Technology Enhanced Learning using Virtual and Augmented Realities: An Applied Method to Improve the Animation Teaching Delivery

Rosana W. Marar and Edward Jaser
Princess Sumaya University, Khalil Saket Street, Amman, Jordan

Keywords: Animation, Augmented Reality, Google Cardboard, Interactive Media, Technology Enhanced Learning, Virtual Reality.

Abstract: This paper presents a software solution to enhance the content and presentation of graphic design and animation related textbooks. Using augmented and virtual reality concepts, a mobile application is developed to improve the static material found in books. This allows users to interact with animated examples and tutorials using their mobile phones and stereoscopic 3D viewers which will enhance information delivery. The application is tested on Google Cardboard with visual content in 3D space. Evaluation of the proposed application demonstrates that it improved the readability of static content and provided new experiences to the reader.

1 INTRODUCTION

The use of Technology Enhanced Learning (TEL) is increasing over the years and becoming more vital for improving the educational process. TEL depends on the use of technology and facilitating information accessibility for individuals from any location possible (Klimova, 2014). Nowadays, teachers adopt the use of technology in classrooms to make the educational process more efficient, effective, and appealing (Srisawasdi, and Panjaburee, 2014). In addition, the use of technology helps students overcome some of the learning problems that they are facing. Interactivity in the educational process plays a major role in enhancing student's productivity and outcomes. To ensure its efficiency those technologies must be available and updated.

In this paper, a TEL based system will be used to improve knowledge delivery in an undergraduate animation course in which presenting the graphical content of the material will impact the learning process and aid in visualizing the animated content of textbooks. To master the basic skills of animation, students require many hours of envisioning the content followed by hands-on practice. Several students face many problems that limit their ability to understand and apply what they learned. One of the main problems is that when instructors explain the 12 principles of animation (Lasseter, 1987), students will not be able to imagine how to apply those principles and what difference would it make if they do not implement them. Also, taking into consideration that all life aspects are dependent on technology and computers, reading content intended to teach animation from a book will not provide the experience that they are after.

There are many technologies that can be used to enhance knowledge delivery such as e-learning, multimedia, Augmented Reality (AR), Virtual Reality (VR), beside others. This paper presents a solution combining VR and AR technologies to attempt enhancing the animation teaching process in universities and colleges. This will provide students with better perspective in the learning process due to incorporating traditional teaching methods with AR and VR technologies to provide a unique experience and approach in animation learning.

This paper is organized as follows: section II provides an overview of current AR and VR usage in teaching. Section III discusses the proposed solution and evaluating its impact on the learning process. Section IV concludes the paper and provides some future intended work that will improve current existing technologies.

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2 AR/VR IN EDUCATION

Lately, VR technology has been widely used due to its interesting and captivating experience that it offers to users. It lets them experience an enhanced 3D space that improves their perspective in interacting with virtual objects. It also gives them the feeling of existence in a real-like environment that might not be available in real life. These qualities motivate users to get more engaged in the 3D experience. VR has many tools and wearable head gears that give users more depth to the detected objects.

Nowadays, mobile phones are becoming more affordable to purchase and their penetration rate is remarkable. Therefore, reaching the needed information is getting effortless and easier to approach. Furthermore, the use of AR and VR with mobile phones to interact with virtual objects in real life is becoming more appealing to everyday users. Such technologies grant people the opportunity to be involved in a whole new experience that combines virtual objects with real ones. The use of AR and VR technologies nowadays will increase the user's interest whether it was a game or any other applications because of its exceptional experience that has to offer to the users. AR and VR are employed in many fields and used in various applications to serve humans and enhance their interaction with objects around them. Both AR and VR have been used in education systems. Since the curriculum has a great importance in forming a well-educated generation, it has to stay updated with the latest inventions and technologies.

