AN ABSTRACT OF THE THESIS OF

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Title: The Effect of Virtual Reality on Learning Motivation and Academic Performance

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Abstract approved:

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This study is designed to investigate whether Virtual Reality (VR) has positive effects on students' learning activities. This study focuses on exploring the effect of VR on learning motivation and academic performance.

Discovering the impact of VR for learning activities will assist institutions to design instruction more effectively. Many current instructional environments use a minimum level of traditional multimedia technologies, such as PowerPoint. Few instructors have moved the classroom content from textbooks to slideshows. With the assistance of instructional designers, instructors could customize their training contents to integrate more advanced instructional technologies. VR can help turn abstract concepts into concrete facts, by combining senses of sight and sound during the learning procedure.

A pretest and a posttest design was used for this study. Test scores were collected from the experimental group and control group. An assessment with seven questions was administered before and after the lesson. In addition a survey measuring the learners' motivation for the lesson was given. Both groups' test results were collected and compared. Participants included grade students in elementary school.

By comparing two groups pretest scores, an ANCOVA test was applied to determine if there was a significant difference between utilizing VR or not. Results indicate that VR has a positive effect on student learning motivation and assessment performance.

Key words: virtual reality, learning motivation, academic performance

The Effect of Virtual Reality on Learning Motivation and Academic Performance

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"I will be journeying far, and my eyes are full of tears in writing this memorial upon my departure. I can hardly express what else I should say." (Luo, 2005)

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CHAPTER 1

Introduction

In recent years, a large number of multimedia, such as PowerPoint and videos, have been applied in instruction. They have had increasing effects on teaching methods and forms (Champagne, 2013). Modern media has become an important tool for the dissemination of educational information. In the early 1980's, computers began to be more wildly used in auxiliary teaching. Computer Assisted Instruction (CAI) was gradually becoming more familiar (Suppes & Morningstar, 1969). Since the term Virtual Reality (VR) has been put forward back in the 1960s, many fields, such as engineering, architectural design and therapy, utilize the technology to enhance their work (Rheingold, 1991).

There are several deficiencies in the traditional multimedia education currently used in many primary and secondary schools. For example, instructors do not utilize multimedia as teaching methods properly. In the traditional classroom, learners only receive texts, sounds, images, and videos individually. Though accessibility to technology has greatly increased, some instructors still only use it to perform these basic functions (Chen, 2011). This situation shows that the interaction function of multimedia education is not being used. Through the use of interaction, efficiency of teaching has the potential to improve. An example of an efficiency is a decrease in time or an improvement in academic scores (Duan, n.d.). Due to the lack of using multimedia, Zhang & Zhang (2013) argue it is difficult for students to apply what they have learned from the class to the real world.

The purpose of this study was to investigate the effect of utilizing VR during instruction on elementary school student learning motivation and assignment scores. This study focused on addressing the following two research questions: 1) Does instruction applying VR influence students' learning motivation? And 2) Does instruction using VR affect students' academic performance as measured by assignment scores?

Previous research shows that VR increases middle school students' academic performance and disability students' learning motivation (Vogel, Green-Ericksen, Canoon-Bowers, & Bowers, 2006). This study specifically tested the following two hypotheses:

- Elementary school students who receive instruction utilizing VR will have higher learning motivation than those who receive lessons without VR, and
- Elementary school students who receive instruction utilizing VR achieve higher assessment scores compared to those who receive regular lessons without VR.

The experiment included the use of an immersive VR application in fifth grade science classes as part of learning activities. Experimental data, which included assignment scores and the Intrinsic Motivation Inventory (IMI) (McAuley, Duncan, & Tammen, 1989) scores, will be collected.

Definition of Terms

VR mixes computer software and hardware to generate a virtual three-dimensional space, which allows users to interact with digital content (Moore, 1995). The sensations provide a real world experience and simulate the physical presence in this environment, which allow the users to feel immersed.

The features of VR include immersion, interaction and imagination (Wu & Huang, 2002). VR is built based on human visual and auditory, psychological and physiological characteristics, creating an immersive environment. The computer generates a realistic three-dimensional image. Users wear interactive devices, such as VR glasses and data gloves, to immerse themselves in a virtual environment. The interactions between the users and various objects in the virtual environment are similar to the real world. When users move their head, the image in the virtual environment also follows the changes in real-time.

Human-computer interaction in a VR system is an almost natural interaction. Users not only use the keyboard and mouse to interact, but can also use sensing devices, such as VR glasses and data gloves. The computer can adjust the image and sound, which are presented by the VR system, according to the body movement of the user (Wu & Huang, 2002).

