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Development of Realistic Mathematics Education (RME) Integrating Agricultural Activities to Improve Numeracy Skills

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Abstract: This study aims to develop Realistic Mathematics Education (RME) learning tools integrated with agricultural activities, fulfilling the criteria of valid, practical, and effective to improve numeracy skills, particularly in the topics of direct and inverse proportionality. This study used the research and development with the Plomp model, comprising three phases. The first phase, preliminary research, involved 26 teachers and prospective teachers. The second phase, development or prototyping, engaged three experts and three students. The third phase, assessment, was conducted through trial testing with 31 participants in the experimental class and 31 participants in the control class. Data collection techniques included questionnaires, surveys, observations, tests, and interviews. Data processing was conducted using descriptive statistics. The results of the study indicate that the developed RME learning tools integrated with agricultural activities fulfills the criteria of valid, practical, and effective. The validity criteria were achieved with scores of 3.77 for the teaching module, 3.81 for the LKPD, 3.84 for the learning achievement test, and 3.87 for the instruction manual. The practicality criteria were met with a learning implementation rate of 95% (very good), and student activity reaching 84.9% (active). Additionally, student and teacher response questionnaires showed positive feedback, with scores of 95.48% and 100%, respectively. The effectiveness criteria were achieved with an average N-Gain score of 0.65 (moderate) and the experimental class achieved higher average scores than the control class. This study implies that RME integrated with agricultural activities can be recommended for mathematics teachers to support numeracy teaching.

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Introduction

Numeracy is an essential skill that students must possess, as it serves as a foundation for solving real-life problems (Putra & Purnomo, 2023). Numeracy skills are essential for students to understand, interpret, and prepare themselves for the important role of mathematics both in the present and the future (Kemendikbudristek, 2021). Moreover, numeracy skills are a primary focus in assessments such as PISA and the National Assessment (Kemendikbudristek, 2023). However, the 2022 PISA results reveal that Indonesia still ranks 68th out of 79 countries in mathematical literacy (OECD, 2023). Similarly, the 2023 National Assessment highlights that numeracy skills at junior high school have the lowest scores (Kemdikbud, 2023). Therefore, numeracy skills at this level require special attention so that they can be improved effectively.

At junior high school level, numeracy questions often cover a variety of topics related to students' daily lives, one of which is the topic of comparison (Han et al., 2017). However, research conducted by Septiati & Susanti (2022) and Dewi & Ekawati (2022) indicates that students still struggle to solve numeracy questions on this topic. The difficulties include understanding the problem, analyzing information, interpreting analysis results, and making calculation errors (Dewi & Ekawati, 2022). These challenges arise because the learning process in many educational institutions often employs teaching strategies that do not align with students' characteristics and, in some cases, ignores numeracy as a foundational thinking skill (Kemdikbud, 2021). Supporting this opinion, a questionnaire distributed to several junior high schools in East Java revealed that 20 out of 26 mathematics teachers and prospective teachers who participated in the survey reported having implemented various teaching strategies for numeracy. These strategies include Culturally Responsive Teaching (CRT), Blended Learning, Teaching at the Right Level (TaRL), differentiated instruction, Discovery Learning, and Problem-Based Learning (PBL). From the results of the implementation, 12 teachers including one from SMP Negeri 2 Bangorejo, reported that students' numeracy skills remained in the sufficient category. This indicates the need for a more suitable and effective learning approach to improve these skills.

Realistic Mathematics Education (RME) is a promising approach to improving numeracy skills (Risdiyanti et al., 2024). his approach emphasizes contextual learning by presenting problems based on students' environmental conditions, enabling them to visualize and relate to the learning topics (Batul et al., 2022; Widana, 2021; Marleny et al., 2024). Moreover, RME integrates mathematics with other subjects, supporting meaningful learning while introducing students to activities within their local communities (Soraya et al., 2018). Learning through RME has proven effective in enhancing students' literacy and numeracy skills (Fauzan et al., 2024). Supporting this, research by Putra & Purnomo (2023) demonstrated a significant impact of the RME approach on numeracy skills among fifth-grade elementary school students. Similarly, a study by Amarta et al. (2023) found that the PMRI (an Indonesian adaptation of RME) approach, applied in the context of Palembang Light Rail Transit (LRT), significantly improved numeracy skills among junior high school students. While numerous studies have highlighted the effectiveness of RME in improving numeracy skills, this study offers a unique perspective by focusing on RME with a new contextual emphasis on integrating agricultural activities.