One of the most entertaining system applications for AR is incorporating the technology in interactive books and games. In (Tomi, and Rambli, 2013), despite not using the head-worn displays, a study targeted the book reading enhancement process using mobile phones to make story time more attractive for kids. This is done by displaying 3D rendered virtual models, sound effects, and animated characters. Consequently, this helps boosting their imaginative fantasy world. Additionally, it might give the opportunity for children to gain some useful life values or morals in the learning process. Furthermore, it engages kids more in reading and writing that will result into developing well educated generations. Nowadays, children are more interested in using technology than the traditional means of education that the older generations grew up on. Thus getting such generation more involved in reading books and receiving education using the regular ways might seem confusing and uninteresting to them. Blending any task they need to accomplish with technology will motivate them to perform anything in a better way. The study in (Tomi, and Rambli, 2013) also reported that some of the previously developed story books that use AR technology consist of only unappealing markers that are inserted in the physical book without taking into consideration their visual examination of the inserted pictures. That might be diminishing for the interactive process between the child and the visual demonstrations and animations. They applied the same concept of AR technology but with more appealing images in the book to look at before the process of placing the virtual objects on the mobile display. Their process does not vary from the regular reading of a book, where it includes the storylines and pictures demonstrating the going events that will capture the child's attention before using any technology. However, the main addition is the use of the AR technology to enhance the book even further. They designed the markers in a way that is not visible for the user. That will illuminate any distractions from the main story or taking away the appeal of the pictures themselves. Using mobile phones with their developed application presented a blended animated virtual characters and objects with the real physical book. Moreover, children have the chance to interact with those demonstrated visuals with their hands to give them an enhanced reading experience. The narration audio adds more to the interaction process. Their evaluation reported positive reactions from children who used this application. The children were interested in reading and completing the story book.

In (Islam, Ahmed, Islam, and Shamsuddin, 2014) authors reported about blended learning and its importance nowadays in the learning experience for students. In their research study they developed an application that displays an animated 3D solar system that shows the order of the planets consequently. It comes with an audio that describes and explains the contents and all the information about the solar system, which is represented by 3D objects rendered in real time. They tested their application on school children. The first group in their test they only used the traditional ways of teaching without any virtual demonstrations, or any technological methods. The teacher depended only on the book that is taught in all Dhaka schools. The second group used VR technology to achieve Blended learning. They did not replace the traditional teaching ways but they adopted VR to enhance it even further. For their research purposes, projectors were employed in order to demonstrate 3D virtual objects for students to enjoy and learn at the same time. The third group used only VR technology without relying on the traditional means of teaching. Each group had different number of students. After concluding the three experiments,

they gave each group certain questions to examine their perceiving level of the explained material. They concluded that the group which was exposed to VR technology combined with the traditional ways of teaching had a better and more improved understanding to the explained material. Their exam outcomes were better than both of the other groups. In addition, because of the interactive nature and appeal of blended learning they noticed that the process was more enjoyable and amusing for students than the other groups, which created the feeling that they are playing a game.

A lot of various and different studies talk about enhancing the educational process by using AR or VR technologies. Time after time they have proven that there are great ways to achieve blended learning. In (Johnson, Moher, Cho, Lin, Haas, and Kim, 2002), a VR technology used to enhance the educational process for elementary kids is proposed. The study consisted of two developed applications. The first application is about exploring a gardening world called “The field”. Each group of students stand in front of big displays that demonstrate the virtual world while wearing a head-worn gear and headphones in order to get the students more involved in the learning process. The application consists of a wide field that has fences and different types of plants. Students can observe plants and revisit the application from time to time to examine the growing process of plants. Students learn the kinds of trees and flowers while enjoying a virtual experience that gave them the feeling of existence in this virtual field. After going through the process, students were tested with a set of questions, to examine their acquired knowledge. Their second developed application is called "The Bee Dance”. In this application, students should press certain buttons that appears on the display to move the rendered 3D model of the bee from one flower to the other. Certain animations will appear once the button is clicked. This application required some directing from teachers in order for students to understand what should be done. This proves that the traditional means of interaction are still needed in the learning process to direct students correctly. The application was tested with different groups of students with different ages. It had better results with younger students due to their fascination of the VR technology, the display resolution, and animation. But all ages of students showed good results when they answered the question about the application.

