

Innovative Ethno-Realistic Mathematics-based modules: Promoting Pancasila values in Indonesian mathematics education

Nur Ika Pujiastuti¹, Rully Charitas Indra Prahmana^{1,2,*}, Brian Evans³

¹Mathematics Education Department, Universitas Ahmad Dahlan, Yogyakarta, Indonesia

²Ethno-Realistic Mathematics Education Research Center, Universitas Ahmad Dahlan, Yogyakarta, Indonesia

³Department of Mathematics Education, Pace University, New York, United States

*Email: rully.indra@mpmat.uad.ac.id

Abstract

The teaching of mathematics in Indonesia faces notable challenges, particularly in effectively conveying mathematical concepts to students. This has created a need for instructional modules that provide better support for learners. Current modules, however, do not adequately incorporate the Pancasila Students Profile (PSP), especially in terms of fostering critical reasoning skills. Therefore, there is an urgent demand for alternative instructional materials based on the Ethno-Realistic Mathematics Education (Ethno-RME) approach, which aligns with the competencies outlined in the PSP—a framework grounded in the nation's foundational values—and connects learning with students' daily experiences. This study aims to develop an Ethno-RME-based module that is valid, practical, and effective in enhancing students' critical reasoning abilities. The research adopts a design research methodology of the development studies type, structured into two key phases: preliminary and formative evaluation. Data collection methods included the use of assessment sheets, walkthroughs, document analysis, and tests of students' critical reasoning skills. The study was conducted with 22 eighth-grade students at a private secondary school in Yogyakarta. The results indicate that the Ethno-RME-based module is both valid and practical, with promising potential to improve students' critical reasoning. Specifically, the module received high validity ratings, with the material scoring an average of 165 out of 175 and the media quality receiving 129 out of 135. The one-to-one evaluation phase produced an average score of 74 out of 75. During the small group trial, the module achieved an average student response score of 66.33 out of 75, and in the field test stage, it scored an average of 64.45 out of 75, confirming its practicality. Furthermore, the second stage of the field test revealed a positive effect on critical reasoning. These findings demonstrate the efficacy of the Ethno-RME-based module in enhancing the critical reasoning skills of students in accordance with the Pancasila Student Profile.

Keywords: Design Research, Development Studies, Ethno-RME, Module, Pancasila Students Profile

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INTRODUCTION

Mathematics education in Indonesia encounters significant challenges, particularly in the instruction of probability concepts at the middle school level (Beatty et al., 2021). Students often struggle with comprehending foundational and abstract concepts, as well as interpreting questions related to chance (Thompson & Harel, 2021). A comprehensive study involving 40,000 students from 360 primary and secondary schools, conducted over two consecutive years (2011 and 2012), revealed that approximately 40 percent of students failed to master basic arithmetic after three years of schooling, indicating that learning outcomes did not align with curriculum expectations (Beatty et al., 2021). The rapid advancement of technology necessitates that students cultivate critical and creative thinking skills to navigate and address increasingly complex problems (Tolla & Jabu, 2022). However, traditional teaching methods often fall short, as they frequently fail to bridge the gap between theoretical knowledge and practical real-world applications (Risdiyanti et al., 2024). Consequently, adopting more innovative approaches may be crucial in enhancing students' understanding of intricate concepts like probability and their real-world applications.

A needs analysis conducted by researchers in 2022 at a private secondary school in Yogyakarta aimed to explore innovative strategies to enhance students' comprehension in mathematics. The results revealed several inadequacies in the eighth-grade mathematics curriculum, particularly concerning probability concepts. Students encountered difficulties in understanding these concepts, primarily due to the lack of contextualized problems that incorporate local cultural perspectives. Moreover, the curriculum was found to be deficient in tasks that promote critical reasoning. The prevalent use of traditional teaching methods and over-reliance on extensive textbooks were also identified as contributing factors to student disengagement (Beatty et al., 2021). In contrast, a study by Utami and Pramudiani (2024) demonstrated that integrating a traditional game-based learning design, specifically the Damdas 3 Batu game, significantly improved students' critical thinking abilities.

In response to the challenges associated with teaching probability, this study seeks to develop innovative solutions through the introduction of a probability module grounded in the Ethno-Realistic Mathematics Education (Ethno-RME) approach. This method aims to enhance students' critical reasoning abilities, a key component of the Pancasila Students Profile (PSP). The PSP aligns with Indonesia's educational philosophy, which emphasizes lifelong learning and the cultivation of global citizenship (Susanti et al., 2023; Utami et al., 2024). It advocates for fostering critical reasoning, creativity, and an appreciation of global diversity, which play a vital role in shaping students' identities and attitudes (Ahmadi et al., 2021). One of the core elements of the PSP is critical reasoning, which encompasses the capacity to critically process, analyze, and evaluate data, leading to informed conclusions (Kemendikbud Ristek, 2021). Additionally, it reflects the character traits and competencies that students are expected to develop, grounded in the fundamental values of Pancasila, which serves as the state's ideological foundation.

Ethno-RME integrates local cultural elements, traditional games, folklore, and other indigenous knowledge into mathematics instruction (Prahmana, 2022). This integration makes learning more relevant and engaging for students (Prahmana et al., 2023). By embedding probability theory within familiar contexts like traditional games such as *Hompimpah*, this module not only enriches mathematical learning but also fosters cultural appreciation among students. The Ethno-RME-based module is expected to address these problems.

Previous studies have investigated the integration of cultural elements into mathematics education; however, there has been no specific focus on probability learning through the Ethno-RME framework at the middle school level, particularly with an emphasis on developing critical reasoning skills aligned with the PSP (Mendrofa et al., 2022; Fiantika et al., 2023; Utami et al., 2024). Additionally, research by Yusuf et al. (2024) highlighted three key challenges in solving probability word problems: a lack of understanding of essential terms, unfamiliarity with probability concepts, and difficulty in identifying the problem's objective. These obstacles significantly impede students' ability to apply correct terminology and strategies effectively.

This study seeks to address this gap by designing an innovative Ethno-RME-based probability module tailored to middle school students, thereby offering new insights into effective pedagogical strategies that connect cultural contexts with mathematical learning (Hariastuti et al., 2022; Khasanah

et al., 2023; Nurmaningsih et al., 2024; Pangestuti et al., 2024). Developing a probability module through the Ethno-RME approach is crucial as it enhances the relevance, engagement, and contextualization of learning for students.