The integration of agricultural activities into RME is grounded in the findings of the 2023 Banyuwangi Regency Agricultural Census, which reported Bangorejo District as one of the regions with extensive agricultural land (BPS, 2023). This agricultural prominence results in the majority of Bangorejo residents working as farmers. Agricultural activities include a range of processes such as land preparation, seeding, fertilization, spraying, irrigation, and harvesting. These processes inherently involve mathematical applications, making them highly relevant for integration into RME learning. By incorporating these activities into RME, students can connect mathematical concepts to real-life contexts, facilitating an easier understanding of the material and fostering meaningful learning experiences.

In Merdeka Belajar curriculum, designing learning experiences that are both meaningful and tailored to students' needs is entirely the teacher's responsibility (Indarta et al., 2022). To improve numeracy skills, one effective strategy teachers can employ is designing learning tools that focus on enhancing numeracy and integrating technology to create broader and more meaningful learning experiences (Putri et al., 2022; Habibi et al., 2024; Susanto et al., 2024). Learning tools are considered effective for improving numeracy if they implement appropriate teaching strategies and facilitate the development of students' numeracy skills (Nurdalilah & Harahap, 2024; Agustin et al., 2022; Syafitri et al., 2024). This underscores the importance of developing teaching modules, student worksheets (LKPD), test packages, and instructional manuals oriented toward realistic problems to improve numeracy skills, particularly in comparative topics. The novelty of this research lies in its integration of the RME approach with contextualized rice and orange farming activities, complemented by LKPD assisted by Liveworksheets, focusing on the material of proportionality and inverse proportionality. This study aims to develop Realistic Mathematics Education (RME) learning tools integrated with agricultural activities, fulfilling the criteria of valid, practical, and effective, with the goal of improving numeracy skills, particularly in the topics of direct and inverse proportionality.

Research Method

This research uses the development research method (research and development) with the Plomp Model consists of three phases, starting from preliminary research, then the development or prototype phase, and finally the assessment phase. (Plomp & Nieveen, 2013). In the preliminary research, a needs exploration in East Java was conducted involving 26 teachers and prospective teachers from several junior high schools. In the development or prototyping phase, 3 experts reviewed the validity of both the tools and instruments, along with a readability assessment by 3 students. In the assessment phase, the valid tools were tested at SMP Negeri 2 Bangorejo, involving one experimental class and one control class. Learning tools fulfilling the criteria of valid, practical, and effective are considered the final product of development. The control and experimental class trial schemes are presented in Table 1 below.

Table 1. Experimental and Control Class Trial Scheme

Class	Pretest	Treatment	Posttest
Experiment	Y_1	X_1	Y_3
Control	Y_2	X_2	Y_4

Description:
Y_1 Y_2 : numeracy pretest results
X_1 : Learning with RME integrated with agricultural activities
X_2 : Learning with a blended learning model
Y_3 Y_4 : numeracy posttest results

This study utilized several data collection techniques, including questionnaires, surveys, observations, student numeracy tests, and specially designed interviews. The questionnaire method was employed to gather information related to learning strategies and student numeracy achievements at the junior high school level in East Java. Additionally, it assessed the validity of both the tools and instruments through validation by experts before the study and gathered responses after the implementation of the learning tools from students and teachers. Observations were divided into two, namely observations of student activities and observations of the implementation of learning. These observations took place in the experimental class, with 4 observers attending 3 meetings. Student numeracy tests were administered before and after the tools implementation to assess its impact. The tests included 4 questions centered on agricultural activities, with scoring guidelines aligned with numeracy indicators. Lastly, the interview method was used to explore detailed information on school needs, test the quality of readability, and as supporting data for the teacher response questionnaire.