Animation is considered one of the most challenging fields, which requires a lot of patience and experience to master. Animators always have to keep in mind a lot of thing while animating a scene. Even for just a normal walk cycle, the twelve principles of animation have to be applied to make sure that it looks as believable as possible by showing the actual weight of the character. In addition, demonstrating the correct timing and spacing between frames is vital to give the feeling of realistic motion. When it comes to 3D animation, if the motion was too slow or too fast it will lose the sense of authenticity. Even though people might think that it is an easy thing to do, it requires a lot of skills and expertise (Dorribo-Camba, and Fitzgerald, 2007). In this study the authors aim to ease the process of animating walk cycles for animation students by developing a tool that gives more insight for learners on how to animate a walk cycle properly. Users are able to manipulate rendered walk cycles to gain more knowledge about how to animate them. Students can experiment with animating different walk cycle that indicates different character personalities. Every person has their own personality walk that differs from everyone else. Thus manipulating a generated walk cycle will give students the knowledge that they need to achieve correct character motion. In addition, noticing the applied twelve principles on those animated rigs will motivate users to use them while animating a character and understand how they are employed.

3 A PROPOSED AR/VR APPLICATION TO SUPPORT ANIMATION EDUCATION

In this section a detailed description of the proposed application to enhance the education of animation topics is discussed. The main focus is biased towards walk cycles animation.

The main aim of the proposed application is to provide students with a tool that enables them to learn animation. Traditionally, a student will use an animation book to understand the concept of animating 2D or 3D models. As described earlier, the main challenge in using static content for learning animation is the visualization limitations of the animated examples. To enable such visualization and allowing interaction, we proposed complementing animation book by AR/VR application. Using this application, will give the opportunity for readers to bring some animations examples to life and interact with them. To do this, the user needs to download the proposed application on his/her mobile device. Furthermore the user needs to have access to Google Cardboard device as a tool to view virtual content. The static material (i.e. books) will have a predefined marker for each example available in the content. If the user is

interested in gaining additional knowledge about the material of interest while reading the book, he or she needs to scan and recognize the marker using their mobile phone. This will activate the content specified to that specific example. Then the user can interact with the animation and listen to an auditory instruction.

Our proposed applications aim at enhancing the teaching of animation and elevate the use of the traditional book. Students can easily engage in the developed experiences with Google Cardboard, it does not require any previous knowledge to be able to use it. For the AR application, the user has to focus on the given marker that comes along with the text book to render the needed models. As for the VR application, the user goes into a virtual world where they are engaged in an interactive experience that explains how walk cycles are animated following Richard Williams's book. The traditional ways of teaching are still considered very vital for the learning process, and using technology will not be enough. So it is important to mention here that depending on the experiment that students are performing, they still have to use the book, because we are trying to enhance and support the book by these developed applications and not replace it. Several experiments are done to evaluate the degree of enhancement. Each one differs and has different steps students have to go through but most importantly both applications will not change in the process. In addition, after each experiment, results will be gathered and analyzed to determine the improvement level.

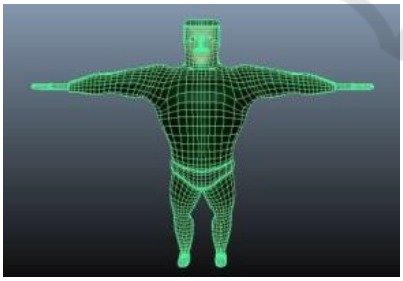

Figure 1: Character 1 Geometry Divisions and Loops.

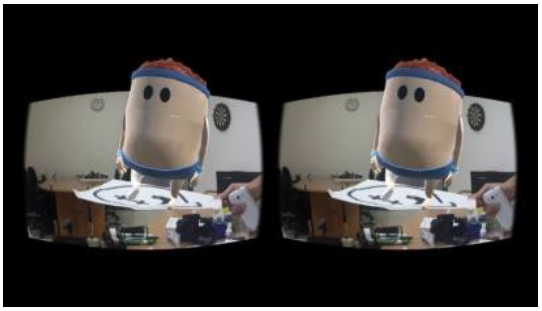

Figure 2: Character 2 Geometry Divisions and Loops.