CHAPTER II

Review of the Literature

Development of Media in Education

As the means of human communication information changes constantly, the methods used in education are changing as well (Yang & Yang, n. d.). Education is a targeted communication activity, using various media, such as languages, texts and pictures. The historical development of media which human beings used for educational activities include the following stages (Yang & Yang, n. d.):

- Using body language and onomatopoeia to exchange information before the primitive society
- 60,000 years ago, language was the main method of communication
- Around three or four thousand years BC, the emergence of text made it possible to spread information across time and space. The emergence of print assisted the information dissemination to expand to a greater temporal and spatial range.
- In the 1800's, slide, film, radio, television, projection and other audio-visual media began to evolve.
- Combination of audio and visual technology began to emerge in the 1950s.
- As multimedia technology and networks developed, information communication entered three-dimensional stage in 1990s.

The methods of education changed according to the evolution of education media. Each evolution in media, which is mentioned previously, has affected education profoundly (Yang & Yang, n. d.).

Definition of Virtual Reality

Chow (2009) defined VR as using computer technology to create a virtual world. It uses computer technology to generate a realistic virtual environment to see, to hear, and to feel. Users interact with the objects in the virtual environment by using a variety of interactive devices to create an immersive visual simulation and to achieve information exchange. VR uses an advanced digital man to machine interface. Compared to the traditional simulation technology, VR's main feature is that the operator can enter and interact with a computer-generated interactive three-dimensional virtual environment. Through the interaction between the participant and the simulation environment, the participant is able to obtain spatial information, such as traveling in outer space or the bottom of the sea.

VR systems can be classified into desktop VR and immersive VR (Beutel, 2000). The desktop VR system is the most convenient and flexible application form of a VR system, which is also known as window VR. It utilizes personal computers or primary graphic workstations to generate three-dimensional interaction scenarios. The monitor acts as a window for the user to view the virtual world. Three-dimensional interaction scenarios are built by utilizing three-dimensional graphics and natural interaction technologies. Users manipulate VR by applying various input devices, such as keyboards, mouse and torque balls, to achieve the interaction with the virtual world. The advantages of desktop VR include low costs, convenient and flexible applications, and low requirements for hardware. Users can increase the display screen by using three-dimensional projectors to increase immersion and multi-viewing purposes. The desktop

VR system is suitable for developers and users who are engaged in the initial stage of VR research (Beutel, 2000).

Immersive VR is an ideal system using a helmet-mounted display (HMD). It first closes up the user's vision, hearing and other senses, then provides a new virtual sense of space. The advantages include providing high degrees of immersion and real-time interactions. It supports multiple input and output devices at the same time (Beutel, 2000).

Chow (2009) stated that the application of VR in education applies new ways of teaching and learning. It builds a self-learning environment, instead of the traditional learning by teaching (Chow, 2009, Para. 16). Students acquire new knowledge and skills through their interactions with the virtual environment. VR provides students with a vivid and realistic learning environment, such as, constructing human models, space traveling, and compound molecular structure display. Learning by real experiences is more persuasive than traditional lectures, because there are essential differences between active interaction and passive indoctrination.

VR in Education

One area in which VR is being utilized is medical training and assessment (Lovquist, Shorten, & Aboulafia, 2012). Medical training focuses on patients' safety, which increases the training institutions' interest in utilizing VR. VR based training systems require experts in different areas to cooperate with each other, share information and come up with agreed objectives. While developing the system, the developers should pay attention to both technology and evaluation. Clinicians and educators need to be involved in VR training system development as well. For example, system developers, such as computer scientists, work on developing a VR simulation system; clinicians assess the system; and the instructors decide the training principles and learning materials. A necessary factor of maximizing the computer scientists' work is collaborating with subject experts and educators to ensure the simulation systems will deliver the training content as efficiently as possible. Also, in order to build the appropriate training system, the computer scientists require systematic guidance from clinicians. The Participatory Design (PD) is being used as a design philosophy to promote close relationships between developers and users. In recent projects, called DBMT and MedCAP projects, the system developers had a deeper understanding of the project to ensure that training goals are incorporated with training analysis.

In addition, VR is also applied when using Wire Electrical Discharge-Machining systems. "Wire Electrical Discharge Machining (WEDM) uses a metallic thin wire to cut a programmed profile with high strength having sharp edges such as extrusion dies and blanking punches" (Kao, Tsai, Cheng, & Chao, 2009, p.1). The cost of installing the system is high, which increases the training institutions and industry's expenses. A VR based WEDM system could achieve most functions, such as tool path simulation, but reduces the training cost dramatically. Currently the price of real WEDM is high and the operation pace is low. The resulting education quality is poor, and it is insufficient to be applied in a hands-on training environment. The machine may be damaged by the improper operations of inexperienced students. Therefore, a virtual environment for WEDM training is expected. The main purpose of this research paper was to provide a 3D interactive system which allowed the students to practice on the virtual machine before operating the real machine to reduce the improper operation cost, enhancing the learning interests and reducing the danger of operating a real machine. As a result, the VR-WEDM system was developed. After testing the system, the researchers found there were more functions that could be added to the VR-WEDM. The researchers also found that the VR-WEDM was suitable for education and training purposes (Kao, et al. 2009).