Data processing was conducted using descriptive statistics to assess the achievement criteria of the developed tools. A learning tool and its instruments are considered valid if they achieve a minimum score of 3 out of a maximum of 4 (Hobri, 2010). Additionally, the tool is deemed practical if it meets several assessment criteria, including: (1) An implementation result of at least 75%, (2) Student activity observed at a minimum of 80%, and (3) Positive questionnaire responses from students and teachers, with at least 80% answering "Yes"

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(Munir et al., 2023; Isroaty et al., 2023; Islamiah et al., 2024). Lastly, a tool is considered effective if it satisfies two criteria: (1) N-Gain value of at least 0.3, indicating moderate effectiveness, and (2) The average posttest numeracy for the experimental class is better than the control class (Islamiah et al., 2024; Nuryadi et al., 2017; Pambudi et al., 2023).

Results and Discussion

The development of RME learning tools integrating agricultural activities to improve students' numeracy skills, following the Plomp development model, is described as follows.

Preliminary Research

This stage begins with identifying needs and contexts, focusing on addressing basic mathematical subject problems, particularly those related to junior high school students' numeracy. An exploration of numeracy issues was conducted by distributing questionnaires to 26 teachers and prospective mathematics teachers from several junior high schools in East Java. The results of the needs analysis showed that 77% of teachers and prospective teachers had facilitated students' numeracy skills, but 60% of teachers reported that students' numeracy achievement still required improvement. This indicates that while efforts have been made, students' numeracy outcomes still need further enhancement (Putra & Purnomo, 2023). Following this, a more in-depth needs analysis was conducted by visiting SMP Negeri 2 Bangorejo to explore the context and specific needs. The findings highlighted numeracy as a key area requiring intervention. This is significant because strong numeracy skills have a direct positive impact on various life aspects (Habibi et al., 2024). A literature review was then conducted to explore the theoretical foundations underlying the intervention. One form of intervention identified was the development of a learning tools to address the identified problem (Putri et al., 2022). At this stage, a conceptual framework for developing RME learning tools was created, rice and orange farming activities aimed at improving students' numeracy skills.

Development or Prototyping Phase

At this stage, a prototype was developed based on the analysis from the previous stage. The prototypes include: (1) teaching module, the development of teaching modules is aligned with the learning objectives for topics on differences in values and reversing values, guided by the learning achievements of phase D. These modules are designed considering students' characteristics, context, and needs (Angraena et al., 2022). Therefore, the module integrates the RME approach with agricultural activities to enhance numeracy skills. (2) Student Worksheets (LKPD) Assisted by Liveworksheets, this LKPD is designed using Liveworksheets technology to address students' lack of interest in learning through printed LKPD. The integration of technology in learning is essential to meet the evolving demands of modern education (Yusmar et al., 2024). (3) test package, the research test package includes grids, test questions, alternative answers, and scoring guidelines. As per Rustam et al. (2024) test packages need to be meticulously designed to accurately assess the abilities they aim to measure, ensuring reliable data on student learning outcomes. (4) instruction manual, this manual serves as a comprehensive guide for implementing teaching modules, LKPD, and test packages effectively. Alfiani & Sb (2024) highlight that the instruction manual provides instructions to optimize reader activities. Additionally, this study incorporates research instruments such as sheets of learning student activity observation, sheets of implementation observation, interview guidelines, and student and teacher response questionnaires. These instruments are designed according to the research needs and are used to collect data (Adib, 2019).