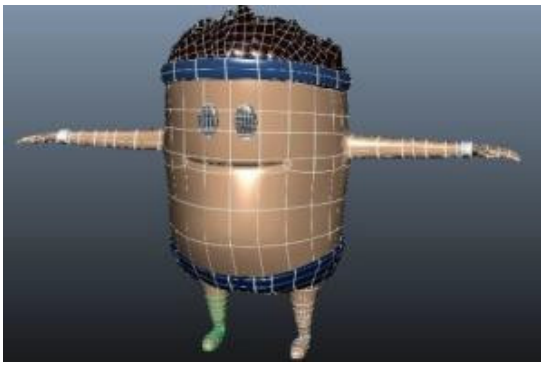

Figure 3: Augmented reality application on mobile.

The developed applications consist of two parts AR and VR, they have some differences between them on how they are integrated and developed.

Figure 4: Stereoscopic 3D view on mobile device to be used with Google Cardboard.

Since the aim of this study is to enhance the traditional educational process using these technologies, marker based tracking is used. We chose marker-based tracking due to its suitability and because it blends well with the use of physical books. The AR application will identify the pre-defined marker and render 3D characters according to the specified examples (Figure 1and Figure 2). Extended tracking was done in order to keep the characters in place and in sight of the marker while moving the mobile phone. Users changed the apparent characters by pressing the magnetic button that comes with Google Cardboard. Each character has its own audio file that is played once it is detected to explain how to animate 3D characters walk cycle. Examples of stereoscopic 3D view of the characters are presented in Figure 3 and Figure 4.

The second application gets the user into a virtual world mode where a voice over audio accompanies the animation of the characters. The animation shows the user what is needed to be done in order to produce good quality animations. The audio explains and directs the user to further

understanding of the walk cycle following the explanations of Richard Williams (Williams, 2009).

3.1 Application Evaluation Process

In order to evaluate if our proposed TEL intervention added value to the animation teaching, we designed a number of experiments to validate this. After we gathered a defined number of students for each experiment, a study was conducted to measure the impact of TEL. Each experiment differs in its requirements and preformed steps. Two types of experiment designs were used to evaluate the degree of enhancement of the developed applications and to determine their efficiency and effectiveness in supporting the book. These two types are between-subjects and within-subjects.

In order to study the improvement gained from using AR/VR technologies in delivering animation knowledge, a study was designed and conducted. The null hypothesis was determined to be: "*the book is enough for teaching walk cycle animation* or *there is no added value from using TEL to teach animation*". The hypothesis to be tested was that "*the proposed intervention of applications will improve animation knowledge delivery*". Two experiments were conducted, Experiment 1 and Experiment 2.

Experiment 1.

As depicted in Figure 5 and Figure 6, twenty students were randomly selected from the Computer Graphics Department at PSUT to test the application. Those students have experience in animation and have some knowledge about the animation techniques.

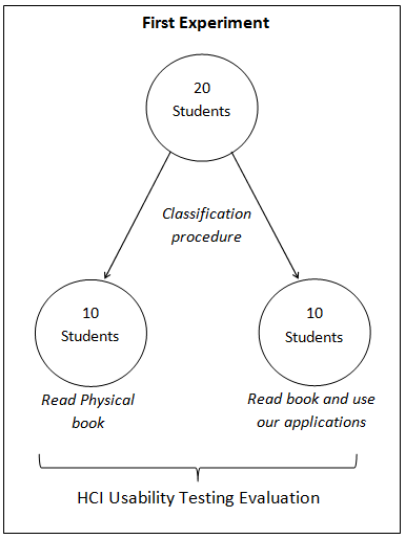

Figure 5: Experiment 1 - Between-Subject Design.

We opted for a between-subjects design in which those twenty students were divided into two groups. A classification procedure was designed to ensure that the two groups are equivalent in terms of skills and education. The goal of Experiment 1 was to measure if there were significant differences between the two learning procedures. Participants of the first group read how to animate a walk cycle from the traditional book of (Williams, 2009) and were given the time to understand the utilization of the twelve principles from the author's explanation. Participants of the second group read the book and had the application available to engage in the augmented and virtual reality experiences using Google Cardboard. After that, participants of each group were required to fill up an assessment evaluation to gather evaluation data. The gathered data were then analyzed in order to accept or reject the hypothesis. A statistical hypothesis testing was conducted to determine if the two sets of data collected are significantly different from each other.