In their research, Ma et al. (2011) investigated whether practicing reaching for virtual moving targets would improve motor performance in people with Parkinson's disease. They found that VR training improved the patients' move pace, but had minimal effects on improving move pace to moving objectives. The virtual environment allowed the therapists to design the therapy programs according to each patient's situation. Also, VR offered important training information, such as performance feedback, to ensure the training quality.

Shim et al. (2003) developed a learning program for middle school students about biology education. The researchers designed a learning program about the structure and function of the eye. One group used the traditional 2D learning materials and the other group used VR resources, which allowed students to observe eye structure from different angles inside and outside. As a result, tenth grade students had more interest in learning by using VR compared to other multimedia educational programs. Students were willing to be provided with more VR learning materials. Students believed VR would help them learn science.

Definition of Learning Motivation

According to Ye (2013), learning motivation is the driving force of conducting learning activities, promoting spontaneous efforts and maintaining learning activities. Learners are willing to learn without other enforcement. Fan and Zhang (2007) found that learning environment variables affect students' learning motivation. The interaction between learning motivation and cognitive factors affects the involvement of students learning activities, which in turn affects academic performance. They also found that as students enter the upper grades of primary school or middle school, their learning motivation generally declines. Fan and Zhang's (2007) research also showed that most of the middle school students have poor perceptions of the classroom environment, such as a negative relationship between teachers and students, and the few chances students participate in learning style decision-making. As the result, their learning performance, learning potential and value towards teaching were lower than when they were in primary school. Academic performance is often used as an indirect indicator of learning motivation. The greater effort and persistence students have on learning tasks, the more likely they are to achieve good learning outcomes.

In Lim's (2004) research, he found that different factors affect students' learning efficiency in different cultures. For example, course relevancy, course interest, reinforcement and self-efficacy have higher effects on American students' learning motivation. Korean students think learner control affects their motivation. One way to improve students learning motivation is by improving course relevancy as the most important factor during the instructional design. From the student perspective, receiving encouragement from teachers and friends and taking responsibility to ask for help from others improves students' learning motivation (Kozminsky & Kozminsky, 2002).

Technology and Learning Motivation

Several studies looked at how using technology in the classrooms may improve students' learning motivation (Huizenga, Admiraal, Akkerman, and Ten Dam, 2009;

Tüzün, 2009; Rosen, 2009). There are several methods to use technology in classroom instruction, such as mobile games and PBL. Huizenga, Admiraal, Akkerman, and Ten Dam (2009) applied mobile games in geography and history classes. It helped students adapt to the first year of learning activities in secondary school. When students opened the learning app, it exhibited a fictional layer on top of the real world context, such as historical or geographical sites. Under this situation, students with mobile games experienced their surroundings in a new way, which lead to more active and simulated learning. This research focused on the method’s effect on learning motivation. Results were not significant, indicating mobile games did not improve learning motivation. In their discussion, researchers believed that they needed to narrow down the definition of motivation, because they only examined motivation towards class content, while other researchers defined motivation as having fun or engagement. In addition, because the duration of using mobile games was one day, it was hard to establish clear motivation effects.

Tüzün (2009) designed a three-dimensional geography computer game for elementary school students. Students used the game to learn world continents and countries for three weeks. By comparing the pretest scores and posttest scores, the researcher found that there was significant improvement in intrinsic motivation. In addition, when students engaged in game learning procedure, their focus on grades decreased.

Rosen (2009) studied whether BrainPOP affects students learning motivation for science and technology. BrainPOP uses varying videos and accessory tools in an animation-based online learning environment. All of the videos and accessory tools were designed for instructors and students. The participants included 5^{th} grade and 7^{th} grade students. The research results showed that BrainPOP increased students learning motivation and ability to transfer knowledge significantly. PBL is an approach to challenge students to learn when working on real problems. It develops both problem solving strategies and disciplinary knowledge bases, placing students in a role of a problem solver. This system is student-centered. It improves students' learning motivation by letting them deal with the real problem. The result showed that students increased their science knowledge significantly from pretest to posttest after utilizing the PBL system. The students were motivated to learn and enjoy the learning experiences.

Another study found that an online learning environment could be a powerful context for spreading professional development (Renninger, et al., 2011). Utility of online learning improved learners' engagement. They felt more challenged in an online learning environment.

The improvement of learning motivation, however, cannot be measured quantitatively. Hsu and Wang (2011) designed two research questions, which were whether blogs affect college readers' reading performance, and whether blogs affect participants learning motivation. There were no factors indicating participants' reading performance and learning motivations were improved. However, compared to the non-blogging class, the retention rate of the blogging class was higher. Only one student (2.5%) in the blogging class withdrew, and fifteen students (13.8%) in the non-blogging class withdrew. Even though the attitude survey did not indicate students had more motivation on reading courses, the retention rate revealed students were more willing to take the class with technology involved.

