding daily, but it is also being developed in various fields to benefit educational programs. For example, the cost of field trips each year prevents many students from hands-on experiences; however, schools can purchase AR technology that will allow students to experience a field trip without leaving the classroom. With technology continuously changing, it is extremely important for our educators to develop new methods of teaching to take advantages of the affordances of these devices for teaching and learning. Ionitescu and Radu (2015) posits that AR would benefit from companies producing easier to use AR programs and systems. It is exceedingly important to know how to use AR effectively in order for students to develop skills from the activity.

CONCLUSION

By expanding our teaching and learning environments, AR is a tool that can be used to support students in becoming 21st century thinkers and problem solvers. The increase in technology is daily life has dramatically increased in recent times; therefore, it is important to take advantage of these new tools and the affordances they provide. In this chapter, four overarching benefits have been identified of how AR can extend and enhance teaching and learning. These affordances are the ability to support; authentic learning, student-centered learning, contextualized learning, and visualize subject content.

Authentic learning is having students connecting to real-world tasks. Students can use a mobile device to become surgeons, pilots and many other important roles as learners get to act out this role in the safety of a digital environment. Learning with AR supports student-centered learning as it allows the students to see and experience what the subject content is. Contextualized learning is learning that is directly connected to the real-world context in which is occurs. AR is a tool that directly engages the student in looking at the world around them while providing additional supports such as prompts and tools to take the learner to a further depth of understanding than they would independently.

Information visualization is to represent abstract information in a dynamic way that facilitates human interaction for exploring and understanding (Klerkx et al., 2014). Graphical illustrations, interactive demonstrations, tutorials, and audio and video presentations can be used for students to fully grasp and understand the meaning of a certain topic. Empirical evidence show that AR can positively make a difference to how students learn and there is promise and potential for the future of AR.

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