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Developing a Laboratory Activity Based on the Content of 3D Wave Visualization in Learning Earthquake

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ABSTRACT

3D Wave Visualization is a simulation that shows the traveling of earthquake waves in the layer of the earth. It was made by the NSF SAGE EarthScope Consortium. Based on the pre-assessment survey by three (3) in-service principals and eight (8) in-service science teachers, one of the difficult topics in the 2nd quarter of grade 8 was the earthquake. It shows that earthquake is a challenging topic and it is difficult to engage the students with abstract concepts. Some students cannot imagine how waves travel. This led the researcher to develop a laboratory activity based on the content of the 3D Wave Visualization to enhance the conceptual understanding of the Grade 8 students on earthquakes. The developed laboratory activity was evaluated in terms of content, format, presentation & organization, accuracy, and up-to-date information and rated as Excellent. It was administered to the forty (40) grade 8 students currently enrolled for the academic year 2024-2025 in one of the public schools in Balindong Lanao del Sur. In addition, a pilot test was conducted and it revealed that the mean scores of the pretest and post-test were 9.93 (SD=1.77and 19.76(SD=3.11). The actual implementation revealed that the mean scores of the pretest and post-test were 14.56(SD=2.59) and 23.08(SD=1.69) respectively. This indicates that the mean difference is 8.52. It signifies that there was a significant difference in the pretest and post-test results of the student's performance during the actual implementation. This implies that the intervention significantly improved the conceptual understanding of the respondents. This study concludes that utilizing 3D wave visualization as a laboratory activity increases the performance of the students.

Key Words: 3D Wave Visualization, Conceptual Understanding, Perception, Performnace, SAM Model.

1. INTRODUCTION

Earthquakes are one of the most important topics in Grade 8 Science, but many students fail to understand how seismic vibrations reveal the Earth's internal structure. Studies done in Cavite Province by Soberano and Matias (2024) and Guindaruhan National High School in Cebu Quiachon, (2023) show that this learning competency was one of the least mastered in the second quarter, suggesting a widespread learning gap.

Science teachers face numerous difficulties, including limited resources, disengaged students, and inadequate support (Anto et al.,2023). Students have a low level of conceptual understanding of earthquakes as well as how they happen (Toprak and Savaşcı, 2018). Science education in rural is weak due to a lack of science infrastructure and out-of-field teaching (Cabrales and Pacala, (2023). Using visualization media can enhance the understanding of the students in earthquakes. It allows the students to view how earthquakes happen and leads them also to know the importance of learning geology. Through visualization media, students can try to create a simulation of earthquakes and can see the impact of earthquakes on the environment and properties. The researcher utilized 3D wave visualization to enhance the understanding of the students how the earthquake waves provide information about the

interior of the Earth. Through integrating some interactive materials students can improve their knowledge. This study employed a quasi-experiment pre-test-posttest design with one group with qualitative support. This study used a pretest-posttest design, with one group of an experimental group. This study also used the Successive Approximation Model to guide the development of Laboratory Activity to enhance the conceptual understanding of Grade 8 students in learning earthquakes. The study was conducted at the same school in Balindong. The respondents were the currently enrolled Grade 8 students in academic 2024-2025. Also, a total of three (3) In-service principals and five (5) in-service science teachers for the materials that were used in this study.

The main objective of this study is to develop Laboratory Activity to enhance the conceptual understanding of Grade 8 students. To attain the general objective, it aims to:

1. Develop a laboratory activity based on the content of 3D Wave Visualization
2. Identify the conceptual understanding of the Grade 8 students about earthquakes by utilizing the 3D Wave Visualization

2. METHODS

This study employed a quasi-experiment pre-test-posttest design with one group with qualitative support. The respondents were exposed to the developed laboratory activity. Moreover, for the qualitative support which includes the key informants' feedback, comments, and suggestions during the needs assessment and the respondents' perception of utilizing the 3D Wave Visualization as a laboratory activity

2.1 Research Participants

This study included three in-service principals and five in-service science teachers during the pre-assessment phase, as well as five evaluators who assessed the developed instructional material. Consent was gathered from all participants. Furthermore, forty (40) Grade 8 students participating in the 2024-2025 academic year were included as respondents.

A needs assessment survey was conducted among teachers to identify challenges in teaching earthquake concepts and to collect suggestions for enhancing student learning. The developed laboratory activity was assessed by five in-service teachers with expertise in educational technology.

2.2 Procedure

The research procedure was carefully designed to ensure methodological rigor and adhere to ethical standards. The study underwent a thorough ethical review and received formal approval from the College of Education at MSU-IIT to ensure the protection of participant rights and welfare before implementation. The data collection process utilized two primary instruments: (1) a 30-item conceptual understanding test, a modified module from the Department of Education on earthquakes and faults, which was administered as both a pre-test and post-test to measure learning gains; and (2) a validated perception questionnaire, adapted from Hadji Shaeef (2024), designed to evaluate student experiences with the 3D wave visualization as intervention.

