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Development of RME-Based E-Modules with Ethnomathematics Integration to Improve Graphic to Symbolic Transformation Skills in Junior High School Mathematics

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ABSTRACT

Students often experience difficulty translating graphic representations into symbolic mathematical forms, indicating the need for learning resources that connect abstract concepts with meaningful contexts. This study aimed to develop an e-module based on Realistic Mathematics Education (RME) integrated with the ethnomathematics of *rumah betang* to improve students' ability to transform graphic representations into symbolic representations. This research employed a development design using the ADDIE model, comprising analysis, design, development, implementation, and evaluation. The feasibility of the e-module was evaluated by material and media experts. Its practicality was examined through a small-group trial, while its effectiveness was tested in a large-group implementation using pretest and posttest scores. Expert validation indicated that the e-module was categorized as "very feasible" in terms of material and media quality. The small-group trial showed that the e-module was "practical" for use in mathematics learning. In the large-group trial, students' average score increased from 63.92 on the pretest to 84.72 on the posttest. The N-gain score was 0.59, indicating a medium improvement, with an effectiveness percentage of 58.81%, categorized as moderate. The findings suggest that the RME-based e-module integrated with *rumah betang* ethnomathematics is feasible, practical, and moderately effective in supporting students' representation ability. The e-module can be used by teachers as an innovative culturally contextualized learning medium and by students for independent or collaborative learning. Further studies may examine its effects on other mathematical abilities, such as critical thinking and problem solving.

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1. INTRODUCTION

Education is a systematic effort to transmit cultural and scientific values across generations and to develop students' physical and spiritual potential in accordance with society's demands (Abhi Rama et al., 2023; Chodzko, 2023). This process is sustainable and applies to local values and Pancasila (Dhiaulhaq et al., 2023; Herwina & Madjid, 2018). In this context, mathematics plays a vital role as a foundation for logistical and scientific thinking, as well as improving the quality of human resources (Barut & Retnawati, 2020; Trung, 2019). However, abstract math and statistics often make it difficult for students to understand concepts, especially in real life (Gualdrón-Ortiz, 2020; Hertleif, 2017).

One of the essential math skills that students must have is mathematical representation, which is the ability to express mathematical ideas through pictures, tables, graphs, symbols, or written narratives (Minggi & Talib, 2021). In a global context, the ability to interpret data and transform visual information into mathematical models is a core competency in the 21st-century digital era. Unfortunately, international studies such as TIMSS show this low ability in Indonesian students, who rank 36th out of 49 countries. Students still have difficulty converting mathematical symbols into visual forms or vice versa, and communicating mathematical ideas verbally (Koyimah & Yuliandari, 2020; Marasabessy, 2020). This indicates the need for learning innovations that can accommodate the needs of mathematical representation through contextual and technological approaches.

This research addresses a critical scientific gap: the lack of theoretical synthesis between digital pedagogy and socio-culturally based mathematics. While previous studies have extensively discussed Realistic Mathematics Education (RME) as a general tool for understanding concepts, there is limited empirical focus on how RME, when combined with ethnomathematics, facilitates the specific cognitive leap from graphic to symbolic representation. This transformation is often the point where students fail, as they lack a familiar "visual bridge" to formalize abstract symbols.

The integration of ethnomathematics provides this bridge by utilizing local cultural artifacts as the primary "graphic" stimuli. Theoretically, this fulfills the RME principle of "mathematization," where learning starts from a reality rooted in the student's local wisdom, then gradually transitions into formal symbolic notation. By developing an ethnomathematics-based e-module, this study not only answers the global challenge of digital-based learning but also addresses the local need for a curriculum that honors cultural identity, thereby filling the void between abstract technology and concrete cultural experience.

Use of technology-based teaching materials, such as e-modules (Fajriah & Suryaningsih, 2021) This is a potential solution to address these challenges. E-modules present the material interactively and allow students to learn independently through electronic devices (El Hikam & Malasari, 2023; Son, 2020). Previous research, such as that conducted by (Doli & Armiati, 2020)Proving that e-modules based on Realistic Mathematics Education (RME) are effective in improving concept understanding and critical thinking (Palinussa, 2025; Palinussa et al., 2021). However, the focus on mathematical representation capabilities, especially the transformation between graphical and symbolic representations, is still little explored.

Based on this background, this study aims to test how valid and practical, as well as the extent of the effectiveness of RME-based e-modules integrated with the local cultural context (ethnomathematics) to improve the ability to transform graphic representations into symbolic. The use of RME was chosen because of its principles, which are based on the reality and activities of the students. At the same time, cultural integration is expected to strengthen the contextualization of the material. The development method follows the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model to ensure the product is valid, practical, and effective (Jui-Che Tu, 2021; Paredes, 2020). The research results are expected to contribute to mathematics learning innovations that are adaptive to technological developments and local wisdom and become a reference for further research related to mathematical representation.

