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Identifying Students' Numeracy Skills through Realistic Mathematics Education

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ABSTRAK

Tujuan dari penelitian ini adalah untuk mendeskripsikan tingkatan kemampuan numerasi siswa yang menggunakan pendekatan PMRI dalam pembelajarannya. Penelitian ini dilakukan selain karena adanya masalah mendasar dalam literasi matematika siswa dan masih sedikitnya penelitian mengenai pendekatan pembelajaran yang efektif untuk mengembangkan numerasi siswa, keterampilan ini adalah bekal siswa dalam kehidupan untuk dapat menggunakan matematika dalam berbagai konteks kehidupan nyata untuk pengambilan keputusan dan pemecahan masalah. Penelitian ini adalah penelitian deskriptif kualitatif dengan subjek penelitian adalah 18 orang siswa kelas X SMK Muhammadiyah di Yogyakarta. Data yang dikumpulkan dalam penelitian ini berupa hasil observasi, hasil wawancara, catatan lapangan, dan dokumen hasil pekerjaan siswa. Teknik analisis yang digunakan dalam penelitian ini adalah reduksi data, penyajian data, dan penarikan kesimpulan dan verifikasi. Hasil penelitian menunjukkan bahwa kemampuan numerasi siswa berada pada level perlu intervensi khusus, dasar, dan cakap. Beberapa faktor yang menjadi penghambat dalam pelaksanaan penelitian di antaranya siswa belum terbiasa dengan pendekatan PMRI dalam kegiatan pembelajaran dan minimnya pengalaman siswa dalam menyelesaikan soal-soal numerasi atau masalah matematika yang memiliki konteks atau situasi yang berkaitan dengan kehidupan.

Kata Kunci: Numerasi; PMRI; AKM; Tingkat kompetensi numerasi

ABSTRACT

The aim of this present study is to describe students' level of numeracy competence using PMRI approach in learning mathematics. This research is conducted not only because og the fundamental issues in students' mathematical literacy and the lack of studies on effective learning approaches to develop students' numeracy, but also because these skills are essential for students in life to use mathematics in various real-life contexts for decision-making and problem-solving. This study is a qualitative descriptive which involved 18 Vocational School students grade X in Yogyakarta. Data collection in this research consisted of observation result, interview results, field notes, and students' works. The analysis techniques used in this research are data reduction, data presentation, and drawing inferences and verification. The study showed that students' level of numeracy competence was in the level of need for specific intervention, elementary, and capable. Several factors that inhibited the impelementation of research included students not being accustomed to the PMRI approach in learning and students' lack of experiences in solving numeracy problems or mathematical problems that have a context or situation related to daily life.

Keywords: numeracy; PMRI; AKM; level of numeracy competence

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1. INTRODUCTION

Numeracy which was known as mathematics literacy or quantitative literacy (Bennison, 2016; Wake, 2015), has become a topic that has been widely discussed in recent years. The term numeracy, which was originally used in England as a reflection of literacy, is intended to represent a higher level than just the knowedge of numbers (Coben & Research, 2001). In Indonesia, the term numeracy has been mostly used, particularly since the government issued new regulation for the implementation of the National Assessment (AN) at all levels of education (Pusat Asesmen dan Pembelajaran Kemendikbud, 2020). In definition, numeracy is the ability to read, listen, think creatively, and communicate (NCTM, 2000) to identify and understand role of mathematics in implementing concept, procedures, facts, and mathematical tools to make decisions, solve problems with various contexts relevant to individual as citizens of Indonesia and the world (Wijaya & Dewayani, 2021) which constructive, caring, and reflective (Arora & Pawlowski, 2017).

One of the reasons for the issuance of National Assessment regulation is Indonesia' s PISA results on the world stage, which was still far from satisfactory and clearly need to be improved (Malasari et al., 2020; OECD, 2019; Yuda & Rosmilawati, 2024) or in other words, have not yet demostrated the level of mathematical literacy needed to participate in the development of the world today (Bennison, 2016). Moreover, previous studies show that the numeracy skills required in the workplace are increasing every year (Arora & Pawlowski, 2017). Although it has been announced for several years, students' numeracy skills in schools have not shown significant improvement. Indonesian education report year 2024, which was the result of an eveluation of the education system, where one of its scopes is student learning outcomes, presents that the majority of Indonesian students' numeracy skills were still in the moderate category or between 40% and 70% (Kemendikbudristek, 2024). Besides the lack of understanding among teachers regarding the numeracy competencies needed by students in school (Rizkianto et al., 2025), the unavalilability of textbooks that support the development of numeracy skills (Ain et al., 2023), the students' ability to understand texts is still low (Caponera et al., 2016), and there has bot been much studies on the methods or approaches that are suitable for helping students develop their numeracy skills (Bolstad, 2020; Nurhanurawati et al., 2022; Sari & Aini, 2022).

