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Development of a 3D Ethnomathematics Model for the Dayak Tribe of Central Kalimantan with the Assistance of Virtual Reality Media

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ABSTRACT

This research aims to test the feasibility of the 3D Ethnomathematics model for the Dayak Tribe of Central Kalimantan as well as provide alternative learning media for students using Virtual Reality technology and create a 3D Ethnomathematics model based on Virtual Reality so that students get an in-depth and interesting learning experience to strengthen numeracy literacy. This research uses the Research and Development (RnD) method with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model. This research was conducted using qualitative and quantitative solving approaches. A qualitative approach is used at the analysis stage, model development design stage, and assessment stage of product feasibility obtained from an open questionnaire in the form of input, responses, criticism, and suggestions. A quantitative approach is used in product feasibility assessment tests from media experts and material experts as well as testing the effectiveness of 3D models from students. Feasibility assessments by media experts and material experts were obtained from closed questionnaires. The effectiveness test was carried out through a pretest-posttest design in small groups, namely 5 elementary school students. Based on the research results, the results of the feasibility test by media experts and material experts showed that the 3D Ethnomathematics model of the Dayak Tribe of Central Kalimantan was in the feasible category with a percentage of 92% and 90%. The results of the effectiveness test carried out in small groups through pretest-posttest increased from the pre-test average with a score of 64 to 84 during the post-test after using the 3D Ethnomathematics model. So, it can be concluded that the 3D Ethnomathematics model of the Dayak Tribe of Central Kalimantan is feasible and effective to use.

Keywords: Ethnomathematics; Dayak tribe; Virtual Reality; Numeracy Literacy; Immersive Learning

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INTRODUCTION

Skills in using numbers and mathematical symbols to be able to think rationally, systematically, and critically in analyzing and solving contextual problems in everyday life are really needed by students. The ability to empower mathematical skills and knowledge in solving contextual problems is called numeracy literacy ability (Aisah, Siti., Panglipur, Indah Rahayu., & Sujiwo, 2023; Anugrahana, 2021; Lailatul & Khuzaini, 2024; Maziyah & Zumrotun, 2024; Priyani, 2022). Numeracy literacy is the knowledge and skill to use various kinds of numbers and symbols related to basic mathematics to solve practical problems in everyday life and then analyze information displayed in various forms and interpret the results of the analysis to predict and make decisions (Kemdikbud, 2017).

Numeracy can be defined as the ability to apply number concepts and arithmetic operation skills in everyday life (for example, at home, work, and participation in community life and as a citizen) and the ability to interpret quantitative information found around us. This ability is demonstrated by being comfortable with numbers and being able to use mathematical skills practically to meet the demands of life. This ability also refers to the appreciation and understanding of information expressed mathematically, for example, graphs, charts, and tables. Numeracy literacy is defined as a person's ability to use reasoning. Reasoning means analyzing and understanding a statement, through activities in manipulating symbols or mathematical language found in everyday life, and expressing the statement through writing or verbally (Abidin, et. al, 2017).

Numeracy literacy skills include the application of mathematical concepts and rules in real situations or circumstances, where problems are often non-routine and ill-structured (Dedi et al., 2023; Hazimah, Ghina Fauziah & Sutisna, 2023; Ulfa et al., 2022). The numeracy literacy skills of students in Indonesia are relatively low and still lag behind compared to other countries (Rahayu, Sari., Syahrul, Santi Farida., Arifin, M. Zainal., & Ardianto, 2024). Based on data from the latest PISA Indonesia survey in 2022, it is shown that only 18% of students are declared proficient in mathematics, while the other 82% of information is not available (OECD, 2022). The International Community of Teachers of Mathematical Modeling and Applications (ICTMA) states that in improving numeracy, students need active learning according to real-world contexts using real-world examples, so they can solve real-life problems too (Stillman & Blum, 2013). Learning mathematics using real-world examples cannot be separated from the habits or culture of the environment around students, so mathematics and culture are two things that are closely related. Culture-based mathematics learning is a study of ethnomathematics (Assidiqi, 2024; Dinarti, Siti., Qomariyah, Umi Nur., 2023; Fatmawati, Ira & Hanik, 2024; Sarwoedi., Marinka et al., 2018; Yustinaningrum, 2024).