2. METHOD

This research falls under the research and development (R&D) category, aiming to develop an e-module based on Realistic Mathematics Education (RME) on the topic of a two-variable linear equation system. (Hidayat & Nizar, 2021; Supriyanto et al., 2020). The R&D approach is used to create innovative products while testing their validity, practicality, and effectiveness. The development process follows the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model, because the stages in this model are assessed according to the needs in producing applicable learning products (Rosdiana et al., 2022; Widiana & Rosy, 2021).

This research procedure follows five stages in the ADDIE model: Analysis, Design, Development, Implementation, and Evaluation.

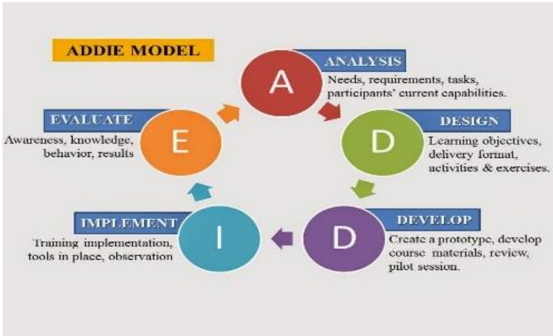

Figure 1. ADDIE Model Flow

This research employs a five-stage development process: analysis, design, development, implementation, and evaluation. In the analysis stage, the curriculum, learning environment, technological trends, and student characteristics are reviewed. Based on this analysis, an e-module is designed in the second stage, followed by an initial evaluation. In the development stage, the conceptual design is transformed into a tangible product and validated by two subject-matter experts and two media experts for content, media, and visual quality. The validated e-module is then implemented with Grade VIII MT students at Muhammadiyah Lempengan, selected through purposive sampling. The final evaluation stage assesses the e-module's feasibility, practicality, and effectiveness using quantitative methods. Product testing includes expert validation and user trials first with a small group (6 students) and then a larger group (25 students). Data were collected via three Likert-scale (1–5) questionnaires: one for subject-matter experts (assessing content), one for media experts (evaluating design and functionality), and one for students (measuring practicality and perceived usefulness), along with pretest-posttest items to gauge improvement in mathematical representation skills. Data analysis followed a quantitative descriptive approach: validity was determined using ideal mean (Mi) and ideal standard deviation (Sbi), with feasibility defined as scoring at least 50% of the maximum possible score; practicality required at least 61% positive student responses; and effectiveness was established using the Normalized Gain (N-gain) formula, with a value of ≥0.3 indicating medium or better improvement in learning outcomes.

The data analysis technique used in this study is a quantitative descriptive analysis technique based on the e-module developed. Data analysis was carried out after data were obtained from all research subjects, including material experts, media experts, and students. Data analysis was carried out by converting scores obtained from material experts, media experts, and students using the Likert scale. The scores obtained from the validation of questionnaires of subject matter experts, media experts, and students as users were then converted into four scales of eligibility categories that had score intervals (Sudjana, 2017).

Table 1. Eligibility categories

No	Group	Score interval
1.	Highly feasible	$Mi+1.5Sbi < X \leq Mi+3Sbi$
2.	Proper	$Mi < X = E+1.5Sbi$
3.	Quite feasible	$Mi-1.5Sbi < X \leq Mi$
4.	Not eligible	$Mi-3Sbi < X \leq Mi-1.5Sbi$

Information:
Mi = ideal average = (highest score + lowest score)
SBI = ideal standard deviation = (highest score - lowest score)

This analysis is used to determine the level of practicality of using the product in the learning process. The practical principle means that it is easy to use for the students who will be using the product. Data was obtained from a questionnaire of students' responses to using the developed learning modules. The formula used to calculate the percentage of each subject is as follows (Sugiyono,2028):

$$P = \frac{\sum Xi}{\sum X} \; x \; 100\%$$

P = Percentage of questionnaire score
$\sum Xi$ = Total questionnaire score
$\sum X$ = Total ideal score (highest answer) of respondents

Test the effectiveness of this product using a pretest group *Design.* This design uses one class to obtain data on student learning outcomes obtained before and after using *Electronic Modules* Developed. The comparison of student learning outcomes obtained before and after learning comics was calculated using the Normalized-gain formula by Hake (Sudjana, 2017). N-gain is determined based on the pretest and posttest scores' average gain (g). The calculation is as follows:

Information:

$$g = \frac{S\ Postest - S\ Pretest}{S\ maks - S\ Pretest}$$

S Posttest = Average post-test score
S Pretest = Average pretest score
S max = Maximum score

Furthermore, the N-gain acquisition category in the form of a percentage (%) can be referred to in the following table (Sudjana, 2017):

Table 2. Categories of interpretation of N-gain effectiveness

No	Percentage (%)	Group
1.	< 40	Effective
2.	40 - 55	Less effective
3.	56 - 75	Quite effective
4.	> 75	Effective

3. FINDINGS AND DISCUSSION

The researcher obtained findings from the study "Development of Realistic Mathematics Education-Based E-modules to Improve the Ability to Convert Graphic Representations into Symbolic Representations". Research and development were carried out at MTs Muhammadiyah Lempengan. In this study, the researcher adopted an R&D research method with the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. The purpose of using the ADDIE model in this development is to design and develop products that are practical and effective in the learning process in junior high school.