VR and Learning Motivation

According to previous research, researchers found that VR improves student learning motivation significantly (Mantovani, Castelnuovo, Gaggioli, and Riva, 2003; Vogel, Green-Ericksen, Canoon-Bowers, and Bowers, 2006; Jarrell, Poitras, Duffy, and Lajoie, 2016). Mantovani, Castelnuovo, Gaggioli, and Riva (2003) found that when applying VR to health-care professionals, the result showed that it increased the interaction between students and learning content and raised learning motivation and interest. When learning boring materials, VR is more interesting than interacting with real things, like using game formats.

Not only for adult learners, Vogel, Green-Ericksen, Canoon-Bowers, and Bowers (2006) found that VR could increase a child's learning motivation. Special populations, such as deaf children, also benefit from VR. It is difficult for deaf children to learn skills such as reading comprehension and higher-level mathematics. However, Vogel, Green-Ericksen, Canoon-Bowers, and Bowers found using VR assisted children to think and learn in a less abstract way. They could connect the abstract concepts with concrete scenarios, which showed on the screen. The study also found that in comparison to using two dimensional computer games or pictures, using three-dimensional VR could significantly improve deaf children's thinking skills and the ability to solve problems from different angles. Without frustrating other learners, the customized learning environment may increase children's learning motivation.

In addition to helping children with disabilities, VR could also enhance students' learning experience and allow them to enjoy the learning procedure. Harley, Jarrell, Poitras, Duffy, and Lajoie (2016) studied the effectiveness of virtual and location-based augmented reality. There were two groups of students. One group utilized the augmented reality indoors, and the other group used augmented reality outdoors. Students reported that they had a high level of learning enjoyment when they utilized both indoor laboratory and outdoor training systems.

Definition of Academic Performance

Academic performance is also known as academic achievement. It refers to how a student meets the short-term or long-term goals in education. It can be measured by course grades or GPA (York, Gibson, & Rankin, 2015). Ndege, Bosire, and Ogeta (2015) found several factors affecting student academic performance. These included the amount of homework at home, distance of home from school, student teacher relationship, and teachers teaching experience and so on. In traditional face-to-face education, students need to go to school and attend classes. The distance between home and school may not affect academic performance, but time wasted on the road and fatigue may lead to poor motivation on learning. The authors also mentioned that an instructor with a negative attitude has a negative effect on students' academic performance.

Technology and Academic Performance

Huang (2015) researched whether a handheld sensor-based vocabulary mobile game with assistance of scaffolding strategy would improve students' learning motivation and performance in vocabulary learning procedure. The game allowed students to learn vocabulary without limitation of time and location. The research results showed that in comparison to the control group, which did not use a scaffolding strategy, students in the experimental group who had low-achievement improved their learning motivation and performance in vocabulary learning significantly.

Valencia Community College (1997) in Orlando, Florida believes that technology can improve student academic performance. Valencia Community College began to use interactive mathematics, a program utilizing online interactive multimedia instruction through the Internet. Instructors found that students were learning more about professional mathematics knowledge and doing better in subsequent mathematic courses compared with the traditional courses. In addition, the retention rate increased and dropout rate decreased. The overall grades increased, as well. Learning with the interactive system allowed students to review the learning materials as many times as they needed. Each student had customized homework according to his/her performance online. Instructors reported that the interactive system allowed students to be more active and see the mathematical relationships. The system also allowed instructors to track individual student progress minute by minute. The students considered this interactive system made substantial difference in their mathematic class performance.

The English department at California State University integrated online course materials into writing courses (“Effective Uses of Technology”, 1997). They utilized the interactive English system. The system allowed instructors to create an individualized learning environment that let students have more control over the learning processes. Students could ask questions online and the tutors answered questions in real time. Instructors reported that student writing was more fluent and they could see the connections between writing pieces.

Hung, et al. (2012) indicated that technology could improve student academic performance. Hung et al. (2012) used a Project-Based Learning (PBL) system as an experimental tool. After comparing the pretest scores and posttest scores between the experimental group and control group, he found that the experimental group had a higher post-test score compared to the control group. He concluded that PBL could enhance student science learning achievement effectively.

VR and Academic Performance

Vogel et al. (2006) found that Computer-Assisted Instruction (CAI) had attributes that improved student motivation, reward, interactivity and scores. In this research, the author tested the original form of VR as a CAI program. It was designed to assist students to understand the link between the idea of the question and meaning of the question. For example, when students were asked, “ If Cow A has two quarts of milk, Cow B has three quarts of milk, and Cow C has six quarts of milk, which one has the most milk?” (Vogel et al., 2006) Students could see the question, as well as images of cows with milk, and bottles holding accurate amounts of milk, rather than only seeing the words of the question in a traditional text form. The results showed that there was significant improvement in understanding complex mathematic concepts such as spatial sense, graphing, geometry and reading comprehension problems. The test scores, which is a form of academic performance, improved significantly.

