2016

The impact of augmented reality on curriculum and training design

Destery K. Hildenbrand

The impact of augmented reality on curriculum and training design

Abstract
Augmented reality (AR) is a relatively emerging technology that is being applied in a somewhat exploratory stage, for training design and curriculum development. In this review, 30 articles were selected and analyzed to identify some current uses of augmented reality in training and curriculum design. Four major themes were identified: 1) a brief introduction about AR; 2) the current uses of AR in curriculum and training development, 3) a review of the effects AR has on student engagement, and 4) the future implications of augmented reality in curriculum and training development. Recommendations for the future are also discussed.

The Impact of Augmented Reality on Curriculum and Training Design

A Graduate Review

Submitted to the

Division of Instructional Technology

Department of Curriculum and Instruction

In Partial Fulfillment

Of the Requirements for the Degree

Master of Arts

UNIVERSITY OF NORTHERN IOWA

by

Destery K. Hildenbrand

May 2016

This Review by: Destery Hildenbrand

Titled: The Impact of Augmented Reality on Training and Curriculum Design

has been approved as meeting the research requirement for the

Degree of Master of Arts.

5/6/16
Date Approved

Ping Gao
Graduate Faculty Reader

5/6/16
Date Approved

Leigh E. Zeitz
Graduate Faculty Reader

5-9-16
Date Approved

Jill Uhlenberg
Head, Department of Curriculum and Instruction

Abstract

Augmented reality (AR) is a relatively emerging technology that is being applied in a somewhat exploration stage for training design and curriculum development. . In this review 30 articles were selected and analyzed to identify some current uses of augmented reality in training and curriculum design. Four major themes were identified: 1) a brief introduction about AR; 2) the current uses of AR in curriculum and training development, 3) a review of the effects AR has on student engagement, and 4) the future implications of augmented reality in curriculum and training development. Recommendations for the future are discussed.

Keywords: Literature review, augmented reality, training design, curriculum development

Table of Contents

List of Figures

The Impact of Augmented Reality on Curriculum and Training Design

On a trip to the local museum James was looking at the exhibits and reading the descriptions to learn more about more about each. As he was reading another individual stepped up and pulled out a mobile device, scanned a symbol by the exhibit, and then watched the screens intently. As James looked over he saw the same exhibit, through this screen, joined now with the artist himself looking intently back. The artist was explaining details about this exhibit and offering additional information not written in the description in front. James looked back at the exhibit, stationary and manual, then again on the screen. This enhanced version of the exhibit was much more interesting, immersive, and engaging as an experience. The entire museum, he thought, would be a very different experience with this technology at his fingertips.

As training and curriculum designers, our goal is to create the most effective learning environment for students possible. The importance of recognizing how a new technology can be integrated into that learning environment and to have relevance in its application becomes a greater challenge and promise as technology evolves. Instructors are always looking for ways to make learning "sticky" for students. Recognizing evolving technology and facilitating its purposeful use is one way to accomplish this. Augmented reality (AR) has immense potential as a technology that when planned out can be effective in knowledge transfer, making things stick, and has a relevant place when applied in training and curriculum development (Bower, Howe, McCredie, Robinson, & Grover, 2014). Augmented reality has the ability to enhance an interactive learning experience for students in a way that allows for hands on learning and computer based objects to interact.

AR has just recently seen an increase in use and researchers are the beginning stages of gauging its place in education and teaching (Combra, Cardoso, & Mateus, 2015). AR is defined

as the process of combining real world objects with a virtual overlay of technology (Bower, Howe, McCredie, Robinson & Grover, 2013). Virtual objects can include text, video, audio, and 3D models that are used as enhancement and instruction over real world environments. Including these types of objects in designing learning solutions has become the trend in instruction models and AR offers an added dimension to the incorporation of these objects (Yen, Tsai, & Wu, 2013). AR technology as a whole has been around since the 1990's (Azuma, 1997), however, it is still in its relative infancy. Augmented reality is a technology we are looking towards and it is important to explore current application and benefits as well as the direction it's trending in the future. In this review, curriculum design is defined as planning, developing and evaluation for education.

This review will address the following questions:

1. How is augmented reality being used in curriculum and training development today?
2. What are the effects of augmented reality on student engagement?
3. What are the future implications of augmented reality in learning?

This review may benefit educators and trainers who are looking for new ways to engage students with technology through the environment around them. The results of this review can provide data surrounding the use of AR technology in training and curriculum and provide clearer expectations to its use when designing for the learning environment.

Methodology

Sources for this review were located through searches of *Google Scholar* and *EBSCO Academic Search Elite* databases. The descriptors used to locate peer-reviewed articles were combinations of the following *Augmented Reality in Higher Education, Inquiry Based Learning, Augmented Reality Interactive Learning,* and *Augmented Reality in Training, Training and Curriculum.* To expand on the original descriptors chosen for this search the snowball research

process was used to leverage additional keywords and topic focus from the original articles that were located. The descriptors noted here were used for searches in Google Scholar and in EBSCO.

The amount of articles found for each combination of descriptors varied greatly. When using the "and" operator to connect several of the descriptors results become more scarce and more manageable. Factor in the date restrictions of 2012 or above to begin with and it became a little more difficult. In some instances there were several hundred to no more than five thousand articles available to research on Google Scholar, however when using more than two descriptor combinations with the "and" operator the results also ranged anywhere from one hundred to under three thousand. Combinations with EBSCO academic Search Elite whittled that number down to no more than one thousand for each search regardless of descriptor combinations and use of the "and" operator.

Criteria for the articles included their location in a credible database, varying research methodology, having been peer reviewed, and having been written within the last 5 years. Each source was chosen due to its recognized credibility in educational research. Articles selected were varied in their own research methodology. This included qualitative research, quantitative research, case studies, action research and literature review. To be considered, all articles needed to reference the use of augmented reality in an educational or training setting, specifically requiring content around an interactive learning activity. The time frame of this research was set from 2012 to 2016 initially. A small window was used to eliminate out dated and irrelevant content however it also eliminated some of the foundational knowledge in prior years that was found to be relevant and necessary in some cases. The reviewer determined the most relevant AR studies to this review have happened within the recent timeframe and that the use of any

information prior to that would be subject to use in background information regarding augmented reality and augmented reality in training or if used in support of prior research that holds relevance within the current technology available. These exceptions were carefully vetted to ensure the articles most relevant to our current technology augmented reality information were reviewed.