3.1 Findings

The following is the sequence of stages in the ADDIE model development method: Analysis, Design, Development, Implementation, and Evaluation. The needs analysis revealed limited use of electronic media in learning, prompting the researcher to develop an ethnomathematics-based e-module focused on regional culture to enhance student engagement. The resulting e-module offers a more interesting and user-friendly learning experience and supports independent study at home, as it is accessible via laptops and mobile phones. This is in line with research (Dehani, 2019) Applying mathematics teaching materials based on Realistic Mathematics Education improves students' mathematical representation skills.

Development plan *Electronic Modules* arranged according to the format (1) The opening consists of a cover page with the title "Teaching Module of the Two-Variable Linear Equation System", the identity of the researcher, the foreword and the table of contents, (2) The content consists of the learning objectives and materials related to triangles and boxes, (3) The closing consists of the last page of the cover and a list of references. The results of developing the "Teaching Module of the Two-Variable Linear Equation System" were made using *Canva* and *Fliphtml5.* After the product development process, the next step is to conduct a feasibility test by validating the developed product. This validation test is carried out in two stages: design validation by media experts and material validation by material experts. This is in line with research by Muryati et al. (2023), which states that, based on expert validation, e-modules fall into the very feasible category, with a large percentage of 85%.

The study was carried out with Grade VIII students at MTs Muhammadiyah Lempengan, involving both small- and large-group trials. During the implementation phase, an updated e-module link was shared with Class VIII B, and the module was integrated into two face-to-face classroom sessions held on October 17 and October 24, 2024. The first session included a pre-test, yielding an average score of 63.92, while the second session concluded with a post-test, in which students scored an average of 84.72. Prior to the post-test, students were assigned to review the e-module materials independently. This approach aligns with findings by Marpaung et al. (2024), who noted that e-modules can enhance teaching quality, aid instructors in explaining complex concepts, and ultimately boost student learning outcomes (Marpaung et al., 2024).

The evaluation is the final step in the ADDIE development model, which aims to assess the practicality and effectiveness of the home ethnomathematics-based home e-modules that have been developed: a) Expert validation: Based on the input of material experts and media experts, the e-modules get a very worthy category. Some revisions are carried out by expert recommendations such as increasing the richness of the material and improving the font size, b) Small group trials: This trial is conducted to find out the level of practicality and opinions of students before the large group trials are carried out, c) Large group trials: This trial is to find out the level of effectiveness of using e-modules developed to improve students' mathematical representation skills. The improvement of ability can be seen from the results of *the students'* pre-test *and* post-test.

The researcher tested the validity through a validation process by material and media experts. Material validation was carried out through an assessment questionnaire with four aspects and 13 indicators. The material validation was carried out by two experts, namely: (1) a lecturer from the mathematics education study program at the University of Palangka Raya, and (2) a vocational school principal in the city of Palangka Raya who has a background in mathematics education. At the validation stage, subject matter experts provide evaluations and inputs related to product development carried out by researchers. The eligibility data obtained can be seen in the table below:

Table 3. Material validation feasibility data

No	Aspects	Grain	Score Members (1)	Score Members (2)	Middle Expert score	Maximum score
1.	Material	3	14	14	14	15
2.	Serve	4	19	19	19	20
3.	Concept of conformity	3	12	14	13	15
4.	Effectiveness	3	14	14	14	15
	Sum	**n = 13**			**∑x=60**	**65**

No	Aspects	Grain	Score Members (1)	Score Members (2)	Middle Expert score	Maximum score
Ideal red (Mi) = (highest score + lowest score) = (65 + 13) = 39			Ideal standard deviation (Sbi) = (highest score - lowest score) = (65-13) = 8.6			

Product material eligibility criteria:

Mi+1.5Sbi < X ≤ Mi+3Sbi
39 + 1.5(8.6) < **60** ≤ 39 + 3(8.6)
39 + 1.5(8.6) < **60** ≤ 39 + 3(8.6)
51.9< **60 (very decent)** ≤ 64.8

Based on the results above, it is known that the material feasibility criteria of the product are very feasible, with a value of more than 64.8%. This is in line with (Wardani & Susilowibowo, 2021). Based on the results of studies and validation by material experts, this flipbook-based electronic teaching material is very suitable for use.