Huizenga et al. (2009) found that pupils who used mobile games as a learning method received higher scores compared with those who received regular lessons. Pupils gained more knowledge because the information was showed in a realistic and meaningful method.

CHAPTER III

Methodology

The purpose of this research was to examine the possible effect of instruction applying VR on elementary school students learning motivation and academic performance, as measured by their assignment scores. The Intrinsic Motivation Inventory (IMI) (McAuley et al., 1989) was used to measure learning motivation. Academic performance was measured by students' assignment grades. The experiment applied immersive VR in the fifth grade science classes. Experimental data for analysis included assignment grades on the lecture content and survey scores of students' learning motivation.

Participants and Learning Materials

Thirty-nine students with ages ranging between 10-12 years old from two classes in a public elementary school in a small city in the rural area of Kansas were conveniently selected to participate in this study. The same instructional method with one exception was used in the two classes. One class of 20 students, the experimental group, applied VR as the final learning activity. The other class of 19 students, the control group, did not use VR as the final learning activity. Each class had a different instructor. The class duration for both groups was 30 minutes. The duration for both receiving lectures and doing learning activities was 30 minutes as well.

Vimicy VR headsets and Apple iPod Touches were used for the VR learning activity for the experimental group of students. Vimicy VR headsets are a generic third party brand of VR glasses that fit over iOS and android devices and support over 300 VR apps. Their pupil distance and focal distance can be adjusted.

The VR app used for the learning activity, called VR - Explore Solar System in 3D, was installed on each iPod Touch. The VR headset and iPod Touch allowed students to observe each planet in the solar system by moving their heads. All of the planets were listed on the screen. When students moved their heads and aimed their eyes at one planet, students started to “travel” toward the planet automatically. Students could observe the distances between planets when traveling. They could also observe the diagram, gravity and temperature when they were close to the planet. All of the planet information was listed on the screen, which students could read.

The learning goal of the class for the two groups was to introduce the differences in the apparent brightness of the Sun compared to other stars, and to understand that these differences in brightness are due to their relative distances from the Earth. The control group used a lecture-based lesson with a final learning activity using flashlights to observe shadows on the basketball court. Students viewed the brightness of a flashlight from various distances and angles to observe the sunshine on planets. The experimental group received a final lesson activity with VR. In this class, the flashlight activity was replaced by using the VR headsets and iPod Touch with the *VR – Explore Solar System in 3D* app. Students observed the distance between planets in solar system through the VR technology.

Design and Instruments

This research used a quasi-experimental design using pretest and posttest measures. The independent variable for this study was the instructional method of using VR or not. The dependent variables were learning motivation and academic performance as measured by assignment scores.

One week before the experimental lesson class, all the student participants in both groups took a pretest (Appendix A) measuring their prior knowledge on the solar system as their regular assignment. After the experimental group completed the VR activity and the control group completed the flashlight activity, both groups completed this same assignment as a posttest. Questions in this assignment included seven multiple choice questions. Assignment scores were used to measure their academic performance. The instructors from the elementary school, where the research happened, provided questions for the assignment. All of the questions came from Mystery Science, a website aiming at "inspiring children to develop a scientific understanding of the natural world and helping elementary teacher to teach science" ("MysteryScience", 2017).

The Intrinsic Motivation Inventory (IMI) (McAuley et al., 1989) was used in this study to measure the participants' learning motivation (see Appendix B). The IMI measures multi dimensions. It assesses target activities for the participant subjective experience in laboratory experiments. It has been utilized in experiments related to intrinsic motivation or self-regulation (Deci, Eghrari, Patrick, & Leone, 1994). It assesses participant's interest, perceived competence, effort, value, perceived choice when performing a given activity, and pressure. McAuley et al. (1989) tested the validity of IMI and they found there was strong support for its validity. The alpha coefficients for the four subscales were shown in parentheses: interest (α= 0.78); perceived competence (α =0.8); effort (α =0.84); and pressure tension (α =0.68). The overall scale of the four subscales with each other is α =0.85 coefficient. In addition, a Greek version of IMI scale was found by Tsigilis and Theodosiou (2003), which enhanced its reliability.

In this study, the interest and enjoyment section of the IMI (McAuley et al., 1989) was used. It is considered a self-report measure of intrinsic motivation. For example, “I enjoy doing this activity very much.” The response choices for each item was a Likert scale ranging from 1 to 7 with 1 representing “not at all true” and 7 representing “very true”. Survey questions marked as (R) were reversed items (Appendix A).

