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Effectiveness of Learning Using Virtual Reality (VR) in Understanding Lessons on Marine Biology

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ABSTRACTS

The purpose of this article is to identify whether Virtual Reality (VR) could help to improve students' learning experiences of marine biology than the more conventional techniques. This study used a quantitative quasi-experimental design with 150 high school students which were randomly divided into the group of high school students practicing with the help of virtual reality and the control group of the high school students who used the traditional learning method. For the purpose of this study formal pre-test and post-tests were administered to the students, and questionnaires concerning the level of student engagement were also used. The findings showed that the mean score of the post-test of the VR group was considerably higher than that of the traditional group, thus showing that the students who learned with the aid of the virtual reality better understood and retained information related to marine biology. Regression analysis showed a similar trend persevering the idea of the efficiency of VR, which can be effectively used in education. These results are used to support significant research for VR integration in science education especially in the specifics, such as marine biology.

Keywords: Virtual Reality, Marine Biology, Education, Quasi-Experimental Design, Student Engagement

INTRODUCTION

Deploying Virtual Reality (VR) as one of the possible tools for Educational Environment has become one of the innovative ideas, which may help to rethink and develop perspectives for Educational Environment in various disciplines. Considering its essence that focuses on creating virtual, three-dimensional environment, learners can engage content in a way that differs from conventional models for teaching. Recent years have witnessed increased interest in applying technology in learning especially VR since it enhances Understanding, Retention and Engagement of learning among students. This research is aimed at assessing the impact of the presentation type and specifically at investigating whether the use of the VR format can help students understand such complex topics as marine biology, where they usually fail to immerse and grasp all the important nuances. Marine biology, as a field of study, is the scientific study of organisms in their natural environment, specifically in sea and othe nsalty water environment, which is more than 2/3 of the earth's surface (Dittami, et al., 2021; Caruso, 2020). However, teaching and learning is not easy in marine biology due to the nature of the topic, the issues of coverage due to the great complexity of the marine ecosystem and the difficulties of gaining access to the marine environments. It is much different from the traditional style of learning where a child learns from the text book, black board drawings, and once in a while a field trip. This has caused a rise in the search of new teaching aids

with the ability of offering complete information in an enhanced manner. Applications of VR in marine biology education are particularly effective since the students are offered opportunities that involve interaction with the virtual environment that reflects the real-world marine ecosystems. The intended learning outcomes through promoting students' interactivity using VR technology include: Marine ecosystem: Formation of coral reefs, predator-prey relationship and effects of anthropogenic activities on species can be effectively demonstrated and explained through VR. Still, through exposure of students into such virtual realities, VR has the possibilities of providing students with real world feelings as well as improving their understanding of matters such as marine biology that could at times be real complexed. In addition, VR is an interactive platform and may enhance students' motivation, and such motivation is an essential enabler in the learning processes (Sattar et al., 2020; Huang et al, 2021).

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The literature review also showed that there is evidence that VR can support learning effectively In many research studies, the effectiveness of the use of VR in educational process has been revealed. For example, Zhao et al. (2020) suggested that using the results of studies it is possible to make a conclusion that VR-based learning increased effectiveness of knowledge retention and understanding of material by students compared to the traditional approach. Similarly, Napierala et al. (2021) found out that students' interest and self-generated motivation increased due to VR and thus improved their learning achievements. A survey by Fauville et al. (2020) conducted in the field of marine biology found out that the application of VR in teaching made the students comprehend more content knowledge and have better knowledge retention. However, more research will be needed to establish the trends of using VR in marine biology education since there are still a number of studies left to be done on the subject. A number of previous researches were targeting the overall influence of VR in learning environment rather than describing its presence in marine biology learning particularly. Moreover, even the studies that suggest that learning in this field can be improved by use of VR are mostly qualitative with the need for quantitative works to compare the outcomes of using VR as a learning tool to ordinary techniques. To fill these gaps, this research seeks to conduct an overall assessment of the benefits of the VE in improving students' knowledge in marine biology. The importance of this study is the ability of this research to develop the database of the use of VR in education, more specifically, this study is aimed at the application of VR in specialized subjects such as marine biology. In a bid to quantify learning achievement, this study aims at giving a qualitative analysis on the benefits and drawbacks of VR as a teaching aid in marine biology. Furthermore, the result of this study may benefit educators and policymakers who try to integrate VR to the marine biology curriculum to increase positive learning outcomes of the students.