Incorporating local cultural heritage and Pancasila values into mathematics education, this research seeks to address the following question: To what extent does the Ethno-RME-based probability module, oriented towards critical reasoning as defined in the PSP, impact students' reasoning abilities? The objective of this inquiry is to assess the effectiveness of the Ethno-RME-based probability module in fostering critical reasoning skills in alignment with PSP standards. Consequently, the development of this module represents a viable strategy for addressing challenges in mathematics education at a private secondary school in Yogyakarta, particularly by enhancing students' critical reasoning skills through an Ethno-RME framework. Moreover, improving students' reasoning abilities better prepares them to face global challenges (Nasir et al., 2008; Tai, 2022).

METHODS

This study employs a design research methodology within the framework of development studies, with the objective of designing and validating interventions that enhance critical reasoning skills in alignment with the PSP. Design research is geared towards the development of innovations that address educational challenges, such as increasing student engagement and validating theoretical frameworks in education (Jacobsen & McKenney, 2023). The primary aim of this research is to develop an Ethno-RME module with a specific focus on the topic of probability.

The development process follows two main stages: a preliminary evaluation, which encompasses the initial analysis and design, and a formative evaluation, which involves iterative testing and refinement (Tessmer, 1993; Zulkardi, 2002). The iterative refinement process is illustrated in Figure 1, which outlines the formative evaluation design flow and serves as a guide for the ongoing development of the module.

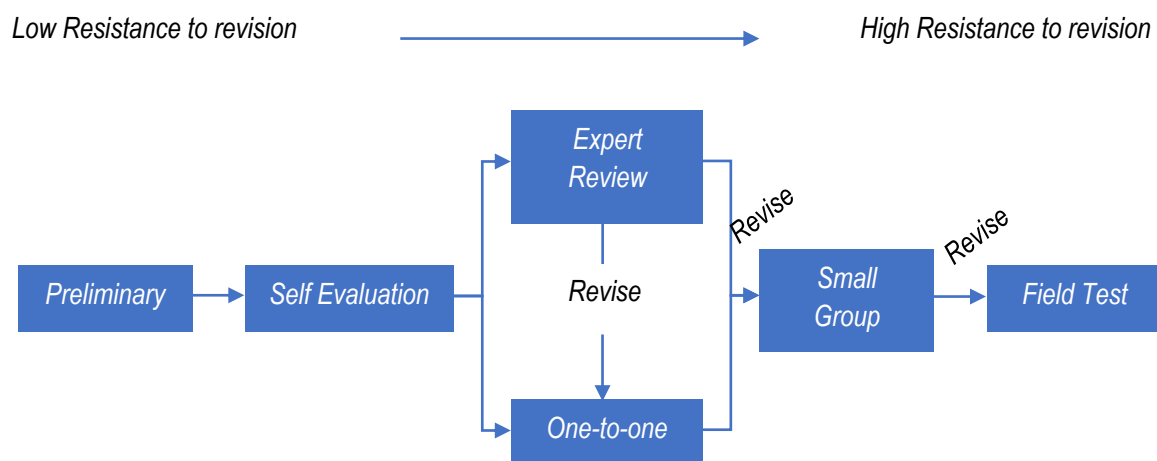


Figure 1. Formative evaluation design flow

The study engaged 22 eighth-grade students from a private secondary school in Yogyakarta. Data collection occurred across multiple stages. Initially, document analysis during the preliminary stage provided critical insights for the module's development. This phase involved integrating content on probability, learning outcomes, instructional objectives, and quality assessment tools in accordance with the independent curriculum and Ethno-RME principles.

The subsequent stages of the research involved validation through expert reviews and one-on-one sessions. These sessions were supplemented by interviews and tests, conducted across individual, small group, and field test settings, each addressing distinct research objectives. The one-to-one phase was dedicated to evaluating Prototype I, while the small group stage was utilized for refining Prototype II. The field test phase aimed to assess the module's potential impact on students' critical reasoning skills, as framed by the PSP.

Data analysis was conducted to determine both the practicality and potential effectiveness of the intervention. The validation process included feedback from subject matter and media experts, which was analyzed using a Likert scale ranging from 1 to 5. The module's validity was established based on predefined criteria, ensuring a comprehensive evaluation following the completion of testing phases.

RESULTS AND DISCUSSION

The research was conducted in a systematic manner, encompassing several key stages: analysis, design, and prototyping. Each stage involved a comprehensive approach that included self-evaluation, expert review, one-to-one assessments, small group evaluations, and field testing. These methodologies were employed to refine the development of the probability module, grounded in the principles of Ethno-RME. The primary objective of this module is to enhance critical thinking skills in alignment with the PSP, effectively integrating cultural values into mathematics education. Through a process of iterative refinement and rigorous evaluation across multiple stages, this research endeavors to assess the efficacy of the Ethno-RME-based probability module and its potential impact on fostering critical reasoning skills as outlined in the PSP.

The study underscores the significance of methodological rigor in the development of the module, particularly within the Ethno-RME framework. By assimilating diverse feedback derived from self-assessment, expert evaluations, and practical experimentation, this research enhances the instructional design of the probability module. This approach not only aligns with educational standards but also adheres to the cultural principles embedded within the PSP. The iterative process of analysis, design modifications, and prototyping demonstrates the study's commitment to advancing educational outcomes through innovative pedagogical strategies that are deeply rooted in local contexts and values. Consequently, this research contributes to the broader discourse on effective practices in mathematics education.

Preliminary Stage

During this phase, meticulous analysis and design activities were conducted. The researcher

performed comprehensive literature reviews, assessed student needs, evaluated the curriculum, and designed assessment tools that aligned with the established curriculum framework. The module was carefully developed to integrate probability content, Learning Outcomes (LOu), Learning Objectives (LOb), and high-quality assessment instruments, all tailored to the principles of Ethno-RME. This systematic approach ensured that the module not only addressed essential educational objectives but also closely adhered to cultural and contextual considerations, thereby enhancing its relevance and effectiveness in facilitating student learning and development.

The analysis revealed several critical needs within the educational context. Firstly, students exhibited significant difficulties in comprehending and analyzing probability, which indicated challenges in applying logical reasoning to these concepts. Secondly, there was a conspicuous lack of contextualized problem-solving approaches that were grounded in local cultural perspectives within teaching practices. Thirdly, the necessity to enhance students' critical thinking abilities emerged as a vital area for improvement. Fourthly, the instructional materials utilized by educators were found to inadequately foster students' mathematical literacy, revealing a gap in the effectiveness of available resources. Lastly, teachers' tendencies to prioritize rapid completion of syllabus content, often relying on dense and uninspiring textbooks, highlighted the need for more engaging and pedagogically sound instructional methods. These findings underscored the urgent requirement for targeted interventions to address these multifaceted challenges and improve the overall quality of mathematics education.