Strengthening numeracy literacy through ethnomathematics with the help of technological media is the right solution. Learning that involves technology is generally used interactively. Students can take action on a technology-based learning product that is being developed and will receive a response at that time (Kusumah & Dahlan, 2021). The development of this VR-based 3D Ethnomathematics model can help increase the potential for visual perception and absorption of information received by students, as well as develop students' practical and social skills (Bahari, Heryana, & Ridha, 2023). The use of VR media in learning is considered more efficient, this is because VR can be done anywhere and at any time without being bound by space and time as long as it is on the network and its use gets the most positive response from students because VR is able to show a pseudo-world such as images or videos that are dynamic in nature, can bring students as if they were in that world, making learning interesting (Pramesti et al., 2022).

Virtual Reality (VR) is defined as an immersive display a computer-generated simulation of a three-dimensional image or environment that can be interacted with in a real or physical way by a person using special electronic equipment, such as a helmet containing a screen or gloves equipped with sensors (Freina & Ott, 2015). VR has the potential to significantly enhance the educational experience for students, especially those with limited literacy and numeracy levels (Farley, 2019). Virtual Reality (VR) has also been widely adopted in various domains of education, especially in vocational education (Allcoat & Mühlenen, 2018; Fitriyanto, et. al., 2024; Mckechnie & Wilson, 2021; Merchant et al., 2014; Mikropoulos & Natsis, 2011). The use of VR can also be spread widely from primary education to higher education.

The integration of VR technology for learning mathematics, especially geometry, can increase student motivation, achievement, learning performance, student attitudes towards mathematics, and student involvement in learning and can easily introduce basic geometric concepts that are integrated with the surrounding culture and environment (Akman, E., & Çakır, R., 2020; Priyani, NE, 2022; Su, Yu-sheng., Cheng, Hung-Wei., & Lai, C.-F., 2022; Tsaaqib et al., 2022; Zulfikri, 2023). The use of VR can encourage educators and policymakers to create dynamic and engaging mathematics classrooms that empower students to explore, visualize, and interact with mathematical concepts in meaningful ways. These findings highlight the potential of VR to change mathematics education by providing an immersive and interactive learning experience, especially in the introduction of geometry material. An introduction to geometry material can be easily conveyed to students because it is packaged in a different form, namely by involving 3D technology and culture that is closely related to students' lives. With this Virtual Reality technology, students are invited to play and learn so that children are able to work on math problems in a fun way. So, in developing the VR-based 3D Ethnomathematics model, it is necessary to test the feasibility and effectiveness of the model in order to achieve the goal of an interesting and enjoyable mathematics learning experience (joyful learning).

Continuous innovation regarding the development of technological media, especially virtual reality which is integrated with ethnomathematics, is really needed to help students understand mathematics contextually in culture and the use of current technology. The adaptation of VR technology in ethnomathematics can provide a new and potentially good atmosphere in understanding mathematics broadly to increase students' motivation and numeracy literacy by exploring a place virtually and giving a real impression in every virtual adventure (Koolivand et al., 2024; Lege & Bonner, 2020; Marougkas et al., 2024; Saurik, Herman Thuan To., Purwanto, Devi Dwi., & Hadikusuma, 2019; Serin, 2020).

RESEARCH METHOD

This research uses the Research and Development (RnD) method with the ADDIE (Analysis, Design, Development, Implementation, Evaluation) development model.

