

DEVELOPMENT OF A REALISTIC MATHEMATICS EDUCATION (RME)-BASED LEARNING MODULE ON SOCIAL ARITHMETIC TO ENHANCE STUDENTS' MATHEMATICAL LITERACY

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ABSTRACT This study addresses the low level of students' mathematical literacy, which is partly attributed to the limited availability of teaching materials that explicitly support the development of mathematical literacy skills. The study aimed to develop a learning module based on Realistic Mathematics Education (RME) on the topic of social arithmetic that is valid, practical, and effective in improving students' mathematical literacy skills. The study employed a research and development approach using the 4-D model, consisting of the define, design, develop, and disseminate stages. The participants were seventh-grade students of SMP Negeri 2 Binjai. The results indicate that the developed module achieved a validity level of 93.48% (very valid) based on expert review and one-to-one evaluation, a practicality level of 86.01% (very practical) in the small-group trial and 86.96% (very practical) in the field test, and demonstrated effectiveness as reflected in the significant difference in posttest mean scores between the experimental and control classes. Furthermore, the improvement in students' mathematical literacy skills, measured using the N-gain index, showed a high category in the experimental class (0.7012) and a medium category in the control class (0.4029). These findings indicate that the RME-based learning module is suitable for use as instructional material to enhance students' mathematical literacy skills, as it fulfills the criteria of validity, practicality, and effectiveness.

Keywords: Realistic Mathematics Education, learning module, mathematical literacy, social arithmetic

ABSTRAK Penelitian ini dilatarbelakangi oleh rendahnya kemampuan literasi matematis peserta didik yang salah satunya disebabkan oleh keterbatasan bahan ajar yang secara khusus mendukung pengembangan literasi matematis. Penelitian ini bertujuan untuk mengembangkan modul pembelajaran berbasis Realistic Mathematics Education (RME) pada topik aritmatika sosial yang valid, praktis, dan efektif dalam meningkatkan kemampuan literasi matematis peserta didik. Metode yang digunakan adalah penelitian dan

pengembangan dengan model 4-D yang meliputi tahap define, design, develop, dan disseminate. Subjek penelitian adalah peserta didik kelas VII SMP Negeri 2 Binjai. Hasil penelitian menunjukkan bahwa modul pembelajaran yang dikembangkan memiliki tingkat validitas sebesar 93,48% dengan kategori sangat valid berdasarkan tahap expert review dan one-to-one, tingkat kepraktisan sebesar 86,01% pada tahap small group dan 86,96% pada tahap field test dengan kategori sangat praktis, serta memenuhi kriteria keefektifan yang ditunjukkan oleh perbedaan rata-rata skor posttest antara kelas eksperimen dan kelas kontrol. Peningkatan kemampuan literasi matematis peserta didik yang diukur menggunakan indeks N-gain menunjukkan kategori tinggi pada kelas eksperimen (0,7012) dan kategori sedang pada kelas kontrol (0,4029). Dengan demikian, modul pembelajaran berbasis RME yang dikembangkan layak digunakan sebagai bahan ajar dalam pembelajaran matematika karena telah memenuhi kriteria valid, praktis, dan efektif.

Kata-kata kunci: Realistic Mathematics Education, modul pembelajaran, literasi matematis, aritmatika sosial

INTRODUCTION

The current educational system in Indonesia has implemented the Merdeka Curriculum, which emphasizes the development of students' cognitive abilities so that learners are able to think critically and analytically. One of the core competencies promoted in this curriculum is mathematical literacy (Naufal & Amalia, 2022). Mathematical literacy is a fundamental objective of mathematics learning within the Merdeka Curriculum, where instructional processes are directed toward strengthening students' literacy skills. The Organisation for Economic Co-operation and Development (OECD, 2018) defines mathematical literacy as an individual's capacity to formulate, use, and interpret mathematics in various contexts to describe, predict, and explain phenomena. Therefore, mathematical literacy is an essential competence that students are expected to master (Ayunis & Darisno, 2022).

