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Table of Contents

E-ISSN: *2656-5846*
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Vygotsky: Jurnal Pendidikan Matematika dan Matematika
6 (2) August 2024, pp. 71 - 86
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Development of LSLC-Based Collaborative Learning Model Learning Tools and Their Effects on Critical Thinking Skills

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ABSTRACT

The purpose of this study is to develop collaborative learning-based learning resources and their impact on students' capacity for critical thought. This study used a combination of methods, namely development research (R&D) with Thiagarajan 4D model and experimental research. Data was collected through observations, questionnaires, tests, and interviews. The validity coefficients for the Teaching Module, worksheet, and test were 3.80, 3.80, and 3.70, respectively. Observations showed that 96% of the learning tools met practical criteria. The tools were effective, with 93% of student activities rated very good, 96% of students giving positive responses, and 85% achieving learning completion. A t-test (sig = 0.007) confirmed the collaborative learning tool based on LSLC significantly enhanced students' critical thinking skills.

1. Introduction

The industrial revolution's fast advancements in science and technology 21st-century Version 4.0 encourages human resources to compete globally. The Partnership for 4C Skills are formulated by 21st Century Skills (4C's) especially critical thinking, communication, collaboration and creativity as 21st Century skills (Anwar et al., 2017; Hidayati et al., 2021; Saleh, 2019; Tohani & Aulia, 2022; Widana, 2018). Since 2022, Indonesia has launched the Merdeka Curriculum to catch up with education with other countries as a way to respond to challenges in the 21st century (Hanipah, 2023; Lubis et al., 2023; Sartini & Mulyono, 2022;

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Triadi et al., 2022). The Merdeka curriculum emphasizes critical thinking is one of the Pancasila student profile's aspects (Khasanah & Muthali'in, 2023; Muna & Moh. Fathurrahman, 2023; Purwanto et al., 2023). In the twenty-first century, critical thinking is a crucial talent that kids need to be empowered with (Miterianifa et al., 2021; Saavedra & Opfer, 2018; Živkovic, 2016).

The capacity for critical thought shows that learners have skills in decision making (Tohani & Aulia, 2022) logically with rational and reflective reasoning, able to solve problems, conclude and evaluate decisions (Prameswari et al., 2018) and high order thinking skill (Kurniawan et al., 2021), so that it affects the cognitive of students. Students are said to have the capacity for critical thought if they can find solutions to issues with various knowledge and information possessed by students (Peter, 2012), therefore students who are only able to solve problems without knowing the reason for the concept, cannot be regarded as possessing critical thinking skills.

Ennis provides six indicators circumstance: focus, reason, inference, clarity, and overview (FRISCO) that can demonstrate critical thinking abilities (Andiarini et al., 2018; Mirunnisa & Razi, 2021). FRISCO criteria are explained as follows (1) focus means that students must understand the problem, (2) reason means that students must give the right reason for the answer decision from solving the problem, (3) inference means that students can make reasonable conclusions so that students are able to identify assumptions about problem solutions and consider interpretations of evidence, (4) situation means that students are able to dig up various reinforcement information or supporting parts to help clarify questions in focus and know the answers, (5) clarity means that students can explain all parts of the answers in solving, (6) overview means that students research, check and recheck the correctness of answers thoroughly (Ulfa et al., 2018). FRISCO indicators are widely used by previous researchers, for example research conducted in Pontianak (Raudhah et al., 2019) and in Malang (Zubaidah et al., 2020) to analyze Critical thinking abilities of students.

Subjects that may enhance and cultivate critical thinking abilities in mathematics (Apriza, 2019). This is supported by research conducted by (Arisoy & Aybek, 2021) problem-solving activities learning mathematics has a big impact on critical thinking abilities. However, in fact, the response of students and learning achievement in mathematics subjects is relatively low. Students find it difficult to solve problems in mathematics subjects because they tend to memorize formulas rather than understand the actual concepts. Students' critical thinking abilities, which are directly linked to problem solving, may be developed through initiatives that focus on developing their interpretation, analysis, inference, assessment, explanation and justification, and self-regulation skills (Kravchenko et al., 2022), which begins with habituating the disposition of critical thinking in solving mathematical problems (Kurniati & As'ari, 2021) in the classroom.

