MaPan : Jurnal Matematika dan Pembelajaran
p-ISSN: 2354-6883 ; e-ISSN: 2581-172X
Volume 12, No 2, Dec 2024 (274-293)
DOI: https://doi.org/10.24252/mapan.2024v12n2a5

FUNETHNOMATH: DEVELOPMENT OF VIRTUAL REALITY TOUR WEB LEARNING MEDIA WITH AN ETHNOMATHEMATICS

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Received August 21, 2024; Revised October 30, 2024; Accepted November 15, 2024

Abstract:
This research aims to develop a funethnomath learning media based on a virtual reality tour in the form of a website using a valid ethnomathematics approach. This research is a development type or RnD with the ADDIE model, consisting of the stages of analysis, design, development, implementation, and evaluation, which is limited to the development stage. Data collection techniques include interviews, observations, documentation, and questionnaires. The validation questionnaire is given to material and media experts. The research instrument uses a validation questionnaire for media and material experts. The media expert validation questionnaire has several assessment aspects, including appearance, software engineering, and visual communication. The material expert validation questionnaire has several assessment aspects, including material design and language. The data analysis of the questionnaire is determined according to the media validity assessment guidelines. The results of this study show that the developed media has valid criteria with a final score of 3.015 in the media expert validation with assessment aspects of appearance, software engineering, and visual communication, and a final score of 3.0625 in the material expert validation with assessment aspects of material design and final value.

Keywords: Ethnomatemathics, Instructional Media, Mathematics, Virtual Reality Tour

FUNETHNOMATH: PENGEMBANGAN MEDIA PEMBELAJARAN WEB VIRTUAL REALITY TOUR DENGAN PENDEKATAN ETNOMATEMATIKA

Abstrak:
Tujuan penelitian ini untuk mengembangkan media pembelajaran funethnomath berbasis virtual reality tour dalam bentuk website dengan pendekatan etnomatematika yang valid. Jenis penelitian ini merupakan pengembangan atau R&D dengan model ADDIE melalui tahapan analysis, design, development, implementation, and evaluation yang dibatasi pada tahap development. Teknik pengumpulan data melalui wawancara, observasi, dokumentasi, dan angket. Angket validasi diberikan kepada ahli materi dan media. Instrumen penelitian ini

menggunakan angket validasi ahli media and materi. Angket validasi ahli media memiliki beberapa aspek penilaian yaitu tampilan, rekayasa perangkat lunak, dan komunikasi visual. Angket validasi ahli materi memiliki beberapa aspek penilaian yaitu desain materi dan kebahasaan. Analisis data angket ditentukan sesuai dengan pedoman penilaian kevalidan media. Hasil penelitian ini menunjukkan bahwa media yang dikembangkan memiliki kriteria valid dengan hasil akhir pada validasi ahli media 3,015 berdasarkan aspek penilaian pada tampilan, rekayasa perangkat lunak, serta komunikasi visual dan hasil akhir pada validasi ahli materi 3,0625 dengan aspek penilaian pada desain materi and nilai akhir.

Kata Kunci: Etnomatematika, Media Pembelajaran, Matematika, Virtual Reality Tour

How to Cite: Hasanah, N., Purnomo, E. A., & Mawarsari, V. D. (2024). Funethnomath: Development of Virtual Reality Tour Web Learning Media with an Ethnomathematics. *MaPan : Jurnal Matematika dan Pembelajaran*, *12*(2), 274-293. https://doi.org/10.24252/mapan.2024v12n2a5.

