Indonesian Journal of Educational Science (IJES)
ISSN 2622-6197 (Online)
DOI : 10.31605/ijes.v8i1.6231

Volume 8, No. 1 Maret 2026
ISSN 2655-4402 (Cetak)
Hal. 26 - 38

Modul Manarang Berbasis Etnomatematika dan Realitas Tertambah untuk Meningkatkan Kemampuan Metakognitif Siswa dalam Masyarakat 5.0

Nursyam Anaguna[1*], Sri Wardani[2], Mira[3], Nurtaqiya[4]
[1*]Universitas Sulawesi Barat, Majene, Indonesia

[*]e-mail: nursyamanaguna@unsulbar.ac.id

(**Accepted:** 15-02-2026; **Revision:** 18-03-2026; **Published:** 30-03-2026)

Abstrak

Rendahnya kemampuan metakognitif siswa Sulawesi Barat, dan terbatasnya media pembelajaran digital yang mengintegrasikan kearifan lokal merupakan masalah yang dihadapi oleh guru masa *society* 5.0. Pendekatan etnomatematika dan *Augmented Reality* (AR) dapat digunakan sebagai solusi dalam menyelesaikan masalah tersebut melalui budaya Mandar tarian *Pattu'du Kumba* yang memuat unsur geometris dan nilai-nilai filosofis. Tujuan penelitian ini adalah mengembangkan Manarang sebagai modul ajar digital berbasis etnomatematika dan AR untuk meningkatkan kemampuan metakognitif siswa. Metode penelitian yang digunakan adalah *Research and Development* (R&D) dengan model ADDIE (*Analysis*, *Design*, *Development*, *Implementation*, dan *Evaluation*). Partisipan penelitian adalah 26 siswa kelas XI B dan satu guru matematika. Instrumen yang digunakan meliputi angket respon guru dan siswa, serta *pre-test* dan *post-test* yang divalidasi oleh dua validator. Hasil penelitian menunjukkan bahwa Modul Manarang telah valid, praktis, dan efektif digunakan pada pembelajaran transformasi geometri. Uji efektivitas menggunakan Uji *Paired Sample t-test* (p = 0,000 < 0,05) dan N-gain menunjukkan skor 0,62 berarti ada peningkatan kemampuan metakognitif dalam kategori sedang. Produk ini diharapkan mendukung pembelajaran yang interaktif dan kontekstual yang mampu meningkatkan metakognitif siswa dalam mewujudkan pendidikan yang berkualitas.

Kata Kunci: Etnomatematika; *Augmented Reality*; Kemampuan Metakognitif

Manarang Module Based on Ethnomathematics and Augmented Reality to Enhance Students' Metacognitive in Society 5.0

Abstract

The low metacognitive abilities of students in West Sulawesi and the limited availability of digital learning media that integrate local wisdom are problems faced by teachers in the 5.0 society. The ethnomathematics and Augmented Reality (AR) approaches can be used as solutions to these problems through the use of the Mandar culture of Pattu'du Kumba dance, which contains geometric elements and philosophical values. This study aims to develop Manarang as an ethnomathematics and AR-based digital teaching module to improve students' metacognitive abilities. The research method used was Research and Development (R&D) with the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation). The participants were 26 eleventh graders and one mathematics teacher. The instruments used included teacher and student response questionnaires, as well as pre-tests and post-tests validated by two validators. The results showed that the Manarang Module was valid, practical, and effective as a digital learning module on geometric transformation learning. The effectiveness assessment using the paired sample t-test (p = 0.000 < 0.05) and N-gain score of 0.62 represented a moderate improvement towards students' metacognitive skills. This product is expected to support interactive and contextual learning that is able to improve students' metacognition in realizing quality education.

Keywords: *Ethnomathematics; Augmented Reality; Metacognitive Ability*

1. Introduction

Quality education is one of the goals to be achieved in the sustainable development goals. To achieve this, mathematics can be used to support the Sustainable Development Goals (SDGs) (Olasoji et al., 2023). However, the development of education, especially the mathematical ability of students in Indonesia, still faces great challenges. Based on the results of the Programme for International Student Assessment (PISA) which measures students' reading, math, and science skills and abilities in 2022, Indonesia ranks 67th out of 81 countries and ranks 6th in ASEAN with a math score of 366, far below the average (OECD, 2024). This low achievement is supported by the results of the 2019 TIMSS which revealed that only 11% of Indonesian students achieved intermediate proficiency in mathematics, while 47% were still at the most basic level (Mullis et al., 2020). One of the contributing factors is the low metacognitive ability of students, such as planning, monitoring, and self-evaluation in problem solving (Supriadi et al., 2023). This is also supported by the results of research by Ulkhaq (2023) which found that low metacognitive levels in students have a negative impact on their abilities.