However, the importance of mathematical literacy is not yet aligned with the actual achievement of Indonesian students. The results of PISA 2022 indicate that Indonesia ranked 68th out of 81 participating countries, with an average mathematics literacy score of 360 (Ministry of Education, Culture, Research, and Technology, 2023). This result shows that Indonesian students' mathematical literacy skills remain below those of many other countries. Previous studies have also consistently reported that students' mathematical literacy in Indonesia is relatively low (Eidimuslim et al., 2019; Putri et al., 2020). This low level of mathematical literacy is largely attributed to students' difficulties in analyzing, interpreting, and representing problem-solving processes related to real-world situations (Safitri et al., 2020; Hidayatulloh et al., 2021; Sari et al., 2023). Empirical findings at SMP Negeri 2 Binjai further support this condition, where students were given mathematical literacy test items at levels 1 and 4. The results showed that out of 32 students, only 14 were able to correctly solve level 1 items, and only 8 students successfully solved

level 4 items. These findings indicate that students' mathematical literacy skills still require serious improvement.

Based on the researcher's observations, one contributing factor to this condition is the limited learning resources that adequately support the development of mathematical literacy. According to Syawahid and Putrawangsa (2017), factors influencing mathematical literacy achievement include the quality and methods of instruction as well as the availability of appropriate learning media or teaching materials in schools. In addition, limited understanding of mathematical literacy concepts among teachers and students has resulted in the insufficient use of learning materials designed to foster these skills (Khikmiyah & Midjan, 2017). Therefore, systematic efforts are needed to improve students' mathematical literacy through innovations in teaching materials, one of which is the development of learning modules (Sholikin, 2019). Learning modules function as instructional materials that support independent learning and facilitate students' understanding of mathematics while enabling them to apply mathematical concepts in real-life contexts.

Along with the development of appropriate learning materials, the use of an effective instructional approach is also essential. Realistic Mathematics Education (RME) is recognized as an approach that effectively enhances students' mathematical literacy by emphasizing contextual problems and meaningful learning experiences (Babys, 2017; Hilaliyah et al., 2019). The use of RME-based learning modules is particularly important because such modules systematically facilitate the implementation of RME principles in classroom instruction. Previous studies have shown that learning modules developed using the RME approach have a positive impact on improving students' mathematical literacy skills (Istriana & Satianingsih, 2020; Hilaliyah et al., 2019; Putri et al., 2020). Consequently, the strong relationship between mathematical literacy and the RME approach provides a solid foundation for developing RME-based learning modules aimed at enhancing students' mathematical literacy.

Social arithmetic is one of the mathematics topics that is highly suitable for mathematical literacy development, as it is closely related to contextual and real-life problems encountered by students. However, previous studies on the development of RME-based learning modules have not explicitly focused on improving students' mathematical literacy skills. For example, Wati et al. (2024) developed RME-based social arithmetic teaching materials to facilitate mathematical reasoning skills but limited the evaluation to validity and practicality. Similarly, Hilaliyah and Sudiana (2019) developed an RME-based module to enhance students' mathematical literacy in social arithmetic, but the module was integrated with Islamic values and designed within the 2013 Curriculum framework. Other studies have also focused on developing RME-based teaching materials to support students' critical thinking skills without directly addressing mathematical literacy improvement (Zameza et al.,

2025). Therefore, this study focuses on developing a Realistic Mathematics Education (RME)-based learning module on the topic of social arithmetic to improve the mathematical literacy skills of Grade VIII junior high school students (SMP/MTs).

METHODS

This study employed a Research and Development (R&D) method aimed at developing a Realistic Mathematics Education (RME)-based learning module on the topic of social arithmetic to improve the mathematical literacy skills of Grade VIII SMP/MTs students. The research was conducted at SMP Negeri 2 Binjai during the 2024/2025 academic year. The research subjects consisted of students from classes VIII-1 and VIII-2. The development process followed the Four-D (4D) model, which includes four stages: define, design, develop, and disseminate. The overall development procedure of the learning module is illustrated in Figure 1.