INTRODUCTION

Mathematics is a subject commonly encountered at every level of education (Afsari, Safitri, Harahap, & Munthe, 2021), even in higher education (Khairunnisa, Gozali, & Juandi 2022). Strong mathematical skills can help individuals think more systematically (Nurfadhillah, Ramadhanty, Rahmah, Ramadhan, & Maharani 2021). A person's mathematical ability is considered proficient if they can effectively analyze, reason, and convey knowledge and skills in mathematics and solve and interpret mathematical solutions well (Maslihah, Waluya, Rochmad, & Suyitno 2020). Students with high mathematical abilities can recognize and understand the role of mathematics in problem-solving (Latif, 2022). In contrast, those with lower mathematical abilities may struggle to reason or create, making it difficult to solve problems in their surroundings (Selan, Daniel, & Babys, 2020). Indonesian students' math abilities are still relatively low, as seen in PISA test results from 2000 to 2022 in numeracy. Especially in the latest test in 2022, Indonesia scored 366, which is far from the international average of 472 (OECD, 2023). The same issue is also observed at MTs Rembang, the research site.

Observations conducted by the researcher at MTs X revealed similar challenges. Students' math skills there are still quite low. When given math problems related to real-life situations, students struggled to answer and solve them. Many students appeared disinterested in the teacher's explanations

during math lessons. The learning process seemed dominated by teacher explanations, while students mainly listened. Students also reported that teachers only used textbooks in teaching. Teachers indicated that when students were given problems related to their surroundings, they were unable to solve them, as these questions differed from examples provided in the classroom. Teachers also mentioned that the only teaching media used were mathematics textbooks, and digital learning media had never been applied. One method to address this issue is to use learning media aligned with student needs. This suggests that technology has yet to be incorporated into the teaching process. Haleem, Javaid, Qadri, and Suman (2022), in their study, reviewed the role of digital technology in education and how limited or suboptimal technology usage in schools can hinder students' cognitive development, including their understanding of mathematics. The absence of technology restricts students' ability to gain a deeper understanding of mathematical concepts (Bright, Welcome, & Arthur, 2024; Cirneanu & Moldoveanu, 2024).

However, there is an ongoing debate between Richard Clark and Robert Kozma on instructional media, focusing on the role of media in enhancing learning effectiveness. Richard Clark (1983) argued that media is merely a tool for delivering instruction and does not directly impact learning outcomes (Share & Beach, 2022). Conversely, Robert Kozma (2022) argued that media can influence learning and is designed to support appropriate teaching methods (Cirakoglu, Toksoy, & Reisoglu, 2022). This debate underscores the importance of combining effective teaching methods with supportive media, rather than relying solely on media. According to Pena-Ayala (2021), diverse digital learning media can enhance mathematical skills, such as using website-based instructional media. Using websites in learning can help convey material more effectively and be more enjoyable for students (Suryandaru & Setyaningtyas, 2021). Another technological development that can be integrated into websites is the virtual reality (VR) Tour. According to Zulfikri (2023), VR Tour plays a significant role in math learning, as modern VR Tour technology offers more engaging virtual learning experiences that can enhance students' understanding of mathematics (Rasyida & Ali, 2023). To create media that meets students' needs, referring to the debate between Richard Clark and Robert Kozma, it is essential to include a learning approach within the media, one of which is ethnomathematics.

According to D'Ambrosio, ethnomathematics is a field that studies how specific cultural groups understand, express, and use mathematical concepts in their daily lives (Orey & Rosa, 2022). Ethnomathematics acts as a bridge between mathematics and culture, as this approach enables students to deepen their understanding of their culture while improving their mathematical skills (Latif, 2022). Culture is a critical factor in shaping students' identities and emphasizes the importance of multicultural education that values diverse backgrounds (Maulidiah, Nisa, Rahayu, Irma, & Fitrianti, 2023; Surahman, Pratiwi, Imron, Cakranegara, & Putra, 2022). Kiptiyah, Purwati, and Khasanah (2021) confirmed the success of ethnomathematics in helping students understand mathematics. Through an ethnomathematics approach, students are presented with situations that require problem-solving based on cultural contexts, stimulating critical and creative thinking skills (Wardana & Suyitno, 2022). Ethnomathematics has also been shown to improve mathematical abilities (Njonge, 2023; Owens, 2024).