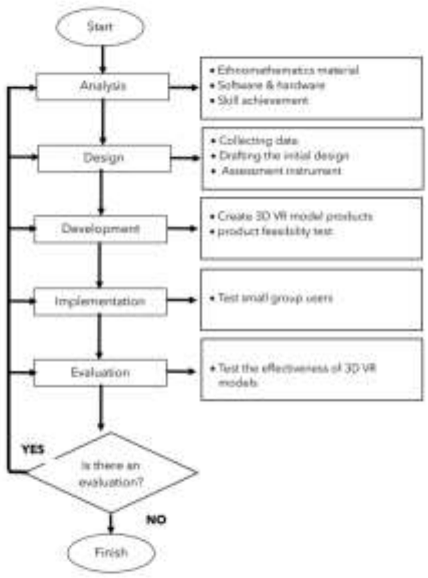

Image 1. Research Flow

Development of a 3D VR model with the ethnomathematics concept of the Dayak tribe of Central Kalimantan using a qualitative and quantitative solving approach. A qualitative approach is used at 1) the analysis stage, namely analyzing content for product development through library and literature studies, analysis of software and hardware requirements, and analysis of expected skills. 2) The design stage, namely collecting reference data, designing the initial product design, and designing product assessment instruments, and 3) the assessment stage, namely the assessment of media experts and material experts regarding the suitability of the product obtained from an open questionnaire in the form of input, responses, criticism, and suggestions.

A quantitative approach is used in product feasibility assessment tests from media experts and material experts as well as product effectiveness tests from students. Feasibility assessments by media experts and material experts were obtained from closed questionnaires. The effectiveness test was carried out through a pretest-posttest design in small groups with 3 effectiveness level criteria, namely high, medium, and low.

RESULT AND DISCUSSION

Results

Analysis Stage

The main activities carried out at this stage are analyzing the background or need for developing learning media and analyzing the feasibility and requirements for developing learning media. After analyzing the need for development, researchers also need to conduct an analysis of the feasibility and requirements for developing learning media. This analysis was carried out to determine the suitability of the learning media before it was widely used. Apart from analyzing the suitability of the learning media, at this stage, an analysis was also carried out on the mathematical material contained in the ornaments of the Dayak Tribe of Central Kalimantan, especially geometric material.

The results of the exploratory analysis of mathematical elements, especially geometry, in the ornaments of the Dayak tribe of Central Kalimantan include the following.

1) The Value of Ethnomathematics in Huma Betang
   a) The "Point" concept on the Huma Betang door
   b) The "Line" concept on the Huma Betang door
   c) “Flat Rectangular Build” on Huma Betang doors and windows
   d) “Flat Triangle Building” on the roof of Huma Betang
   e) “Flat Trapezoid Building” on the roof of Huma Betang
   f) “Build a Tube Room” on the support beam
2) The Value of Ethnomathematics in Talawang
   a) The concept of "parallel lines" in Talawang
   b) “Flat Hexagonal Building” in Talawang
   c) “Build Flat Rectangles and Triangles
   d) "Curve Concept" in Talawang
3) The Value of Ethnomathematics in the Garantung Gong
   a) "Build a Flat Circle" on the Gong

3D model Design Stage

At this stage, the design and collection of design assets for Central Kalimantan Dayak Tribe ornaments were carried out on the VR display, including the designs for Huma Betang, Gong Garantung, Kalakai, Talawang, Supporting Pillar, Huma Betang Roof, and so on.

Figure 1. Huma Betang Design.

Figure 2. Garantung Gong Design

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Figure 3. Kalakai Design

Figure 4. Talawang Design

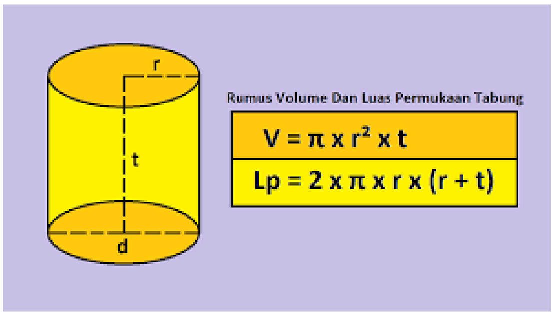

Figure 5. Concept of building a tube space on a support pole

Figure 6. Triangular Flat Shape Concept

Ethnomathematics 3D Model Development Stage

The stages of developing this 3D model are integrating ethnomathematics, especially geometric concepts, into Virtual Reality (VR) technology, VR design, and the development of learning media based on VR technology. The phase of integrating ethnomathematics is by modeling the geometric concepts that exist in the ornaments of the Dayak Tribe of Central Kalimantan.