In response to these identified challenges, the researcher developed targeted solutions. This initiative culminated in the creation of a probability module based on Ethno-RME. The module's design specifically aimed to enhance students' critical reasoning skills, aligning closely with the fundamental principles of the PSP. This strategic approach sought to integrate cultural perspectives and contextualized learning experiences, fostering a deeper understanding of probability concepts among students and effectively addressing the identified educational needs.

Formative Evaluation Stage

In this stage, the researchers implemented a series of sequential steps, which included self-evaluation, expert review, one-to-one evaluation, small group evaluation, and field test. The formative evaluation phase comprised several critical components:

1. Self-Evaluation

During this phase, the researchers conducted a thorough evaluation of the Ethno-RME probability module, concentrating on the content, structure, and linguistic elements. This critical assessment aimed to identify and rectify typographical errors, inappropriate word choices, and conceptual deficiencies that may have emerged during the module's development. By systematically reviewing each component—from mathematical content to language clarity—the researcher ensured that the module was aligned with educational standards and culturally relevant, thereby enhancing its effectiveness in

fostering students' critical thinking skills.

The evaluation process progressed through multiple stages, commencing with self-assessment and followed by expert reviews, one-to-one evaluations, small group assessments, and rigorous field testing. Each step within the formative evaluation phase was designed to validate the module's educational value and refine its instructional design. Through iterative refinement based on feedback from various evaluation methods, the researcher aimed to optimize the module's instructional efficacy and relevance within the Ethno-RME framework. This meticulous approach not only sought to enhance the module's educational impact but also underscored the researcher's commitment to integrating cultural perspectives and improving students' mathematical reasoning abilities in alignment with the PSP.

2. Expert Reviews

In this phase, expert reviews were conducted to evaluate the validity of Prototype I against predefined criteria. The validation process involved both face-to-face meetings and email correspondence. Specifically, a face-to-face validation session was held on Saturday, January 6, 2024, with Expert 1, a Mathematics Education lecturer at Universitas Ahmad Dahlan. Feedback and suggestions were collected using product quality assessment sheets from subject matter experts, media experts, student and teacher responses, as well as the critical reasoning assessment instrument aligned with the PSP. Based on these evaluations, it was concluded that while revisions were necessary for the assessment sheets, they were ultimately deemed "suitable for use" following the modifications.

After revising and confirming the product quality assessment sheets, the subsequent step involved the validation of Prototype I of the module. This validation was conducted by Ethno-RME expert validators (Expert 2) and the Curriculum Deputy Head, in conjunction with mathematics teachers (Expert 3). The results from the subject matter expert validators regarding Prototype I are detailed in [Table 1](#).

Table 1. Results of questionnaire on material quality criteria

No	Validator	Score	Criteria
1	Expert 2	156	Very Good
2	Expert 3	174	Very Good
	Total Score	330	
	Average Score	165	Very Good

[Table 1](#) indicates that the average score from both validators is 165. This score comprises 156 from Validator 1 and 174 from Validator 2. The average score reflects "very good" criteria. The classification of scores is as follows: scores less than or equal to 63 receive "very less" criteria; scores between 63 and 91 are rated as "less"; scores from 91 to 119 are considered "sufficient"; scores from 119 to 147 receive "good" criteria; and scores greater than 147 are classified as "very good." This classification is based on the theoretical framework established by Widoyoko (2009). Comments and suggestions from expert validators are presented in detail in [Table 2](#).

Table 2. Comments and suggestions

No	Comments and Suggestions
1	The material aligns with LOu and LOB. Clarification is needed to differentiate LOB from the flow of LOB, which represents LOB arranged in a cohesive phase. The current arrangement of LOB aids students in developing expected critical thinking skills; however, attention should be given to the operational verbs used in LOB to ensure measurability. Each exercise in the module should incorporate operational verbs specified in LOB.
2	The module's language adheres to good writing conventions. Nevertheless, a review of sentence structure is recommended to rectify a few remaining typographical errors and minor issues.
3	Concepts are presented sequentially, progressing from simple to complex, concrete to abstract, and easy to difficult.
4	Problem examples are appropriate for the learning activities presented.
5	The material and problems incorporate decision-making elements in critical thinking skills. However, some steps in the problem-solving descriptions, particularly in Learning Activities 1-3, do not fully elucidate the step-by-step critical thinking process aligned with the Ethno-RME approach.
6	Descriptions, exercises, and examples effectively encourage students to analyze problems thoroughly.

These comments and suggestions provide valuable insights for further refining the module to enhance its instructional effectiveness and alignment with the Ethno-RME principles. Additionally, assessments conducted by media experts are detailed in [Table 3](#).

The average score from both validators in [Table 3](#) is 129 out of a possible 135, indicating excellent adherence to the criteria. Consequently, the developed RME-based module is considered valid. Comments and suggestions provided by media experts are listed in [Table 4](#). These suggestions offer valuable insights for enhancing the module's visual presentation and overall coherence, thereby improving its effectiveness in educational settings aligned with the Ethno-RME principles.

Table 3. Media expert assessment scores

No	Validator	Score	Criteria
1	Expert 3	129	Very Good
	Total Score	129	Very good

Following extensive feedback and recommendations from expert reviews, significant refinements were made to various components of the module. Notably, in the introduction of Prototype I, the researcher responded to expert insights by strategically revising the layout. Adjustments included repositioning the author's name on the title page to prevent any overlap with the program name, as highlighted in the enhanced title layout illustrated in [Figure 2](#).

The revisions emphasized the module's commitment to integrating feedback from expert assessments, ensuring meticulous attention to detail in enhancing visual clarity and professional

presentation. By addressing these recommendations, the introduction of Prototype I was fortified, aligning more closely with standards of clarity and aesthetic coherence. These refinements aimed to optimize the module's initial impression and facilitate clearer identification of key elements, thereby enhancing its overall effectiveness in educational contexts aligned with the Ethno-RME principles.

Table 4. Media expert comments and suggestions

No	Comments and Suggestions
1	For the back cover, consider slightly reducing the author's photo size.
2	Reposition the author's name to avoid overlap with the program name.
3	Concepts should be presented in a progressive sequence from easy to difficult, concrete to abstract, and simple to complex.
4	The font color on the Table of Contents is not sufficiently clear or contrasting in black.
5	Adjust the size of the girl in the image to ensure proportionality with the boy students. Consider using a different color for the "Example" text instead of red.
6	Ensure consistency in page design throughout the module.