Based on these issues, this research aims to develop funethnomath: an ethnomathematics-based VR tour web development. This study aims to design a creative, innovative, engaging, and interactive mathematics learning media based on a VR Tour that also introduces local culture. Through Funethnomath, students can apply mathematical concepts within cultural contexts, offering a new learning resource for students.

METHODS

This study is a research and development (R&D) study, typically utilized to produce a product by testing the effectiveness of the product (Sugiyono, 2017). This developmental research employs the ADDIE model, which consists of several stages: (1) analysis, (2) design, (3) development, (4) implementation, and (5) evaluation (Rayanto, 2020). In this study, the ADDIE model is limited to the development stage. Here is the explanation of the stages of development that will be carried out using the ADDIE model, as follows.

1. Analysis Stage

This stage will involve the process of needs analysis to identify problems, analysis of the Rembang culture, and analysis of the needs for media design. Data collection will be done through observation, interviews, and documentation. Observation is conducted to visualize the environment of the observed location and to understand the problems present there. The

interviews conducted in this study are unstructured interviews with students and mathematics teachers. Documentation is carried out to obtain data and information that can support the research data.

2. Design Stage

This stage will involve several processes for designing the VR Tour website media with an ethnomathematics approach. Some of the activities include editing 360-degree photos of Rembang Regency, designing mathematics materials with an ethnomathematics approach, creating VR Tours, and designing the website. This design will be combined into one as a Funethnomath learning media as the development of the VR Tour website with an ethnomathematics approach.

3. Development Stage

This stage will involve validation by media and material experts of the VR Tour website with an ethnomathematics approach. This testing is conducted to determine the validity of the media. If there are inconsistencies in the media, corrections will be made until the results indicate that the media is valid. Data collection in this stage uses a questionnaire instrument, namely a validation questionnaire from media and material experts. The media and material expert validation questionnaires are created based on several aspects. The media expert validation questionnaire has several assessment aspects including appearance, software engineering, and visual communication, each consisting of several statements for each aspect. The material expert validation questionnaire has several assessment aspects including material design and language, each consisting of several statements for each aspect. Media and material expert validation is carried out by two lecturers from Unimus for each. The criteria for media validity can be seen in table 1.

Table 1. Media Validity Criteria

Score	Criteria
$1{,}00 < \bar{x} \leq 1{,}75$	Invalid
$1{,}75 < \bar{x} \leq 2{,}50$	Fairly Valid
$2{,}50 < \bar{x} \leq 3{,}25$	Valid
$3{,}25 < \bar{x} \leq 4{,}00$	Very Valid

Source: Arikunto (2021)

The stages of developing Funethnomath learning media using the ADDIE development model in this research can be seen in the picture diagram below.