The Society 5.0 era demands the creation of innovative, interactive, and adaptive teaching media to answer the increasingly complex needs of students (Susanto et al., 2024). Although this era makes use of contemporary technology, its main component is still human. In the era of society 5.0, technological advances must enable humans to create new values to reduce economic problems and human inequality in the future, especially in the field of education (Ramadhan et al., 2023). In this era, metacognitive skills are indispensable as the key to learning success in the 21st century (Silistraru & Vetrila, 2023). According to Putra et al. (2025), it shows that digital-based learning media can improve students' metacognition so that student learning effectiveness increases significantly. However, many students in Indonesia, especially in the West Sulawesi region, continue to face challenges in improving their metacognitive skills (Ministry of Education and Culture, 2025), this is due to traditional and non-contextual teaching approaches (Swajir, 2023).

The use of technology that exists today has penetrated the world of education and plays an important role in mathematics learning (Ramadhan et al., 2023; Bito & Masaong, 2023). The application of technology in abstract mathematics learning makes it easier for students to understand the material (Kariadinata et al., 2023). One form of innovation in creating an interactive, contextual, and fun learning experience is Augmented Reality (AR), which is a technology that combines the real world with virtual objects interactively in 3D form so that students can more easily understand difficult concepts (Sari et al., 2023; Resti et al., 2024). This certainly provides a meaningful learning experience for students.

Mathematics is a science that is closely related to the daily culture of society (Sakinah et al., 2023; Saputra et al., 2022). Meanwhile, the ethnomathematical approach shows that the concept of mathematics is present in the practice of people's lives through traditions, works of art, and daily activities (Dhiki et al., 2021). By integrating ethnomathematics in mathematics learning, students can view mathematics as a science that is close to their lives, rather than as a rigid and culturally separate discipline (Miftahurrahmi et al., 2024).

The development of digital learning media based on ethnomathematics and AR offers innovative solutions to improve students' metacognitive abilities. Ethnomathematics associates mathematical concepts with local culture (Marlissa et al., 2024), so that it can increase students' motivation and understanding (Prastica et al., 2025). In addition, the use of AR in mathematics learning effectively improves students' reflective abstraction and visualization of complex concepts. Umam et al. (2024) found that AR visualization helps

understanding geometry and overcomes negative paradigms towards mathematics, but also promotes students' metacognitive abilities (Kariadinata et al., 2023). However, currently, there has been no development of digital teaching modules based on ethnomathematics and AR, especially in Mandar culture.

Mandar is one of the largest tribes in West Sulawesi Province that has many cultural values and customs. One of the Mandar cultural traditions that is full of values is the *Pattu'du Kumba* dance (Radawati et al., 2020). The movements in this dance depict calmness, human harmony with nature, and the relationship between humans and their ancestors (Ahmad et al., 2024).

Many are unaware that the *Pattu'du Kumba* dance not only embodies philosophical and spiritual values, but also an interesting geometric concept. Unfortunately, this view contrasts with students who have difficulty understanding mathematics, especially geometry because they are considered to have no connection with daily life (Pawitra & Kusumadewi, 2025). The study of ethnomathematics provides an opportunity for cultures, particularly *Pattu'du Kumba*, to be used in mathematics learning. In ethnomathematics, the *Pattu'du Kumba* dance visually and harmoniously shows how abstract mathematical concepts such as angles in geometry are expressed through dance movements (Kusumayanti et al., 2025). Associating geometric concepts with local cultures like this not only makes learning more contextual, but also encourages students to improve their metacognitive abilities. Ethnomathematics provides meaningful cultural context (Hasibuan & Suparni, 2024), while AR supports interactive visualization to strengthen understanding (Safitri et al., 2024).

Based on previous research, it was found that there is an ethnomathematical exploration in the *Pattu'du Kumba* dance, but there has been no development of digital teaching modules based on ethnomathematics and AR. In fact, this integration has the potential to improve students' metacognition through culture and technology. Therefore, the purpose of this study is to develop a Manarang module based on ethnomathematics and AR to improve students' metacognition in the society 5.0 era.

2. Methods

This study uses the Research and Development (R&D) method with the ADDIE development model, which consists of five systematic stages, namely Analysis, Design, Development, Implementation, and Evaluation (Kariadinata et al., 2023; Safitri et al., 2024). The R&D approach aims to produce a product and assess its effectiveness based on the results of a needs analysis (Robbih et al., 2024).