Following the expert review, significant improvements were implemented in the module, particularly regarding the Table of Contents and the consistency of student images. The researcher enhanced the Table of Contents to improve color contrast, ensuring better alignment with the overall design of the module pages. Additionally, adjustments were made to maintain uniformity in the student image across all pages. These refinements are clearly illustrated in Figure 3, showcasing the updated and improved presentation.

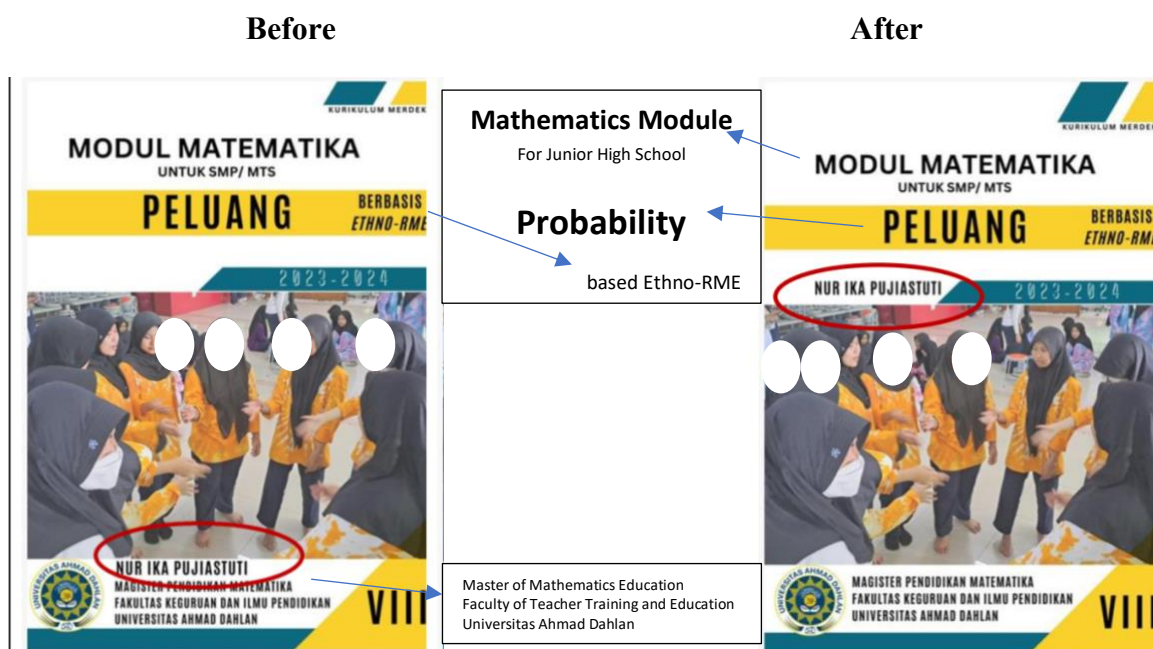


Figure 2. Revised title section

These enhancements reflect the module's responsiveness to expert feedback, aiming to improve

visual clarity and consistency throughout its layout. By refining the Table of Contents and ensuring uniformity in the depiction of student images, the module now offers enhanced navigational clarity and aesthetic cohesion. These changes are pivotal in aligning the module's design with educational standards and optimizing its usability within the framework of Ethno-RME, thereby enhancing its effectiveness in supporting student learning and engagement.

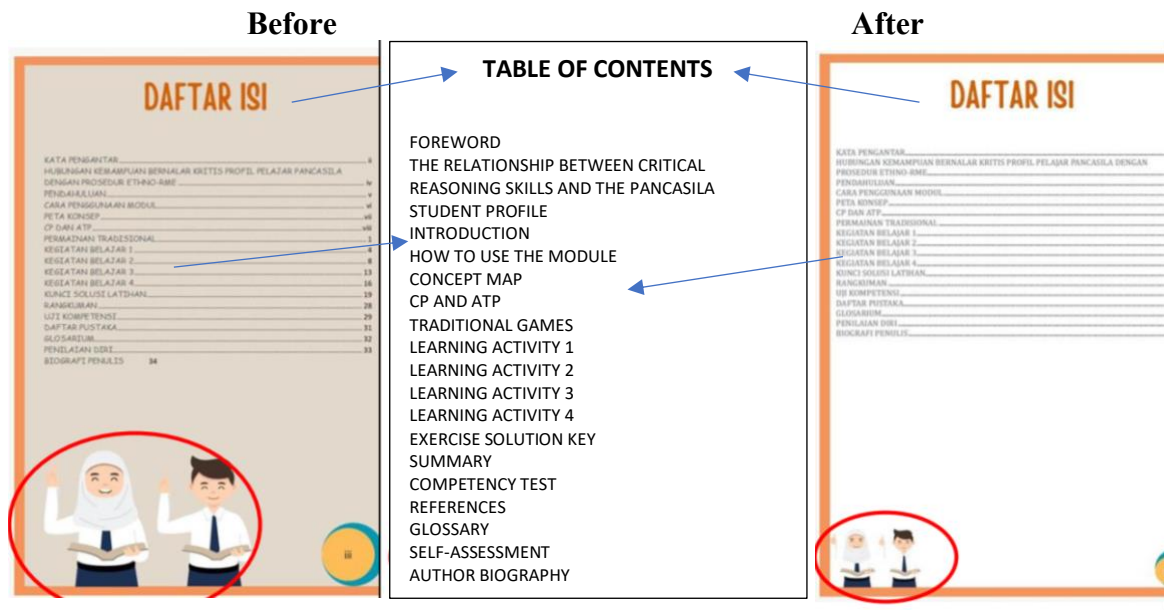


Figure 3. Module color contrast revision

In addition, following the expert review, the text "Example," which was previously colored red, has been updated to blue. This adjustment is highlighted in Figure 4, illustrating the enhanced presentation within the module.