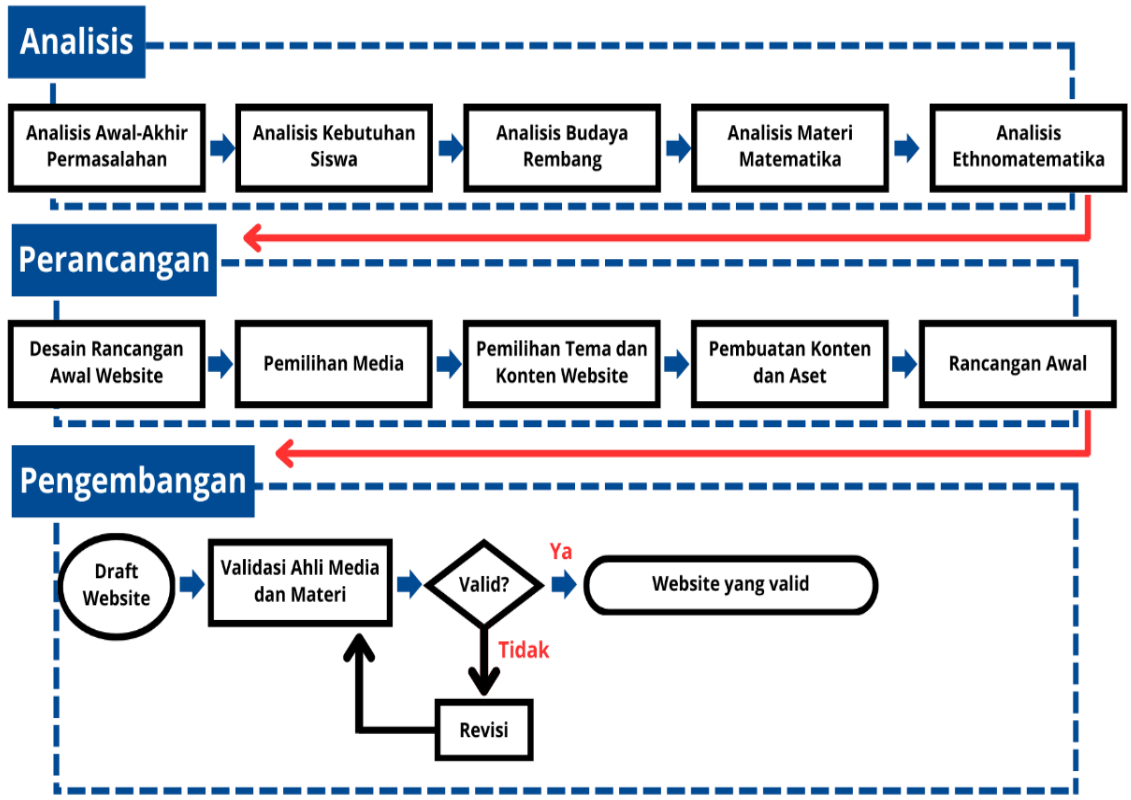


Figure 1. Funethnomath Media Development Stages Diagram

RESULTS AND DISCUSSION

This research has resulted in a learning media product in the form of the Funethnomath website based on VR Tour with an ethnomathematics approach. The VR Tour website is designed for mathematics learning at the junior high school level or equivalent. The development model used in this research is the ADDIE model, which consists of analysis, design, development, implementation, and evaluation. This research is focused on the development stage, which is divided into two activities: expert appraisal and development testing. A detailed explanation of the development activities can be seen below.

1. Analysis Stage

Table 2. Analysis Stage

No.	Aspect	Explanation
1	Needs analysis to find out problems at school	The analysis results were obtained through interviews with students and mathematics teachers at MTs X. The analysis revealed (a) that teachers still use conventional methods in their teaching, leading to student passivity, (b) students struggle with problems that differ from the examples provided, especially story problems or problem-solving, resulting in a lack of mathematical ability, (c) some students feel bored during explanations by the teacher, (d) teachers only utilize textbook materials as instructional media, (e) digital technology is underutilized in teaching. The solution to address these issues is to develop the Funethnomath media.
2.	Student's cultural analysis to find out the relationship between mathematics and regional culture.	The results were obtained through observation and documentation activities in Rembang Regency. The observation results include data on several historical sites and cultural heritage sites in Rembang, such as Masjid Jami' Lasem, Alun-alun Lasem, Praukuno Site, Pasujuand Bonang. The documentation results include 360^o photos of several historical sites and cultural heritage sites in Rembang, as well as the analysis of materials according to observation data.
3.	Media needs analysis to find out the data and software needed to create a VR Tour website.	The materials needed for creating the media include 360^o photos of several historical sites and cultural heritage in Rembang, along with mathematics materials that have been analyzed about Rembang culture. The 360^o cultural photos that have been produced will be combined through H5P and then analyzed for the structural forms or traditions in the culture related to mathematics. The results of this connection will be presented in the form of photos created as image spots in the VR Tour that have been made, along with descriptions of how mathematics relates to that culture. Through this analysis, students will be able to see the connection between concepts and the surrounding culture, thus helping them understand the concepts presented. The tools or software needed for creating the media include an Insta 360 camera (for taking 360^o photos), Photoshop

	(for editing 360° photos), Canva (for creating mathematics materials), H5P (for creating VR Tour content that includes mathematics materials), and a website domain (as the main media for storing the elements of the learning media). This media can be used by anyone.