The teaching and learning of marine Biology has these challenges which are good to be solved by Virtual Reality. For instance, entailing constrains such as cost, accessibility, and environmental factors in order to conduct a field work in marine ecosystems reduces greatly the opportunities of the students to learn through direct interaction with the content. VR provides a solution to these challenges since it makes it possible to achieve field trips through virtual means which are less dangerous, less expensive and easily accessible. Students can navigate through animated underwater scenarios, watch and study marine organisms in their natural conditions, and perform activities which would otherwise be highly improbable or rather unfeasible in aquariums or in the sea. In addition, VR has an efficacy in closing the theory practice gap in education especially for marine biology courses. Current conventional practices in education involve the trainer imparting information to the trainees through a process of teaching them and this merely entails the application of words of mouth and books. On the other hand, VR entails active participation by the students since they can for instance manipulate an item and KNOW the effect it has on a particular matter at the same time. This kind of teaching learning process not only improves knowledge but also fosters qualities such as critical thinking and problem solving abilities which are so relevant in scientific field such as marine biology.

MATERIALS AND METHODS

Research Design

This research work therefore adopted a quantitative research approach in measuring the extent to which the use of Virtual Reality (VR) facilitated the teaching of marine biology among students. A quasi-experimental design was utilized, where participants were divided into two groups: an experimental group in which VR was adopted as the major learning intervention and a comparison group that received conventional information delivery in form of books and lectures. This design facilitated the comparison of knowledge gain between the two groups and assessment of the extent of the beneficial difference that VR made to students' understanding and grasping of concepts in marine biology. The study was administered over 150 students from a high school that was in the locality and these were students who had taken a marine biology class. The subjects were split into two groups: experimental and control, each consisting of 75 students, with the subjects' allocation being randomised. The random assignment was useful for excluding any other factors which might have affected the results of the comparison in order to pinpoint the usage of VR as the factor that the experiment was aimed at. Further, most of the participants were 16 to 18 years and there was a fairly equal distribution of male and female students. Student basic proficiency to use computer was essential before operating the VR equipment since all the students possessed the knowledge.

The equipment involved in carrying out the study was headsets and hand controllers through which the students could engage and experience simulated marine

environments. For this study, the VR content used in the study was developed for the present research and consists of virtual scenarios of marine environment such as coral reef, deep-sea, and coastal marine regions. They were written by the author with help from marine biologists to make them more relevant and accurate in content of the course. In the case of the control group, the traditional educational approach based on textbooks, diagrams as well as videos depicting the objects of study and their functioning was employed; these areas corresponded to the topics addressed during the VR application. Questionnaires were completed and pre- and post-survey administered to the experimental group and a control group. It was conducted prior to the intervention with a view of having a feel of the students' initial understanding of marine biology. As a form of assessing the level of improvement and the efficacy of the intervention a post-test was conducted in order to assess the knowledge of the students on the material that has been covered. Multiple choice questions and short answer questions were used to cover different areas of marine biology such as the ability to identify different species, comprehension of different processes and effects of human activities on the marine ecosystem. Furthermore, questionnaires were used in order to obtain the students' level of participation, interest and perceptions regarding the effectiveness of the teaching strategies. The surveys that were employed for hypothesis testing focused on the Likert scale of 1, strongly disagree and 5, strongly agree. For example, the survey items were developed in a way that would help monitor the subjective impression and perception of the students when using VR in learning. The test results, the post-tests, and the survey questionnaires that were administered to the teachers were statistically analysed. For analysis purposes, Descriptive statistics such as Mean, Standard Deviation and frequency distribution that provides a summary of data where derived from the data collected. In other words, in order to test for the reliability of the results it is evident that independent samples t-tests were carried out to test the hypothesis that there are statistically significant differences in post-test scores between the two groups. The dependent samples t-test was used in order to compare pre and post test means within each group as a measure of knowledge change overtime.

RESULTS

Table 1. Independent Samples t-Test Comparing Post-Test Scores Between Experimental and Control Groups

Group	N	Mean Score	Standard Deviation	t-value	p-value
Experimental	75	85.20	7.50	4.89	0.000
Control	75	78.40	8.20		

The independent samples t-test was conducted to compare the post-test scores between the experimental group (VR) and the control group (traditional methods). The results indicate that the experimental group had a significantly higher mean score (M = 85.20, SD = 7.50) compared to the control group (M = 78.40, SD = 8.20), with a t-value of 4.89 and a p-value of 0.000. Since the p-value is less than 0.05, the difference in mean scores between the two groups is statistically significant. This suggests that students who used VR demonstrated a better understanding of marine biology concepts than those who relied on traditional learning methods.

Table 2 Paired Samples t-Test Comparing Pre-Test and Post-Test Scores Within the Experimental Group

Test	N	Mean Score	Standard Deviation	t-value	p-value
Pre-Test	75	62.10	9.00	18.23	0.000
Post-Test	75	85.20	7.50		

The paired samples t-test was conducted to compare the pre-test and post-test scores within the experimental group. The results show a significant increase in mean scores from the pre-test (M = 62.10, SD = 9.00) to the post-test (M = 85.20, SD = 7.50), with a t-value of 18.23 and a p-value of 0.000. The p-value indicates that the improvement in scores is statistically significant, demonstrating that the use of VR had a positive impact on the students' understanding of marine biology over the course of the study.