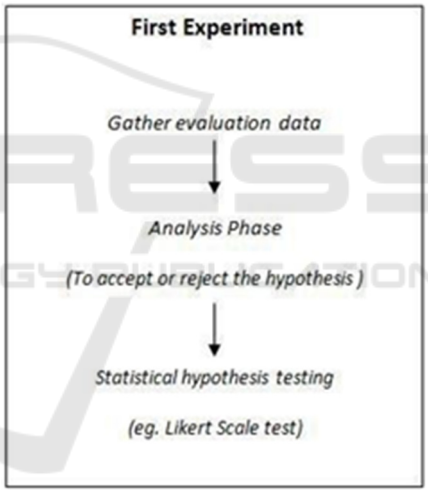

Figure 6: Evaluation Steps of Experiment 1.

Experiment 2.

In the second experiment, ten students were randomly selected from the Computer Graphics Department as well as other departments at PSUT. Students from the other departments have no experience in animation and do not have any knowledge about animation techniques. We opted for a within-subjects design. The subjects were randomly assigned to two groups. The first group read about animating the normal walk cycle from the traditional book (Williams, 2009), understood how it should be animated, and comprehend the utilization of the twelve animation principles. Consequently, they performed the same tasks using our

applications, as seen in Figure 7. The second group performed the same tasks in a reverse order. Every participant was interviewed in a structured approach after each task to measure his/her satisfaction, motivation, immersion and enjoyment of the two setups.

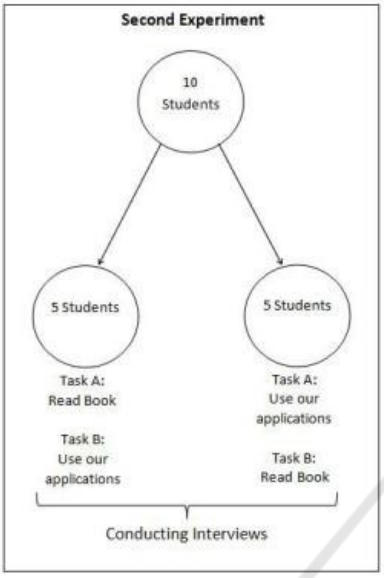

Figure 7: Experiment 2 – Within Subject Design Experiment.

3.2 Discussion

After conducting both experiments, results were gathered and analyzed. A point system was put to the assessment questions from one to five according to the answers. For example, an 'agree' answer was assigned one point whereas a 'disagree' answer was appointed five points.

In (Lazar, Feng, and Hochheiser, 2017) and (Camilli, and Hopkins, 1978), the authors discussed how a Likert Scale test is conducted and analyzed. In analysis, results of a Likert Scale questionnaire are divided into three categories: agree, disagree, and neutral. In order to analyze a Likert Scale test, the total of each category as well as the grand total of all categories should be calculated, as presented in Table 1. Following that a Chi- square test was performed in order to see if the hypothesis is correct (Lazar, Feng, and Hochheiser, 2017). Table 2 shows the calculated expected values. As presented in the table, the expected values are the same for the application and book because the same number of evaluators was selected for both experiments.

Table 1: Summation of the Results for the Likert-Scale Questionnaire Analysis.

	Book only	Book & App	Grand total
Agree	68	83	**151**
Neutral	21	12	**33**
Disagree	11	5	**16**
Total	**100**	**100**	**200**

Table 2: Likert Scale Test - Expected Range of Values.

	Book only	Book and App
Agree	75.5	75.5
Neutral	16.5	16.5
Disagree	8	8

Based on a 95% confidence interval, the value resulted is 0.045, which is less than 0.05. This indicates that the results are not random and that our applications improved the delivery of animation material. Therefore, the null hypothesis was rejected.

Results show a great potential in that the developed applications enhance and support the use of the traditional book. Moreover, results showed that the applications are easy to use and do not require a lot of experience. Also, a lot of students either agreed or strongly agreed that using the applications enhanced and supported the Animator's Survival Kit book (Williams, 2009) in the learning process. Furthermore, all randomly selected samples of students agreed that the use of AR and VR technology is interesting to use in learning. In addition, the applications gave a great perspective to students on imagining how 3D walk cycles would look like. All ten students agreed or strongly agreed that they are satisfied with the developed applications.