The results of the needs analysis indicate low mathematical proficiency among students and the lack of implementation of digital technology-based learning media. According to Stit and Nusantara, (2020), low mathematical proficiency among students can be caused by the inadequate use of learning media. Pagarra, Syawaluddin, Krismanto, and Sayidiman (2022) state that learning media serves as a tool for teachers to convey information effectively for students to receive the message correctly and effectively. According to Larasati and Widyasari (2021), digital technology-based learning media can enhance students' understanding of mathematics.

The analysis of Rembang's culture indicates that several local cultures are related to mathematics, like the architectural form of the Masjid Jami' Lasem, which has existed since 1583, the main structure features a Joglo design with a trapezoidal roof and ends shaped like a rectangular prism. According to Ardiansyah, Putra, and Ikhwan (2022), culture can serve as a learning medium for teachers to directly explain mathematics. Pulungan and Adinda, (2023) suggest a strong connection between local culture and mathematics in daily life, as mathematics learning requires a bridge between mathematics and its culturally relevant surroundings. According to Putra and Prasetyo, (2022), culturally-based mathematics learning is an application of ethnomathematics aimed at enhancing mathematical skills while also fostering cultural awareness.

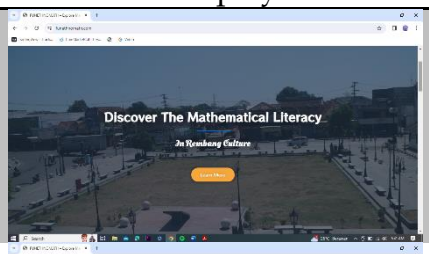
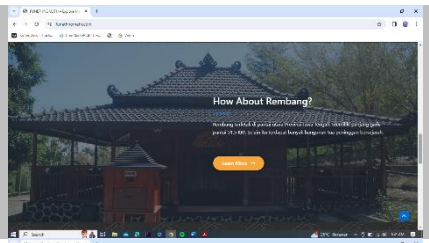
The media needs analysis indicates that the data and software required for creating a VR Tour website include 360-degree photos as primary data for the Funethnomath website. According to Lesmana, Lauryn, and Hay, (2022), 360-degree panorama images are essential assets for creating VR tours. Girmay, Yliniemi, Nieminen, Linnera, and Karttunen (2024) suggest using H5P software to create VR tours of real-world locations. According to Kasma, Rusmala, and Siaulhak (2023), websites are appropriate platforms for accessing VR tour results because they can be accessed anytime and anywhere.

Based on the above analyses, it can be concluded that Funethnomath, as a development of VR tour web-based learning media with an ethnomathematics approach, can bridge mathematics learning with local cultural practices. According to Aryani, Khaira, Arsa, and Saputra (2024), the use of VR tour-based media can facilitate cultural learning activities in the form of destinations. Mahayani, Agustini, and Sudatha (2023) also suggest that the use of VR tour media can aid in the delivery of mathematics learning information.

2. Design Stage

The second stage, namely the design stage, the appearance of the VR Tour website media can be seen in table 3.

Table 3. Media Display

No.	Display	Information
1.		The home page of the website describes the philosophy of the web domain on the "Learn More" button.
2.		The main features of the website are the VR tour and other additional features including the ethnomathematics module, mathematics quizzes, and fun learning games. Moreover, in the "Mathematics Quizzes" feature, questions are provided that are directly related to the culture that has been studied in the previous feature.
3.		The middle section of the website consists of articles about Rembang City as an icon in the creation of this media.
4.		Inside the " VR Tour" feature, there are several places in Rembang with 360-degree images that have been linked with an ethnomathematics approach.