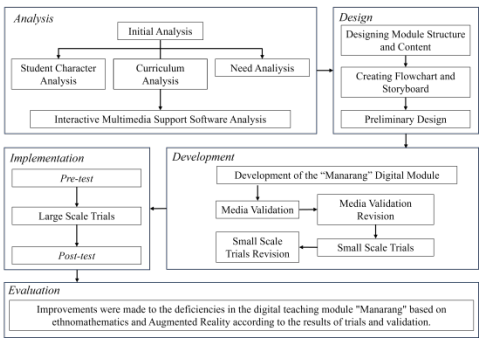

Figure 1. Stages of Manarang Module Development

The product developed in this study is in the form of a digital teaching module based on ethnomathematics and AR named Manarang, designed to improve students'

metacognitive abilities on geometry transformation materials in the society 5.0 era. This research was conducted at one of the Senior High Schools in Majene Regency., West Sulawesi for twelve weeks. There were 15 students who participated in the small-scale module trial activity from class XI A. Then, at the time of the research, the participants who joined amounted to 26 students of class XI B for the large-scale trial.

The stages of development of the Manarang module refer to the ADDIE model (see Figure 1) (Kariadinata et al., 2023). In the initial stage, (1) Analysis, is carried out to analyze the need for module development. The analysis carried out includes student character analysis, curriculum analysis, needs analysis, and supporting software analysis. (2) Design, the design stage is carried out with the aim of designing the writing of modules based on the results of the analysis stage. structure and content of modules based on the results of the analysis. Activities include the preparation of module frameworks, the creation of flowcharts and storyboards, as well as the development of the initial design of the Manarang module. (3) Development, the stage at which the design of AR media and the design of the Manarang module are carried out. After the module is completed, at this stage it is also validated by experts in terms of content, language, and usefulness. The validation results are input to revise the module before implementation. Revisions are carried out based on validator input, then the validated modules are then tested in class XI A through small-scale implementation. Then, module revisions from small-scale trial results are used to ensure product quality and feasibility before implementation. (4) Implementation, the validated Manarang module is then tested in class XI B. The implementation is carried out on students in the class to see the extent to which the module helps the learning process. At this stage, practicality, student involvement, and user responses to the module are observed. The data obtained during implementation is important material to determine the effectiveness of the module in improving students' metacognition. (5) Evaluation, the final stage is carried out to assess the quality of the module as a whole. At this stage, assessments and improvements are carried out based on reviews by validators, teachers, and student responses to determine the feasibility of the ethnomathematics and AR-based modules developed. The results of the evaluation are used as a basis for further improvement, so that the Manarang module can continue to be refined according to the development of student needs.

Data collection uses three instruments: (1) Expert validation sheets to assess the content, language, and display of modules, (2) Student and teacher questionnaires aimed at assessing the level of practicality of the modules, and (3) Pre-test and post-test to measure the effectiveness of the Manarang module. Before use, the entire instrument is validated by two validators. Based on the validator's suggestion, a number of statements in the questionnaire were revised to improve clarity and avoid ambiguity.

The average percentage of validity and practicality is obtained through the following formula.

$$x = \frac{\sum(score \times number\ of\ responses}{n \times highest\ score} \times 100$$

Information:
x = Validity/Practicality Percentage
n = Number of Rubric Items

The level of validity and practicality of the module is then determined by referring to the criteria of Razak (2023) presented in Table 1.

Table 1. Material Validity Criteria and Media Validity Criteria

Interval	Criteria
85% ≤ x ≤ 100%	Very valid/Very practical
70% ≤ x < 85%	Valid/Practice
55% ≤ x < 70%	Quite valid/Quite practical
40% ≤ x < 55%	Invalid/Impractical
0% ≤ x < 40%	Invalid/Impractical

Then the effectiveness of the Manarang module is determined by comparing the results of the pre-test and post-test. This instrument is in the form of test questions in the form of description questions that have been tested for validity, where the test of requirements that must be met is the data normality test. Then, the data was analyzed using the Paired Sample t-test, where if the value of sig. (2-tailed) < 0,05 means that the modules are effectively used in learning. In addition, the N-gain score was used to determine the improvement of students' metacognitive abilities after using the Manarang module in learning.

3. Results

3.1. Needs Analysis

Based on the results of observations, it was found that learning is still dominated by lectures and routine practice questions, so that students are less active and rarely reflect on their own thinking process, in this case their metacognitive abilities. Three indicators are used in metacognitive skills, namely planning indicators, monitoring indicators, and evaluation indicators (Setyaningsih & Rahmawati, 2022; Lusiana et al., 2020). Metacognition plays a role in regulating a person's ability to be aware, control, and evaluate his or her own thought processes in learning (Putrayasa et al., 2024; Putra et al., 2025).