Once the 30 articles were chosen, each was analyzed for content. Each abstract was reviewed to identify key words and search terms outlined earlier. Articles were then divided into nonacademic and academic use categories. Each article was then coded throughout the research process. This coding included concept, technology, application, sample size, participant information, and method of research. This information was used for organization and comparison throughout.

Analysis and Discussion

Augmented reality (AR) is a relatively emerging technology that is being applied in a somewhat exploration stage for training design and curriculum development. Within this section a discussion and analysis will occur covering the following topics in the order they are listed here: 1) a brief introduction about AR; 2) the current uses of AR in curriculum and training development, 3) a review of the effects AR has on student engagement, and 4) finally what are the future implications of augmented reality in curriculum and training development.

A Brief Introduction about AR

Before elaborating about the applications of AR for curriculum design and training development, it is important to understand more about AR. AR was first coined as a term in 1990 by Tom Caudell while working for Boeing. It was used to reference the integration of virtual images with the real world (Azuma, 1997). As technology advanced and options were expanded, the AR definition was amended to specifically include 3D virtual objects into a 3D real world environment

(Azuma, 1997) as well. Augmented reality allows for the manipulation and interaction of the real world with a set of information provided by the technology from a user's point of view (Kesima & Ozarslanb, 2012). The overlay of technology on top of what we see offers a greater versatility in application and use for a wide variety of applications that when being used keeps the user tethered to their real environment (Cardoso, Mateus, & Coimbra, 2015). Augmented reality has to be used through a digital device. This digital device could be a mobile device (cell phone or tablet), on a computer screen (laptop or PC/Mac), or more recently through wearable technology (head mounted goggles or other wearable technology options). The content for augmented reality also requires specific software to develop and applications to view on any of the mentioned digital devices.

Although AR has been around for quite some time its use has only been growing as technology and development have become less of an obstacle for its use. AR has been and is being used in numerous industries. Education, manufacturing, entertainment, military, health care, consumer design and robotics are a few of the industries exploring potential uses for AR (Kesima & Ozarslanb, 2012). With such a wide variety of industries courting this technology a rapid increase in its presence has been seen in the last several years (2012 to present), however, a lack of content has shown users have not quite caught up to the availability in many cases. AR is struggling to gain mainstream traction is in part due to a high cost for development and a difficult learning curve of the technology used (Borrero & Marquez, 2012). However with the advent of higher rates of data transmission (cellular and Wi-Fi), it's access and availability on mobile devices such as tablets and phones, and the development of applications for these devices aimed at a broader skill level of user (ease of use technology with a low learning curve needed to develop) has made AR an option of consideration for a wider audience.

Current Use of AR

There are two sub-themes under the current use of AR. Namely uses in curriculum design and training design, which are discussed respectively in the following sections.

Uses in curriculum design. When looking at the current uses of AR in curriculum design and training development, a search was conducted locating as many current uses and their respective environments and industry was used. The main focus was training and curriculum design at the level of classroom was flexible as long as AR was a part of it (K-12, higher education, vocational schools). In curriculum design (for this paper curriculum will refer to educational applications). AR is being approached as a tool to enhance learning projects or sections of the curriculum. Based on the research for this review, augmented reality is not currently being used with any frequency as the foundation or scaffolding of a course or program of study.

In higher education uses of AR for learning primarily focus in the Science, Technology, Engineering, and Math fields (STEM). In these fields students evaluated and provided feedback indicating that AR provided a welcomed addition to their studies or in some cases a non-distracting way to learn. For instance, the field of engineering education has piloted the use of augmented reality through enhanced lab opportunities (Borrero & Marquez, 2012). In their experimental design study they explored the effect of adding AR to a remote lab environment and compared that to a virtual and classroom lab environment. When the students in the experimental group had the opportunity to utilize AR labs at a distance this allowed added benefit from the lab portion of the course even though their physical location was away from the classroom. This AR group was compared to additional groups that held virtual labs and classroom-based labs without the AR component. Each of the groups was of the same level in their degree program and the content was the same. The AR enhanced lesson was small in scope,

10 instructors and 20 students made up the different lab groups to be compared, but positive results were still seen. The results showed that compared to students participating in an in-class lab setting the AR enhanced lesson did as well, if not slightly better, than students in the face to face lab (a +/- 5% differential). Overall the Borreno and Marquez' experimental design showed that AR-based labs could provide improved possibility of current virtual and remote labs being used. Also AR shows potential possibilities over the standard lessons completed in a classroom lab.

A similar result was seen in another study in the field of engineering education. In this validation study, an AR book was developed to assess spatial ability development (Martın-Gutierrez, et al., 2010). With this AR-enhanced book (referred to as MagicBoŏk) 24 mechanical engineering students in their first year of the program sought to see if this AR enhanced object could improve student spatial ability. Students were tasked to use three-dimensional images to test their spatial ability using only a computer and webcam. Although this again has a limited amount of participants to make concrete declarations of outcomes it did show a positive effect on the test group's ability to improve their spatial ability. In the Martin-Gutierrez' study the authors were able to conclude that the training had a measurable positive effect on the student's spatial ability. Although there were positive results as far as measurable improvements, the results also showed a positive impact on student reception to using AR as a technology. One large issue with this study and many others is the small sample size. They will need to be repeated in larger scale studies to reinforce the results from them.