At the define stage, an initial analysis was conducted to identify students' learning needs and characteristics. This stage included an analysis of students' characteristics, curriculum analysis, concept analysis, task analysis, and the formulation of learning objectives related to social arithmetic and mathematical literacy. The results of this stage served as the foundation for designing a learning module that aligns with students' needs and the principles of mathematical literacy.

The design stage focused on preparing the structure and format of the RME-based learning module. Activities at this stage included designing learning activities based on realistic and contextual problems, developing assessment instruments, selecting appropriate learning media, determining the module format, and preparing the initial draft of the learning module. The design emphasized the principles of Realistic Mathematics Education by linking mathematical concepts to students' real-life experiences.

The develop stage involved self-evaluation and expert validation to assess the feasibility of the developed learning module. Validation was conducted using validation instruments for the learning module and mathematical literacy test items. The level of validity of the learning module was determined based on the validity criteria presented in Table 1. The learning module was declared feasible for trial implementation if the validity score obtained exceeded 70.01%.

Table 1. Criteria of Learning Module Validity

Interval	Criteria
85% – 100%	Very Valid
70.01% – 85%	Valid
50.01% – 70%	Less Valid
1% – 50%	Not Valid

(Source: Sa'dun Akbar, 2013)

Revisions were carried out based on expert feedback until the learning module met the required validity criteria. After being declared valid, the module was implemented in a limited trial to examine its practicality.

The practicality of the learning module was measured using a student response questionnaire. The level of practicality was determined based on the practicality criteria presented in Table 2. The learning module was considered practical if the student response questionnaire score exceeded 70.01%.

Table 2. Criteria of Learning Module Practicality

Table 1. Criteria of Learning Module Validity

Interval	Criteria
85.01% – 100%	Very Practical
70.01% – 85%	Practical
50.01% – 70%	Less Practical
1% – 50%	Not Practical

(Source: Sa'dun Akbar, 2013)

The disseminate stage was conducted after the learning module met the criteria of validity and practicality. At this stage, the final version of the RME-based learning module was produced and implemented in classroom learning as a valid and practical instructional resource to support the improvement of students' mathematical literacy skills.

Data collection techniques used in this study included observations, interviews, documentation, questionnaires, and mathematical literacy tests. Observations and interviews were conducted during the preliminary stage to obtain information related to learning conditions and students' needs. Documentation was used to collect supporting data related to the module development process. Questionnaires were used to evaluate the validity and practicality of the developed module, while mathematical literacy tests were administered to measure students' learning outcomes after using the module.

FINDING AND DISCUSSION

At the define stage, the results of the initial and final analyses were obtained, including: (1) the implementation of learning under the Merdeka Curriculum at SMP Negeri 2 Binjai had not yet been optimal, and the availability of facilities and learning resources that support learning was still limited; (2) mathematics learning modules aligned with the Merdeka Curriculum had not yet been available at the school; and (3) the learning process was still dominated by lecture and assignment methods.

The analysis of students' characteristics showed that: (1) students had relatively low enthusiasm during the learning process; and (2) students' mathematical literacy skills

were low, as students had not yet been able to apply mathematical concepts and calculations effectively. Concept analysis resulted in module content oriented toward real-life contexts and students' experiences. Furthermore, task analysis involved formulating Learning Objectives (TP) derived from Learning Outcomes (CP) related to social arithmetic. Based on the specification of learning objectives, the intended learning outcomes to be achieved through the RME-based learning module were clearly defined.

At the design stage, the process began with preparing the research instruments, namely mathematical literacy test items, validation sheets, and student response questionnaires. The selected learning medium in this study was a learning module. The chosen module format consisted of a cover, foreword, table of contents, module description, prerequisite materials, learning objective flow, concept map, module usage instructions, Pancasila learner profile, concept map, learning activities containing (1) learning objectives, (2) guiding questions, (3) RME approach, (4) student worksheets, (5) competency tests, material summaries, final evaluations, answer keys, glossary, references, and author biography. Subsequently, the initial design of the learning module was developed according to the selected format components. Several displays of the initial learning module design are presented in Figure 1.