The difficulty of students relating geometric transformation material (translation, reflection, rotation) with real application also contributes to improving students' metacognition. In addition, there is no digital module that combines Mandar culture and AR technology, even though the culture is rich in visual and geometric elements that can bridge concepts with students' metacognition. Although students are used to using smartphones and schools have Wi-Fi access, most have not yet understood how to utilize AR applications in learning.

To overcome this problem, the development of digital teaching modules is carried out that can improve students' metacognition through geometry transformation materials based on culture and visual technology. Since the use of smartphones in schools is allowed, the modules developed are designed to be accessed by students in chrome or browsers via a link. The developed module is dynamic, allowing interactive manipulation of 3D objects including translation, reflection, and rotation to change the position of objects according to the concept of geometry transformation. To increase the appeal, dance videos were added to the teaching module, colorful visual designs, navigation and storyboards that make it easy to use the module, and equipped with barcodes to bring out AR in each material.

The results of the needs analysis became a guideline for designing flowcharts and storyboards for ethnomathematics and AR-based modules called Manarang. This module is based on the ethnomathematics of the *Pattu'du Kumba* Dance, whose movements represent the concept of geometric transformation and are integrated with AR technology.

Indonesian Journal of Educational Science (IJES)
ISSN 2622-6197 (Online)
DOI : 10.31605/ijes.v8i1.6231
Volume 8, No. 1 Maret 2026
ISSN 2655-4402 (Cetak)
Hal. 26 - 38

This approach fosters contextual learning meaning, instills cultural values, and strengthens students' metacognitive abilities through reflective learning experiences.

3.2. Manarang Design

The design stage is an important phase in the development of the Manarang module that integrates ethnomathematics and AR technology. At this stage, the structure, content, and appearance of the module are designed based on the results of the needs analysis. The design begins with the creation of a flowchart and storyboard (Figure 2) that describes the development flow based on the ADDIE model.

Next, the appearance and layout of the modules were prepared using the Canva application. The module is designed to be easily accessible, has attractive visuals, and contains concept maps, learning objectives, and reflective activities that are in accordance with planning, monitoring, and evaluating indicators.

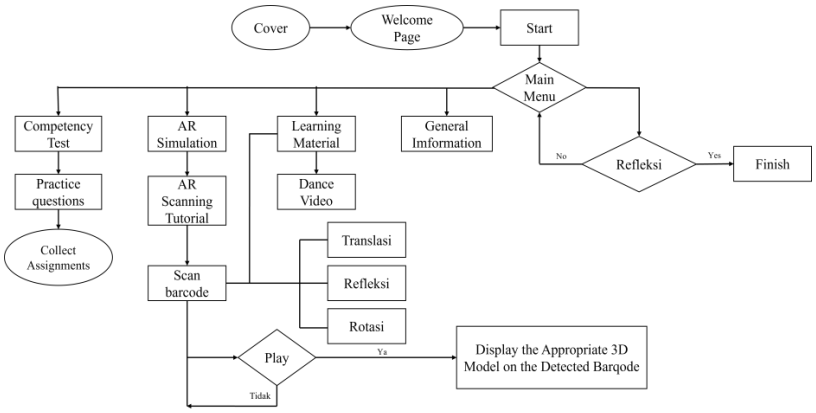

Figure 2. Flowchart Outline

3.3. Development of Manarang Module

The Manarang module developed contains translation, reflection and rotation materials. In compiling the content of the module, the author provides an overview of contextual examples such as a video of the *Pattu'du Kumba* dance culture equipped with an AR barcode to visualize the concept of geometric transformation that appears in the dance culture which can be observed in Figure 3. The development of AR uses the Assemblr Edu application which is designed based on ethnomathematics. Once the content is developed in the application, a barcode scan is then created to display in the module. Students can view 3D object visualizations through scanning the barcodes on the module. It can interactively display a visualization of the context being studied, so that students can more easily understand the geometry concepts they are learning.

Figure 3. Display of Material Content, Dance Videos and AR Barcodes

After the module is developed, then the module validation is carried out by two experts using the likert scale to determine the validity of the content and construct of the module. There are several aspects that are validated and obtained a recapitulation of the results contained in Table 2.