The developed prototype was tested through expert observations to assess its validity in both content and construct. The experts involved include two Mathematics Education lecturers and one mathematics teacher from the school. Alongside expert observations, readability tests were conducted on LKPD and test questions with three grade VII students. Prior to selecting these students, a homogeneity test was performed on the mathematical abilities of all grade VII students. The homogeneity test is crucial for ensuring that any differences observed between groups are truly due to the intervention (Sianturi, 2022). The results confirmed that the mathematical abilities of grade VII students are homogeneous, allowing for the random selection of the readability test class, experimental class, and control class. As a result, class VIIC was chosen for the readability test, with three students appointed as readability testers. The testing process at this stage is detailed as follows.

First Stage Testing

In the first test, Prototype 1 underwent validation in terms of content and construction by three experts, who provided suggestions for improvement. Validity testing, according to Wulandari et al. (2023) aims to produce high-quality learning tools after revisions based on experts' suggestions and feedback. Additionally, a readability test was conducted on three students to ensure that the test questions and LKPD were comprehensible according to students' understanding levels. The results of the first stage of testing provided valuable feedback, which served as the basis for revisions, as outlined in Table 2 below.

Table 2. Suggestions for Improvement from the Results of the First Stage of Testing

	Suggestions
Expert 1	In the teaching module, the assessment should be made clearer by improving the details of the learning time, adding RME characteristics (horizontal mathematization, vertical mathematization, and RME principles) to the LKPD, enhancing the scoring guidelines in the test package, providing explanations regarding horizontal and vertical mathematization in the user manual, improving the assessment scale in the observation of learning implementation, and adding more questions to the interview guidelines.
Expert 2	The font size in the LKPD should be enlarged, and attention should be given to reviewing the writing variables. Additionally, the font type in the user manual should be changed, the activities in student observations should be detailed, and the question sentences in the student and teacher response questionnaires should be improved.
Expert 3	In the teaching module, the terms facilities and infrastructure are replaced with learning media, and variations of questions are added to the LKPD.
Subjek 1	There is a spelling error in the pretest question number 4.
Subjek 2	There is a spelling error in the posttest question number 1 and the font size in the LKPD should be enlarged.
Subjek 3	No errors were found.

Second Stage Testing

Prototype 2 is a revised version of Prototype 1, which was tested during the second stage. In this stage, the experts and readability testers from the first stage were involved again. The second stage of testing aims to produce Prototype 2 that meets valid criteria in both content and construct, and is easily understood by students. The results of this second stage of testing indicate good readability quality, and the product is declared valid, with scores shown in Table 3.

Table 3. Expert Review Results

Product	**Content Score**	**Construct Score**	**Avarage Score**	**Criteria**
Teaching Tools				
Teaching module	3.71	3.83	3.77	Valid

Product	Content Score	Construct Score	Avarage Score	Criteria
LKPD	3.83	3.78	3.81	Valid
Numeracy test	3.78	3.91	3.84	Valid
Instruction manual	3.87	3.87	3.87	Valid
Research Instrument				
Learning implementation observation	4	3.83	3.92	Valid
Student observation	3.78	3.79	3.785	Valid
Student response questionnaire	3.67	3.83	3.75	Valid
Teacher response questionnaire	3.67	3.83	3.75	Valid
Interview guideline	3.67	3.67	3.67	Valid

Table 3 shows that the tools and instruments have surpassed the minimum scores for both criteria, making them valid in terms of both construct and content. This indicates that the developed tools and instruments have met the criteria for use in measuring according to the development objectives (Wulandari et al., 2023). Figure 2 below provides an example of the results of compiling learning tools that have been declared valid.