No.	Display	Information
5.		The initial view shows one part of a historical site in Rembang that has been linked with an ethnomathematics approach.
6.		The historical overview of one of the historical sites in Rembang provides additional insights before learning about mathematics related to this location.
7.		The "Let's Observe" tools at one of the historical sites in Rembang have been linked with an ethnomathematics approach.

At this stage, the process begins with creating the homepage design using WordPress. The use of platforms like WordPress in developing educational websites has proven to facilitate content development and management (Supriyanto, Nurhadi, Prasetya, Hermansyah, & Puspitaningrum, 2022). After that, the "Learning Module" feature is created using H5P. According to Salsabila and Syaban (2022), interactive modules help students become more active in the learning process. The module is designed according to the guidelines for module creation. According to Anggriani, Arsih, & Rahmi (2024), clear guidelines in module creation are essential to ensure that the material is presented effectively. The content in the module consists of mathematics material that has been linked to the culture that has been analyzed. According to Yanti (2024), linking mathematics with cultural contexts can help students understand concepts better because they can see real-world applications of the theories being studied. For example, the material on flat shapes is connected with various buildings such as the Masjid Jami' Lasem, Klenteng Cu An Kiong, and Alun-alun Lasem.

The "Mathematics Quiz" feature is also created through H5P using the "Multiple Choice" tool. Interactive quizzes can provide immediate feedback to students (Prasetya, Bryan, & Ilham, 2023). The questions are formulated by

analyzing the structure of shapes, culture, and traditions present in the students' environment. Research by Aziz and Zakir (2022) emphasizes that relevant local contexts in question creation can help students understand and apply mathematical concepts. The results are then combined as an evaluation after students use the Funethnomath media to understand mathematics through culture. The creation of the "VR tour" feature also starts with analyzing the relationship between culture and mathematics. The use of virtual reality technology in education can enhance students' understanding by providing immersive experiences (Arini, 2023). The analysis results are packaged in the form of images that contain explanations of how that culture relates to mathematics. An additional feature, "Fun Learning Math," is created using H5P with the "Drag and Drop" tool. It consists of a simple game related to an image that has connections to mathematics in the respective material. Engaging in learning through games can help students understand mathematical concepts more interestingly and effectively (Khairunnisak, Asma, & Noviyanti, 2023).

3. Development Stage

In the third stage, namely the development stage, the results of developing the VR tour website learning media with an ethnomathematics approach are validated by subject matter and media experts. Validators in this research consist of 2 subject matter experts and 2 media experts who are mathematics education lecturers at the Muhammadiyah University of Semarang. The validators appointed are mathematics education lecturers from the Muhammadiyah University of Semarang. The researcher's focus in this study is to obtain validation from media and material experts; however, the researcher will actively work to involve teachers in future evaluations to gather diverse insights and improve Funethnomath media. After validation tests by media and subject matter experts are conducted, certain aspects need to be improved according to the surveyed results. The assessment results from the media experts can be seen in table 4.

Table 4. Media Expert Validator Assessment Results

No.	Assessment Aspect	Score		Average	Criteria
		Expert I	Expert II		
1.	Display	3	2,5	2,75	Valid
2.	Software Engineering	3,8	3	3,4	Very Valid
3.	Visual Communication	3	2,8	2,9	Valid
Final score		3,27	2,76	3,015	Valid

Based on table 4, the assessment aspects by media experts consist of (1) appearance, (2) software engineering, and (3) visual communication. The calculation of the scores for these three aspects from all media expert validators indicates that this learning media meets the validity criteria with an average score of 3.015. Based on the validity criteria in table 1, the validation results from media experts fall within the range of $2{,}50 < \bar{x} \leq 3{,}2$ which can be concluded that the average score of 3.015 meets the "valid" criteria, thus indicating that the Funethnomath learning media product is valid for use. Meanwhile, the assessment results from subject matter expert validators can be seen in table 5.