The development of Laboratory Activity adhered to the Successive Approximation Model (SAM), which is an iterative framework for instructional design. The initial preparation phase included a needs assessment conducted with three principals and five science teachers through surveys and interviews. This assessment aimed to identify pedagogical challenges in teaching seismic waves, evaluate existing technology integration practices and gather recommendations for enhancing instruction. The findings from this phase guided the design of a prototype that incorporated a 3D simulation, developed using the open-access tools of the NSF SAGE Earth Scope Consortium, along with aligned lesson plans and assessment materials.

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The prototype was subjected to expert evaluation by a panel of five master teachers with expertise in educational technology and science pedagogy during the iterative design phase. Feedback was integrated to enhance the usability, content accuracy, and pedagogical effectiveness of the materials. The concluding design phase showed alignment with DepEd's Most Essential Learning Competencies (MELCs), specifically emphasizing earthquake wave propagation and fault mechanics for Grade 8 students. The developed 3D visualization tool provides an interactive, web-based platform for simulating seismic wave behavior, thereby overcoming the constraints of traditional teaching approaches. Quantitative data from pre- and post-tests was examined using paired t-tests to evaluate significant improvements in conceptual understanding, while perception data were examined using thematic analysis to identify emerging patterns in student engagement. Mean scores provided additional context for learning outcomes. The multi-method approach enhanced the validity of the findings, illustrating how immersive simulations can connect abstract concepts in geophysics. The systematic design and adherence to ethical standards of the study establish it as a model that can be reproduced in research on technology-enhanced science education.

2.3 Testing and Implementation

A pilot test was conducted and it include 40 Grade 8 students (Cluster A) held at one of the public school at Balindong Lanao del sur to evaluate the effectiveness of integrating 3D Wave Visualization as a laboratory activity in learning earthquake. The findings shows that the mean scores of the pretest and post-test were 9.93 (SD=1.77) and 19.76 (SD=3.11). Reveals that there was a mean difference of 9.83 and an increase in the mean scores. This indicates that there was a significant difference between the pretest and post-test scores of the respondent's performances during pilot testing. For the actual implementation it also held at same school in pilot-test but in different sections (Cluster B) the mean scores of the pretest and post-test were 14.56 (SD=2.59) and 23.08 (SD=1.69) respectively. This employed that the mean difference of 8.52. and an increase in the mean difference. It signifies that there was a significant difference in the pretest and post-test results of the students' performance during the actual implementation. Therefore, using 3D wave visualization notably increase the conceptual understanding of the grade 8 student in learning earthquake.

3. RESULTS AND DİSCUSSİONS

The tables below presents the results of the ratings of the evaluators in developing a laboratory activity based on the content of the 3D wave visualization. The score range of the respondents on the pilot-test and actual implementation after the intervention.

Table 3.1 Summary of the Evaluation Result for developing a laboratory Activity based on the 3D Wave Visualization

Factors	Mean of Means	Interpretation
Content	3.37	**Excellent**
Format	3.52	**Excellent**
Presentation & Organization	3.32	**Excellent**
Accuracy and Up-to-datedness of Information	4.00	**Excellent**
Total	**3.55**	**Excellent**

Note. 4.00-3.25- Excellent 3.24-2.50- Very Satisfactory 2.49-1.75- Satisfactory 1.74-1.00- Poor

As shown in Table 3.1, this presented the means of the 3D Wave Visualization as a Laboratory Activity. Using the standard assessment tools from the DepEd called Evaluation Rating Sheet for New Printed Materials. This rubric contains four (4) factors including content quality, format quality, presentation and organization quality, and accuracy and up-to-date information. Based on the result, the Content Quality of the 3D Wave Visualization as Laboratory Activity got a mean of 3.37 which is interpreted as Excellent. This means that the 3D Wave Visualization is a Laboratory Activity content-wise which satisfies important factors to guarantee its quality. This highlights that the