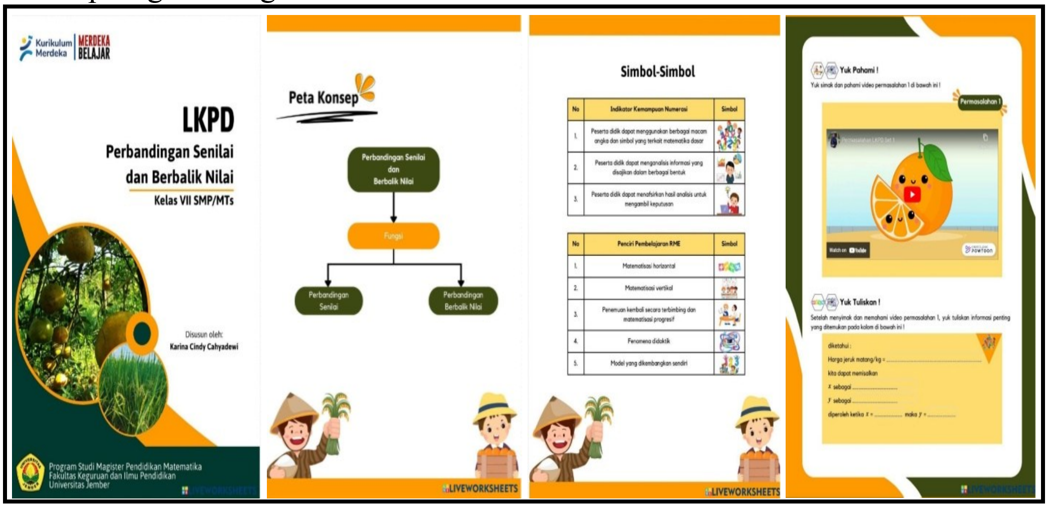

Figure 2. Results of Teaching Tools Development

Assessment Phase

The valid learning tools were then tested to evaluate the practical and effective criteria. This stage involved one model teacher acting as the educator and two seventh-grade classes as participants. The two classes selected were class VIIA(control class) and class VIIE(experimental class). Both classes have an equal number of students, totaling 31 students each.

Experimental and Control Class Trials

The trial began with the administration of initial numeracy test questions on the material of comparing feasible and reversing values in both the experimental and control classes. In the experimental class, learning was conducted using the tools that had been declared valid, while the control class implemented the school's standard tools. Learning for both classes took place over 3 meetings, totaling 6 JP, with the material progressing from functions to comparing feasible values and finally comparing reversing values. In the experimental class, four observers assessed the implementation and student activity. After 3 meetings, both classes were given numeracy posttest to evaluate the impact of using the tools. Additionally, student response questionnaires were distributed in the experimental class, along with teacher feedback questionnaires. Interviews were conducted with teaching

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teachers to gather supporting data for the teacher response questionnaire. Documentation of the tools implementation activities is presented in Figure 3.

Figure 3. Activity Documentation

The practical criteria of the learning tools in this study were assessed through observations of the implementation of learning, student activities, student response questionnaires, teacher response questionnaires, and interview results as supporting data. The summary of the practicality assessment is presented in Table 4.

Table 4. Practicality Assessment

Assessment Aspects	Percentage(%)	Criteria
Observations of learning implementation	95	Very good
Observations of student activities	84.9	Active
Student response questionnaires	95.48	Positive
Teacher response questionnaires	100	Positive

Table 4 demonstrates that all aspects of the assessment meet the minimum requirements of the practical criteria set. Observations during the implementation of the learning tools showed successful implementation of learning and active student involvement. These results align with Pambudi et al. (2022, 2023) which states that RME can foster motivation, leading to greater student engagement in learning. Additionally, the student and teacher response questionnaires revealed positive feedback on the implementation of the learning tools. Furthermore, teacher interviews highlighted that learning in the experimental class became more interactive, and students showed noticeable improvements in numeracy skills. Therefore, the developed learning tools have satisfied the criterion of ease of use in supporting numeracy instruction (Habibi et al., 2024).

Moreover, the effective criteria of the learning tools in this study were evaluated based on the average N-gain score of the experimental class and the comparison of the average numeracy posttest scores between the control and experimental classes. Effectiveness criteria testing begins with calculating the increase in numeracy skills, or N-gain scores, for each class. A summary of the results from the control and experimental class numeracy skills tests is provided in Table 5.