Cardoso, Mateus, and Coimbra, (2015) conducted an exploratory study on augmented reality effectiveness in the discipline of mathematics and put forth the question: Is augmented reality an enhancer for higher education students when learning math? The AR content for this

study was developed in several pre-test examples of an evening engineering math course and the majority of the students had never used AR in an educational setting although they were familiar with what it was. There were thirteen participants in this study. Students were given thirteen tablets with AR software installed. In their textbooks several images were captured and enhanced through AR for the students to use. Students were questioned after the study and results showed that lessons through AR and the use of mobile devices allowed the participants additional opportunity to explore the AR enhanced topics inside and outside of class. This study was small, as stated only including 13 individuals; however several encouraging outcomes were noticed on the survey given at the end of the session. Of those responding (10 out of the 13) they were receptive to AR enhanced content being integrated into their coursework because they stated that it facilitated learning for them. They had a favorable view of the technology as a whole as a way to promote understanding of content. Students also revealed that the use of AR technology was intuitive on the devices that they were given and that it gave them a chance to explore and learn the technology on their own. In instances of the tablets not functioning or having technical issues students were able to move to their own mobile devices, with no prompt from the instructor, to install the AR application and continue the lesson. This was seen from students outside of necessity to finish the lesson as well in students requesting more information about the AR technology used so they could install it on their own devices, and used it to continue their exploration and growth of digital skills (Cardoso, Mateus, & Coimbra, 2015).

In an experimental study by Yen, Tsai, and Wu (2013) they examined the influence of different learning approaches to effectively learning the concept of moon phases through the use of AR enhanced lessons. The total number of 104 participants, all juniors from an education college, was divided into three groups: the experimental group that included AR and two other

control groups made up of the 2D and 3D-content. This AR-enhanced element adds a digital overlay for users to see both the digital device and the real world. It was compared to a 2D-element and a 3D-simulation all based on the same content, the phases of the moon. Results of this study indicated several things including that the use of different learning approaches all three options tested were effective (2D, 3D, and AR) and that the differences between the three were not significant in the results of pre and posttests. They did find through observations and records of the learning experiences that the AR group had a higher motivation and concentration that 2D-materials did not (Yen, Tsai, & Wu, 2013). A large benefit to this study was the sample size. Documented future research is going to be needed preferably including studies with this size.

Unfortunately educational examples like these are not all that statistically telling. They are however encouraging and raise signs of quality potential for this technology in the field of education although this will have to be continually vetted through further studies.

As with much of current learning practices, time is a set variable that we don't always have the most control over. In most cases a set amount of content must be achieved in a relatively short amount of time every semester. This alienates many users and restricts the amount of research and development time available for many educators. This limits the ability to use more technologically-complex options like augmented reality in their curriculum (Wu, Lee, Chang, & Liang, 2013). With technology adept classrooms becoming more prevalent and with AR software and hardware options being more user-friendly in 2016 we could see this as less of an issue. In 2016 AR is available to anyone with access to a mobile device and a few online resources and apps. Technical support provided by AR developer companies like Aurasma, Blippar, and LayAR offer training and support for using their technology. When thinking on where AR fits into a session or lesson plan the creation of simple AR enhanced lessons and

interactions, using the resources available to anyone with an internet connection, can be less intimidating for short bursts of information.

Wu, Lee, Chang and Liang (2013) also point out two additional concerns that were prevalent at the time of their research. First, the augmented reality hardware needed to view the AR enhanced lesson can be cumbersome to wear, difficult to use, and require a steeper learning curve to understand to even get started with the activity. The use of external hardware can also cause physical problems for the wearer including issues with depth perception and balance. They also point out two significant issues that this researcher noted in several other resources regarding augmented reality in curriculum design. The two items noted were a resistance to AR use by educators (which is discussed further later in this paper) and trying to understand where a new technology like AR is best utilized in a lesson or activity. The idea of where AR fits into the design of learning activities is a question that relates to most new technology use in curriculum and training development. With AR essentially combining two realities (the digital and the real world) on one screen or device this is a question that will still need to be explored. Other questions that educators think about when working with a technology like AR include topics like cognitive overload, ease of use, and resource availability. There is no shortage of questions when trying to incorporate new technology those mentioned here are aspects of augmented reality that cause less motivation for use in curriculum design (Wu, Lee, Chang, & Liang, 2013).

Overall a majority of the information documenting AR in education currently tends to be references of studies into student engagement and effectiveness. Studies within the last several years (2012-2016) are taking into account the students' access to mobile tools and technology on-the-go and the BYOD aspect associated with it allowing for less up front cost (Chen, Chen, Huang, & Hsu, 2013). These, and other devices, are being used as digital learning aids to

enhance real-life scenarios through inquiry-based learning activities. Adding this real-world element to the lessons allows for a greater synthesis of the material being covered (Chiang, Yang, & Hwang, 2014).

Uses in training design. Within training (training will reference any uses not associated with curriculum design in an educational setting) a more varied application of the AR technology is seen. In most of these cases this varied approach could be attributed to the resources and funds available to non-educational institutions. Some areas that anticipated growth can be expected and seen currently are in both the manufacturing and healthcare sectors of industry. A large amount of resources are expended in development and training of employees and specific skills, defect prevention, and a faster total-work time for completed items every day (González-Franco, et al., 2016). Being able to incorporate AR to learn and reinforce fine motor skills or specialized skills for a more talented workforce and a more effective workflow is of great interest to these companies. In manufacturing, AR training is used to not only train employees but to reduce defects and assembly errors would have a positive economic impact for the company's bottom line. AR is a complex technology to implement on a manufacturing floor or in a training program. Many factors play into this difficulty including cost, development time, and application. For example, in manufacturing some of the more affordable AR delivery systems are handheld. This limits workers to potentially using only one hand for a build or to constantly have to pick up and put down the handheld device These types of restrictions require rethinking the use of AR or rethinking the device in which AR is being used from(Gonzalez-Franco, et al., 2016; Schwald & Laval, 2003).

Similar to education there are a number of studies being conducted testing potential uses for AR. One study in the manufacturing sector focused on human computer interaction through

the use of an immersive AR set-up. The task was the construction of an aircraft maintenance door and two training groups were shown how to build it. Twenty-four volunteers made up of employees of the company were used in these groups. One group participated in face-to-face training and the other was trained with the immersive augmented reality. Results between the groups showed similar results in the post knowledge check between the two approaches. This is similar to the education studies in this regard. Another point to note here is that knowledge retention did not go down based on AR being introduced into the training materials. Users did not get any worse at the activity with AR involved and in fact AR was the catalyst for users to show more enthusiasm for the enhanced task. Both of these are significant outcomes for businesses. First, employees are excited for the new technology to complete a potentially old task leading to a more motivated workforce. Second, the technology did not hold the employees back from completing their task. The introduction of AR into their workflow did not cause a breakdown in the fundamental task being completed. In this study for manufacturing AR and the face-to-face training are at the least equal in their results. One last point in this study that was noted and will need additional study is that there was a potential greater learning curve of using the immersive AR before even getting to the door training (Gonzalez-Franco, et al., 2016).