Procedures

A pretest including the measure of prior knowledge about the solar system and the IMI (McAuley et al., 1989) was administered to the participants one week before the experimental class. The pre-test in this study served as the controlled factors of background or pre-experimental knowledge and learning interests on the solar system content, which may affect the result of the posttests.

The learning activity using VR occurred one week after the lecture-based instruction began. Students in both groups were given lectures discussing how the apparent brightness of the sun compared to other stars due to their relative distances form the Earth. The experimental group observed the solar system through VR headsets, the iPod Touch, and the VR app *VR – Explore Solar System in 3D*. Students looked through VR devices and recalled what they had learned about the solar system. They could observe the solar system through the VR equipment as many times as they needed. The control group used the flashlight activity using shadows as the learning activity. As a posttest, both groups of students completed their assignments on the solar system and IMI (McAuley et al., 1989) again, which were the same as pretests, after the learning activities.

After the learning activity, assessment and motivation scores from both groups were collected. The instructor graded the participants' assignments and collected the IMI (McAuley et al., 1989) completed by the participants. The instructor sent the data including the assignment scores and IMI scores to the researcher for analysis. The relevant data from both the experimental group and the control group were analyzed to determine the possible differences between the two groups.

Data Analysis

The researcher analyzed the data with SPSS statistical software. Descriptive statistics including means and standard deviations were calculated to describe the level of academic prior knowledge, assignment performance on the solar system and learning motivation before and after the experiments. Independent t-tests were used to determine whether there are significant differences in elementary school students' assignment grade and learning motivation in the pretests between the class who received instruction utilizing VR and the class who received regular lessons without VR. These tests compared means of two pretest dependent variables of assignment grade and learning motivation. Analysis of covariate variances (ANCOVA) using pretest as covariate was used to determine the difference in assignment scores and learning motivation on the posttests between the experimental and control groups.

CHAPTER IV

Results

Means and standard deviations of the pretests and posttests in students' assignment scores and learning motivation by the two groups were presented in Table 1. Independent t-tests indicated that the pretested learning motivation of the experimental group using VR (*M*=5.19. *SD*=1.30) is significantly higher than that of the control group (*M*=4.24. *SD*=1.48), t(36)=-2.12, p=0.041. The pretested assignment score of the experimental group using VR (*M*=5.20. *SD*=1.10) is also significantly higher than that of the control group (*M*=3.63. *SD*=1.21), t(36)=-4.22, p=0.000.

Table 1. Means and standard deviations of learning motivation and scores

	Pretest-Control			Posttest-Control			Pretest-Experimental			Posttest-Experimental		
	N	Mean	SD	N	Mean	SD	N	Mean	SD	N	Mean	SD
Learning Motivation	19	4.24	1.48	19	4.79	1.64	20	5.19	1.30	20	6.43	0.93
Scores	19	3.63	1.21	19	4.10	1.24	20	5.20	1.10	20	5.25	1.21

Table 2. Independent t test for equality of means of learning motivation and scores

	Pretest-Control		Pretest-Experimental	
	t	p	t	p
Learning Motivation	-2.13	0.040	-2.12	0.041
Scores	-4.23	0.000	-4.22	0.000

Since there are significant differences on the pretest, ANCOVA was used to determine the difference on the posttests of Academic Performance (Table 3). It controls the effects of the covariates. Assumptions for ANCOVA include the following: 1) at least one categorical independent and at least one interval independent. 2) Covariate variables should be without errors. 3) Covariate variables should be linearly or it is in known relationship with the dependent variables. 4) Lines that are using to express linear relationships should be parallel, which is the homogeneity of regression slopes.

Research Question One

Research question one was whether instruction applying VR would influence students' learning motivation. ANCOVA indicated that the covariate, the pretested learning motivation, was significantly related to the learning motivation of the posttest, $F(1, 36)=21.894$, $p<0.001$. There is a significant effect of VR instruction method on students' learning motivation in the posttest after controlling for the effect of the pretest $F(1, 36)=9.130$, $p=0.005$. The adjusted means of learning motivation in the posttests for the control and experimental groups are displayed at Table 3.

Table 3

	Posttest-Control			Posttest-Experimental		
	N	Mean[a]	SE	N	Mean[a]	SE
Learning Motivation	19	5.074	0.25	20	6.158	0.243
Academic Performance	19	3.842	0.3	20	5.5	2.94

Note. The mean in figure is adjusted. It indicates the posttest mean without effect of pretest.

Research Question Two

Research question two was whether instruction applying VR affects students' academic performance. ANCOVA indicated that the covariate, the pretested assignment score, was marginally significantly related to the assignment score of the posttest, $F(1, 36)=3.822$, $p=0.058$. There is a significant effect of VR instruction method on students' assignment score in the posttest after controlling for the effect of the pretest F(1, 36)=12.962, *p*=0.001. The adjusted means of assignment score in the posttests for the control and experimental groups are displayed at Table 4.