Table 2 shows that the average percentage of media and material validation is 90,67% and 90% respectively which are included in the very valid criteria. The validator's notes on the module include (1) the need to add AR features in the module, (2) the size and form of the text should be easy to read, and (2) it needs to be improved navigation to make it easier to use. In the development stage, a limited trial was also carried out on 15 students who obtained an average result of 86,04% practicality in the use of the module (very practical).

Table 2. Recapitulation of Validation Results

	Aspects Assessed	Average Percentage	Criteria
Media	Display Screen Design	92%	Highly Valid
	Ease of Use	88%	
	Consistency	90%	
	Benefits	93,3%	
	Average	**90,67%**	**Highly Valid**
Material	Quality of Content/Material	90%	Highly Valid
	Learning Objectives	90%	
	Feedback and Adaptation	85%	
	Motivation	100%	
	Average	**90%**	**Highly Valid**

3.4. Implementation of Manarang Module

At this stage, the module is applied in learning mathematics of geometry transformation material. This phase is called the field trial stage involving 26 students in grade XI B and 1 mathematics teacher who were selected based on the results of the needs analysis. First, a pre-test is carried out to determine students' metacognitive abilities before applying the Manarang module. Furthermore, students used Manarang for 4 meetings on the topics of translation, reflection, and rotation. During the learning process, teachers can also observe the modules used by students, so that they can provide feedback and input in terms of practicality to module development. In the fifth meeting, students were given a post-test to find out the students' metacognitive abilities after going through mathematics learning using the Manarang module. The form of implementation during the meeting can be seen in Figure 4.

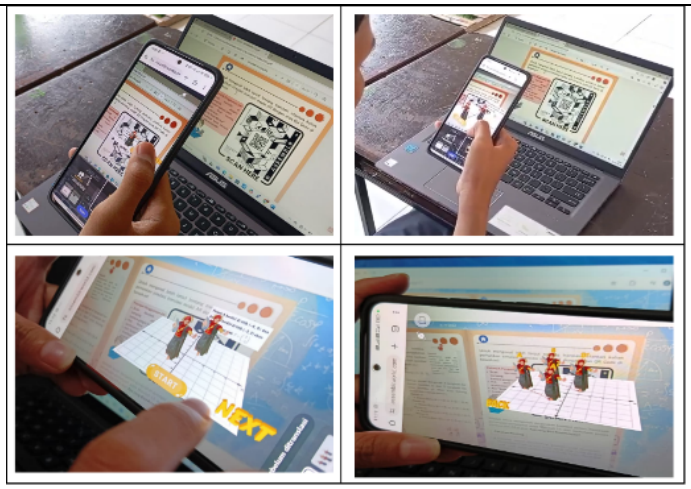

Figure 4. Manarang Implementation Based on Ethnomathematics and AR

3.5. Evaluation

First, the evaluation of the practicality aspects of the module was obtained through a questionnaire of student and teacher responses after a large-scale trial. The assessed aspect of the students' response can be seen in Table 3 where the average percentage result reaches 84,5% (Very Practical). Then, for the assessment of the module based on the teacher's perspective, a figure of 95% (Very Practical) can be seen in Table 4. This shows that the Manarang module developed obtained very practical criteria. The results in this study are in line with previous research that leveraged ethnomathematics and AR technology to improve visualization, students' spatial engagement, motivation, interest, and independence in learning geometry (Kamid & Anwar, 2025; Saumi et al., 2022). Thus, the module has been recognized and can be implemented in mathematics learning, especially geometry transformation material.

Table 3. Results of the Manarang Module Practicality Test by Students

Aspects Assessed	Average Percentage	Criteria
Material Suitability	83,5%	Very Practical
Student Motivation and Confidence	83,8%	
Learning Independence	84,6%	
Clarity and Ease of Use	81,8%	
Appearance and Design	88,8%	
Average	**84,5%**	**Very Practical**

Table 4. Results of the Manarang Module Practicality Test by Teachers

Aspects Assessed	Average Percentage	Criteria
Material Suitability	100%	Very Practical
Language Use	100%	
Presentation/instructions	90%	
Appearance and Design	90%	
Motivation	100%	
Technical (AR)	90%	
Average	**95%**	**Very Practical**

4. Discussion

The application of the Manarang module has a significant positive impact on improving students' metacognitive abilities. Based on the results of the paired sample t-test, a significance value of 0,000 < 0,05 was obtained, which showed a significant difference between the results of the pre-test and post-test of students' metacognitive abilities before and after the use of the module. The improvement in his metacognitive ability can be seen from the N-gain result which shows a score of 0,62, which means that metacognitive improvement is included in the moderate category based on the criteria of Nindiasari et al. (2024). This improvement is seen in 3 metacognitive indicators, namely planning, monitoring, and self-evaluation where students show better abilities during the learning process. Meanwhile, Lusiana et al. (2020) found that the characteristic of students who meet metacognitive indicators is that students belong to the category of students with left brain dominance, meaning that they have a thought process related to numbers and logic.