This particular study, as well as the ones mentioned earlier highlight some consistent themes in training and curriculum design with AR. First is that right now there is no significant benefit to switching to AR from face-to-face. In this review, these results were varied when comparing using AR vs. other training methods. In some cases there were no significant increased benefits to using AR over other methods (Borrero & Marquez, 2012; Yen, Tsai, & Wu, 2013; Zhu, Hadagar, Masiello, & Zary, 2014;). In other instances there were significant differences in the scores (Westerfield, Mitrovic, & Billinghurst, 2014), positive towards AR vs.

other methods (Boud & Baber, 1999). Although there were some additional differences in these tests a more consistently positive outcome will be needed for mainstream adoption by corporations.

Effects of Augmented Reality on Student Engagement and Educators

The second theme as continued from the discussion in the previous section is the positive effect on student engagement when using AR in their lessons or training as well on educators (Bacca, Baldiris, Fabregat, Graf, & Kinshuk, 2014; Boud & Baber, 1999; Gonzalez-Franco, et al., 2016;; Westerfield, Mitrovic, & Billinghurst, 2014).

One of the drawbacks to the current set of studies that have been published is a lack of definitive results to be used in measure and conclusions about the effects of augmented reality as a useful learning technology. Augmented reality has been seen to offer varied results in the results of the studies reviewed in this review. With the lack of use and a wider lack of larger studies done with AR enhanced lessons or activities no measurable results of AR use in curriculum and training development are available at this time. As mentioned in the results of the studies sample sizes are so small for many of these studies that solid outcomes are hard to make. Currently the best description, based on the studies reviewed, is that there is no statistical negative effect on learner performance and it is viewed positively students who use it. The AR approach is seen to encourage participation, stimulation and engagement (Antonioli, Blake, & Sparks, 2014). Novelty and excitement is an accurate way to describe the reactions learners have when augmented reality is used in lesson and activity design (Antonioli, Blake, & Sparks, 2014; Cardoso, Mateus, & Coimbra, 2015; Chiang, Yang, & Hwang, 2014; Ibáñez, Serio, Villarán, & Kloos, 2014; Jorge Bacca, 2015; Yen, Tsai, & Wu, 2013). It's this novelty or unique approach to the lesson that seems to buoy the idea of AR in lesson design. The majority of students who were

a part of the studies researched has shown more willingness and interest in the topics when AR is a part of the lesson.

This researcher sees the positive impact on student engagement through augmented reality as one of the more promising aspect of these early studies and thinks this should a point of emphasis when discussing the integration and use of AR in training and curriculum design. Getting students or participants interested in learning more or going above and beyond the lesson is a difficult obstacle to overcome for educators and developers. Augmented reality is a technology that can generate interest in a topic through its approach of adding interactive digital elements in our everyday world.

Educators are more reserved about the use of AR technology for some old reasons and a few unexpected ones. Combined with a lack of technical ability many instructors are afraid that technology will overtake the lessons and potentially replace them (Antonioli, Blake, & Sparks, 2014). Due to the larger learning curve to implement newer technology like AR many educators and trainers do not have the resources or knowledge to use AR technology in a way that would benefit the subject being taught. Educators have also observed negative effects using AR through mobile devices in that includes students, when immersed into the augmented world in front of them, tend to ignore general safety and spatial awareness of the world outside of that augment. Students also become engrossed in the technology to a point where some of the required tasks, the debriefing between students in person, were not completed. Student's ability to be oblivious to the world around them and to each other in a physical sense, when using mobile technology for location based AR was mentioned as a concern in several scenario or scavenger hunt type lessons (Dunleavy, Dede, & Mitchell, 2009).

Current and Future Implications of Augmented Reality in Learning

Augmented Reality Today. Augmented reality technology is becoming more and more available to the general consumer as a way to enhance and interact with the world. Just a few months into 2016 there has been a push for mobile phones to be compatible with augmented reality (Galaxy Samsung phone now being sold with the Gear VR headset); Google has teamed up with Lovono to create "Project Tango". This Project Tango device will allow users to interact with their physical space including their precise location, 3 dimensional depth perception, and the ability to have apps and games recognize these aspects of the room around them (Lovono, 2016). Wearable technology is still in its infancy but the possibilities for interaction in training and curriculum through AR are out there. Leveraging a fit bit to project data or wayfinding for a physical education class including what route to run or how many calories you would burn depending on the path traveled. Wearable glasses like Google glass to allow for additional information to be displayed at a culinary training school on what ingredients to use and how much to use.

Augmented Reality applications are being developed and resources are being provided for anyone to sit down at the computer and their mobile device and create an augmented reality project. Applications like Aurasma, Blippar for Education, LayAR, and Anatomy 4D are free and accompanied by limited but usable developer tools for training and educational uses (Aurasma, 2015; Blippar, 2016; MAX, 2015). All of these tools offer a greater degree of flexibility to students and educators to incorporate augmented reality into their classrooms and curriculum.

In many cases the uses of AR in curriculum and training development today are expanding with the new hardware and software options and a general easier use of the

technology available. David Kelly (2016), a performance consultant with the eLearning Guild, recently stated that if we want to see how technology affects us in learning and development we need to pay close attention to how that technology influences our behaviors in everyday life. The way people are using new technology like augmented reality in their everyday lives gives us a glimpse into the window of how it could be successfully used in an education of training environment.

Many major technology players in today's markets are looking at or already leveraging an augmented or virtual platform for their products. Hewlett Packard has recently acquired the augmented reality tool Aurasma. Apple and Facebook (both technology developers of widely used mobile and social media platforms) are in the process of building their virtual and augmented reality developer teams and acquiring start-ups specializing in augmented reality (Bell, 2015; Walton, 2016). Video game and mobile phone developers have also spent a great deal of time creating augmented and virtual reality products available now or in the near future including project Morpheus, a headset allowing augmented reality on the PlayStation 4 video gaming system (Lampkin, 2016), and the Oculus Rift, a virtual reality headset used currently with the Samsung digital phone system most recently purchased by Facebook.

