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Analyzing User Acceptance of Augmented Reality Applications for Traditional Musical Instrument Recognition in Indonesia

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Abstract. The continuity of traditional musical instrument recognition in Indonesia faces significant challenges as the younger generation's interest in this cultural heritage diminishes, potentially threatening its preservation. To safeguard and promote traditional musical culture, it is essential to employ media that are relevant and engaging for future generations. This study aims to analyze the acceptance of an augmented reality (AR)-based application for introducing traditional musical instruments across various provinces in Indonesia. Utilizing the Technology Acceptance Model (TAM), the study involved 31 respondents to evaluate two main aspects: the ease of use of the application and the effectiveness of the learning experience it offers. The analysis results indicate that 73% of respondents found the application easy to use, while 87% stated that it provides a good learning experience. These findings suggest that the AR application holds significant potential for adoption by the younger generation, facilitating a more modern and engaging interaction with traditional musical instruments through smartphones. The implications of this study underscore the importance of integrating current technologies in cultural preservation efforts and highlight opportunities to enhance interest and engagement among future generations in maintaining Indonesia's traditional musical heritage.

INTRODUCTION

Traditional music is essential for local cultures, embodying cultural identity and social cohesion. It reflects the cultural practices and ecological knowledge of communities, exemplified by Central Australian Aboriginal songs that preserve ecological wisdom [1]. In Kampung Naga, traditional music education enhances cultural conservation and societal welfare [2]. In Cambodia, teaching traditional Khmer music to disadvantaged children is crucial for cultural survival amid societal changes [3]. Nonetheless, preserving traditional music encounters significant challenges. Globalization threatens local cultures, replacing traditional values with a global monoculture [4]. The dominance of mass media and new genres further diminishes traditional performance contexts [1]. Safeguarding musical heritage involves navigating complex ethical and pragmatic concerns [5]. Innovative methodologies, like participatory action research with the Semai community, engage youth by connecting traditional music to contemporary interests [6]. The enculturation of gambang Semarang music illustrates modeling and internalization for cultural awareness in youth [7]. The challenge persists to balance conservation with cultural evolution, ensuring traditional music remains dynamic and relevant [8].

The incorporation of Augmented Reality (AR) in music education offers solutions for cultural heritage preservation, educational enhancement, and increased student engagement. AR addresses the challenge of preserving traditional music culture by promoting interactive learning, particularly for youth. An AR application for traditional Chinese instruments in Guizhou demonstrated increased cultural understanding among students, illustrating AR's effectiveness in educational outcomes [9]. Traditional music in Indonesia faces the challenge of declining interest from the younger generation who prefer western music, which is considered more modern [10]. To overcome this, the integration of local cultural values into the music education curriculum is proposed to make students more interested

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[11]. In addition, accessibility in learning traditional music, such as angklung, requires innovation to remain relevant. Technology is cited as a potential solution to ease students' access to learning traditional musical instruments [12]. Furthermore, AR improves the integration of modern technology in music education, enhancing comprehension, skill mastery, and creativity, as shown by research indicating higher proficiency rates with informatized teaching methods [13]. Additionally, AR enriches the music learning experience with digital content, fostering creativity and embodied learning essential for skill development [14]. AR also enables remote music education, exemplified by the HoloKeys system, which offers immersive distance learning, surpassing traditional video conferencing limitations [15]. The design of AR experiences enhances the learning of cultural elements by creating a more authentic and engaging environment [16]. The convergence of music and Extended Reality (XR) signifies a transformative approach to musical interaction, expanding traditional music education's scope [17]. Additionally, AR-based serious games have been found to decrease cognitive load and enhance comprehension in complex traditional art forms, making learning more effective [18]. The application of AR in music education presents a viable alternative in response to budget constraints within K-12 education, facilitating virtual skills acquisition [19]. AR enhances traditional music education by making cultural learning more engaging, accessible, and effective while preserving and promoting musical heritage within a modern educational framework.