Table 4

Tests of Effects Between Control Group and Experimental Group

	Learning Motivation			*Assignment Score*		
Source	*df*	*F*	*Significance*	*df*	*F*	*Significance*
Pretest	1	21.894	0	1	3.822	0.058
Group	1	9.13	0.005	1	12.962	0.001
Error	36			36		
Total	39			39		
Corrected Total	38			38		

CHAPTER V

Research Questions

The purpose of this study was to investigate the effect of utilizing VR during instruction on elementary students' learning motivation and academic performance. This study focused on addressing the following two research questions: 1) Does instruction applying VR influence students' learning motivation? And 2) Does instruction using VR affect students' academic performance as measured by assignment scores?

This study specifically tested the following two hypotheses:

- Elementary schools students who receive instruction utilizing VR will have higher learning motivation than those who receive lessons without VR, and
- Elementary school students who receive instruction utilizing VR achieve higher assessment scores compared to those who receive regular lessons without VR.

The experiment included the use of an immersive VR application in fifth grade science classes as part of learning activities. Experimental data, which included assignment scores and the IMI (McAuley et al., 1989) scores, were collected.

Relationship between VR and Learning Motivation

To determine if there was a relationship between VR and learning motivation, the IMI (McAuley et al., 1989) survey scores were collected. An independent t-test and ANCOVA were performed to determine whether applying VR as a learning activity had a relationship with learning motivation, which was measured with the IMI survey scores.

The analyses of the independent t-test and ANCOVA comparing the means and standard deviations showed that VR positively affected learning motivation. Therefore, it was concluded that there is a positive relationship between applying VR as a learning activity and learning motivation.

Implications

In previous research, researchers found that VR helped students improve learning motivation significantly (Mantovani et al., 2003; Vogel, et al., 2006; Harley, et al., 2016). In the current study, applying VR in elementary school science class as a learning activity stimulated student motivation on science. The result indicates that VR can be an effective accessory for teaching and has positive effect on students learning motivation.

Recommendations.

In this research, applying VR as a learning activity improved students learning motivation significantly. VR can be a widely used instructional tool to improve elementary school students' learning motivation, especially for those subjects which are abstract, such as science and history. VR provides students a virtual environment and allows them to observe through this environment. It converts abstract concepts to concrete facts.

There was a significant difference in the results of the learning motivation pretest between the two groups. It is possible this difference was due to the two groups communicating with each other prior to the activity. The two groups of participants were located closely together and were aware one group was going to use the VR activity and the other was not. This may have impacted the level of motivation for the control group, causing their pretest scores to reflect a lower level of motivation than if they had not known the other group was going to use the VR activity.

Relationship between VR and Academic Performance

To determine if there was a relationship between VR and academic performance, the assignment scores were collected. An independent t-test and ANCOVA were performed to determine whether applying VR as a learning activity had a relationship with academic performance, which was measured as assignment scores.

The analyses of independent t-test and ANCOVA comparing the means and standard deviations showed that VR affected academic performance. Therefore, it was concluded that there is a relationship between applying VR as learning activity and academic performance.

Implications.

Even though there was significant improvement in academic performance after applying VR as learning activity, the content of the VR app *VR – Explore Solar System in 3D* may not have been closely related to the learning goal. The learning goal of the class was to introduce the differences in the apparent brightness of the Sun compared to other stars and that this apparent brightness is due to their relative distances from the Earth. The content of the VR app *VR – Explore Solar System in 3D* was introducing the information of each planet in the solar system. Even though there was significant improvement in academic performance, it may have been caused by the novelty of the technology instead of gaining knowledge through VR.

Recommendations.

There are currently few VR applications which are geared toward education and have a high quality content. The existing educational app may not have matched the learning materials very well. Although VR was invented several decades ago, it has only been used in the education area in recent years. Supporting services are still developing. In Lovquist, Shorten, and Aboulafia's research (2012), they believed that instructors needed to cooperate with computer scientists to create educational VR Applications, which can meet the specific instruction requirements.

Limitations to the Study

There were limitations to this research study. First, the sample size was small, and there were only thirty-nine participants in the experiment. Because the location of conducting the experiment was a rural area of Kansas, there were only two classes in each grade in the elementary school. Future research studies should be designed with a larger population. Perhaps a middle school or high school could provide such a population.

Second, different instructors taught each group. In the pretest, there were significant differences between control group and experimental group for both academic performance and learning motivation. This may have resulted from different teaching methods, different receptivity for new knowledge, and different levels of prior knowledge. Different teaching methods can result in different receptivity for new knowledge. According to Myers-Briggs Type Indicator (MBTI) (Briggs, K., & Myer, I., 1946), instructors with different personalities will have different teaching and learning styles.