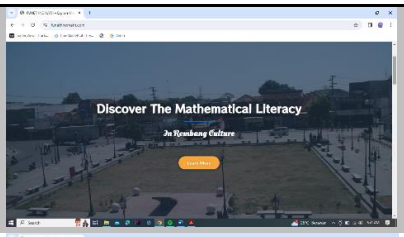
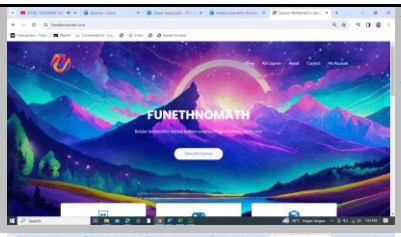
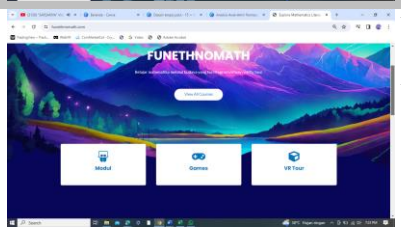
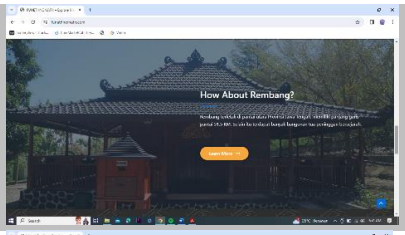
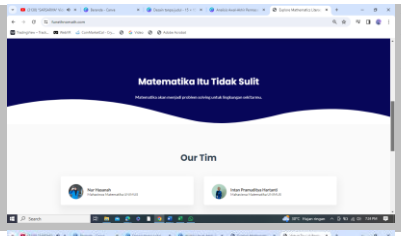
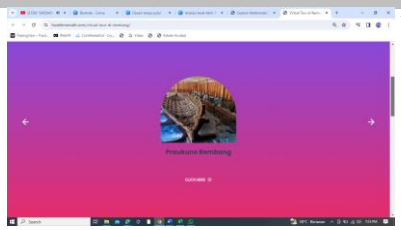
Table 5. Meter Expert Validator Assessment Results

No.	Assessment Aspect	Score		Average	Criteria
		Expert I	Expert II		
1.	Material Design	3,1	2,9	3	Valid
2.	Language	3	3,25	3,125	Valid
	Final score	3,05	3,075	3,0625	Valid

Based on table 5, the assessment aspects by subject matter experts consist of (1) material design and (2) language. The calculation of the scores for these two aspects from all subject matter expert validators indicates that this learning media meets the validity criteria with an average score of 3.0625. Based on the validity criteria in table 1, the validation results from subject matter experts fall within the range of $2.50 < \bar{x} \leq 3.2$, which can be concluded that the average score of 3.0625 meets the "valid" criteria, thus indicating that the VR-based website learning media with an ethnomathematics approach is suitable for use. Suggestions from the previous validation included making the homepage appearance more attractive, from the header to the footer of the website, as well as updating the posts in the VR tour section.

However, according to the suggestions provided by the validators, some improvements are needed for the media that has been tested to make it perfect for use as learning media. Below are the improvement results carried out by the researcher based on the validators' comments.