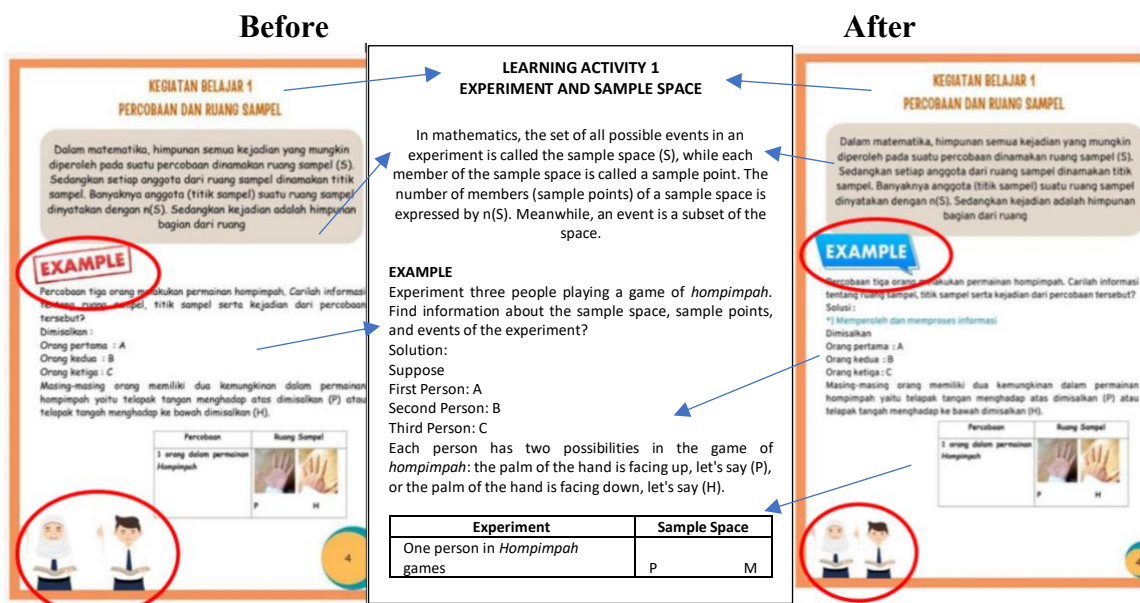


Figure 4. Revision of shape, color, size, proportion of objects to match reality

This change aligns with feedback aimed at improving visual clarity and consistency in

instructional materials. By transitioning the text color to blue, the module now maintains a more cohesive aesthetic while ensuring readability and alignment with educational standards. These refinements underscore the module's commitment to optimizing user experience and effectiveness, particularly in supporting the Ethno-RME principles and enhancing student engagement.

The alignment of the module with LOB and the LOu, particularly concerning the comprehensiveness of probability content and its integration with LOB and their sequential arrangement, is illustrated in Figure 5 for Prototype I.

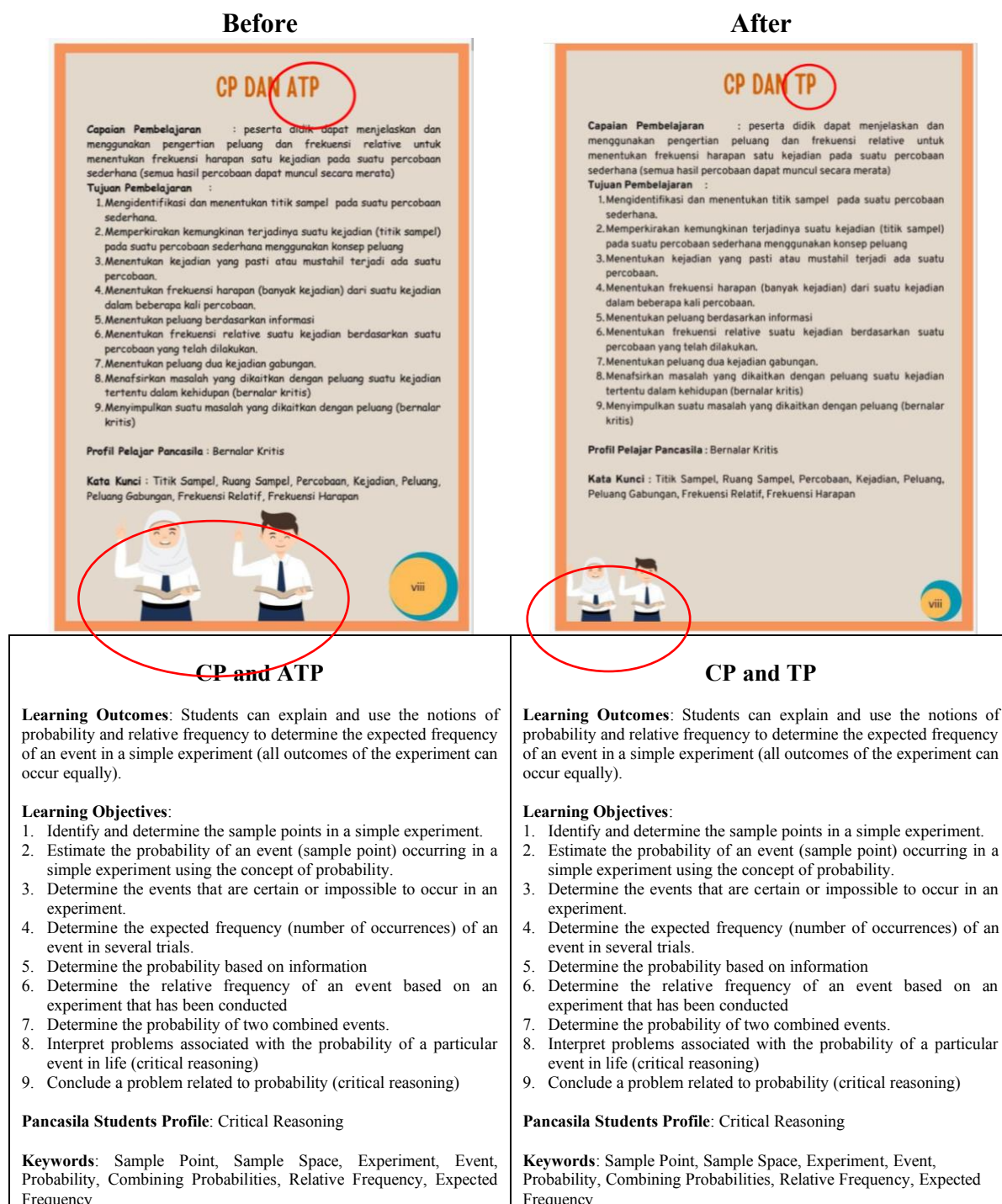


Figure 5. Revision of material adjustment with LOB and LOu

3. One-to-one

In this phase, Prototype II was administered to three students from class VIII-H at SMP Muhammadiyah 2 Yogyakarta, each representing different cognitive abilities. This session took place on March 8, 2024, enabling the researcher to observe challenges and gather responses from DA, AT, and MI as they interacted with the module. Table 5 outlines the students' feedback and suggestions regarding their experience. Insights from DA, AT, and MI provide valuable perspectives on the module's strengths and areas for improvement, contributing to ongoing refinements aimed at enhancing comprehensibility and engagement. This aligns more effectively with the diverse cognitive needs of students within the framework of Ethno-RME.