According to the definition of mathematical literacy or numeracy, this ability is required to satisfy both social and personal mathematical demands by using mathematics in a variety of contexts, such as discussing and debating options by understanding the context while addressing challenges (Bolstad, 2020). Research conducted by Ares and Evan (Ares & Evans, 2014) shows that socio-cultural practices encompassed within the context of numeracy will create an environment with diverse dimensions such as social, political, historical, cultural, and

mathematical, which is beneficial for the current development of students. The goal of helping students develop numeracy skills is not to encourage them to study mathematics harder, but rather to apply and use mathematical skills relevant to the world around them, where they can meaningfully participate in making decisions in various situations they encounter (Bansilal, 2016). In other words, teaching numeracy involves the challenge of promoting students' mathematical knowledge while simultaneously providing conditions where they learn to use mathematics in context.

The underdevelompent of numerasy skills will trigger a series of negative impacts. The low level of numeracy will result in a less competent quality of human resources, hindering decent job opportunities in the field that increasingly demands numeracy skills. This will certainly have the potential to widen social and economic gaps and hinder the nation's economic development due to a lack of innovation and technological adaptation. Furthermore, educational disparities will hinder students with low numeracy skills from progressing to higher levels and actively participating as citizens who are capable of critically understanding and filtering information. Numeracy problems alsi indicate weaknesses in understanding basic mathematical concepts and the development of higher-order thinking skills. This can also raise questions about the effectiveness of existing methods in teaching mathematics and the validity of educational assessments in measuring skills that are important for real-life applications. Therefore, addressing numeracy issues comprehensively and sustainably is an important investment in building superior human resources, an intelligent society, and a competitive nation in the global era.

That information suggests that numeracy encompasses more than just mathematical ideas. On the other hand, life issues can be effectively solved by applying the mathematical ideas that have been learnt. This is in line with the views of Indonesian Realistic Mathematics Education (PMRI) adapted from Realistic Mathematics Education (RME) that situations are used as sources for the development of mathematical concepts, tools, and procedures, and as contexts in which students can eventually apply their mathematical knowledge, which then gradually becomes more formal, general, and less context-specific (Van Den Heuvel-Panhuizen & Drijvers, 2014; Afriansyah & Turmudi, 2022).

In its implementation, PMRI emphasizes six principles that evolved from the original five tenets of RME, which explicitly explain the roles of students and teachers in the learning process (Van Den Heuvel-Panhuizen & Drijvers, 2014; Van Zanten & Van Den Heuvel-Panhuizen, 2021; Lestari et al., 2022). In the first principle, reality, the context of the problems is not only used as an apllication of mathematical concepts or a conclusion from the learning process; rather, the context is used as a source of learning and application of mathematical concepts. Learning should ideally be a process from the concrete to the abstract, so the principle of levels or stages becomes

important in developing students' ability to model mathematical situations. PMRI also uses a new paradigm of mathematics education, where teachers no longer transfer their knowledge to students, but students are responsible for acquiring and constructing their own knowledge (Sarumaha, 2016; Meilina, Mariana, & Ramawati, 2023; Kusuma & Sagita, 2024). This aligns with the activities principle that direct students towards thinking and discussion, leading to reflection on their thought processes and those of their peers, and helps them build their mathematical knowledge.

The guidance principle emphasizes that the learning process is certainly inseparable from the role of the teacher who provides an effective learning environment where students can have the opportunity to learn. The interactivity principle supports the presence of discussion, communication, cooperation, and negotiation in the learning process that fosters students' thinking (Sarumaha & Rizkianto, 2022). This interaction consists of vertical interaction (interaction between teachers and students, either individually or in groups) and horizontal interaction (interaction among students) (Van Eerde et al., 2008; Afriansyah & Arwadi, 2021). Mathematics taught through the PMRI approach also stresses the need to teach the subject simultaneously, tying together mathematical ideas and activities to give students a better grasp of how mathematics is used in everyday life.