Third, the participants of two groups were not randomly selected from two classes. There was a possibility that students in two classes have different levels of prior knowledge about the solar system. That is to say, in this experiment, the experimental group students could have known more about the solar system than control group even before the lecture was delivered and the VR activity conducted. Through running an independent t-test, the researcher found that there were significant differences between two groups. ANCOVA was used to eliminate the effect of the pretest on posttest. In future research, researchers need to select participants randomly, even though there had been two formed groups already.

Summative Conclusion

Even though VR has been in existence for decades, the integration and use of VR in education has only started to occur in recent years. Since VR has the potential to create a similar environment of the real world, it provides solutions for learning media context and learning interaction. In teaching practice, personal experience is more convincing than abstract concepts. It provides an interactive medium instead of passive watching. Therefore, VR can be used to establish learning context and increase student learning motivation. In addition, utilizing VR in education can reduce training costs significantly.

Learning motivation affects students' behaviors during learning activities from several aspects, which include directing the behavior toward particular goals, leading to increased effort and energy, increasing persistence in learning activities, and enhancing learning performance. According to social cognitive theorists, motivation directs the specific goals which learners endeavor (Maehr & Meyer, 1997). Therefore, it affects students making choices.

Motivation also increases student effort and energy when dealing with a subject. It encourages learners to invest more energy in activities if the activities relate to their goals (Csikszentmihalyi & Nakamura, 1989). In other words, it decides whether learners can pursue a task with more effort. In addition, students have more motivation when they are willing to start and continue to work on a task until it is completed, even though they may be interrupted or frustrated during the procedure (Larson, 2000).

Because motivation directs behaviors toward a particular goal, leading to increased effort and increased persistence during learning activities, it will improve academic performance as a result. Walberg and Uguroglu (1980) found that students who were most motivated in learning activities tended to become the highest achievers.

Several external factors affect students' academic performance, such as communication between students and teachers, learning facilities, proper guidance and support from family (Mushtaq, 2012). These factors are difficult to control by learners themselves. According to Kusurkar et al. (2013), based on good learning strategy and high efforts, quality of motivation is an important factor, which determine good academic performance.

VR has a strong potential for use in the classroom. While the results show positive relationships between the use of VR and learning motivation and the use of VR on academic performance, there were several limitations that may have confounded this study. Further research, with these limitations corrected, should be conducted to validate these results.

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Appendix A

Name ____ Date _________________

Spaceship Earth - Unit Assessment - Multiple Choice

1) We know that the Earth is rotating once each day because ___________ .
   a. there is video from space of the Earth spinning.
   b. the sun rises in the morning.
   c. the sun sets in the evening.
   d. the shadows change size throughout the day.

2) There are places called the North Pole and South Pole but there aren't any places called the West Pole and East Pole because ____________________.
   a. explorers haven't discovered those poles yet.
   b. there are West and East poles but they just aren't as famous as the North and South Poles.
   c. those poles would be on the equator where the ice would melt.
   d. the planet is spinning around an axis through the northern and southern points.

3) If it is 8:30pm in the evening and the sun is just starting to go down, it is probably summertime because __________________________ .
   a. it's warmer in the summertime.
   b. the sun sets later in the summer.
   c. the stars are not as bright during the summer.
   d. the days are shorter during the summer.

4) We see different constellations in the summer than we do in the winter because _______________ .
   a. it's hotter in the summer than in the winter.
   b. it's too bright in the summer to see constellations.
   c. as the Earth orbits the sun, the night time sky points in different directions in space.
   d. we see the same constellations during all seasons, it's just that some stars are dimmer in different seasons.

Appendix A

5) The moon changes shape during the month because ________________
   a. different parts of the moon light up at different times.
   b. the Earth's shadow moves across the moon.
   c. the moon orbits the Earth so the angle of the sun's reflection changes.
   d. the moon is spinning so the sun shines on different parts.

6) How can you tell if an object in the night sky is a star or a planet?
   a. If it moves across the sky each night, it's probably a planet.
   b. If it's really bright, it's probably a star.
   c. If it's big, it's probably a star.
   d. If it's blue, it's probably a planet.

7) It isn't possible to send a space probe to land on the surface of Jupiter because ________________
   a. Jupiter is too far away.
   b. Jupiter is made of gas.
   c. Jupiter is too cold.
   d. Jupiter is too big.

Appendix B

The Post-Experimental Intrinsic Motivation Inventory							
	Not at all true 1	2	3	Somewhat true 4	5	6	Very true 7
I enjoyed doing this activity very much.							
This activity was fun to do.							
I thought this was a boring activity (R)							
This activity did not hold my attention at all. (R)							
I would describe this activity was very interesting							
I thought this activity was quite enjoyable.							
While I was doing this activity, I was thinking about how much I enjoy it.							