The habituation of critical thinking disposition must be accompanied by the strength of components in the learning system, such as learning models, methods, learning tools and evaluation materials to be implemented. Reinforcement of these components will stimulate students to take a more hands-on approach to learning. Selecting an appropriate learning model is crucial in helping students comprehend the content being taught (Prasetiyo & Rosy, 2021)

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and sharpen their analytical abilities. In addition, learning objectives are significantly impacted by the creation of educational resources using certain learning models. If the process of finding information to solve a problem that requires students to think critically is done individually, then students will experience boredom because it feels boring and very burdensome.

The collaborative learning model is anticipated to enhance pupils' capacity for critical thought because collaborative learning is a learning process of discussing in groups to find various opinions or thoughts issued by each individual in the group. (Hobri, 2020). Working together in groups (collaborative learning) rather than being competitive to achieve shared learning goals results in higher achievement and greater productivity (Salma, 2020). Collaborative Learning awakens learners to know known and unknown knowledge, so that they will share and interdepend positively, have relational skills to respect each other's contributions, opinions or ideas (Aderi et al., 2018; Respati, 2018). The application of learning that focuses on discussions between individuals in groups (Collaborative Learning) will create anticipation during KBM, critical thinking skills, exploration, and good problem solving (Sunismi & Fathani, 2017). With the implementation of five stages of Collaborative Learning adapted from Reid, namely engangment, exploration, transformation, presentation, and reflextion can improve critical thinking skills (Anwar et al., 2017; H et al., 2021; Sari et al., 2021).

The mathematics collaborative learning paradigm in this study is combined with Lesson Study Learning Community activities, namely plan (planning), do (implementation), and see (reflection) to be more successful in enhancing pupils' capacity for critical thought. This is supported by previous research, that LSLC can improve learning outcomes (Asih et al., 2018), creative thinking skills (Kusumawati et al., 2019) and students' critical thinking skills (Rinjani, 2023). In addition to the LSLC-based collaborative learning model, providing contextual problem-based essay questions that require students to apply concepts, knowledge or various information that has been learned into a problem to solve problems, can develop critical thinking skills (Nurfathurrahmah, 2018; Yasinta et al., 2020; Zubaidah et al., 2020) and create more meaningful learning.

The creation of devices that are in line with student characteristics and learning objectives is the first step in learning innovations that can accommodate students to achieve learning objectives, according to a review of the literature on the significance of students' critical thinking abilities, particularly in mathematics subjects and mathematics learning problems. In order to test their theories that collaborative learning tools based on lesson study and learning communities might enhance students' critical thinking abilities and learning motivation, researchers built them.

2. Method

This study employed a variety of research methods, including experimental and development research (R&D) using the Thiagarajan 4-D model. Twenty students from SMA Unggulan Hafsa Zainul Hasan Genggong's Class XI 2A served as the study's subjects for the 2023–2024 academic year. In contrast, the population of the experimental study consisted of students from Class XI 2B, which served as the experimental class, and Class XI 2C, which served as the control class.

The initial step in this research is to conduct device development research using Thiagarajan, Semmel & Semmel 4-D model development procedures

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consisting of 1) the define step, which involves front-end analysis, learner analysis, conceptual analysis, task analysis, and defining instructional objectives, in order to ascertain learning needs, 2) the stage of design is the stage carried out to design learning tools according to the define stage, in the form of initial design (prototype) of LSLC-based collaborative learning tools, 3) the develop stage to develop learning tools (prototype) by revising the results of expert assessment, readability tests and learning device tests, 4) the final step in the process of implementing reliable, useful, and efficient learning resources is the dissemination stage.

The learning tool products developed consist of Teaching Modules, student worksheet, and Critical Thinking Test Composition Functions which contain systematic steps of LSLC-based collaborative learning. The six Ennis indicators—focus, reason, inference, circumstance, clarity, and overview—are the standards for critical thinking that are used. (FRISCO). Table 1 displays the indicator that was created, which is the Ennis indicator.