This research has established an educational framework for Indonesian musical instruments utilizing augmented reality technology. The distinctiveness of the musical instruments presented embodies the diverse musical artifacts from each of Indonesia's provinces, amounting to a total of 38 provinces. The AR application developed for this research is called AR SWARA

METHOD

This study employs an approach that involves the development of an Augmented Reality (AR) application, followed by testing using the Technology Acceptance Model (TAM) to evaluate the application's effectiveness in supporting the learning of traditional musical instruments from the Nusantara region. The Technology Acceptance Model (TAM) is a robust framework for evaluating the effectiveness of applications across various domains by analyzing user acceptance and behavioral intentions. Originally designed to understand why users accept or reject technology, TAM has been widely applied and extended to different contexts, including healthcare, education, construction, hospitality, and consumer goods. In healthcare, TAM helps assess the perceived efficacy and user-friendliness of Health Information Systems (HIS), highlighting the importance of training users and considering factors like gender in acceptance models [20]. In educational settings, TAM has been adapted to include constructs specific to learning, such as cognitive engagement and student comfort, demonstrating its utility in evaluating virtual classrooms and emphasizing the importance of student well-being [21]. The application of TAM has also shown its success in various domains, including education and tourism. Han et al. highlighted that the use of Augmented Reality (AR) in the context of heritage tourism can enhance the visitor experience and increase acceptance of the technology [22]. Although there are various other models such as the Unified Theory of Acceptance and Use of Technology (UTAUT) and Diffusion of Innovations (DOI), TAM remains excellent due to its ease of implementation and understanding of its key variables in specific contexts.

Design and Development of AR Musical Instrument Application

Based on Figure 1, the application development follows the Multimedia Development Life Cycle (MDLC) method. The MDLC is a systematic framework comprising six stages: concept, design, material collection, assembly, testing, and distribution. This methodology is extensively utilized in educational media projects to improve learning outcomes. For example, in creating Edinata, a multimedia tool for children with intellectual disabilities, the MDLC approach enabled effective learning through interactive activities, with successful functionality confirmed via black box testing [23]. In this process, Unity 3D and Vuforia are used as the main technologies. Vuforia is utilized to create markers that can be recognized by the AR system based on keypoint ratings, while Unity is used to integrate elements and create interactivity within the application in response to the markers.

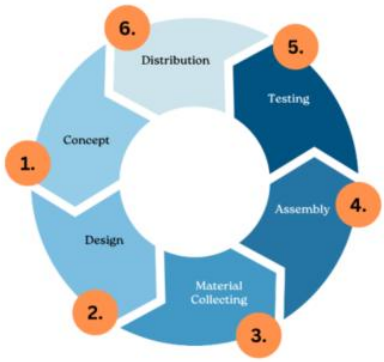


FIGURE 1. The Multimedia Development Life Cycle (MDLC)