Table 5. Student comments and suggestions

No	Comments and Suggestions
1	The module is engaging, but there could be more illustrations.
2	Some of the language used is difficult to understand.

During this phase, students' feedback primarily focused on the desire for more visually appealing illustrations within the module and the need for clearer explanations for unfamiliar phrases. To address these insights, the researcher conducted one-to-one sessions, as illustrated in Figure 6.



Figure 6. Implementation of one-to-one sessions

The outcomes from this stage did not yield significant results; thus, the researcher proceeded to the next phase, which involved small group sessions. The results of the student response survey conducted during the one-to-one sessions are presented in Figure 7, where SO1 represents Student One-to-One 1, SO2 represents Student One-to-One 2, and SO3 represents Student One-to-One 3.

Figure 7 indicates that the average score from the one-to-one survey is 74. This score is derived from SO1 with a score of 73 (32.9%), SO2 with a score of 74 (33.3%), and SO3 with a score of 75 (33.8%). The average score of 74 signifies a high level of practicality and effectiveness in using the

module, categorized as "Very Good." These findings underscore the positive reception and utility of the module among students, supporting ongoing refinement and development to enhance the learning experience in alignment with the principles of Ethno-RME.

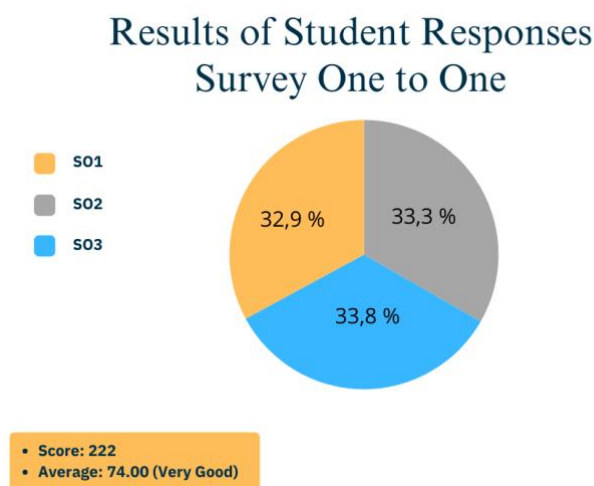


Figure 7. Results of student responses survey: One-to-One

4. Small Group

After incorporating improvements based on feedback from one-to-one sessions and expert reviews, the next phase focused on testing the module in small groups. Six students with varying abilities—two each categorized as high, moderate, and low—participated in this stage. The objective was to evaluate the module's readability and gather feedback from the small group before advancing to the field test phase.

During Learning Activity 4, which involved analyzing the frequency of expectations, students engaged with challenges related to expected frequencies in the traditional game of *Hompimpah*, employing multiple trial attempts. They adhered to a structured approach aligned with the critical thinking indicators outlined in the PSP. Details regarding the issues encountered and the outcomes of the students' work are presented in Figure 8.

Problems

LATIHAN YUK. 4

Permasalahan

1. Diketahui permainan hompimpah dengan empat pemain. Tentukan frekuensi harapan tiga orang saling menampilkan warna tangan yang sama jika total percobaan adalah 10 kali?
2. Diketahui dua anak melakukan suit. Tentukan frekuensi harapan dua anak tersebut menampilkan jari yang sama jika suit dilakukan sebanyak 5 kali?

Let's Exercise 4

Problems

1. Given a four-player game of *hompimpah*. Find the expected frequency of three players showing the same hand color to each other if the total number of experiments is 10?
2. Suppose two children make a suit. Find the expected frequency of two children showing the same finger if the suit is performed 5 times?

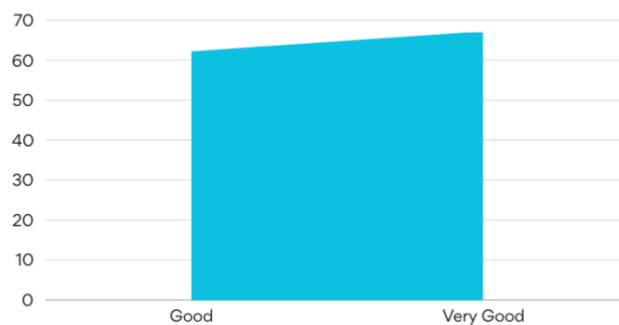
Student Work Results

The image shows handwritten student work on the left and a typed solution on the right. The handwritten work includes a problem statement in Indonesian about a game called 'hompjah' with 4 players (A, B, C, D) and a probability calculation for event K. The typed solution provides a formal answer, defining the sample space, event K, and calculating the probability $P(K) = \frac{8}{16} = \frac{1}{2}$. It then calculates the frequency of three players showing the same hand color as $Fh(K) = P(K) \times N = \frac{1}{2} \times 10 = 5$.

Figure 8. Student work results in small group stage

Students demonstrated a high level of comprehension of the instructions and successfully completed the module during the small group stage, underscoring its practicality and effectiveness. The researcher then administered a student response questionnaire to collect feedback from participants. The findings from this survey are detailed in [Figure 9](#).

Results of Student Responses Survey Small Group



Average: 66,33333 (Very Good)

Figure 9. Results of student responses survey (Small Group)

In [Figure 9](#), the average score of 66.33 reflects a "Very Good" level of practicality in the module's usage, highlighting its effectiveness among students. In addition to evaluating practicality, the researcher analyzed students' feedback and suggestions for enhancing Prototype II prior to advancing

to the field test stage. Based on input from the small group participants, further improvements were implemented on Prototype II. The module's usage instructions were clarified through the incorporation of additional guidance items to enhance student understanding. Furthermore, efforts were made to simplify the language used in various activities, particularly in sections where students found certain sentences or explanations of formulas challenging to comprehend.

The improvements made to Prototype II following the one-to-one and small group testing phases have culminated in what is now referred to as Prototype III. Qualitatively, Prototype III is deemed valid and practical based on feedback and suggestions, as well as the students' ability to effectively follow each instruction. Quantitatively, its validity and practicality are supported by questionnaire ratings that indicate a "Very Good" criterion. Prototype III will now proceed to the field test phase for further evaluation and refinement.