Figure 1. Several Displays of the Learning Module

The developed learning module was designed by integrating five characteristics of RME, namely: (1) understanding contextual problems, by presenting contextual problems that stimulate students' curiosity; (2) modeling, where students are given opportunities to represent problems and mathematical concepts by modeling problems into mathematical forms such as images, tables, diagrams, or concrete tools; (3) interconnection, by linking various mathematical concepts integratively within a single contextual problem; (4) student contribution (construction), by providing freedom for students to discover and develop their own strategies in

solving problems; and (5) interactivity, by encouraging students to actively discuss, collaborate, and exchange ideas in the classroom.

At the development stage, formative evaluation was conducted based on Tessmer's evaluation framework, which consists of five phases: self-evaluation, expert review, one-to-one, small group, and field test. During the self-evaluation stage, the module cover was redesigned to better align with the selected material and theme. The revised results were referred to as Prototype 1.

In the expert review stage, Prototype 1 was validated by three validators, specifically three mathematics education lecturers. The validators assessed the developed learning module by completing validation sheets. The average validation result of the learning module was 93.48%, categorized as *very valid*, while the average validation percentage of the mathematical literacy test items was 91.21%, also categorized as *very valid*. Several suggestions and comments from the experts were revised accordingly. The validation results of the learning module and the mathematical literacy test items are presented in Table 3 and Table 4, respectively.

Table 3. Results of Learning Module Validation

No	Aspect	Validator Scores			Percentage
		1	2	3	
1	Learning Module Appearance	22	23	24	91.67%
2	Language	16	14	16	95.83%
3	Presentation	36	36	29	91.67%
4	Quality of Content	40	44	38	92.42%
5	Mathematical Literacy	9	12	12	91.57%

The average validity percentage obtained was 93.48%, which indicates that the learning module falls into the very valid category.

Table 4. Validation Results of the Mathematical Literacy Test Items

No	Aspect	Validator Scores			Percentage
		1	2	3	
1	Learning Material	11	12	11	94.45%
2	Content	6	8	8	91.67%
3	Language	16	14	12	87.50%

The average validity percentage obtained was 91.21%, indicating that the mathematical literacy test items are categorized as very valid.

In addition to expert validation, the mathematical literacy test items were trialed with 32 Grade VIII students at SMP Negeri 2 Binjai to examine item validity, reliability, discrimination power, and difficulty level before being used in the study. The mathematical literacy test consisted of four items representing levels 1 to 4 of mathematical literacy. The validity results showed that item 1 had a good interpretation, while items 2, 3, and 4 had very good interpretations, indicating that all four items were valid. The reliability result was 0.65, categorized as high. The discrimination power of item 1 was classified as sufficient, while items 2, 3, and 4 were classified as good. According to Kadir (2015), test items can be used if they have sufficient, good, or very good discrimination power. The difficulty level analysis showed that item 1 was classified as easy, while items 2, 3, and 4 were classified as moderate. The results of each analysis are presented in Tables 6, 7, 8, and 9.

Table 6. Results of Instrument Validity Test

Item Number	Correlation	Validity Interpretation
1	0.887	Good
2	0.923	Very Good
3	0.937	Very Good
4	0.924	Very Good

Table 7. Results of Reliability Test

Correlation Coefficient	Correlation Level	Reliability Interpretation
0.65	High	Good

Table 8. Results of Discrimination Power Test

Item Number	Discrimination Index	Interpretation
1	0.33	Fair
2	0.41	Good
3	0.44	Good
4	0.42	Good

Table 9. Results of Difficulty Level Test

Item Number	Difficulty Index	Criteria
1	0.71	Easy
2	0.60	Medium
3	0.53	Medium

Item Number	Difficulty Index	Criteria
4	0.40	Medium

In line with expert validation, the learning module was also trialed with three Grade VIII students through a one-to-one evaluation. This stage aimed to assess readability and identify obstacles encountered when using the developed learning module. Students' responses indicated that the RME-based learning module greatly assisted them in learning, particularly in social arithmetic material, and facilitated problem-solving in daily-life contexts. Students showed high enthusiasm and motivation when learning using the module. The obstacles identified during the learning process were used by the researcher as input for improving the module. After revisions, the researcher decided to proceed to the small group stage. The overall revisions from the expert review and one-to-one stages were referred to as Prototype 2.