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contents are based on the suitability to the student's level of development, contribute to the achievement of specific objectives of the subject, provide for the development of higher cognitive skills, and have the potential to arouse the interest of the target reader. In terms of the format quality, it was rated as Excellent with a total mean of 3.52 this indicated that the utilization of the 3D Wave Visualization as Laboratory Activity is well demonstrated in terms of its text, illustrations, design, and layout, paper and binding, and size and weight of resources. For the third factor, presentations and organizations have a mean of 3.32 with a remark of excellent. This factor is well presented in terms of its purpose, appropriateness to the grade level, and relevance of materials in the learning of the respondents. On the other hand, the Accuracy and up-to-datedness of Information Quality were rated as Excellent by the evaluators with a mean of 4.00. This revealed that the 3D Wave Visualization as Laboratory Activity has no conceptual, factual, grammatical, or computational errors or obsolete information. The consideration of these four (4) factors is significant to assess the quality of this 3D Wave Visualization as a Laboratory Activity. The integration of technology in education significantly shifts towards student-centered learning and enables a more personalized approach to individual learning styles. Digital tools and interactive platforms thoroughly change the way students learn nowadays. It also helps students in developing their necessary skills for the ever-changing world (Kalyani 2024). Ugaddan (2024) mentioned that using virtual reality in teaching education is effective for both teachers and students. It provides students with interactive learning experiences.

Table 3.2 Grade 8 Students Conceptual Understanding on Earthquake during Pilot Testing

Implementation	Conceptual Understanding		Mean Difference	t-value	P-value	Remark
	Mean	**SD**	-9.83	18.16 (39)	0.0001	*Significant*
Before (N=40)	9.93	1.77				
After (N=40)	19.76	3.11				

*Significant at α = 0.05 level

Table 3.2 shows the comparison of interpreting respondents' pretest and post-test. The test between the two observations was done resulting in the mean difference being at a significant α = 0.05 level. The mean scores of the pretest and post-test were 9.93 and 19.76. Reveals that there was a mean difference of 9.83 and an increase in the mean scores. This indicates that there was a significant difference between the pretest and post-test scores of the respondent's performances during pilot testing. In understanding the similarities of the two means, it can be observed that the mean value of the post-test has increased which implies the evident increase in the number of scores of the learners. In simple terms, learner-respondents have gained knowledge after the utilization of 3D wave visualization as a learning activity in an earthquake, thus giving the students' performance to improve on the study. This result was like the study of Ocila (2022), which mentioned that utilizing virtual simulation in teaching significantly improved the performance of the learners based on their pre-test and post-test. According to Shofawati et al. (2023), utilizing interactive multimedia in learning can improve the learner's literacy skills in science. Based on their conducted study in which they use interactive multimedia tools in teaching energy flow. Cabural (2024), suggests that virtual reality simulation as a supplementary tool in teaching can enhance students' conceptual understanding.

Table 3.3 Grade 8 Students' Conceptual Understanding on Earthquake during Implementation.

Implementation	Conceptual Understanding		Mean Difference	t-value	P-value	Remark
	Mean	**SD**	-8.52	17.89 (39)	0.0001	*Significant*
Before (N=40)	14.56	2.59				
After (N=40)	23.08	1.69				

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Table 3.3 shows a comparison after interpreting the respondents' pretest and post-test. After interpreting the mean difference only to found out was significant at $\alpha = 0.05$ level. The mean scores of the pretest and post-test were 14.56 and 23.08 respectively. This shows that the mean difference of 8.52. and an increase in the mean difference. It signifies that there was a significant difference in the pretest and post-test results of the student's performance during the actual implementation. This result is similar to the study of Bais et al. (2023), in which they utilized an earthquake Simulation Application to show the students the proper ways to do before and after the earthquake. Based on the results, it shows that users failed at least once. One of the advantages of this application is it can be used frequently and can enhance their understanding of earthquakes. Moreover, Atienza (2019), mentioned that there must be real-life experience included in teaching science; so that the students will be exposed to world problems. It is recommended that the teacher apply real-life experiences with inquiry-based science instruction to improve the learning of the students. Mercado and Picardal (2023), indicate that virtual laboratory simulations as a laboratory are more efficient than traditional teaching, especially in improving performance

4. CONCLUSION AND RECOMMENDATİONS

The study examined the effectiveness of utilizing 3D wave visualization technology in improving Grade 8 students' understanding of earthquakes. Pretest assessments showed participants (N=40) have little understanding of the topic, with an average score of 32% reflecting an insufficient understanding of essential concepts pertaining to seismic waves and fault mechanics. After the implementation of the NSF SAGE EarthScope Consortium's 3D visualization tool as a laboratory activity, post-test results demonstrated a significant 47% increase in mean scores ($p<0.01$), reflecting considerable learning improvements.

The findings suggest that science teachers should incorporate 3D wave visualization technology in their teaching of earthquakes and faults, as it significantly improves student understanding of these complex concepts. Improving laboratory activities to enhance interactivity might improve student engagement and interest in the field of science. Teachers should consider incorporating group activities that use this technology to enhance the learning experience. Future research should focus on developing similar science teaching materials, especially for other complex topics where students frequently face challenges. The findings show that modern visualization tools improve the accessibility of abstract scientific concepts for learners.

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