5. Field Test

In this phase, Prototype III was tested with 22 eighth-grade students from SMP Muhammadiyah 2 Yogyakarta, who participated in the study. The testing process was divided into two phases. The first phase involved observing how teachers integrated the module into their instructional practices. During this phase, the researcher acted as an observer, assisting teachers in clarifying sentences that students found challenging within the module.

Following the instructional phase, a survey was conducted among the students to assess the practicality of using the module and to gather recommendations for further improvements. The findings from this survey are presented in [Figure 10](#).

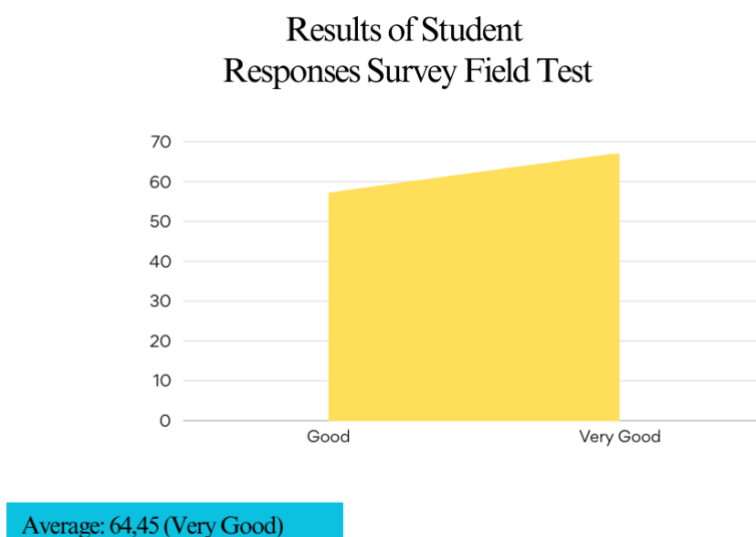


Figure 10. Results of student responses survey (Field Test)

As illustrated in [Figure 10](#), the results indicate that the module's practicality criteria during its usage in the field test class were rated as "Very Good." Following their experience with the probability module based on Ethno-RME, students provided feedback and suggestions, summarized in [Table 6](#).

Table 6. Student responses to the module in field test

No	Comments and Suggestions
1	The cover is very attractive and colorful.
2	The pictures are very appealing and well-done.
3	The cover could be improved further, although it's already good.
4	The sentences and paragraphs in this module are clear and easy to understand.
5	Very straightforward and easy to comprehend.
6	The text is clear and easy to read.

These responses highlight positive aspects such as the module's visual appeal and clarity of content while also suggesting areas for potential enhancement, particularly regarding the cover design. Overall, the feedback reflects a favorable reception among students, affirming the module's effectiveness in supporting learning objectives aligned with the principles of Ethno-RME.

The second phase of testing involved administering two critical thinking questions aligned with the PSP. The results obtained from the test are presented in the following bar diagram shown in [Figure 11](#).

TEST RESULTS OF CRITICAL REASONING ABILITY OF PANCASILA STUDENT PROFILE

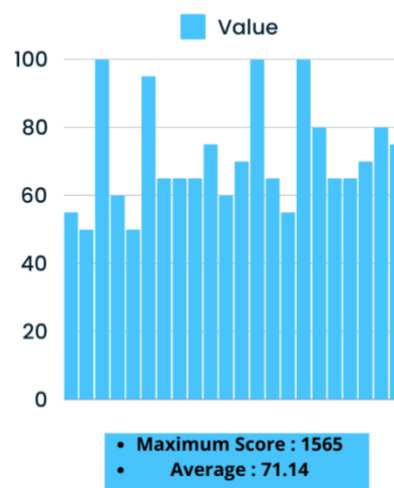


Figure 11. Test results of critical reasoning ability of PSP

As observed in [Figure 11](#), the impact of using the module on critical thinking abilities, as aligned with the PSP, reveals that among the 22 students assessed, the average score achieved was 71.14. This indicates that students generally exhibit a solid level of critical thinking skills, although there remains room for enhancement. Specifically, 10 students scored 70 or higher, demonstrating a strong proficiency in critical reasoning. Conversely, 4 students scored below 60, indicating a need for additional support to strengthen their critical thinking abilities. Furthermore, 8 students scored between 60 and 70, suggesting they are close to achieving higher proficiency with targeted assistance. Overall, while a majority of students show a good foundation in critical thinking, ongoing instructional efforts and

support can help all students maximize their potential in this area.

The development process of the Ethno-RME-based probability module progresses through two distinct stages: preliminary evaluation and formative evaluation. Rigorous evaluations at each stage have validated the module as effective and practical. Additionally, these assessments highlight the module's potential to enhance critical thinking abilities in alignment with the PSP.

During the preliminary evaluation stage, researchers conducted a thorough analysis of the curriculum, content, and students' learning characteristics to identify specific educational needs. The concept of probability was identified as crucial for students, as it forms a foundational basis for subsequent learning. However, many students encounter difficulties in grasping this concept. This finding aligns with the research by Minerva et al. (2022), which highlights common challenges faced by students related to probability, often stemming from inadequate familiarity with essential concepts like sample space and sample points. In response to these identified needs, the Ethno-RME-based probability module was structured into four comprehensive Learning Activities, namely Activity 1 focuses on "Experiments and Sample Space," Activity 2 on "Probability of an Event," Activity 3 on "Relative Frequency," and Activity 4 on "Expected Frequency."

The activities outlined in the results section are designed not only to address foundational concepts of probability but also to integrate principles of Ethno-RME (Prahmana, 2022). This approach enhances students' comprehension and application of probabilistic reasoning within real-world contexts. Through interviews with students and educators, alongside an analysis of educational documents, it was discovered that schools are implementing a curriculum that emphasizes the PSP, particularly focusing on critical thinking and global diversity. The integration of global diversity in mathematics education can be achieved through incorporating examples rooted in local wisdom (Sumarni et al., 2022). Therefore, teaching materials that connect mathematical content with cultural elements, such as traditional games, are crucial for making learning more meaningful (Adipat et al., 2021; Zeng et al., 2020; Yu et al., 2021). This supports Resa et al.'s (2023) claim that local wisdom is vital in integrating the independent curriculum to achieve the PSP. These insights formed the foundation for the researcher's development of the learning tool, referred to as Prototype I.