The previously mentioned companies and products are only a small sampling of what is being developed and available for consumer use in the near future. How people are able to incorporate these devices in their day to day life will shed a great deal of light on how training and development will be able to use them. The term gamification is the use of game thinking, mechanics, dynamics, and framework into situations where they would normally not be used (Chantzi, Plessa, Gkanas, Tsolis, & Tsakalidis, 2013). Augmented reality could be used to

gamify content. The developing AR platforms of the future including the hardware and software could be utilized for this. I see this being a very popular and positive trend moving forward.

Bridging the consumer-to-learning gap is a huge opportunity for those of us in the learning industry however it will require some additional training for ourselves to be able to use this new technology or it will require additional funding to hire developers to create it for us. Either way presents a potential roadblock. Educators already cite that a lack of time and perceived usefulness in their lessons to name a few as reasons they don't learn and introduce current technology into their curriculums (Herold, 2015). Corporations are not much better. Their perceived value of using technology in training is marginal to negative at best (Silva, 2015). The second issue is always funding. It is equally challenging to find money for new technology and development. It may be a simple case that most schools or private organizations do not have the funding or are unwilling to spend it in training and development. (Silva, 2015) . These are just two of the bigger hurdles that lay in wait for educators and trainers as technology like augmented reality becomes more prevalent.

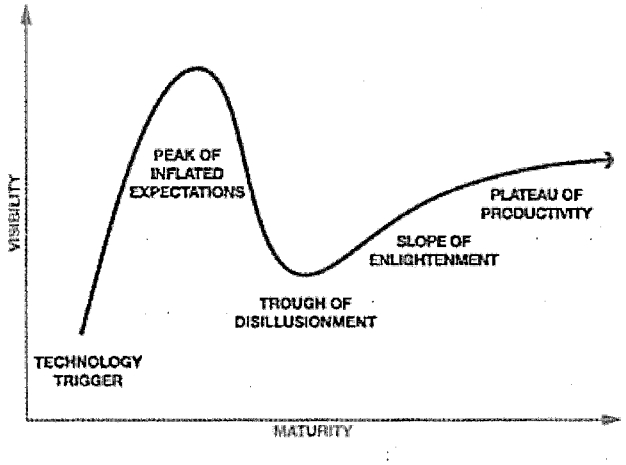

Figure 1: Hype Cycle five key phrases of technologies (Gartner, n.d.).

Augmented reality has been surrounded by a lot of hype in its early growth. According to the Gartner Hype cycle (Figure 1, Gartner, n.d.) which provides the recorded promise of a

particular technology through the Gartner research methodology, we are seeing that Augmented reality falls somewhere at the bottom of the peak of inflated expectations and just making its way to the trough of disillusionment (Figure 2). AR falls into this category on the Gartner Technology Hype Cycle for a few reasons. The expectations of augmented reality have been larger than the actual promise. This hype for augmented reality in 2016 is high in that leaders in the technology industry have AR in their future plans. Facebook has acquired the AR wearable Oculus, an AR start-up Magic Leap is a growing company that has raised a large bit of capital (over $800 million) on mixed reality hype alone. As of the writing magic leap has no product, software, or hardware that has been seen by consumers (Sherr, 2016). Gartner Principal Research Analyst Toung Huy Nguyen whose studies focus around immersive technologies like augmented reality reports that recent trends and acquisitions of AR tech vendors should keep the industry in more of a wait and see approach to AR vs a strong development time. In 2015 Gartner had placed AR in the deepest section of the disillusionment section of the graph indicating that although there was promise for the technology it has not been adequately realized yet. In 2015 Gartner stated that the potential timeframe before AR fulfills its original expectations and promise could be as many as 5 to 10 years away (Gartner, 2016;Gartner, 2015).

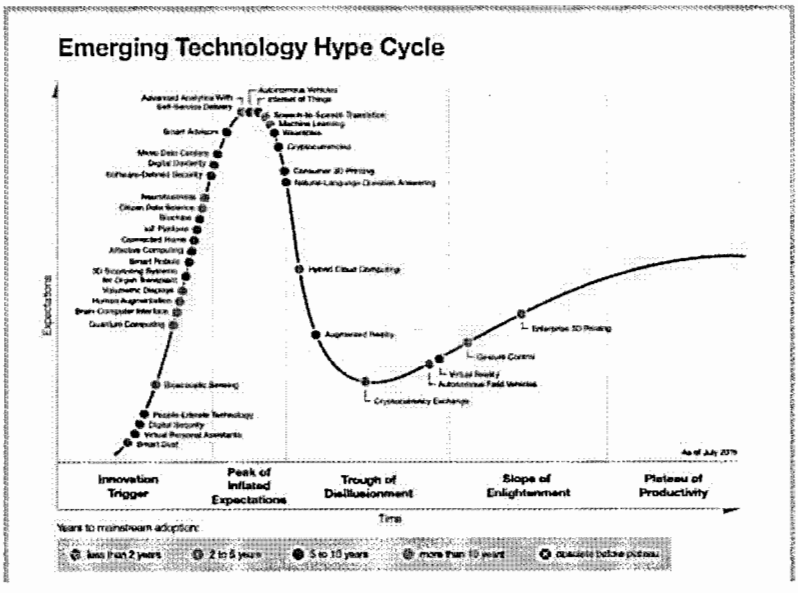

Figure 2: (Gartner, n.d.) Gartner Hype cycle identifying current technologies (2015)

This is an accurate representation based on the research I have done and the projects I have attempted on my own with augmented reality. Although I have been working directly with augmented reality for a little over a year, its use is limited to basic just-in-time graphical overlays and video if you lack a programming background.

In the example images on the following pages are some of the AR work that I have been doing. These AR enhanced activities are being used to test HP's Aurasma App a possible low cost AR enhanced solution. For the examples to function examples scan the QR code to install the Aurasma app and follow my channel (Figure 3)

Figure 3: QR code to install Aurasma and follow a channel

With the Aurasma app scan the images (Figures 4, 5 & 6) to see the AR enhanced activities. In creating the AR enhanced activities the trigger is one of the building blocks needed.