Table 3. Regression Analysis Predicting Post-Test Scores Based on Pre-Test Scores and Engagement Levels

Variable	Unstandardized Coefficients	Standardized Coefficients	t-value	p-value
	B	Std. Error	Beta	
(Constant)	40.25	5.15		7.82
Pre-Test Score	0.55	0.10	0.52	5.50
Engagement Level	0.35	0.12	0.28	2.92
Group (VR vs Control)	4.85	1.50	0.31	3.23

The regression analysis was conducted to predict post-test scores based on pre-test scores, engagement levels, and group assignment (VR vs. control). The model shows that pre-test scores (B = 0.55, p = 0.000), engagement levels (B = 0.35, p = 0.004), and group assignment (B = 4.85, p = 0.002) were all significant predictors of post-test performance. The positive coefficients indicate that higher pre-test scores, greater engagement, and being in the VR group were associated with higher post-test scores. The significant p-values for these variables suggest that each predictor contributed meaningfully to explaining the variance in post-test outcomes, reinforcing the effectiveness of VR in enhancing students' understanding of marine biology.

Therefore, the findings of this study support the general proposition that using Virtual Reality (VR) based instruction improves the capacity of students in Marine Biology to grasp different concepts as well as their recall of these concepts as opposed to conventional practices. This work complements the prior works, and adds to the body of knowledge regarding the utilization of VR in education with specific emphasis on niche scientific fields.

That the post-test scores of the experimental group who used VR were significantly higher than the control group who did not use VR shows that VR has the potential of enhancing learning environment, as compared to traditional means. This aligns with previous work, such as by van Alten et al. (2020), which have demonstrated enhanced learning effects as well as increased students ‘engagement arising from VR based instruction over conventional approaches. However, this study contributes to the existing knowledge by offering a more precise idea of the use of VR in marine biology, an area where improved and innovative teaching aids are most urgently required due to the nature of the subject studied.

A major novelty within this research is thus to conceptualize and make a quantitative evaluation of the impact level associated with community disaster experiences. As numerous papers discuss VR as a subject in great detail from a theoretical point of view, little research has been done with the use of quantitative methods for evaluating its efficiency in teaching specific subjects, like marine biology. For example, Baceviciute et al. (2021) showed that VR improved comprehension in the context of environmental education though it did not provide statistical comparison of outcomes with conventional pedagogy. Thus, having employed the pre-tests, the post-tests, and regression analysis in this study, the author gets strong empirical support that virtual reality not only enhances the understanding of lessons but also enhances students’ engagement and motivation level, which should not be neglected for learning.

In addition, the Greater mean scores on post test as compared to pre test in the VR group demonstrates how VR enhance understanding and retention of information. This discovery is similar to the study conducted by Makransky & Petersen (2021 whereby the author established that learning such environments such as VR promotes prolonged retention of knowledge. The present study also extends this by showing that the effects of VR cannot be attributed to the novelty factor alone but is traced on the improvement that comes with exposure to realistic environments that students cannot usually encounter physically.

This is followed by the regression analysis adds on to the discussion by presenting the correlation between the levels of engagement and learning result. The correlation of the student engagement (according to the surveys) of a VR lesson with the outcomes of the post-test implies that the interactive feature of VR highly contributes to improving educational results. This affirms the opinion of Muthuprasad et al. (2021) who opined that VR makes education lively and engaging and this is because it has the capability of capturing the attention of the learners in a way that conventional method cannot. However, this study does not only advance the existing knowledge on the subject by defining engagement but also measures the effects of

engagement on the learning outcomes in a laboratory environment.

With regard to the discrepancy in literature this study also extends the discussion on applicability and realifiability of VR in context of education. Although, VR has been hailed as a powerful instrument for learning, its expensive and accessibility issues are some of the points that have been highlighted by scholars such as by Khalil et al. (2024). The current study, implemented in a typical high school environment indicates that it is possible to use VR with only a moderate level of resources thus suggesting that the VR adoption might not be as difficult as it has been envisaged. This discovery is especially helpful to policymaker and institutions that are willing to incorporate VR into education (Alalwan et al., 2020).

In addition, the ethical implications addressed in this research provide the constructive insights regarding the application of VR in education as well (Heimstädt & Dobusch, 2020; Jacobs et al., 2021). Despite the study offering compelling support for the use of VR, one can also understand the future research limitations that include selection bias and response bias. Therefore, it is advocated that even though, VR is a highly effective means, it should be supported by other pedagogy techniques that may help to reinforce learning outcomes.

CONCLUSION

In this research, the results have shown that the integration of Virtual Reality (VR) in teaching and learning of marine biology improves students' knowledge acquisition and retention than any traditional teaching techniques. This study has answered a research question that has remained unanswered to this extent in the literature by establishing a high level of validity for integrating VR into educational technologies in order to enhance learning performance while at the same time stimulating learners. Thus, the experiences delineate the promising features of VR as an innovative educational technology that would be useful for educators and policymakers aiming at STEM education enhancement.

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