Previous studies show that PMRI has proven effective in enhancing students' understanding of mathematical topics (Gravemeijer et al., 2013; Sarumaha et al., 2018; Uyen et al., 2021), training students to communicate (Sarumaha & Rizkianto, 2022), encouraging students to create models that bridge their concrete and abstract abilities (Doorman, 2002; Simon & Tzur, 2004), and training students to solve problems with contexts relevant to their lives (Fauzan & Diana, 2020; Sarumaha et al., 2018). Therefore, the researchers are interested in implementing this approach in the classroom and studying its impact on the development of students' numeracy skills. The question posed in this study is how the numeracy skills of students using the PMRI approach in their learning are? The level of students' numeracy skills will be reviewed based on the four criteria issued by the goverment regarding the Minimum Competency Assessment (AKM) (Pusat Asesmen dan Pembelajaran Kemendikbud, 2020).

2. METODE

Guiding effective research and answering the proposed research questions, this study uses a descriptive qualitative approach. The qualitative mathod was chosen because the research results obtained do not use statistics or statictical analysis (Marczyk et al., 2005) but aim to understand social, cultural, or human behavior phenomena in depth. The descriptive qualitative method aims to describe phenomena in detail and depth by involving data collection in the form

of interviews, observations, and document analysis in the form of student final tests (Creswell & Creswell, 2018). This study was conducted from November to Desember 2024.

The research subjects are 10th – grade students of Muhammadiyah Vocational High School in Yogyakarta. There were 18 students involved in this study. There were no specific criteria in the selection of research subjects. However, based on the information obtained, the mathematics teacher in this class has not yet emphasized mathematics instruction on developing students' numeracy skills, so the students do not have experience solving numeracy problems. In its impelementation, the learning was conducted in four sessions and involved the mathematics teacher – who usually teaches those students. Data collection was carried out by conducting interviews with students, classroom observations, small group or individual observations, field notes, and analysis of student work documents or answers. After the data collected, it is then processed and organized, to be interpreted and reported in narative form.

Interviews with students are conducted individually using an interview guide. This guideline contains a list of open-ended questions that will be posed to the students. These questions are designed with the aim of obtaining in-depth qualitative data regarding students' understanding, perspectives, and thoughts related to their actions or responses to the mathematics concepts being taught. Classroom observations were conducted during the research implementation with the intent of collecting direct data in student behavior and interactions. The researcher was present in the classroom during the learning process and recorded observations based on the prepared instruments. Researchers also conduct observations of small groups and individuals. The aim is to gain a deeper understanding of how students collaborate, solve problems together, or individually complete the given numeracy tasks. Field notes are also used in this research to help researchers capture unexpected events that may not be included in other instruments. These notes also serve as a source of data in qualitataive analysis. The assessment rubric is used to analyze students' work results, such as worksheets and written tests. The rubric is used to assess students' understanding skills, and ability to apply numeracy concepts.

The data analysis techniques used in this research consist of data reduction, data presentataion, and conclusion drawing and verification. The data reduction process involves selection, focus, simplification, and transformation of raw data collected from various research instruments used. The goal is to select information that is relevant to the research question. After the data is reduced, it is presented in an organized and systematics manner so that patterns and relationships between the obtained data become visible. From the interpretation of the data conducted, the researchers draw conclusions. This conclusion is then verified by rechecking the data, discussing with other researchers, and data triangulation.

3. RESULTS AND DISCUSSIONS

Based on the AKM numeracy component, this present study takes the topic of linear equations, which falls under algebra content. Whereas based on the cognitive processes used, the problems or activities focus on the aspects of understanding, application, and reasoning. In the aspects of understanding, the context of the problems used encourages students to comprehend the facts and understand each step taken. In the aspect application, the activities presented encourage students to be able to apply mathematical concepts in real-life situations that are routine in nature. Whereas in the reasoning aspect, students are encouraged to reason using the mathematical concepts they have mastered to solve non-routine problems.

a. Results

In line with the PMRI approach impleemnted in this present study, the contexts or situations of the problems used is close to students' daily life and relevant to the current circumtances. Most of the questions still use personal cntexts related to students' situations or environments or things that are familiar to them.