The trigger image (Figure 5) is placed and used to activate the augmented content. Overlays are made up of multimedia or static image content that are then placed on top of the trigger image once it has been activated within the app (Figure 6). These overlays allow for the digital file superimposing over the real world that activated it. Elements that can cover the trigger include interactive icons, links, and multimedia.

Figure 4: Visual Overlays identified when using the augmented reality app

Figure 5: Trigger image (scan for content)

Figure 6: Overlay superimposed on trigger

Because AR as a technology is readily available and easier to use, some of the hurdles that once limited new technology from entering the classroom are being eliminated. The maturation of the software and hardware for emerging technologies like AR to this level makes application and practical uses easier to discover for developers and learners alike (Bacca,

Baldiris, Fabregat, Graf, & Kinshuk, 2014). Because the technology is evolving at such a rapid pace little educational research has been done in the state we are now.

Conclusions and Recommendations

People learn differently through technology. We also design and plan differently when technology is involved in learning. As technology evolves and becomes easier to use and readily available we need to find a place for it that will benefit the learners. Students will bring the technology they have and look for ways to use it. Technology use will find its way into our training and classrooms. How we influence and direct that technology use within our classes will dictate its effectiveness. . It is our responsibility as instructional designers and educators to get past own reservations, perception, and bias when it comes to technology. If technology does not seem to fit into the lessons and plans we are making then we need to step back, take off the blinders, push aside our reservations about technology and try again.

This literature review attempts to answer the three research questions and ends up with three major findings.

Augmented Reality in Curriculum and Training Development

Augmented reality use in curriculum and training development today is being used in a variety subjects, different types of lessons, and interactive activities. For instance, in curriculum design it was found that AR is being used in a minor role and is not used as the foundation or scaffolding of a course or program of study. The studies I have reviewed for this paper tended to focus in the areas in the STEM fields. Engineering and math pilot programs are the more prevalent types of applications that are found when searching current articles. These types of pilots have focused on several aspects including small interactive images all the way to a more effective e use of augmented reality through enhanced lab opportunities (Borrero & Marquez, 2012; Cardoso, Mateus, & Coimbra, 2015; Yen, Tsai, & Wu, 2013). Within the STEM fields AR

math applications have also been seen in the enhanced collaborative learning resources. Examples of this include the MagicBook and its use in 3D spatial ability learning (Cardoso, Mateus, & Coimbra, 2015). The AR lessons about the phases of the moon that were developed fall into the STEM categories as well (Yen, Tsai, & Wu, 2013). All of these applications are currently being used allowing students to incorporate augmentation of their lessons and activities through a novel and engaging way that increases interest in learning the topic.

AR and Student Engagement

In terms of answering the second question: The research evidence suggests that students tend to have positive response to the use of AR in lessons or activities (Chiang, Yang, & Hwang, 2014; Ibáñez, Serio, Villarán, & Kloos, 2014; Yen, Tsai, & Wu, 2013). However, there is no strong evidence about the improved learning outcomes associated with its use (Antonioli, Blake, & Sparks, 2014; Borrero & Marquez, 2012; Cardoso, Ibáñez, Serio, Martın-Gutierrez, et al., 2010; Mateus, & Coimbra, 2015; Villarán, & Kloos, 2014). One of the main conclusions inferred from these studies is that AR does not have a statistical measurable impact on learner performance. The results seen in these studies moved from a position of no discernable effect positive or negative to a positive direction. Studies reviewed have been small in participants and scope as a caveat to the results. One big takeaway from the studies reviewed was the learner engagement aspect of the lessons. Research evidence suggests there is a positive effect on student engagement when using AR in their lessons or training as well on educators (Bacca, Baldiris, Fabregat, Graf, & Kinshuk, 2014; Boud & Baber, 1999; Gonzalez-Franco, et al., 2016; Westerfield, Mitrovic, & Billinghurst, 2014). This positive effect of using augmented reality in lesson and activity design motivates students to not only engage in the activity but to embrace and explore the technology as well.

Future AR Implications

Question three is difficult to answer directly. AR is expanding into our everyday technology use but it still falls outside of everyday users. Its current application is limited to apps and basic interactions unless you possess programming resources. Despite its limitations at this time the continuous updates of software and hardware that have and will happen the future is wide open for continued growth and application of augmented reality in curriculum and training development. An abundance of AR applications, increased ease of use, and mobile technology all contribute to furthering collaborative and inquiry based learning opportunities. These lessons allow students to engage with the topics through digital interaction with the real world, interact with their peers, and to interact in a more unique way with educators too (Hsu & Ching, 2013; Ke & Hsu, 2015). The Future use of augmented reality looks to be a growth technology specifically in health care medical devices are now capable of such fine detail during use that an entire field of study and research surrounds the use of augmented reality to bring these advanced visual capabilities to hospitals and clinics in a wide variety of disciplines including diagnostics and surgery (Sielhorst, Feuerstein, & Navab, 2008; Zhu, Hadagar, Masiello, & Zary, 2014).

Augmented reality as a technology is more visible now thanks to the entertainment and marketing industries. AR as a technology is new in the field of education and training. Realizing the true potential of augmented reality in this area will take some time. The future of AR does look to be positive. Many well-known technology companies are investing into augmented and virtual reality hardware and software hit the in the consumer market. Technology pioneers like Apple, Hewlett Packard, and Sony are investing in the research and development of game and app based AR hardware and software options (Bell, 2015; Lampkin, 2016; Walton, 2016). With the consumer release of AR technology interest in it will grow in the public sector which in turn

can lead to inclusion within curriculum and training design. The next three to five years will be very telling for the full realization of the technologies longevity and effectiveness.

Mobile Technology May be the Future. We are a society that is more connected by the day. Expensive hardware and software are become less of an obstacle and easy to use development apps are becoming more available. Mobile devices, wearable devices, and computer based AR applications are the main way AR enhanced content is accessed. Today many individuals already own a mobile device of some kind that could be used for AR. This access has the potential to provide more AR opportunities for curriculum and training design as the hardware purchase could be null. With a key cost reduced or eliminated entirely development of future AR lessons and activities become more likely. (Merchant, 2012). Utilizing the technology already in everyone hands will go a long way to overcoming the financial hurdles experienced in schools and corporations. Studies are being conducted regarding the use of mobile devices in education using augmented reality. Teachers are taking into account the audio visual and just in time aspects of mobile technology and applying them to various educational contexts and subjects and the computing power of newer mobile technology offers the ability to run more arduous programs (Cadavieco, Goulao, & Costales, 2012; Bower, Howe, McCredie, Robinson, & Grover, 2014; Tarng & Ou, 2012).