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Table 4. Media validation eligibility data

No	Aspects	Grain	Score Members (1)	Score Members (2)	Middle Expert score	Maximum score
1.	Display	5	22	24	23	25
2.	Serve	3	13	13	13	15
3.	Language	3	14	14	14	15
4.	Effectiveness	3	12	14	13	15
	Sum	**n = 14**			**∑x=64**	**70**

Product media eligibility criteria:

Mi+1.5Sbi < X ≤ Mi+3Sbi
42 + 1.5(9.3) < **66** ≤ 42 + 3(9.3)
42 + 13.9 < **66** ≤ 42 + 27.9
55.9 < **66 (very decent)** ≤ 69.9

After the subject matter experts and media experts validated the results, the next activity was to conduct a small group trial involving six students as respondents to test the feasibility of the electronic module product. After the trial, students are asked to complete a questionnaire and get a score to be included in the "practical" category. The total score obtained from six students across 10 Likert-scale items (rated 1–5) was 227 out of a possible maximum of 300, resulting in a percentage score of 75.6%, which indicates a high level of agreement or positive response regarding the practicality of the exercises.

The next stage is a trial in a large group to determine the developed product's effectiveness. *The N-gain score* is designed to evaluate the effectiveness of the developed product.

Table 4. Product effectiveness test results (n-gain score)

	Pre-tests	Post-tests	Post-Pre	Ideal score (100- Pre-test)	N-gain score	N-gain (%)
Mean	63.92	84.72	20.8	36.08	**0.59**	**58.81**

The N-gain value of 0.59 falls into the "medium" category, and the effectiveness rate of 58.81% are also classified as moderately effective. While these results suggest a noticeable improvement in students' numeracy, they do not necessarily confirm full success of the module without deeper critical analysis. According to Cahyadi et al. (2023), a medium N-gain indicates that the module is *reasonably practical,* not highly effective in enhancing numeracy skills. Therefore, although the findings are promising, they may not be sufficient on their own to declare the module fully successful; further refinement, larger-scale trials, or additional supporting evidence would strengthen the claim of effectiveness.

3.2 Discussion

The findings of this study indicate that the e-module based on Realistic Mathematics Education (RME) and ethnomathematics is a valid, practical, and effective tool for improving students' mathematical representation skills. The validation results from material and media experts, which reached the "Very Feasible" category, demonstrate that integrating local culture (ethnomathematics) into a digital format meets the technical and pedagogical standards required for junior high school mathematics. This high level of validity is a crucial foundation, as expert consensus ensures that the content is mathematically sound and the interface is user-friendly.

The practicality test, which yielded a score of 75.6%, suggests that the e-module is accessible and easy to use for students. This usability is largely attributed to the use of Canva and Fliphtml5, which provide an interactive experience compared to traditional printed materials. From a pedagogical perspective, the transition from graphic to symbolic representations was facilitated by the RME approach. By starting with "realistic" cultural contexts (house ethnomathematics), students could more easily visualize abstract linear equations. This aligns with the principle that learning is most effective when it starts from an identifiable reality before moving toward formal mathematical modeling.

The effectiveness of the product is evidenced by the significant increase in student scores. The improvement from a pre-test average of 63.92 to a post-test average of 84.72, supported by an N-gain score of 0.59, places the e-module in the "Quite Effective" category. While the improvement is substantial, the "Medium" gain suggests that while students' representation skills improved, there is still room for optimization in how complex symbolic transformations are taught within the digital platform. These results are consistent with previous research by Rizqi et al (2021) and Yuliani (2020), confirming that RME-based electronic materials significantly contribute to better learning outcomes and student independence.

Furthermore, the integration of ethnomathematics addressed the researcher's goal of increasing interest in regional culture. By using local house structures as the basis for geometry and linear systems, the module made mathematics feel less abstract and more relevant to the students' daily lives. As noted by Ramadhani et al (2023), the use of such electronic modules not only delivers complex material more efficiently but also modernizes the learning environment, making it more compatible with the needs of 21st-century learners who are proficient with mobile devices and laptops.

4. CONCLUSION

Based on the research findings, the traditional home-based ethnomathematics e-module developed using the ADDIE model was found to be valid, practical, and effective in improving students' mathematical representation abilities, as shown by expert validation, positive student responses, and significant improvement between pretest and posttest results. However, the e-module was only categorized as "quite effective," indicating that it should be used as a supporting learning tool rather than a replacement for teacher-guided instruction, especially in developing students' symbolic reasoning skills. Future research is suggested to test the e-module with a larger and more diverse group of students, improve its learning activities, and examine its long-term impact on students' mathematical understanding and reasoning abilities.

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