Table 6. Result of Improvements to the Appearance of Funethnomath Media

No.	Initial View	Media Repair	Information
1.			Website front page
2.			Website features
3.			Middle of the website
4.			Virtual Reality Tour

The results of developing the VR tour website learning media with an ethnomathematics approach have been validated by subject matter and media experts. The purpose of the validation test is to obtain feedback for further improvement of the media. According to Beard and Aghassibakes (2021), media validation can be conducted by several experts or competent individuals in their fields. The assessment by media experts resulted in a final score of 3.015 with a valid criterion. The validity assessment of Funethnomath media is based on several aspects: appearance, software engineering, and visual communication. The appearance aspect of the website met the "valid" criterion because it aligned with indicators from Pratama, Yusuf, and Hendra (2022), including an attractive appearance, suitable and appealing tools presentation, and an easy-to-understand and appealing layout. The software engineering aspect of the website met the "highly valid" criterion as it aligned with indicators from Setyawati, Wibowo, and Adilla (2023), including

effectiveness, efficiency, reliability (no easy crashes), maintainability, simplicity, and ease of operation, and accessibility across multiple devices. The visual communication aspect of the website met the "valid" criterion as it aligned with indicators from Setyawati, Wibowo, and Adilla (2023), including conveyed content, creativity and innovation, simplicity and attractiveness, appealing typography that's easy to understand, appropriate and appealing colors, relevant images, and clear usage instructions.

The results of the material expert assessment indicate that this learning media meets the validity criteria with an average score of 3.0625. The validity evaluation of Funethnomath material is based on several aspects, namely material design and language use. This is because, in the material design aspect, it has been adjusted to the indicators of Henry, Ackerman, Sancelme, Finon, Esteve, Nwabudike, Brancato, Itescu, Skovron, Solomon, Winchester, Learning, Cookbook, Husain, Reddy, Schwartz, Brier, Neal, Feit, and Rello (2020), which include relevance, consistency, and adequacy. The material is provided in a module format aligned with the module creation guidelines, and the concept application material is presented in a VR Tour format following the ethnomathematics approach. In terms of language use, it also aligns with the indicators from Pramesti, Dibia, and Ujianti (2021), which require that the material complies with PUBI standards and uses easily understandable language.

The characteristics of Funethnomath media as a development of VR Tour web-based learning media with an ethnomathematics approach are reflected in the website's features. Accessing the website can be done through a Google search, typing the domain of the Funethnomath website, and then exploring its features. The Modul feature can be accessed by clicking the icon above the Modul label. Users will be directed to the relevant learning module post page, where they can click on a module they want to study. The Quiz feature can be accessed by clicking the Quizz icon, leading users to a multiple-choice mathematics page. Users can select a correct answer and click "Check" below the question. Finally, the VR Tour feature can be accessed by clicking the VR Tour icon, guiding users to a slider page where they can select a place to visit. After choosing a place, users will be directed to the indicated VR Tour location. For a better experience, users can click the full mode in the top right corner, then click the scan button for the next entry, and access materials by clicking the plus icon on the image. However, our team recommends using the Modul feature first for learning, followed by the Quizz feature, and finally,

using the VR Tour feature for applying knowledge in the surrounding environment or culture.

CONCLUSION

The developed learning media, Funethnomath, is an enhancement of a VR Tour website using an ethnomathematics approach. The development aimed to innovate valid virtual reality-based mathematics learning media, utilizing the ADDIE model with a limitation up to the development stage. The media expert evaluation resulted in an average score of 3.015, categorized as valid, and the material expert evaluation resulted in an average score of 3.0625, also categorized as valid. Revisions suggested by the validators have been addressed, as presented in table 7, and re-evaluations by experts confirmed the media's validity. This media is highly relevant to students as it combines VR tours and modules, allowing students not only to learn through theory but also to experience an immersive environment that demonstrates the real-world application of mathematical concepts in cultural contexts. The VR tour enables students to explore cultural objects, such as historic buildings or traditional motifs while learning their mathematical elements in an engaging virtual environment. The modules support students in systematically and continuously understanding mathematical steps. This combination encourages active student engagement, fosters a closer connection with the material, and helps students visualize the practical application of mathematical concepts in everyday life. Based on these results, it can be concluded that the Funethnomath learning media, as a VR tour website development with an ethnomathematics approach, is valid and ready for field testing.

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