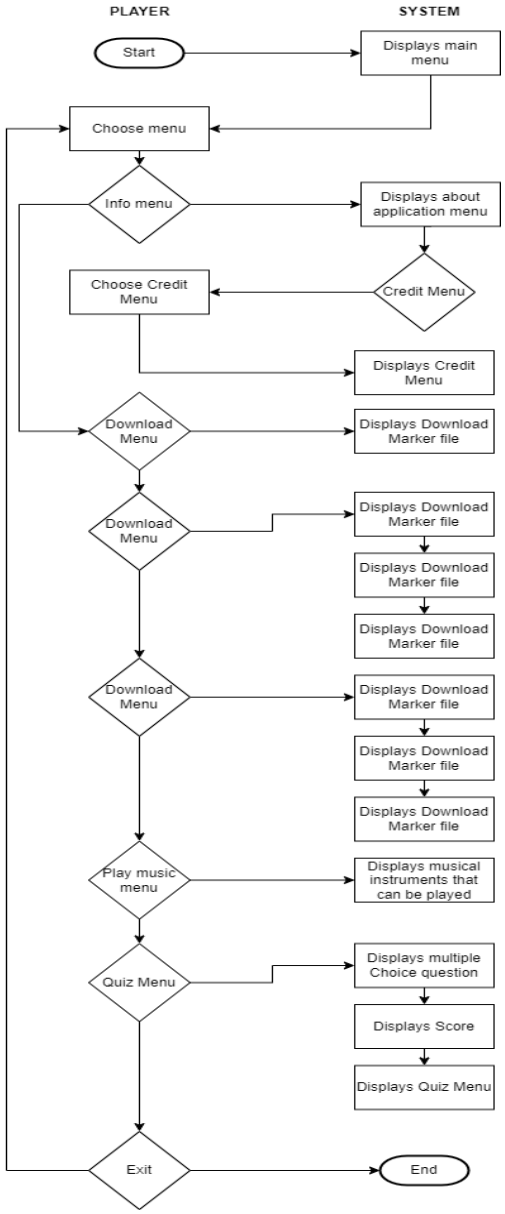


FIGURE 2. Development workflow of an AR SWARA

Based on Figure 2, this augmented reality (AR) application is designed to provide an interactive learning experience about various musical instruments. Users are guided to start by viewing the main menu of the application. From the main menu, users can access various features such as viewing the application user guide, downloading markers to activate the AR feature, and starting the AR experience. After scanning the marker with the device's camera, users can view a 3D model of the musical instrument, listen to the sound of the instrument, and even interact with the 3D model. Additionally, the application also provides an interactive quiz to test the user's understanding of musical instruments. Users can view their scores after completing the quiz. Finally, users can exit the application at any time.

AR Instrument Marker Design

To enhance the learning experience, unique markers were designed with distinct geometric shapes and patterns. These markers were printed precisely on the pages of the smart book, aligning with relevant musical instrument information. Using Unity 3D and Vuforia, AR content like 3D models, animations, and interactive elements was created to complement the printed material. Advances in marker design, such as vertex markers, enabled larger digital objects to be displayed, enriching the learning process. User tests assessed the marker design's effectiveness and overall user experience, leading to refinements in the smart book. Figure 3 illustrates the marker creation process for the angklung musical instrument. The process begins with designing a 2D image of the angklung and saving it as a .png file. Subsequently, the marker is registered through the Vuforia portal to generate a keypoint for AR system recognition. The created marker has been assigned a five-star rating, indicating that the marker is highly recognizable by the AR system.

FIGURE 3. The creation of an angklung marker and 3D model of angklung

Evaluation methods of the AR SWARA application

This study evaluated the AR SWARA application for musical instrument recognition based on its Ease of Use and Learning attributes [24]. A questionnaire with 8 Likert-scale questions (4 for ease of use, 4 for learning) was administered to 31 respondents to assess these attributes (See Table 1). To measure the application's acceptance, a TAM instrument was used. To ensure the questionnaire's quality, both validity and reliability tests were conducted. Pearson's validity formula (1) was used to assess the questionnaire's validity.

$$r_{xy} = \frac{n\sum X_i Y_i - (\sum X_i)(\sum Y_i)}{\sqrt{(n\sum X_i^2 - (\sum X_i)^2)(n\sum Y_i^2 - (\sum Y_i)^2)}} \quad (1)$$

The correlation coefficient (r_{xy}) is calculated using the number of respondents (n), individual item scores (X), and the total score (Y). A t-test determines the statistical significance of this correlation. By comparing the calculated t-value (t-count) to the t-value from the t-table, significance is assessed. If the calculated t-value exceeds the table value, the correlation is considered significant, indicating a valid item. Formula (2) shows the t-count calculation.

$$t_{count} = \frac{r_{xy}\sqrt{(n-2)}}{\sqrt{1-r_{xy}^2}} \quad (2)$$

To evaluate the test's reliability, the Cronbach alpha formula (3) can be applied.

$$r_n = \frac{n}{n-1}(1 - \frac{\sum_{n-1}^{n} S_i^2}{S_t^2}) \quad (3)$$

r_n is the reliability coefficient, n is the number of items, , S_i^2 is the variance of item i, and , S_t^2 is the total score variance. TAM analysis uses descriptive analysis, including the percentage of criterion scores and the total score of data collection results formulated (4).

$$P = \frac{\sum \text{SH} \times 100\%}{\sum \text{SK}} \quad (4)$$

P represents the percentage of respondents' answers, $\sum$SK is the criterion score, and $\sum SH$ is the total data collection score. The online questionnaire, based on Google Forms, includes personal data questions for demographic mapping. It also incorporates TAM instruments to assess AR application acceptance, focusing on perceived usefulness and ease of use, key factors in technology adoption [25][26]. The QUIS provides a comprehensive evaluation of user experience and satisfaction. Research suggests effective AR applications can enhance learning, especially when users are confident in their technological abilities. The research instrument underwent validity and reliability testing.