The integration of ethnomathematics and AR in Manarang encourages students to learn reflexively and contextually. Visualization of *Pattu'du Kumba* dance movements through AR helps students associate the concept of geometric transformation with real cultural experiences, so that their thought process becomes more conscious and directed. In addition, reflection activities at the end of the material are able to train students' metacognitive. Thus, the use of Manarang can foster awareness of high-level thinking as the core of metacognitive abilities. These findings are in line with research (Sutarto et al., 2022; Rani et al., 2025; Wardani et al., 2025) who revealed that ethnomathematics and AR-based e-modules can improve students' metacognitive abilities in mathematics learning.

5. Conclusion

The conclusion obtained from the results of the research is that the Manarang module developed has proven to be very valid, practical, and effective for use in mathematics learning. In particular, the results of expert validation showed a validity rate of 90,33%, practicality of 84,5%, and an improvement in metacognitive abilities after the module was implemented in mathematics learning. In general, the development of digital teaching modules based on ethnomathematics and AR is not only able to improve the quality of mathematics learning, but also integrates local cultural values in a contextual and interactive learning process. Thus, the Manarang module produced can be a learning innovation that is relevant to the society 5.0 era.

Acknowledgement

We would like to thank the University of West Sulawesi, especially the Mathematics Education Study Program, Faculty of Teacher Training and Education for the support provided during the research. Appreciation is also addressed to teachers and students as participants in this study. Finally, many thanks also go out to the Directorate of Learning and Student Affairs of Higher Education, Science and Technology Ministry for the funding toward this research.

References

Ahmad, M. P. U., Syahrir, N., & Padalia, A. (2024). Representation of form and educational values in pattuqduq kumba dance: local cultural values in the educational curriculum. *ETDC: Indonesian Journal of Research and Educational Review*, *4*(1), 107-118. https://doi.org/10.51574/ijrer.v4i1.2730

Bito, N., & Masaong, A. K. (2023). Peran media pembelajaran matematika sebagai teknologi dan solusi dalam pendidikan di era digitalisasi dan disruption. *Jambura Journal of Mathematics Education,* *4*(1), 88-97. https://doi.org/10.34312/jmathedu.v4i1.17376

Dhiki, Y. Y., & Bantas, M. G. D. (2021). Eksplorasi etnomatematika sebagai sumber belajar matematika di kabupaten ende. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 10*(4), 2698-2709. https://doi.org/10.24127/ajpm.v10i4.4254

Hasibuan, A.H. & Suparni, S. (2024). Etnomatematika: eksplorasi amak lampisan mandailing dalam pembelajaran matematika. *Jurnal Ilmiah Pendidikan Matematika Al Qalasadi, 8*(1), 93–101. https://doi.org/10.32505/qalasadi.v8i1.7839

Kamid, K., & Anwar, K. (2025). E-magazine-education etnomatematika batik jambi berbasis teknologi augmated reality untuk meningkatkan hasil belajar matematika siswa. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 14*(1), 70-82. http://dx.doi.org/10.24127/ajpm.v14i1.9569

Kariadinata, R., Milah, A.M. and Sugilar, H. (2023). Development of interactive augmented reality multimedia based on ethnomatematics. *Jurnal Analisa, 9*(1), 22-36. https://doi.org/10.15575/ja.v9i1.26032

Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi. (2025). Asesmen Nasional Berbasis Komputer (ANBK). URL: https://anbk.kemdikbud.go.id/ . Diakses tanggal 18 Agustus 2025.

Kusumayanti, A., Putry, E.D., Hidayat, M.N. & Sriyanti, A. (2025). Etnomatematika: eksplorasi konsep geometri pada tari pattu'du kumba. *Numeracy, 12*(1), 1-18. https://doi.org/10.46244/numeracy.v12i1.3082

Lusiana, R., Murtafiah, W., & Oktafian, F. (2020). Kemampuan metakognitif siswa dalam menyelesaikan permasalahan pada materi pola bilangan ditinjau dari brain dominance. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 9*(4), 962-976. https://doi.org/10.24127/ajpm.v9i4.3044

Marlissa, I., Juandi, D., & Turmudi. (2024). Persepsi etnomatematika dalam pembelajaran matematika. *Indiktika: Jurnal Inovasi Pendidikan Matematika, 7*(1), 148-159. https://doi.org/10.31851/indiktika.v7i1.16993

Miftahurrahmi, M., Pratiwi, I. O., Huda, F., & Habibi, M. (2024). Ethnomathematics exploration in the traditional art of randai minangkabau. *Kalamatika: Jurnal Pendidikan Matematika,* *9*(1), 99-120. https://doi.org/10.22236/KALAMATIKA.vol9no1.2024pp99-120

Mullis, I. V., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. (2020). *TIMSS 2019 international results in mathematics and science*. TIMSS & PIRLS International Study Center.