During the formative evaluation stage, Prototype I was thoroughly reviewed through a self-evaluation conducted by the researcher. This evaluation included the Ethno-RME-based probability module for Grade VIII students, expert material and media quality assessment sheets, student response questionnaires, and test questions designed to evaluate the module's potential impact on critical thinking aligned with the PSP. The module underwent expert reviews, one-to-one evaluations, and small group evaluations. Based on feedback from these expert reviews and individual evaluations, the module was deemed valid in both content and media, receiving a "Very Good" rating and subsequently progressing to Prototype II.

After Prototype II was established as valid and practical, the researchers conducted a small group observation to further assess its practicality. The practicality criteria were evaluated based on student

feedback regarding the presentation of the material, visual graphics, and the module's overall usefulness. In this stage, six students with varying cognitive abilities (high, moderate, and low) participated. Students were able to follow the instructions for each activity in the module with ease. Additionally, the contexts utilized in the module were familiar and easily understood by the students. The tools and materials provided for the module activities were also easily used by the students. Feedback and suggestions from this small group evaluation informed the revision of Prototype II, resulting in Prototype III, which was then validated and rated as practical with a "Very Good" rating.

Prototype III, having been validated and rated as practical, was then tested in a field setting. The field test consisted of two stages: the first involved direct observation of how teachers utilized the module in their instruction, and the second involved administering test questions to evaluate the module's impact on critical thinking abilities in alignment with the PSP.

In the first stage of the field test, teachers did not face significant challenges in implementing the module. The structure of the module adhered to the Ethno-RME framework (Prahmana et al., 2023), which included the following stages:

- a. Determining the Ethnomathematics Context: This stage involved adapting the traditional game of *Hompimpah* to the lesson.
- b. Exploring and Processing Information about the Ethnomathematics Context: Students gathered information from the traditional game of *Hompimpah*.
- c. Finding Mathematics in the Ethnomathematics Context: Mathematical problems, such as Probability, were introduced within the context of *Hompimpah*.
- d. Self-Development Modeling: Students addressed probability issues related to the game *Hompimpah* by exploring and solving various elements such as sample points, sample space, relative frequency, expected frequency, and event probability
- e. Critical Reflection as Assessment: In solving *Hompimpah* problems, students were required to reflect on their approaches, draw conclusions, and make informed decisions.

In the second stage of the field test, researchers administered a set of test questions to evaluate the module's impact on students' critical thinking abilities, as aligned with the PSP. The four critical thinking elements from the PSP—acquiring and processing information and ideas, analyzing and evaluating reasoning, reflecting on thinking processes, and making decisions (Saputro et al., 2023)—were the focus of this assessment. The results indicate that the majority of students were able to complete the tasks, corroborating the findings of Rabindran and Madanagopal (2020), who suggest that middle school students, particularly those between the ages of 11 and 15, show significant improvement in critical thinking skills and can be considered proficient in this area.

The first critical thinking element, acquiring and processing information and ideas (Maulida et al., 2024), was assessed using questions a and b. Question a asked students to identify the information they gathered from the problem, while question b inquired whether the problem involved any

probability. On this element, most students successfully completed the tasks, demonstrating their ability to process information effectively.

The next critical thinking element, analyzing and evaluating reasoning (Mahtum et al., 2023), was evaluated through question c, which asked students to address the issues presented in the problem. However, not all students were able to solve this task effectively. This is consistent with Piaget's cognitive development theory, which posits that children between the ages of 11 and 15 are primarily capable of analysis and hypothesis formation (Ahmad et al., 2016). Furthermore, children in this age range use scientific reasoning (Träff et al., 2019), but the eighth-grade students in this study, with an average age of 11-15, were found to possess only analytical capabilities.

The third critical thinking element, reflecting on thinking processes, was assessed through question d, which asked students to determine the best approach to resolve the problem. Here, again, not all students demonstrated proficiency in effectively solving the problem, reflecting their developmental stage in cognitive skills (Saputro et al., 2023).

The final critical thinking element, making decisions (Nurhayati et al., 2022), was examined through question e, which required students to solve the problem based on the gathered information and justify their reasoning. Most students struggled with this element, indicating that they have not yet fully developed decision-making skills at this level.

Overall, the Ethno-RME-based probability module demonstrated potential for enhancing students' critical thinking abilities in alignment with the PSP at the junior high school level. However, despite the module's effectiveness in fostering critical thinking, not all students were able to successfully complete tasks involving analysis, reasoning, and decision-making. Cognitive development during adolescence, particularly at the junior high school level, represents a peak in the maturation of critical thinking abilities (Ren et al., 2020; Bağ & Gürsoy, 2021). According to Piaget's developmental stages, children aged 11 to 15 exhibit operational thinking but are not yet proficient in theoretical thinking, hypothesis formulation, or decision-making, which typically develops between the ages of 16 and 19 (Rabindran & Madanagopal, 2020).

CONCLUSION

This study successfully developed a probability module based on the Ethno-RME approach, with the primary aim of enhancing the critical thinking skills of eighth-grade students in alignment with the PSP framework. The results indicate that the module is both valid and practical, as evidenced by its effectiveness in fostering critical thinking. Additionally, the module demonstrated significant potential in improving students' critical thinking abilities, particularly in relation to the key competencies outlined in the PSP.

The developed module followed by the Ethno-RME framework, which incorporated several stages, namely Determining the Ethnomathematics Context, wherein the traditional game of *Hompimpah* was

integrated into the lesson; Exploring and Processing Information, where students gathered insights from the game to better understand its mathematical aspects; Identifying Mathematical Concepts, in which probability concepts were introduced through the context of *Hompimpah*; Self-Development Modeling, where students engaged with probability topics such as sample points, sample space, relative and expected frequency, and event probability within the game context; and Critical Reflection, where students were tasked with reflecting on their problem-solving approaches, drawing conclusions, and making informed decisions. This structured approach proved to be effective in not only teaching probability but also promoting deeper analytical skills through culturally relevant contexts.

Based on the findings of this study, several recommendations are proposed for educators, researchers, and practitioners focused on the development of Ethno-RME-based instructional materials. First, clear and consistent communication between researchers and teachers is essential to ensure proper alignment and clarity in the implementation of such modules. Additionally, the incorporation of a variety of question types and the broader application of Ethno-RME principles across diverse mathematical topics are crucial strategies for enhancing the learning experience. The preliminary results of this study suggest that the module holds promise for wider use in educational settings.

Future research should investigate the application of Ethno-RME in different cultural contexts and explore its integration into a broader range of mathematical topics. Such studies could contribute to the development of more comprehensive and engaging instructional modules, ultimately enriching students' learning experiences and fostering deeper understanding in mathematics.

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