Figure 7. Triangle Concept

Figure 8. Rectangle and Triangle Concept

Figure 9. Point Concept

Figure 10. Trapezoid Concept

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Figure 11. Circle Concept

Figure 12. Parallel Lines Concept

Figure 12. Tube Concept

At this stage of developing the 3D model design, Virtual Reality learning media was also assessed by media experts and material experts. The product assessment questionnaire indicators for media experts and material experts are as follows.

Table 1. Media Expert Product Assessment Indicators

No.	Aspect	Indicator
1.	DeviceSoft	Integrated learning resource product packaging that is easy to execute
		Complete independent learning resource program documentation includes: installation instructions, troubleshooting, and program design
		Effective and efficient in developing and using learning resources
		Accuracy in selecting the type of application for development
		Reliable
		Maintainable (Ease of Management)
		Reusable
		Usability
2.	Visual Communication	Audio
		Visual
		Navigation
		Communicative
		Creative in ideas
		Moving media (animation)

Table 2. Product Assessment Indicators for Material Experts

No.	Aspect	Indicator
1.	Learning materials	Clarity of learning objectives
		The relevance of learning objectives to the competencies achieved and the curriculum
		Suitability of material to the curriculum
		Depth of material
		Providing feedback on evaluation results
		Ease of understanding
		Consistency evaluation with learning objectives
		Clarity of description, discussion, examples, simulations
		Systematic, coherent, and clear logical flow

The assessment instrument uses an observation sheet which is then interpreted into a feasibility level according to table 3. At this stage, revisions and evaluations are also carried out according to expert advice if necessary.

Table 3. Interpretation of media and material qualifications based on expert assessment

Percentage (%)	Qualification	Information
90-100	Very worthy	No need for revision
70-89.9	Worthy	No need for revision
50-69.9	Decent enough	Minor revision
30-49.9	Not feasible	Major revision
20-29.9	Not really worth it	Major revision

After carrying out the feasibility test, the results of the feasibility test by media experts and material experts are as follows.

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Table 4. Validation test results of media experts and material experts

	Validator	Stage 1	Stage 2	Stage 3	Category
1	Media Expert	50%	68%	92%	Worthy
2	Materials Expert	65%	90%	-	Very Worth It

After going through validation by experts, the model was then tested through field trials (limited trials) to measure the effectiveness of the 3D Ethnomathematics model. Limited trials were carried out on a small group of elementary school students.

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Implementation Stage

After the 3D model development stage and feasibility testing by media experts and material experts, the next stage is the implementation of the 3D ethnomathematics model product by conducting limited tests on students with the aim of finding out the

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percentage results of the effectiveness of the 3D ethnomathematics model. The effectiveness test was carried out through a pretest-posttest design on 5 students at SD IT Muhammadiyah Palangkaraya.

The completeness of student learning can be seen from the post-test scores that have been completed after using the 3D ethnomathematics model. From the learning result data of 5 students, on the questions given, the KKM score was 70 and the average score on the post-test was 83. The following is a recapitulation of student learning results.

Table 5. Recapitulation of Student Learning Results

No.	Student Name (Initials)	Pre Test Score	Category	Post Test Score	Category
1	QSA	65	Not Completed	85	Complete
2	GTH	70	Complete	90	Complete
3	AAS	60	Not Completed	85	Complete
4	ADP	55	Not Completed	70	Complete
5	BAG	70	Complete	90	Complete
	Average	64		84	

All students are in the complete category. If present, the completeness of the student's learning results shows a completeness percentage of P > 80% in the very good/effective category. So, the 3D ethnomathematics model can be said to be effective to use.