At the small group stage, Prototype 2 was tested on 10 Grade VIII students at SMP Negeri 2 Binjai with heterogeneous ability levels. This small group trial aimed to examine the practicality of the developed learning module. During this stage, the researcher acted only as an observer and interacted with students only when difficulties occurred. At the end of the learning process using the module, students were asked to complete a response questionnaire based on their opinions regarding the developed learning module. The results of the student response questionnaire in the small group trial are presented in Table 10.

Table 10. Results of Student Response Questionnaire (Small Group)

No.	Assessment Criteria	Average Percentage (%) of Student Responses	Category
1	Learning Module Appearance	87.49	Very Practical
2	Learning Module Content	85.12	Very Practical
3	Ease of Using the Module	85.41	Very Practical
Average		86.01	Very Practical

Table 10 shows that the average practicality result of the small group trial was 86.01%, indicating that the level of practicality of the learning module was categorized as *very practical*. Suggestions and feedback from the student response questionnaire were used as a basis for revising the learning module. The revised result at this stage was referred to as Prototype 3. Subsequently, Prototype 3 was tested in the field test stage to examine the potential effect of the learning module on students' mathematical literacy skills.

Prototype 3 was implemented in the field test stage using an experimental research design, specifically the Nonequivalent Control Group Design. This design involved an experimental class that learned using the developed learning module and a control

class that learned through conventional instruction without using the module. The selection of sample classes was based on recommendations from the mathematics teacher at SMP Negeri 2 Binjai, namely Class VIII-1 as the experimental class and Class VIII-2 as the control class, each consisting of 32 students. Before the intervention, both classes were given a mathematical literacy pretest to diagnose students' initial abilities. This is consistent with Firmansyah (2017), who stated that diagnosing students' initial abilities is necessary because prior knowledge is an important prerequisite for constructing new knowledge and determining learning improvement.

The pretest results showed no significant difference between the experimental and control classes, with a significance value (2-tailed) of $0.368 > 0.05$. Subsequently, the experimental class received learning using the developed RME-based learning module. Learning began with understanding contextual problems presented at the beginning of the lesson. During the learning process, the researcher acted as a facilitator guiding students to think critically and creatively. Students were then encouraged to create models to represent problems and mathematical concepts through tables. This modeling process helped students understand mathematical concepts both visually and abstractly. In the interconnection stage, students solved problems by linking them to previously learned materials to determine the most effective strategies. The researcher remained a facilitator throughout the learning process. In the construction stage, students used their previously developed strategies to solve the given problems. The final stage was interactivity, where student representatives presented their solutions in class. Classroom discussions involved idea exchange, concept clarification, and reinforcement of understanding through shared experiences. At the end of the lesson, students were asked to summarize what they had learned, and the researcher reinforced their responses.

At the end of the learning process in the experimental class, students completed a response questionnaire. The average student response score obtained was 86.96%, categorized as *very practical*. The results of the student response questionnaire in the field test stage are presented in Table 11.

Table 11. Results of Student Response Questionnaire in the Field Test Stage

No.	Assessment Criteria	Average Percentage (%) of Student Responses	Category
1	Learning Module Appearance	87.23	Very Practical
2	Learning Module Content	86.94	Very Practical
3	Ease of Using the Module	86.72	Very Practical
	Average	86.96	Very Practical

After completing learning on social arithmetic material, both the experimental and control classes were given a mathematical literacy posttest. The posttest results showed a significance value (2-tailed) of $0.000 < 0.05$, indicating a significant difference between the mathematical literacy abilities of students in the experimental class using the RME-based learning module and those in the control class receiving conventional instruction.