Future applications of AR in curriculum and training design could include Interactive historical simulations, video and audio overlays ready to be explored through everyday objects that are at students fingertips (Nincareana, Alia, Halima, & Rahman, 2013). In manufacturing training AR interactions could constantly scan and project the next part needed, assist in locating that part on the workbench, and a virtual overlay of how the parts fit together could be projected to ensure accurate construction.

Recommendations

First and foremost as educators, we need to keep testing, trying, and learning from the use of augmented reality to enhance the lessons and training developed. The companies and technology currently being developed needs to be tested to see what possible benefits it can provide. The findings and research into AR studies being conducted are encouraging however during my research I found that very few organizations are using mobile devices, advanced wearables, or even PC based AR enhanced lessons or activities. Based on the lack of studies published on the topic I can only speculate that not many companies and educational organizations have explored this technology. The trick with this technology, for as much potential as I believe it has, is waiting for it to become more viable, user friendly, and affordable. If there is any way we can pilot and try out AR then we should and then we should be documenting and sharing with our peers in the community the results of those trials.

Keep Trying New Things

The next step for us as instructional designers and curriculum developers is to find the most effective ways that we can bridge that gap and include learning and development into that everyday mobile tool. We need to explore the tools that we have in our augmented reality tool belt. Understanding what is out there, how people are using it, and how we can use it in the future. Where does it make sense to incorporate this technology? How can I engage my students with this technology? What does this technology look like in my classroom? There are all questions we can ask ourselves as we continue to grow our 21st century classrooms.

Our ability to do this will go a long way to helping us find better uses for augmented reality in curriculum and training and help us create a more positive and beneficial effect on the students who are learning and the designers and educators who are teaching.

The second recommendation is related to future research. There needs to be more studies and larger sample sizes of participants involved in those studies. The studies reviewed for this paper show a great deal of promise in regards to student engagement (Borrero & Marquez, 2012; Martın-Gutierrez, et al., 2010) however without more studies like this we cannot get a full picture of how successful the implementation of augmented reality technology might be. This future research will also need to be standardized to an extent. The research studied here was aimed at a more recent timeframe however augmented reality is improving at a pretty rapid pace. What was standard and usable in 2014 has changed by 2015. Because of this type of change and the wide offerings that are available to create AR future research will need to follow some sort of standard use case to accurately compare the same technology and application of that technology to get a more accurate and consistent result. Getting these consistent results is going to require a more consistent approach. The overall technology being used in these studies should be similar and how it's being delivered and received by students should be monitored as well. This consistency in delivery and reception could make a difference in the results of the studies.

Conclusion Remarks

References

Antonioli, M., Blake, C., & Sparks, K. (2014). Augmented reality applications in education. *The Journal of Technology Studies, 40*(2), 96-107.

Aurasma. (2015). *Aurasma Gettng Started.* Retrieved 3 6, 2016, from Aurasma: https://www.aurasma.com/

Azuma, R. T. (1997). A Survey of Augmented Reality. *Teleoperators and Virtual Environments. 6*(4), 355-385.

B., J. F.-P., Nex, F., Rizzi, A., & and Remondino, F. (2014). ARCube—The augmented reality cube for archaeolog. *Archaeometry, 57*(S1), 250-262. doi:10.1111/arcm.12120.

Bacca, J., Baldiris, S., Fabregat, R., Graf, S., & Kinshuk. (2014). Augmented reality trends in education: a systematic review of research and applications. *Educational Technology & Society, 17*(4), 133-149.

Bell, K. (2015, Oct 7). *Mark Zuckerberg: Facebook is working on augmented reality.* Retrieved Mar 20, 2016, from Mashable: http://mashable.com/2015/10/07/mark-zuckerberg-vanity-fair-vr/#8kFR5MsjiaqR

Blippar. (2016). *Blippar for Education.* Retrieved 3 6, 2016, from Blippar: https://blippar.com/en/learn-more/blippar-for-education/

Borrero, A. M., & Marquez, J. M. (2012). A Pilot Study of the Effectiveness of Augmented Reality to Enhance the Use of Remote Labs in Electrical Engineering Education. *Journal of Science Education and Technology, 21*(5), 540-557.

Boud, A., & Baber, C. (1999, Feb). Virtual Reality and Augmented Reality as a Training Tool for Assembly Tasks. *1999 IEEE International Conference on Information Visualization*

(Cat. No. PR00210) (pp. 32-36). London: IEEE. doi:DOI: 10.1109/IV.1999.781532 · Source: IEEE Xplore

Bower, M., Howe, C., McCredie, N., Robinson, A., & Grover, D. (2014). Augmented Reality in education–cases, places and potentials. *Educational Media International, 51*(1).

Cadavieco, J. F., Goulao, M. d., & Costales, A. F. (2012). Using Augmented Reality and m-learning to optimize students performance in Higher Education. *Procedia - Social and Behavioral Sciences, 46*, 2970-2977.

Cardoso, D. T., Mateus, D. A., & Coimbra, M. T. (2015). Augmented Reality: an Enhancer for Higher Education Students in Math's Learning. *Science Direct, 67*, 332-339.

Chantzi, A. E., Plessa, C., Gkanas, I. C., Tsolis, D., & Tsakalidis, A. (2013). Design and Development of Educational Platform in Augmented Reality Environment using Gamification to enhance Traditional, Electronic and Lifelong Learning. *BCI (Local)*, 92.

Chen, D.-R., Chen, M.-Y., Huang, T.-C., & Hsu, W.-P. (2013). Developing a Mobile Learning System in Augmented Reality Context. *International Journal of Distributed Sensor Networks*. doi:doi:10.1155/2013/594627

Chiang, T. H., Yang, S. J., & Hwang, G.-J. (2014). An Augmented Reality-based Mobile Learning System to Improve Students' Learning Achievements and Motivations in Natural Science Inquiry Activities. *Educational Technology & Society, 17*(4), 352–365.