Nindiasari, H., Pranata, M. F., Sukirwan, S., Sugiman, S., Fathurrohman, M., Ruhimat, A., & Yuhana, Y. (2024). The use of augmented reality to improve students' geometry concept problem-solving skills through the steam approach. *Infinity Journal, 13*(1), 119-138. https://doi.org/10.22460/infinity.v13i1.p119-138

OECD. (2024). *PISA 2022 Results (Volume III): Creative Minds, Creative Schools – Indonesia Factsheet*. Paris: OECD Publishing.

Olasoji, O. V., Ugwu, U. F., & Onoh, D. O. (2023). The role of mathematics education in achieving sustainable development goals (sdgs). *ESUT Journal of Education, 6*(1), 247-255. https://www.esutjoe.org/index.php/esutjoe/article/view/27

Pawitra, L.S. & Kusumadewi, R.F. (2025). Pengembangan media komik digital edukatif untuk pemahaman konsep matematika. *IHSAN: Jurnal Pendidikan Islam, 3*(2), 91-98. https://doi.org/10.61104/ihsan.v3i2.880

Prastica, A.D., Suliantoro, T. & Irawati, S. (2025). Penerapan pembelajaran dilatasi dengan pendekatan kontekstual berbasis etnomatematika. *Journal of Innovation and Teacher Professionalism, 3*(2), 340-347. https://doi.org/10.17977/um084v3i22025p340-347

Putra, I. H., Novia, H., Muslim, M., & Sihombing, R. A. (2025). Unraveling metacognitive regulation in physics: mapping high school students' skills using the rasch model. *Unnes Science Education Journal, 14*(1), 117-127. http://dx.doi.org/10.15294/usej.v13i1.21637

Putra, I.W.R.A., Widiana, I.W. & Jayanta, I.N.L. (2025). Si ceria AR: an augmented reality-based learning media to enhance scientific concept understanding and student engagement. *Journal of Education Technology, 9*(1), 181-189. https://doi.org/10.23887/jet.v9i1.94929

Putrayasa, I. M., Suwindia, I. G., & Winangun, I. M. A. (2024). Transformasi literasi di era digital: tantangan dan peluang untuk generasi muda. *Education and Social Sciences Review, 5*(2), 156-165. https://doi.org/10.29210/07essr501400

Radawati, R.M. & Padalia, A. (2020). Revitalisasi tari pattu'du' kumba oleh sanggar seni uwake' di kecamatan tinambung kabupaten polewali mandar. *Jurnal Pakarena, 5*(1), 14-26. https://eprints.unm.ac.id/28859/

Ramadhan, S., Purbaningrum, M., Thauzahra, R., & Setyaningrum, W. (2023). Penggunaan teknologi untuk mengembangkan literasi matematika peserta didik pada kurikulum merdeka. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 12*(3), 3231-3245. http://dx.doi.org/10.24127/ajpm.v12i3.7526

Rani, M. M., Irsal, I. L., Hidayat, R., & Khairi, A. U. (2025). Practicality and effectiveness of metacognitive-based flipbook e-modules assisted by geogebra to improve mathematical conceptual understanding of prospective teacher students. *Mandalika Mathematics and Educations Journal, 7*(2), 569-582. https://doi.org/10.29303/jm.v7i2.9011

Razak, A., Amri, Z., & Halomoan, T. (2023). Pengembangan bahan ajar e-modul dengan model addie berbasis flip pdf professional materi bangun ruang sisi lengkung kelas ix smp jambi medan. *Journal Mathematics Education Sigma [JMES], 4*(1), 63-70. https://doi.org/10.30596/jmes.v4i1.13697

Resti, N., Ridwan, R., Palupy, R. T., & Riandi, R. (2024). Inovasi media pembelajaran menggunakan ar (augmented reality) pada materi sistem pencernaan:(learning media innovation using augmented reality on digestive system material). *Biodik, 10*(2), 238-248. https://doi.org/10.22437/biodik.v10i2.34022

