UTILIZING PORTABLE VIRTUAL REALITY IN TEACHING CHEMISTRY

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***ABSTRACT**: Portable Virtual Reality (VR) is a relatively new technology and its potential as a modern instructional technology is being explored. In this study, fifty purposively selected participants were exposed to two different instructional approaches, traditional instruction using a modern multimedia presentation and a virtual reality assisted instruction. The study utilized the MEL Chemistry mobile application and portable VR headsets in conducting the virtual reality assisted instruction. Both groups underwent pretest and posttest and their scores analyzed using the appropriate statistical tools.*

The results have shown that the mean scores of the two groups of participants differ significantly with the scores of the group under virtual reality assisted instruction generally higher than those in the other group which suggests that utilizing virtual reality in the science classroom may help in teaching concepts in Chemistry. This may also serve as a modern strategy to enhance understanding of the concepts, and may as well offer the same advantages to other science subjects.

Keywords: Chemistry, Education, Instructional Technology, Virtual Reality

1. INTRODUCTION

Chemistry is considered by many students as one of the challenging subjects having abstract concepts which may be difficult to grasp and in many times it involves learning activities that require ingenuity and higher problem solving skills. However, regardless of how students view the abstractness of the subject, they are compelled to take it because is a part of the curriculum and is considered a major subject. Understanding technical terms representing the abstract concepts are particularly hard for the learners especially when the activity lacks visualization. In addition, students have already their set of conceptions about the world around them and the subject matter before they enter the classroom. These are usually constructed from common sense understanding of the phenomenon and most of the time they are wrong [1]. This could be a challenge in learning chemistry concepts and the lack of well-equipped science classrooms and laboratories compounds the scenario. With this educational setback, teachers attempt to innovate alternative ways of teaching chemistry concepts utilizing various technologies and methods in actual teaching.

The Philippines, where this study was conducted, still faces the reality that not all the instructional materials necessary for effective teaching will be provided to the students [2]. The students are well exposed to modern technologies but they do not appreciate the roles they play in their education. The teachers also lack awareness of the potentials of using modern technologies for more effective instruction [3]. Nevertheless, students are for the most part reliant on the use of technology or gadgets in their everyday lives [4] making technology integration a possible effective technique in teaching. Recently, portable virtual reality (VR) devices are introduced to the market which roused the interest of the public. While products of modern technology such as the personal computer, the smartphone, and the social media have gained significant roles in education, the educational use of the VR technology is nascent but rapidly developing. The inclusion of virtual reality into the curriculum is seen to allow teachers to supplement their talents with that of engineers and pioneers of virtual technology [5]. In this study, we explore the use of the VR as an educational tool in chemistry, thereby cancelling out some limitations of the traditional teaching method.

Extending the grasp of teaching with the use of VR technology may enhance the teaching-learning process. A learning environment that allows interactivity through the use of simulations which enables the students to participate actively provides the learner the ability build and grasp concepts easily [6]. The appropriate simulations and applications of concepts generally increase learning by allowing students to interact with actual concepts and experience it personally [7]. Chemistry deals with a number of abstract concepts which are necessary to explain the physical world. The atom, in particular, due to its tiny size is considered as an abstract concept by the learner. Notable features, uniqueness, and the components of atoms are undoubtedly hard to grasp in 2D format. But VR technology can potentially close these gaps. By integrating 3D models and making the structure of atom visually possible to describe by using software and a virtual headset, we could easily distinguish these hard to learn areas in chemistry. Virtual reality provides us with the ability to immerse and visualize things and concepts in many possible ways [8].

According to Kolb [9], experience is a very effective way to learn. In a constructivist point of view, learning is an active process and students are actively constructing knowledge from experience rather than being passive receivers of information [10]. Direct manipulation or interaction is superior compared to passively viewing [11]. A well equipped learning environment that allows the involvement of more senses of the learners is strongly encouraged. Virtual Reality is a way to simulate real-life phenomenon that is indirectly engaged by the viewer. Individuals are provided with a sense of being present in the virtual world using control devices that allow human-computer interaction and navigation [12]. The use of virtual reality as an educational technology in science education has been explored in researches and is found to have promising results [13,14,15,16,17]. Although VR seems to be more on the side of visual-spatial learners, it was also found that low spatial ability learners are positively affected [18,11]. However, because virtual reality system is expensive [19] its adoption as effective educational technology in relatively poor areas has been very slow or nonexistent. Nowadays, a cheaper alternative to the virtual reality systems which is the portable virtual reality (VR) headset is gaining popularity among mobile phone users for a variety of purposes. The technology is still developing and still has many limitations. It only allows interaction via a specialized handheld control module and the senses of touch, taste, and smell are out of the picture. Regardless of the limitations of this relatively new technology, in this study, we investigated its potential as a modern educational technology in high school chemistry education by integrating it in the instruction and comparing the performances of the participants using the portable VR with those under traditional instruction using a different but modern technology.