Table 1. The Indicator Critical Thinking

Criteria	Indicators of Critical Thinking
Focus	a. Students are able to gather and record information regarding what is known and requested about the subject, whether it is accurate or not. b. Participants can articulate pertinent details about the topic. c. Students are able to recognize and comprehend the relationship between often asked questions and well-known facts. d. The capacity to communicate knowledge about subjects covered in mathematical puzzles.
Reason	a. Participants can identify methods for resolving issues related to the topic. b. Participants can describe the steps of the method they used to solve the mathematical problem either in writing or verbally. c. In order to reach a conclusion, the student can defend their reasoning using the facts pertinent to each stage of the problem-solving process.
Inference	a. The capacity to solve mathematical problems using appropriately reflected procedures. b. The student is able to make a precise inference.
Situation	Mathematical problems can be solved by students by making connections between relevant facts or past knowledge.
Clarity	The conclusion or response to the question can be understood and clarified by the student.
Overview	From start to finish, students may carefully go over each step and the outcomes of its accomplishment.

Data collection instruments in the study are expert validation sheets, Student activity observation sheets, student response surveys, critical thinking tests, and learning device implementation sheets. The data obtained is primary data to determine the value of validity, practicality, and effectiveness of the product developed. LSLC-based collaborative learning tools are valid if they meet the valid criteria.

The percentage of observations on the learning device implementation sheet indicates the practicality of the device, while student response questionnaires, the Critical Thinking Test recapitulation, and student activity observations show the

E-ISSN: 2656-5846
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effectiveness of the device. Learning tools are said to be effective if student activity as a proportion is at least that of the active category, Over 80% of students meet the requirements for minimum completeness, and the response of students is positive. If the generated product has been deemed legitimate, workable, and efficient, continue doing experimental research utilizing the experimental class's and the control class's pre- and post-test outcomes. The experimental group used an LSLC-based whereas the control group employed a traditional learning model and the collaborative learning methodology.

Quantitative data analysis in experimental research by conducting hypothesis tests to ascertain if LSLC-based collaborative learning tools have a noteworthy impact on students' critical thinking skills. Hypothesis Test employing parametric test, specifically independent sample t-test, when the data is certified normally distributed and homogenous.

3. Results and Discussion

The learning tools produced inside this research are Teaching Modules, student worksheet and Critical Thinking Test using valid, practical and effective LSLC-based Collaborative Learning tools that have been developed have passed 4 stages (4-D Thiagarajan, Semmel & Semmel) specifically, to define, create (design), develop, and distribute (disseminate).

Define stage, conducted through a requirements analysis through observation of the learning process in the classroom, found that during the learning process and interviews with mathematics teachers, the development of learning tools is needed to help students achieve the learning goals to be achieved. In solving contextual problems the composition function students are not able to convert the information on the problem into a mathematical model, but they can do routine problems that are exactly the same as the example questions the teacher gives, because students do not understand the concept of composition function well. This means that learners have not achieved the ability to analyze, find reasons (rational), conclude, make decisions and evaluate information. The cognitive development stage of high school children whose average age range is 16-18 should have the ability to think abstractly, formulate and respond to problems. In fact, students have not been able to construct knowledge independently.

Results from earlier studies that showed pupils had trouble repeating the teacher's explanations are consistent with this conclusion and do not feel confident to express opinions because didk participants have not been able to construct knowledge or concepts independently (Hariyanti & Wutsqa, 2020). Students who are unable to construct their knowledge mean that students are unable to think critically. Because by thinking critically, learners can build mathematical knowledge and develop rational attitudes to choose the best alternative choice (Farib et al., 2019). Apart from observations and interviews, researchers also analyzed the CP and TP of the Composition Function material at Independent Curriculum to design learning tools.

Design stage, designing the initial design (prototype) of LSLC-based Collaborative Learning tools, namely Teaching Modules, student worksheet and Critical Thinking Test composition function materials. Device development must pay attention to supporting components, specifically: etymology, social structure, response theory, assistance network, influence of training, and effect of

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accompaniment in accordance with LSLC-based Collaborative Learning.