Table 5. Numeracy Skill Test Results

	Experiment Class		Control Class	
	Pretest	Posttest	Pretest	Posttest
Participants	31	31	31	31
Highest score	39.44	91.67	47.78	88.89
Lowest score	2.78	43.89	8.33	28.33
Average score	19.4	72.06	21.65	64.44
N-gain score	0.65		0.54	

Based on Table 4, the average N-gain score of the experimental class is higher than that of the control class. This indicates that RME learning incorporating agricultural activities provides a greater improvement compared to the Blended learning model. The experimental class, which initially had an average numeracy score of 19.4, experienced moderate increase to 72.06. These results align with research by Aulia & Prahmana (2022) & Amarta et al. (2023) which shows that RME can effectively improve numeracy skills at the junior high school level. To further evaluate the difference in the average posttest scores between the control and experimental classes, a prerequisite test was conducted, including normality and homogeneity tests using SPSS software. The results of these prerequisite tests are presented in Table 6 below.

Table 6. Prerequisite Test Results

Class	Normality Test		Homogeneity Test	
	Df	Sig.	Levene Statistic	Sig.
Experiment	31	0.053	7.150	0.010
Control	31	0.050		

Table 6 presents the results of the normality test for both classes, with Sig. ≥ 0.05, indicating that the test results for both classes are normally distributed. Meanwhile, the results of the homogeneity test for both classes are also Sig. < 0.05, indicating that the test results for both classes are not homogeneous. Since the prerequisite test shows normally distributed results but non-homogeneous data, a parametric statistical test, the Independent Sample T-Test, was conducted under the Equal Variances not Assumed section. Table 7 below presents the results of the Independent Sample T-Test.

Table 7. Independent Sample T-Test Result

Class	Average	Sig. (2-tailed)
Experiment	72.06	0.049
Control	64.44	

Table 7 shows the test results, with a Sig. (2-tailed) score < 0.05. Based on decision-making, this indicates that the average score of students in the experimental class is better than in the control class. This aligns with research conducted by Lubis & Siregar (2022), which demonstrated that RME learning in the experimental class yielded better results than the control class. Thus, the developed learning tools can be considered effective in improving numeracy skills.

The research results also indicate that the use of technology, specifically Live worksheets in learning, had a positive impact. This positive outcome includes increased student interest in learning and more interactive presentations of material. This aligns with Kuswanti's (2023) view that the integration of technology in numeracy learning has become essential in the digital era, necessitating continuous development.

From the description above, this research has resulted in RME learning tools integrating agricultural activities that meet the criteria of valid, practical, and effective. These tools when implemented, have the capacity to improve students' numeracy skills. Strong numeracy skills significantly influence students' mathematical mindset and decision making abilities in daily life (Baharuddin et al., 2021). Therefore, the development of learning tools supporting numeracy skills plays a vital role in shaping a generation capable of competing on both national and international. The theoretical implications of this study align with Susanta et al. (2022)'s assertion that integrating real-life contexts, such as agricultural activities, can help students understand the material more effectively and foster meaningful learning experiences. Additionally, the use of Liveworksheets as a digital tool offers an interactive and engaging learning experience thereby enhancing students' learning motivation. On the practical side, the integration of agricultural activities into RME-based learning can serve as a valuable recommendation for mathematics teachers in teaching numeracy.

Conclusion

Based on the study results, it can be concluded that the RME learning tools, which integrate agricultural activities and inverse proportionality for grade VII, has met the criteria of valid, practical, and effective. The results indicate that incorporating agricultural-related problems into RME learning effectively enhances students' numeracy skills. Furthermore, the use of online LKPD with Liveworksheets promotes greater student engagement and interactivity in the learning process. The study implication is that RME integrating agricultural activities can serve as a valuable resource and recommendation for mathematics teachers in teaching numeracy.

Recommendation

Before implementing online LKPD, teachers should ensure the quality of the internet connection to prevent disruptions during the learning process and understand the instruction manual for using learning tools. Future research should explore similar studies on other topics by integrating contexts relevant to the student environment in areas with distinct characteristics. Additionally, researchers can also use other online learning media to enrich students' learning experiences.

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