On the other hand, the evaluation of the book alone proved that the book is a good resource to depend on when teaching animation. A fair amount of students, however, agreed on the need of having a supportive tool to enhance the book. It is important to mention here that our main goal is to enhance and improve the use of the book in learning and not to replace it. Results confirmed that the book is a very important resource to depend on while teaching animation.

Qualitative analysis was done to get more insights about user satisfaction of the applications. All interviewed students indicated that the applications have a lot of potential to enhance the educational process. All students showed positive opinions on

using the AR/VR technologies in learning, where they said it is interesting to use, adds a lot of learning value, and gives a better experience instead of looking at a projector in lectures. In fact, some students said that they wished it was used currently in learning program. Furthermore, all students agreed that the book is not enough for the learning process of walk cycles. They explained that the applications give an enhanced experience and fill the void that the book has, where some students might feel bored and skip a few lines while reading. They also had positive opinions on the AR/VR technologies where they felt it added more perspective for their imagination on how walk cycles are done. They added that animating a walk cycle cannot be performed depending on only the book itself. Most students mentioned that AR technology let them view the 3D character from all views, which made them able to notice details of movements. Having a 3D character as a reference is more suitable than observing a 2D image in the book.

On the other hand, students mentioned some of the modification that can be done in future work to enhance the usability of the applications. Some students reported scene navigation difficulties in finding the animated characters. This could be a result of using VR technology for the first time. Some students also mentioned that the accuracy of the tilting could be enhanced. Three students wished if the character in the VR application can move in the environment itself so they can follow and interact more with it.

It was noticed from the experiments that students were impressed with the use of the AR and VR technologies and found it interesting to use for teaching. Some students wondered while using the application of the reason why these technologies are not employed enough in the teaching process of animation. They mentioned that most students have difficulties in lectures imagining how 3D animations are done. In addition, they sometimes lose focus or interest while attending lectures that use traditional books as a mean for teaching. They noticed the difference when they used the applications due to the entertaining and interesting experience that they have to offer. The applications kept them engaged in the lesson in an amusing way.

Furthermore, taking into consideration that most of the students that performed the second experiment are not animation students and have no experience in the animation field, most of them performed the tasks correctly. In addition, although both of the book and the applications did not mention the twelve principles directly, most students answered the principles related task correctly. Our applications were developed in a way to support the information of the book, and had some extra information to benefit students while enjoying the interactive experience.

4 CONCLUSIONS AND FUTURE WORK

This paper proposes a mobile application to support the teaching process of animation topics. The motivation of our work com8es from the fact that 3D animation is considered a hard subject to learn that requires a lot effort and dedication from students to understand and visualize. Most students have difficulties imagining how 3D animation would look like before practicing the animation on any 3D program. We attempted to lessen the effect of this challenge by proposing an interactive content using AR/VR technologies. Using such technologies in learning proved to offer a new experience and adopting them in teaching animation can benefit students greatly in many ways.

In this study our aim was to enhance the use of one of the most referenced animation book: *The Animator's Survival Kit*. The book is used in teaching animation at Princess Sumaya University for Technology. The book is an important reference; however, all examples are illustrated statically. Supporting the book using AR/VR technologies enhanced the reader's understanding. We developed two mobile applications that enable the user to visualize some of the animation examples in the book. The application is based on attaching a code with some challenging animation examples in the book. Using a mobile device, the user can scan the code to activate the interactive content. The content is both animation video and explanatory audio content. This will allow the reader a different perspective of the material they are interested in.

To evaluate the application, we designed a number of experiments. The evaluation of the book itself showed that the book was easy to use and the information gained was adequate for the learning process of animation. Our evaluation demonstrated that using the interactive examples improved the readability of the book and provided new experiences to the reader. It also showed that providing visual and interactive example enriched the static content.

To further improve the application, more examples need to be designed and implemented. This

will be the basis to design a course over one semester to study the impact of our proposed methodology in terms of time and number of participants. This is necessary as the number of students gathered to conduct the experiment should be increased to get more precise and accurate results.

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