The pretest results show that the initial mathematical literacy abilities of students in the experimental and control classes were relatively comparable, with mean scores of 51.84 and 50.53, respectively, indicating similar baseline competencies prior to the intervention. After the implementation of the learning treatments, both groups demonstrated improvement; however, the experimental class exhibited a substantially higher posttest mean score (83.19) compared to the control class (71.84). This difference suggests that the use of the RME-based learning module contributed more effectively to enhancing students' mathematical literacy skills than conventional instruction. The greater increase observed in the experimental group indicates that learning activities grounded in realistic contexts and structured mathematical modeling foster deeper understanding and more meaningful learning outcomes. To quantitatively assess the magnitude of improvement and compare learning gains between the two groups, an N-Gain analysis was subsequently conducted. The results are presented in Tables 12 and 13.

Table 12. Recapitulation of Mathematical Literacy Test Results

	Experimental Class		Control Class	
	Pretest	Posttest	Pretest	Posttest
Mean	51.84	83.19	50.53	71.84
Maximum Score	33	90	61	80
Minimum Score	38	75	60	65

Table 13. N-Gain Test Results of Sample Classes

No.	Assessment Criteria	Improvement in Mathematical Literacy Skills	
		Experiment Class	Control Class
1	Mean	0,7012	0,4091
2	Minimum Score	0,45	0,18
3	Maximum Score	0,89	0,60

Based on Table 13, the average N-Gain score for the experimental class was 0.7012, categorized as *high*, while the average N-Gain score for the control class was 0.4091, categorized as *moderate*. These results indicate that students who learned using the RME-based learning module experienced greater improvement in mathematical literacy skills compared to students who used other learning materials. This finding

is consistent with Sholikin (2021), who reported that students using RME-based learning modules showed higher improvement in mathematical literacy skills compared to those using other modules.

Based on the N-Gain analysis, it can be concluded that the RME-based learning module on social arithmetic is effective in improving students' mathematical literacy skills. Furthermore, based on the results obtained from the small group and field test stages, the RME-based learning module on social arithmetic for improving the mathematical literacy skills of Grade VII SMP/MTs students is valid, practical, and effective, and feasible to be used as a learning resource in the instructional process. Overall, the RME approach is capable of improving students' mathematical literacy skills. These results are in line with previous studies stating that the RME approach improves mathematical literacy skills (Mangelep & Kaunang, 2018; Sholikin, 2021; Heriyadi & Prahmana, 2020). Thus, this study adds empirical evidence supporting the potential of RME-based learning modules to enhance students' mathematical literacy skills and contribute positively as learning resources.

At the disseminate stage, the validated, practical, and effective learning module was distributed to the participating school so that it could be used in learning activities and serve as a reference for teachers in developing learning modules for other mathematical topics.

CONCLUSIONS AND RECOMMENDATIONS

This development research produced a learning module based on Realistic Mathematics Education (RME) on the topic of social arithmetic, designed to improve the mathematical literacy skills of Grade VIII SMP/MTs students. The results indicate that the developed module meets the criteria of being valid, practical, and effective. The validity evaluation showed an average score of 93.48%, categorized as *very valid*, based on the expert review and one-to-one stages. In terms of practicality, the module achieved an average score of 86.01% (*very practical*) in the small group stage and 86.96% (*very practical*) in the field test stage, indicating that the module is easy to use and well accepted by students.

The effectiveness of the module was demonstrated by the difference in posttest mean scores between the experimental and control classes, as well as by the improvement in students' mathematical literacy skills measured using N-Gain analysis. The experimental class obtained an N-Gain value of 0.7012, classified as *high*, while the control class achieved an N-Gain value of 0.4029, classified as *moderate*. These findings indicate that students who learned using the RME-based module experienced greater improvement in mathematical literacy skills than those who received conventional instruction. Therefore, it can be concluded that the RME-based learning module is feasible for use as a teaching material to enhance students' mathematical literacy skills, as it fulfills the criteria of validity, practicality, and effectiveness.

In this study, the mathematical literacy test items were limited to levels 1 through 4. Future research is recommended to include test items covering a wider range of mathematical literacy levels, including levels 5 and 6, and to incorporate more varied problem contexts. Additionally, the RME-based learning module may be further developed for other mathematical topics. Researchers who intend to develop similar RME-based learning modules are advised to allocate sufficient time, as this approach requires longer instructional time compared to conventional learning methods, allowing students greater opportunities to explore and develop their mathematical abilities during the learning process.

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