Dunleavy, M., Dede, C., & Mitchell, R. (2009). Affordances and limitations of immersive participatory augmented reality simulations for teaching and learning. *Journal of Science Education and Technology, 18*(1), 7-22.

FitzGerald, E., Ferguson, R., Adams, A., Gaved, M., & Mor, Y. a. (2013). Augmented reality and mobile learning: The state of. *International Journal of Mobile and Blended Learning, 5*(4), 43-58.

Gartner. (n.d.). *Research Methodologies*. Retrieved Mar 25, 2016, from Gartner: http://www.gartner.com/technology/research/methodologies/hype-cycle.jsp

Gonzalez-Franco, M., Cermeron, J., Li, K., Pizarro, R., Thorn, J., Hannah, P., . . . Bermell-Garcia, P. (2016). *Immersive Augmented Reality Training for Complex Manufacturing Scenarios.* Cornell University Library.

Herold, B. (2015, Jun 10). *Why Ed Tech Is Not Transforming How Teachers Teach*. Retrieved Mar 20, 2016, from Ed Week: http://www.edweek.org/ew/articles/2015/06/11/why-ed-tech-is-not-transforming-how.html

Hsu, Y. C., & Ching, Y. (2013). Mobile computer supported collaborative learning. *The international handbook of collaborative learning*, *44*(5) 420-436.

Ibáñez, M. B., Serio, Á. D., Villarán, D., & Kloos, C. D. (2014). Experimenting with electromagnetism using augmented reality: Impact on flow student experience and educational effectiveness. *Computers and Education, 71*, 1-13.

Jorge Bacca, S. B. (2015). Mobile Augmented Reality in Vocational Education and Training. *Procedia Computer Science, 75*, 49-58.

Ke, F., & Hsu, Y.-C. (2015). Mobile augmented-reality artifact creation as a component of mobile computer-supported collaborative learning. *Internet and Higher Education, 26*, 33-41.

Kesima, M., & Ozarslanb, Y. (2012). Augmented reality in education: current technologies and the potential for education. *Procedia-Social and Behavioral Sciences*, *47*, 297-302.

Lampkin, P. (2016, Mar 16). *Sony PlayStation VR: Essential guide to the hardware, games, release and more*. Retrieved Mar 25, 2016, from Wearable: http://www.wareable.com/project-morpheus/sony-project-morpheus-release-date-price-games

Lovono. (2016). *Levono Project Tango Informational site*. Retrieved 3 6, 20161, from Lenovo Company Website: http://www.lenovo.com/projecttango/

Marc Ericson C. Santos, A. C., Miyazaki, J., & Kato, H. (2014). Augmented reality learning experiences: Survey of prototype design and evaluation. *IEEE Transactions on Learning Technologies, 7*(1), 39-56.

Martın-Gutierrez, J., Saorın, J. L., Contero, M., Alcaniz, M., C.Perez-Lopez, D., & Ortega, M. (2010). Design and validation of an augmented book for spatial abilities development in engineering students. *Computers and Graphics, 34*(1), 77-91.

MAX. (2015, 12 12). *10 Best Augmented Reality Apps – VR for the Rest of Us*. Retrieved 3 6, 2016, from Appcessories: http://www.appcessories.co.uk/10-best-augmented-reality-apps-vr-for-the-rest-of-us/

Merchant, G. (2012). Mobile practices in everyday life: Popular digital technologies and schooling revisited. *British Journal of Educational Technology, 43*(5), 770-782.

Nincareana, D., Alia, M. B., Halima, N. D., & Rahman, M. H. (2013). Mobile augmented reality: The potential for education. *Procedia - Social and Behavioral Sciences, 103*, 657-664.

Schwald, B., & Laval, B. d. (2003). An Augmented Reality System for Training and Assistance to Maintenance in the Industrial Context. *Journal of WSCG, 11*(1-3).

Serio, Á. D., Ibáñez, M. B., & Kloos, C. D. (2013). Impact of an augmented reality system on students' motivation for a visual art course. *Computers & Education, 68*, 586-596.

Sielhorst, T., Feuerstein, M., & Navab, N. (2008). Advanced medical displays: A literature review of augmented reality. *Journal of Display Technology, 4*(4), 451-467.

Silva, D. (2015, Nov 7). *American Training Companies Undervalue Technology As A Training Resource*. Retrieved from eLearning Industry: http://elearningindustry.com/american-training-companies-undervalue-technology-training-resource

Tarng, W., & Ou, K. L. (2012). A Study of Campus Butterfly Ecology Learning System Based on Augmented Reality and Mobile Learning. *Wireless, Mobile and Ubiquitous Technology in Education (WMUTE), 2012 IEEE Seventh International Conference on* (pp. 62-66). Takamatsu: IEEE.

Walton, M. (2016, Jan 22). *Apple hires top virtual and augmented reality expert, FT reports*. Retrieved Mar 20, 2016, from ars technica: http://arstechnica.com/apple/2016/01/apple-hires-top-virtual-and-augmented-reality-expert-ft-reports/

Wang, H.-Y., Duh, H. B.-L., Li, N., Lin, T.-J., & Tsai, C.-C. (2014). An investigation of university students' collaborative inquiry learning behaviors in an augmented reality simulation and a traditional simulation. *Journal of Science, 23*(5), 682–691.

Westerfield, G., Mitrovic, A., & Billinghurst, M. (2014). Intelligent augmented reality training for motherboard assembly. *International Artificial Intelligence in Education Society, 25*(1), 157-172

Wu, H.-K., Lee, S. W.-Y., Chang, H.-Y., & Liang, J.-C. (2013). Current status, opportunities and challenges of augmented reality in education. *Computers & Education, 62*, 41–49.

Yen, J.-C., Tsai, C.-H., & Wu, M. (2013). Augmented reality in the higher education: Students' science concept learning and academic achievement in astronomy. *Procedia - Social and Behavioral Sciences, 103*, 165-173.

Zhu, E., Hadagar, A., Masiello, I., & Zary, N. (2014, Jul 7). *Augmented reality in healthcare education: an integrative review*. Retrieved from peerj: 10.7717/peerj.469