OBJECTIVES OF THE STUDY

Specifically, the study aimed to answer the following questions:

1. What are the performances of the participants under the traditional instructional method and virtual reality assisted instruction in terms of pre-test?
2. What are the performances of the participants under the traditional instructional method and virtual reality assisted instruction in terms of post-test?
3. What is the difference in the performance of the students under traditional instruction method and virtual reality assisted instruction method?

2. METHODOLOGY

The study was conducted within the premises of the University of Science and Technology of Southern Philippines (USTP) on a schedule in accordance to the convenience of the participants and researchers. Using purposive sampling, we selected 50 Grade 11 senior high school students. 25 students were exposed to traditional instructional method and another 25 students to the VR assisted instruction using a head mounted display (HMD).

A researcher-designed pre-test and post-test were utilized as data-gathering instruments. The pre-test and post-test were administered to both groups. Furthermore, we conducted orientation lectures to each group before the activity to allow coherent gathering of data for both traditional and virtual reality instruction methods.

The structured 14-item multiple choice questionnaires restricted the participants to the lesson taught in the lectures to ensure that the data gathered is useful to the study. Moreover, the questionnaires underwent face validity and were revised following the corrections and suggested formats by science education experts. The items in the instruments were in accordance with Table of Specifications (TOS) prepared by the researchers; the TOS includes four cognitive levels with their corresponding weights. The pre-test was administered with two things in mind. The first is to determine the extent of the participants' knowledge in the foundational concepts of chemistry and second is to eliminate the scoring advantages or disadvantages of one group over the other. The posttest was administered after exposing the groups to their respective instructional methods; this is to evaluate the extent of learning acquired by the students that were subjected to both instructional methods.

The analysis of the data gathered in the study involved the following statistical tools: Descriptive Statistics which was used in summarizing the data in a clear and readable presentation which includes the means and standard deviation, and ANCOVA to check for the difference between the posttest scores of two groups.

The following steps were considered and taken into consideration in the development of the interactive lesson:

1. **Formatting the learning Objectives**

In conducting the interactive lesson, the following objectives are:

A. Identifying the three basic components of atoms with their relative masses and charges.

B. Differentiating the three basic subatomic particles by identifying their locations in the atom.

These objectives comply with the K to 12 Science Curriculum Guide for Grade 11 Science.

2. **Lesson Planning**

A detailed lesson plan was prepared to guide the learning activity. The learning objectives were formulated from the learning competencies from the K to 12 Science Curriculum Guide provided by Department of Education with an expected proficiency level of 75%. The planned duration for the entire activity was thirty minutes.

3. **Software/Application Used**

The MEL Chemistry VR Lessons, a mobile application developed by MEL Science in 2017, was the tool used by the researchers in the VR assisted instruction in teaching foundational concepts in Chemistry, specifically, the structure of the atom. This application is available in Google PlayStore and operates with gyroscope in order to adapt with the portable VR Head Mounted Displays (HMDs) that were used in this study.

4. **Lesson Proper**

The Traditional Instructional Method involved a PowerPoint presentation during the lesson proper. The PowerPoint presentation contained the lesson about the structure of atoms depicted with illustrations for the participants to fully comprehend the lesson. The lesson was taught orally by the teacher to the participants.

Figure 1: MEL Chemistry VR

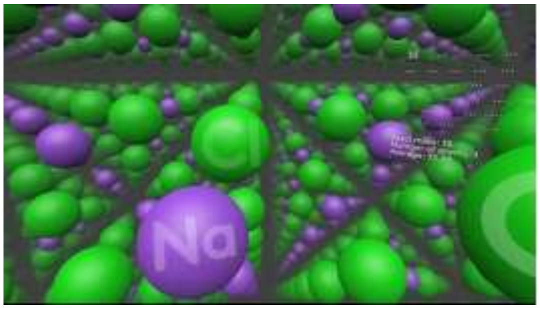

Figure 2: NaCl Atoms in Virtual Reality

Figures 1 and 2 above shows the MEL Chemistry VR as it appears in PlayStore and how NaCl atoms are simulated in virtual reality. The Virtual Reality Assisted Instruction utilized the Virtual Reality (VR) headset where the participants could experience the lesson through a virtual world. The class started as soon as the participants wear the Virtual Reality (VR) headset. The teacher began reciting the explanation synchronized with the current display within the Virtual Reality (VR) headset.

3. RESULTS AND FINDINGS

Table 1: Mean and Standard Deviation of Pretest and Posttest Scores

	N	Mean	Std. Deviation
Control Pretest	25	4.96	1.791
Control Posttest	25	7.20	1.826
Experimental Pretest	25	4.92	1.681
Experimental Posttest	25	8.52	1.917

Table 1 shows the mean and standard deviation of scores of the students under traditional and virtual assisted instruction method. The means of the pretests of the two groups are shown to have little differences whereas the difference seems to be wider in the posttest scores.