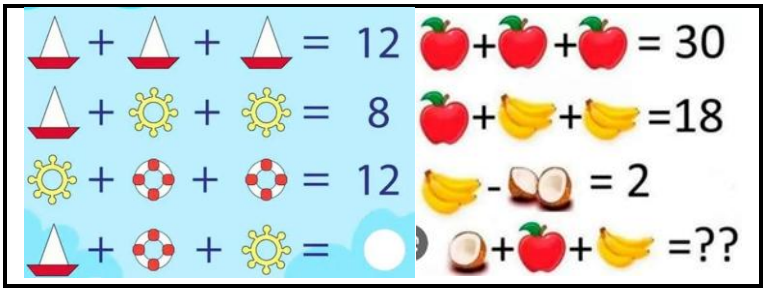


Figure 1. Example of The Context Used

Figure 1 shows an example of the context used in the study. Students were initially invited to look at simple images created in the form equations. Then they were given questions related to the images. In the next meeting, the students were No. longer shown the pictures above but were given questions with descriptions that were still relatable to them. The context of the situation described involves things that students might have experienced or encountered. The goal is for students to develop a model that helps them solve the given problems, Starting from linear equations in one variable to systems of linear equations in two variables. Students are then invited to solve complex linear equation problems using strategies or methods they believe in.

This solution method is then directed towards the use of methods for solving systems of linear equations in two variables, namely the eliminations, subtitutions, and mixed methods. Of course, these procedures were obtained by the students thorugh group discussion and classroom discussion and guidance from the teacher. By prioritizing the principles of PMRI in each session, students are not only encouraged to understand and solve problems well but also learnt to collaborate and communicate their findings or ideas to their peers. Thus, in each meeting, the presentation of problem-solving strategies and class discussions are conducted by listening to

the thoughts of others both individually and in groups. At the end of each discussion, students are asked to reflect thier thoughts afte the class discussion concludes.

b. Discussions

Center for Assessment and Learning of the Ministry of Education and Culture (Pusat Asesmen dan Pembelajaran Kemendikbud, 2020) states that the level of numeracy competence is divided into four criterias, namely (1) requires special intervention, (2) basic, (3) proficient, and (4) expert. To analyze students' numeracy skills, the students' work which were assessed through written tests, at the end of the learning were categorized into four criterias. By considering the PMRI principles in mathematics learning at each meeting, the researchers designed activities or problems with contexts that are familiar to students. Since the topic of learning in this study was a system of linear equations in two variables, the problems designed also involved various disciplines or real-life contexts. Of course, this not only makes the questions more interesting for students to solve but also helps students understand the application of mathematics in the real world (Sarumaha et al., 2018; Van den Heuvel-Panhuizen, 2003). Several contexts related to the system of linear equations in two variables in this study include economics and business, social sciences, physics, engineering, sports, and health.

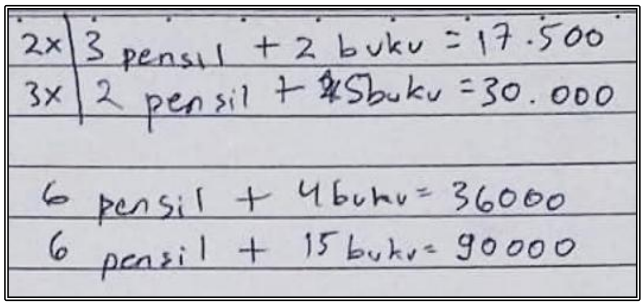
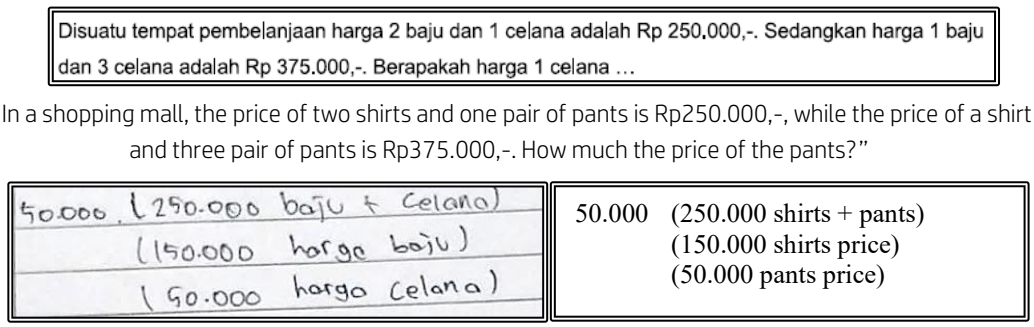