TABLE 1. Research Questionnaire Instrument

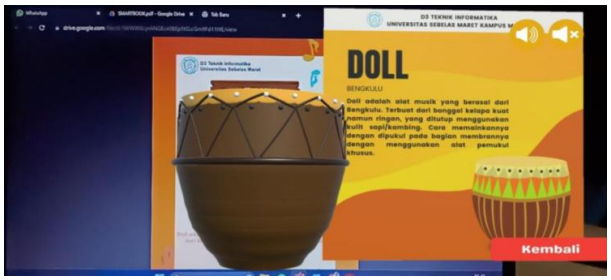
Variable	Code	Indicator
Ease of use	Q1	The markers used in the AR SWARA application are user-friendly.
	Q2	The AR SWARA application has intuitive and easy-to-use interaction buttons
	Q3	The navigation of the AR SWARA application is straightforward and explorable
	Q4	Overall, the AR SWARA application is easy to use
learning	Q5	The text-based information provided within the AR SWARA application is highly comprehensible.
	Q6	The audio output of the musical instruments in the AR SWARA application is clear and audible.
	Q7	The 3D models of the musical instruments presented offer a clear and effective illustration.
	Q8	The AR SWARA application serves as a valuable tool for expanding one's knowledge of Nusantara musical instruments

RESULT AND DISCUSSION

The development of the AR SWARA application, aimed at introducing Indonesian musical instruments, has been successfully completed and is now compatible with the Android operating system. Functionality testing has been conducted, and the application has demonstrated its ability to effectively display information and facilitate user interactions. Figure 4 presents screenshots of the AR SWARA application successfully displaying 3D models of musical instruments, enabling interactive playing, and providing a quiz feature to assess user knowledge.

(a) (b)

(c)



(d)

FIGURE 4. Illustration of the AR SWARA Application: (a) Main application menu, (b) Interaction while playing musical instruments, (c) Quiz feature for knowledge testing, and (d) Camera view when detecting markers to display 3D models of musical instruments.

To measure the application's acceptance, a TAM instrument was used. To ensure the questionnaire's quality, both validity and reliability tests were conducted. Pearson's validity formula (1) was used to assess the questionnaire's validity. Table 2 presents the calculated correlation values and validation results for each question from Q1 to Q8.

TABLE 2. Validity test results

Code	Corrected Item - Correlation Value	Valid/invalid
Q1	0.522	Valid
Q2	0.324	Valid
Q3	0.792	Valid
Q4	0.860	Valid
Q5	0.681	Valid
Q6	0.752	Valid
Q7	0.633	Valid
Q8	0.772	Valid

Table 3 shows that the t_{count} value exceeds the t_{table} value (1.699) for all questions, indicating their validity. A Cronbach Alpha value of 0.7 or higher signifies a reliable research instrument. The TAM variables in this study, with a Cronbach Alpha value exceeding 0.7 (specifically 0.8), are considered reliable.

TABLE 3. TAM Research Description of AR SWARA

Variable	Min	Max	Mean	Standard Deviation
Ease of use	1	5	3.623	0.876
Learning	2	5	4.331	0.759

Table 3 indicates that users found the AR SWARA application easy to use (score: 3.623) and easy to learn through the AR application (score: 4.331). Demographic data collected includes gender and age. More male respondents (4 or 12.9%) participated than female respondents (27 or 87.1%). Respondent ages ranged from 16 to 32 years old. Table 4 presents the descriptive statistical results of the AR SWARA application TAM research.

TABLE 4. Descriptive Statistics Results of AR SWARA

Variable	nI	$\sum SK$	$\sum SH$	P
Ease of use	4	620	450	73%
Learning	4	620	537	87%