Robbih, M. N. I. A., & Sudarwanto, T. (2024). Pengembangan modul ajar berbasis pembelajaran berdiferensiasi pada materi perilaku konsumen kelas x bisnis digital smks ketintang surabaya. *Jurnal Pendidikan Tata Niaga (JPTN), 12*(3), 349-355. https://doi.org/10.26740/jptn.v12n3.p349-355

Safitri, P. T., Raharjo, S., & Kuncara, F. N. (2024). Development of augmented reality-based learning on flat-sided space building materialsversion. *Kalamatika: Jurnal Pendidikan Matematika, 9*(1), 121-134. https://doi.org/10.22236/KALAMATIKA.vol9no1.2024pp121-134

Sakinah, D., Lubis, I. I., & Habibi, M. (2023). Ethnomathematical exploration of tumbu'bugis food. *Kalamatika: Jurnal Pendidikan Matematika, 8*(2), 133-148. https://doi.org/10.22236/KALAMATIKA.vol8no2.2023pp133-148

Saputra, E., Mirsa, R., Yanti, P. D., Wulandari, W., & Husna, A. (2022). eksplorasi etnomatematika pada arsitektur rumoh aceh. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 11*(1), 703-717. http://dx.doi.org/10.24127/ajpm.v11i1.4751

Sari, I. P., Batubara, I. H., & Basri, M. (2023). Pengenalan bangun ruang menggunakan augmented reality sebagai media pembelajaran. *Hello World Jurnal Ilmu Komputer, 1*(4), 209-215. https://doi.org/10.56211/helloworld.v1i4.142

Saumi, F., Muliani, F., & Amalia, R. (2022). Pengembangan e-modul berbasis augmented reality dengan model guided discovery learning pada materi vektor. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 11*(4), 3850-9. http://dx.doi.org/10.24127/ajpm.v11i4.6066

Setyaningsih, N., & Rahmawati, E. Z. (2022). Metacognitive skills of student in solving problems of two-variable linear equation systems in terms of self-regulated learning. *Jurnal Riset Pendidikan Matematika, 9*(1), 82-92. https://doi.org/10.21831/jrpm.v9i1.49163

Silistraru, N., & Vetrila, S. (2023). Metacognition as a component of intelligent behavior. *Vector European*, 2, pp, 124–128. https://doi.org/10.52507/2345-1106.2022-2.25

Supriadi, N., Sari, A.L. & JL, A.R. (2023). Analisis hubungan self-efficacy dan representasi matematis terhadap pemecahan masalah matematis. *Pythagoras: Jurnal Matematika dan Pendidikan Matematika, 18*(2), 148-158. https://doi.org/10.21831/pythagoras.v18i2.64588

Susanto, A.M., Epriliyana, N.N. & Utama, H.H. (2024). Implementation of learning innovations in society 5.0 to stimulate creative thinking skills at higher education. *Jurnal Dimensi Pendidikan dan Pembelajaran, 12*(1), 25-36. https://doi.org/10.24269/dpp.v12i1.8282

Sutarto, S., Muzaki, A., Hastuti, I. D., Fujiaturrahman, S., & Untu, Z. (2022). Development of an ethnomathematics-based e-module to improve students' metacognitive ability in 3d geometry topic. *International Journal of Interactive Mobile Technologies, 16*(3), 32-46. https://doi.org/10.3991/ijim.v16i03.24949

Swajir, N. (2023). Kualitas pendidikan di sulawesi barat. *EDUSTUDENT: Jurnal Ilmiah Pendidikan dan Pengembangan Pembelajaran, 2*(4), 214-222. https://doi.org/10.26858/edustudent.v2i4.48347

Ulkhaq, M.M. (2023). Determinan pencapaian siswa bidang matematika: perbandingan antara indonesia dan singapura. *PowerMathEdu: Jurnal Inovasi Pembelajaran Matematika, 2*(1), 9-16. https://doi.org/10.31980/pme.v2i1.1395

Umam, K., Fatayan, A., Nuriadin, I., Azhar, E., & Slamet, S. (2024). Apakah augmented reality dapat menstimulus pemahaman konsep dan visualisasi geometri siswa. *AKSIOMA: Jurnal Program Studi Pendidikan Matematika, 13*(2), 720-219. http://dx.doi.org/10.24127/ajpm.v13i2.8784

Wardani, S., Mira, M., Nurtaqiya, N., & Anaguna, N. (2025). Validity and practicality of manarang module based on preservice mathematics teachers. *Griya Journal of Mathematics Education and Application, 5*(3), 1497-1510. https://doi.org/10.29303/griya.v5i3.864