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DISCUSSION

Each tribe and region has its own specialties and uniqueness. Each tribe has its own characteristics of local wisdom values such as various languages, traditions, traditional houses, beliefs, food, traditional games, and other forms, including the Dayak tribe in Central Kalimantan.

The Dayak tribe of Central Kalimantan has distinctive ornaments with the philosophical value contained within them. Like Huma Betang or long house as a symbol of harmony among the people of Central Kalimantan. The *talawang* or shield is a Dayak war tool which functions as a complementary shield to the mandau, a traditional Dayak weapon which is believed to have magical powers that can arouse enthusiasm and strength in the person who uses it. Batang Garing is a symbolic tree that was created at the same time as the creation of the Ngaju Dayak ancestors. Batang Garing is considered to be a guiding tree for managing life that must be taught to the Ngaju Dayak people. The Tingang bird is a symbol of the greatness and glory of the Dayak tribe, symbolizing peace and unity, its thick wings symbolize a leader who always protects his people, while its long tail is considered a sign of prosperity for the Dayak people. Then, the Garantung Gong is a traditional Dayak musical instrument. Garantung is also believed to be a traditional object descended from Lewu Tatau (heaven or heaven) as a tool for communicating with ancestral spirits. Garantung is also a valuable object that functions as a traditional item and is used as a means of exchange to value goods or services. Garantung exists at the same time as humans descend from the sky, and Garantung is a marker of social status and valuable possessions. There are many other types of ornaments from other Dayak tribes of Central Kalimantan.

Based on the research results, the development of a 3D VR model that is integrated with mathematical concepts found in the Dayak culture of Central Kalimantan is in the category suitable for use and dissemination to the wider community, especially teachers, students, and education activists. 3D VR models also have a good impact on students' mastery of materials, especially regarding basic geometry. Proven by the level of effectiveness in limited trials of small groups of students as measured through pre-test and post-test results. In other words, the integration of VR technology for learning mathematics, especially geometry, can increase student motivation, achievement, learning performance, student attitudes towards mathematics, and student involvement in learning and can easily introduce basic geometric concepts that are integrated with the surrounding culture and environment (Akman, E., & Çakır, R., 2020; Su, Yu-sheng, et al., 2022; Tsaaqib et al., 2022; Zulfikri, 2023). This is also in accordance with the results of case studies which state that learning with VR media can improve student learning outcomes (Nor et al., 2024).

The integration of technology in learning is a necessity to ensure quality educational processes and outcomes in line with current developments. VR is used as a tool to improve students' dialogue skills in mathematics learning

(Setyawan, Didik Martinus, Hakim, Lukman El, & Aziz, 2023). Virtual Reality allows interaction in a three-dimensional environment that creates an experience as if you were in the real world. Through the use of VR technology, students can undergo different learning experiences by being brought into different learning environments. VR allows interaction in a three-dimensional environment that creates an experience as if you were in the real world. Through the use of VR technology, students can undergo different learning experiences by being brought into different learning environments. VR media provides a new learning experience for students, where students will be directly involved in seeing the real virtual world through dynamic images so that students feel as if they are in the real world (Nor et al., 2024).

CONCLUSION

The development of a 3D Ethnomathematics model for the Dayak Tribe of Central Kalimantan is one of the media that can be used in learning to strengthen mathematical concepts, especially basic geometry, be proficient in using the latest technology, and expand the treasures of knowledge and love for one's own culture. Based on the research results, after being tested for feasibility by media experts and material experts, the development of the 3D Ethnomathematics model for the Dayak Tribe of Central Kalimantan is in the category suitable for use and dissemination to the general public, especially lecturers, teachers, students, and educational activists.

This study may have limitations in terms of sample size, diversity of participants, and breadth of material that may affect the generalizability of the findings, it would be beneficial to include a larger and more diverse sample to increase the external validity of the study.

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