Figure 2. Student' Work 1

Based on the students' work at the end of the learning process, when students were asked to model problems into the form of a two-variable linear equation, it was found that 30% of the students still fell into the category required special intervention. Figure 2 is one example of students' work, showing that a student has been able to model the problem by representing it in the form of a mathematical equation. However, in his work, student still tended to use the words stated in the problems such as "pencil" and "book" instead of subtituting them with certain variables. Calcualtion errors are still found when students multiplied an equation by a constant. Figure 2 shows that a student was at the level of required special intervention, where he has limited knowledge (minimal mastery of mathematical concepts). Students demonstrated incomplete conceptual undertanding, and their computational skills are still at a basic level. Students also often make procedural or conceptual errors when solving problems.

This situation was also demonstrated when students were asked about what they know about the system of linear equations in two variables. Some students still took quite a long time to come up with the answers and were not yet able to provide clear answers. Students still needed guidance from the teacher to direct them towards better understanding. From the interview, it was found that students still had difficulties understanding the mathematical concepts they have learnt.



"In a shopping mall, the price of two shirts and one pair of pants is Rp250.000,-, while the price of a shirt and three pair of pants is Rp375.000,-. How much the price of the pants?"

Figure 3. A Problem and Student' Work 2

The top part of Figure 3 shows the problem presented to the students in the classroom and at the bottom part is one example of a student' s answer. It appears that students concluded that the price of one pair of pants is Rp50.000,00 and on the right side of the answer is the reasoning behind their thought process. It is not clear how he arrived at that value, but on the right side, his reasoning is visible. The interview conducted with the student found that he started by taking one piece of information from the problem, where the price of two shirts and one pair of pants is Rp250.000,00. From this information, the students then assumed the price of the shirt to be Ro150.000,00, leaving Rp100.000,00 as the price for the two pairs of pants.

Albeit the students were not yet able to provide the correct answers to the problems, the results of his interview indicated that he has achieved the minimum competency in learning linear equations with two variables. Figure 3 shows that students were at the basic level of numeracy. Students can utilize the information from the problem to articulate their thoughts, thereby arriving at the answers to the questions given. Students have mastered the basic concepts but still struggle to apply them in the relevant situations. About 30% of students continued to have trouble when faced with problems that require reasoning or more complex contexts.

Figure 4, another example of student' s work, indicates that student' s numeracy competence was at the proficient stage, where he is able to apply his mathematical knowledge in a more diverse context. When students were asked to solve a system of two-variable linear equations, they demonstrated the ability to model the situation into the appropriate mathematical expressions, choosing the procedures thet found easiest to use in solving the problem and obtaining results from those procedures. It could be seen at the end of the learning;

the student was able to reflect on the answers he gained by relating the context presented in the prblem to draw conclusions from the problem-solving results he found.