Table 4 shows that respondents generally agreed on the Ease of Use of the AR SWARA application (73%). This suggests the application is user-friendly. Additionally, respondents agreed that the Learning Value of the application is high (87%), indicating that learning to use AR SWARA is straightforward. Augmented Reality (AR) enhances learning by enabling virtual interaction with traditional musical instruments, offering a more immersive and interactive experience compared to traditional methods [27]. This approach bridges the gap between theory and practice, helping students not only understand but also virtually play instruments, thereby improving their musical skills. AR also aids in grasping complex concepts and encourages cultural preservation by engaging students to practice traditional music [28]. Integrating AR-based lessons into curricula, as suggested by Wu, fosters community learning and deepens students' cultural understanding [29]. Additionally, metaverse-based educational projects provide enriched cultural

insights, emphasizing the importance of cultural heritage amidst globalization [30]. The results of the analysis are in line with Farhani et al.'s research which shows that Android-based learning applications using Augmented Reality (AR) get more positive responses from students than conventional methods such as books or live demonstrations, with satisfaction levels reaching 90% due to a more interactive approach [31]. Similar findings from Agsriyani show that AR, with its features of real-time interaction and instant feedback, not only appeals to the younger generation but also accelerates the understanding and mastery of traditional musical instruments compared to other learning methods [32].

CONCLUSION

The study successfully demonstrates the potential of an augmented reality (AR) application in preserving and promoting traditional Indonesian musical instruments. By offering an engaging and user-friendly platform, the AR application can bridge the gap between the younger generation and the rich cultural heritage of Indonesian music. Based on the survey results, respondents generally agreed on the Ease of Use of the AR SWARA application (73%), suggesting that the application is user-friendly. Additionally, respondents agreed that the Learning Value of the application is high (87%), indicating that learning to use AR SWARA is straightforward**.** While this research focused on Android devices, future development could expand the application's compatibility to other platforms. Furthermore, integrating artificial intelligence with traditional music recognition could enhance the application's capabilities, providing deeper insights and personalized learning experiences. This research highlights the importance of leveraging technology to foster interest and engagement in traditional music among younger generations, contributing to the preservation of Indonesia's unique cultural heritage.

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REFERENCES

1. G. Curran, L. Barwick, M. Turpin, F. Walsh, and M. Laughren, “Central Australian Aboriginal Songs and Biocultural Knowledge: Evidence from Women’s Ceremonies Relating to Edible Seeds,” J. Ethnobiol **39(**3), 354–370 (2019).
2. S. Gunara, “Local knowledge system in music education culture at indigenous community Kampung Naga Tasikmalaya Regency,” Harmonia Journal of Arts Research and Education **17**(1), 48 (2017).
3. A.A. Kallio, and H. Westerlund, “The ethics of survival: Teaching the traditional arts to disadvantaged children in post-conflict Cambodia,” International Journal of Music Education **34**(1), 90–103 (2015).
4. E. C. Alozie, “Conserving Cultures: Technology, Globalization and the Conserving of Local Cultures,” Journal. Mass Commun.Q **82(**1), 215 (2005).
5. C. Grant, “Rethinking Safeguarding: Objections and responses to protecting and promoting endangered musical heritage,” Ethnomusicology Forum **21**(1), 31–51 (2012).
6. C.S.C. Chan, and Z.L. Saidon, “Advocating for the sustainability of Semai Indigenous music through the collaborative creation of new traditional music: a Participatory Action Research (PAR) methodology,” Harmonia Journal of Arts Research and Education **21**(1), 9–22 (2021).
7. E. Raharjo, S. Soesanto, T.R. Rohidi, and U. Utomo, “Preserving Gambang Semarang music through the process of enculturation in the society,” Harmonia Journal of Arts Research and Education **21**(1), 60–67 (2021).
8. Á. Fernández-Llamazares, and D. Lepofsky, “Ethnobiology through Song,” Journal of Ethnobiology **39**(3), 337 (2019).
9. X. Hong, and Y.-H. Wu, “The use of AR to preserve and popularize traditional Chinese musical instruments as part of the formation of the tourist attractiveness of the national art of Guizhou province,” Digital Scholarship in the Humanities **37**(2), 426–440 (2021).
10. A. Saripudin, A.T. Syam, St. Hartina, F.R. Muin, and Y.R. Said, “Analysis of lyrics in Indonesian folksong as local traditional music,” Linguistics Initiative **4**(1), 121–131 (2024).
11. H.A. Hidayat, S. Syeilendra, M. Marzam, and U. Hakim, “Study of the influence of local cultural values in the traditional music learning process in the Sendratasik Education Study Program,” Gondang Jurnal Seni Dan Budaya **8**(1), (2024).
12. J. Julia, P.D. Iswara, and T. Supriyadi, “Redesigning and implementing traditional musical instrument in