Table 2: One-Way ANCOVA Summary of Students Posttest Scores

Dependent Variable: Posttest

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	130.102a	2	65.051	51.027	.000	.685
Intercept	68.257	1	68.257	53.542	.000	.533
Pretest	108.322	1	108.322	84.969	.000	.644
Teaching Method	22.933	1	22.933	17.989	.000	.277
Error	59.918	47	1.275			
Total	3279.000	50				
Corrected Total	190.020	49				

a. R Squared = .685 (Adjusted R Squared = .671)

Table 2 shows the one-way ANCOVA summary of students' posttest scores. A one-way between subjects ANCOVA was calculated to check for difference between the post-test scores of the two groups of students under the traditional instructional method and virtual reality assisted instruction controlling for their scores in pre-test. The teaching method was found to significantly affect the post-test scores F(1, 47)=17.989, p=.000 after eliminating the effect of their pre-test scores. The pre-test was a significant covariate F(1,47)= 84.969, p=.000.

The result suggests that the virtual reality assisted instruction may help in teaching the concept of atoms and improving the performance of the students. The students' liberty to directly interact and control the material may have been the advantage of virtual reality assisted instruction that influenced the students' higher performance. However, this study does not consider the students' technological literacy and their respective learning styles. Further investigation that considers these factors is suggested.

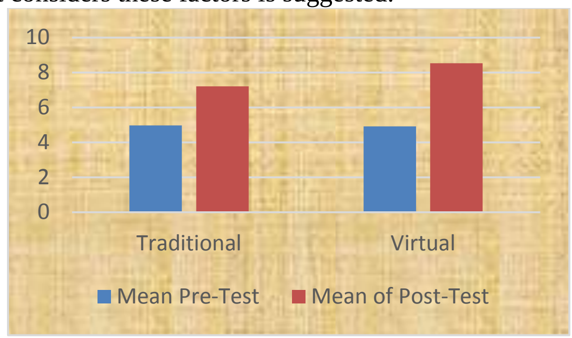

Figure 3: Comparison of Means between Traditional Instructional Method and Virtual Reality Assisted Instruction

Figure 3 illustrates the difference of the means of Traditional and VR assisted instruction where the mean of post-test scores of the latter, 8.52, is apparently higher than the mean of post test scores of the former, 7.2.

The above figures have been shown to illustrate the substantial difference between the post test results of traditional learning and virtual reality assisted learning where the latter's post test scores suggest that it may essentially help teachers in teaching concepts of atom given that further studies are established in order to achieve adaptation in educational institutions.

It has been shown by the results and demonstrated by the figures of the comparison of post test scores that there is a significant difference between the performance levels of students in traditional learning and virtual reality assisted learning, implying that the latter can help teachers in teaching concepts in chemistry and may as well offer similar advantages to other subjects.

Informal interviews with the students regarding their views on the use of VR assisted instruction were also conducted. Generally, the responses of the students have been positive and encouraging which can be summarized into the following:

1. The VR assisted instruction is fun and engaging.
2. The VR could be very useful in other sciences such as physics, biology, earth sciences, and astronomy.
3. Graphics in high resolution would be very much appreciated. The technology, however, is still in development so this is considerable.
4. The VR obviously has limitations and some expected interactions, such as "touching" and rearranging the atom, were not present.

5. CONCLUSION AND RECOMMENDATION

Through the use of a portable virtual reality, we were able to promote positive change in the performance, in terms of scores in the posttest, of the participants. Also, regardless of its shortcomings, we find that the technology was met with enthusiasm by the participants. The entirety of the study suggests that integrating virtual reality in teaching may help in teaching concepts in Chemistry and may serve as a modern strategy to enhance conceptual understanding in Chemistry and even in other sciences. Inadequacy of effective learning materials is still an issue in the Philippines [2] but they are being addressed. Teachers work hand in hand with the Department of Education to promote positive changes in the classroom and in the quality of education. Through this study, teachers may be inspired to discover means to integrate modern technologies in the learning experience and address the limitations of traditional instruction.

The study has been limited only to finding the difference in the performance of the respondents under two instructional methods and their views on the use of VR technology were obtained through informal face-to-face interviews. This study does not take into account the learning styles of the respondents, therefore further investigation taking this as factor or predictor is suggested. The effects of using VR to the respondents' intrinsic motivation are also not considered and are therefore suggested to be included when similar studies are proposed. This paper highlighted a small aspect of this technology. Research on the most cost effective methods of bringing virtual reality to the classroom will be necessary. Attention should also be paid to potential risks in optical health that may be inherent to virtual reality technology.

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