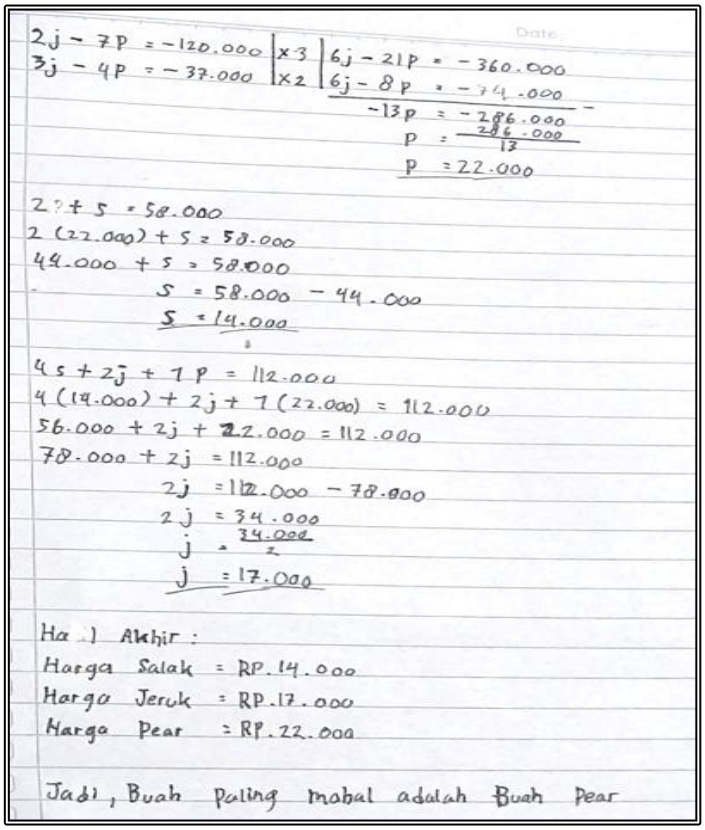


Figure 4. Problem and Student' s Work 3

Based on Figure 4, the students' written responses and the results of the interview conducted, it appears that students at this level have a good grasp of mathematical concepts and are able to apply them in various contexts, including non-routine situations. Students are able to understand and apply mathematical concepts in more compex situations, demonstrating good mathematical reasoning skills, and using appropriate strategies in problem-solving. This was demonstrated by students' systematic works, the selection of preocedures in solving problems, and refelction based on the results obtained by relating the answers back to the context presented in the problem. The majority of students in this study were at a proficient numeracy level.

In this present study, no students were found to be at the expert numeracy level. Although some students have a good grasp of mathematics and are able to apply mathematical concepts in given situations, they have not yet been able to solve problems that require in-depth analysis, logical reasoning, and creativity. Students are also not yet able to provide strong justifications based on tehir reasoning. This is likely because students are not yet accustomed to the PMRI approach in learning activities and rarely encounter math problems that have context or situations related to real life or numeracy problems. The lack of opportunities for students to

solve numeracy problems is also due to the limited knowledge and experience of teachers in implementing numeracy problems in teaching (Rizkianto et al., 2025; Sarumaha & Rizkianto, 2025). To sum up the result of students' numeracy skills after experiencing RME classroom, it can be seen in Table 1,

Table 1. Students' Level of Numeracy Skills

Category	Percentage (%)
Requires special intervention	30
Basic	30
Proficient	40
Expert	0

The development of numeracy skills itself involves lifelong learning that enables individuals to achieve their goals, develop their knowledge and potential, and fully participate in communities and society at large (Zollman, 2012; Siregar, Siagian, & Syahlan, 2024). It is in line with Sumirattana et al.'s findings (Sumirattana et al., 2017) and Muliana et al. (2024) in their study that numeracy is the ability to think about when and how to apply the mathematical knowledge one possesses. The results of the observations during the study indicate that students take a considerable amount of time to understand and solve the given problems. Students also appeared to have difficulty working in groups and expressing their thoughts to their peers. Moreover, the perception among students that mathematics is a diffciult subject, requiring specific procedures or strategies to solve problems, and having only one correct answer, are some of the hindering factors in conducting research. Tha students' low self-confidence causes teachers to spend a lot of time motivating students to learn and asking questions that guide them to construct their understanding

4. CONSLUSION

The present study results show that learning using the Indonesian Realistic Mathematics Education (PMRI) approach helps students develop numeracy skills. This shows relevance of RME as an effective constructivist approach in enhancing the understanding and application of contextual mathematics, as well as identifying the factors that influence student' numeracy development. This is supported by data collected during the research, which categorizes students' abilities into three levels of competence, namely requiring special intervention, basic, and proficient. Although no students have reached the expert level of numeracy, their works have demonstrated understanding, impelementation, and the application of their conceptual understanding of mathematics in problem-solving. The rarely used PMRI approach in learning and the lack of student expericences in dealing with numeracy problems are factors that hinder the optimal development of students' numeracy skills. Students also have difficulties justifying the ideas they have. It happens because students' perceptions of mathematics learning are

poor, and their low self-confidence in solving problems and participating in class becomes a unique challenge for teachers and researchers in managing mathematics learning in the classroom. Practically, the findings in this study can serve as additional information for teachers in designing effective linear equation learning, emphasizing contextual and interactive learning, and providing a foundation for further research to develop more effective interventions in improving students' numeracy skills.

Due to students experiencing difficulties in solving numeracy problems and lack of learning experience with RME approach, it is recommended that teachers integrate numeracy problems relevant to students' daily lives into mathematics lessons. In addition, intensive training and ongoing support for teachers in developing effective numeracy problems are essential to equip them with adequate skills. Efforts should also be made to change students' negative perceptions of mathematics through more interactive and collaborative learning approaches that emphasize conceptual understanding rather than rote memorization of procedures. Furthermore, classroom action research can be conducted to test the effectiveness of various teaching strategies in gradually improving students' confidence and numeracy skills.

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