integrated technology classroom," International Journal of Emerging Technologies in Learning (iJET) **14**(10), 75 (2019).
13. Y. Li, "Combination of efficient informationized music teaching and traditional music culture in the internet era," Applied Mathematics and Nonlinear Sciences **9**(1), (2024).
14. L. Nijs, and B. Behzadaval, "Laying the foundation for augmented reality in music education," IEEE Access **12**, 100628–100645 (2024).
15. A. J. Stanbury, I. Said, and H. J. Kang, "HoloKeys: Interactive Piano Education Using Augmented Reality and IoT,", 2021.
16. Y. Ieiri, H.-Y. Tsai, K. Mizobuchi, S. Tengfei, and R. Hishiyama, "Design of traditional cultural experiences using augmented reality based on environmental presence," IEEE Transactions on Human-Machine Systems **53**(2), 390–400 (2023).
17. L. Turchet, R. Hamilton, and A. Camci, "Music in extended realities," IEEE Access **9**, 15810–15832 (2021).
18. L. Ye, J. Li, S. Yang, and Y. Hang, "The effect of augmented reality-based serious game on traditional pattern learning," Interactive Learning Environments, 1–29 (2024).
19. S. Serafin, A. Adjorlu, N. Nilsson, L. Thomsen, and R. Nordahl, "Considerations on the use of virtual and augmented reality technologies in music education," KELVAR, 1–4 (2017).
20. G. Tetik, S. Türkeli, S. PINAR, and M. Tarım, "Health information systems with technology acceptance model approach: A systematic review," Int. J. Med. Inform **190 ,** (2024).
21. A. Kemp, E. Palmer, P. Strelan, and H. Thompson, "Testing a novel extended educational technology acceptance model using student attitudes towards virtual classrooms," British Journal of Educational Technology **55**(5), 2110–2131 (2024).
22. S. Han, J.-H. Yoon, and J. Kwon, "Impact of experiential value of augmented Reality: the context of Heritage tourism," Sustainability **13**(8), 4147 (2021).
23. A.R. Hakim, A.R. Hasibuan, and P.P. Hariani, "Implementation of Multimedia Development Life Cycle in Learning Media Applications for Children with Mental Disabilities," Hanif Journal of Information Systems **2**(1), 11–21 (2024).
24. F.D. Davis, "Perceived usefulness, perceived ease of use, and user acceptance of information technology," MIS Quarterly **13**(3), 319 (1989).
25. L. Huang, and A.A. Musah, "The influence of augmented reality on creativity, student behavior, and pedagogical strategies in technology-infused education management," Journal of Pedagogical Research, (2024).
26. M. Ghobadi, S. Shirowzhan, M.M. Ghiai, F.M. Ebrahimzadeh, and F. Tahmasebinia, "Augmented reality applications in education and examining key factors affecting the users' behaviors," Education Sciences **13**(1), 10 (2022).
27. H. Guclu, S. Kocer, and O. Dundar, "Application of augmented reality in music education," The Eurasia Proceedings of Science Technology Engineering and Mathematics **14**, 45–56 (2021).
28. O. Elmira, B. Rauan, B. Dinara, and B.P. Etemi, "The effect of augmented reality technology on the performance of university students," International Journal of Emerging Technologies in Learning (iJET) **17**(19), 33–45 (2022).
29. W. Wu, "Traditional Music Education Content and Environment's Influence on the Preservation of Traditional Music in Henan Province," Front. Art Res **5**(17), (2023).
30. X. Zhang, D. Yang, C.H. Yow, L. Huang, X. Wu, X. Huang, J. Guo, S. Zhou, and Y. Cai, "Metaverse for cultural heritages," Electronics **11**(22), 3730 (2022).
31. D.S. Farhani, Y. Sumaryana, and T. Mufizar, "Development of a Traditional Musical Instrument Learning Media Application Based on Android Using the Multimedia Development Life Cycle (MDLC) Method," Journal of Informatics and Applied Electrical Engineering Technology **12**(2), (2024).
32. D. Agsriyani, "Improving Singing Skills Using Simple Musical Instruments for Group B Children Through the Demonstration Method," Educatio Journal FKIP UNMA **7**(2), 404–409 (2021).