The Teaching Modules prepared based on the Independent Curriculum on the Merdeka Learning Platform are divided into two, namely: 1) general identity consisting of general module information, initial competence, Pancasila student profile, facilities and infrastructure, learning models and methods, and student targets, 2) core components consisting of learning outcomes (CP), Learning Objectives (TP), indicators of achievement of learning objectives (IKTP), meaningful understanding, lighter questions, learning activities, assessment, remedial, enrichment, teacher reflection and student reflection.

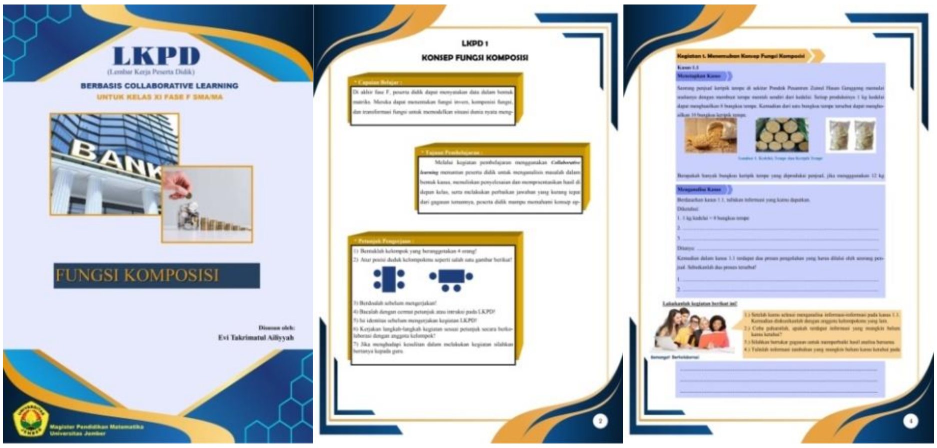
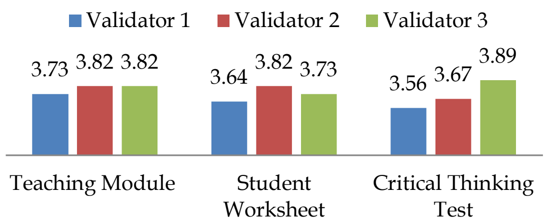


Figure 1. Student Worksheet Design

Furthermore, the LSLC-based Collaborative Learning model's phases were followed in the development of student worksheet, and Ennis' indications were utilized to gauge students' critical thinking abilities on the Critical Thinking Test as a Learning Outcome Test. The following example of student worksheet design can be seen in Figure 1.

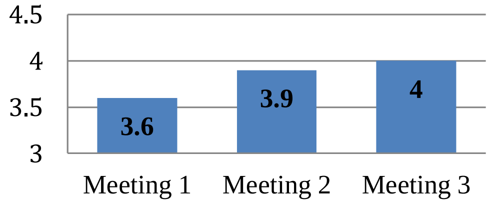
Table 2. Learning Tools Expert Validation Analysis Results

Value (V_a)	Validity Level	Expert Validation Results
$V_a = 4$	Highly Valid	
$3 \leq V_a < 4$	Valid	
$2 \leq V_a < 3$	Quite Valid	
$1 \leq V_a < 2$	Invalid	
Total average		3.79

Develop stage, obtained the outcomes of the learning tool prototype's modification through expert validation. The assessment was conducted by two lecturers of Universitas Jember and one mathematics teacher of SMA Unggulan Hafsa Zainul Hasan Genggong. Table 2 presents a summary of the expert validation outcomes.

Based on Table 2, The average total score of the assessment of the three validators is 3.79, which indicates that it has a valid category. The device that was declared valid was tested in class XI 2A of SMA Unggulan Hafsa Zainul Hasan Genggong for 3 meetings for face-to-face learning and one meeting for the Learning Outcomes Test. The results of the trial with learning devices show a useful analysis derived from the observation sheet of the use of learning equipment. The practical data summary is displayed in Table 3.

Table 3. Examination of Observational Data from the Use of Learning Tools

Value (SR)	Validity Level	OKPP Results
$90\% \leq SR$	Excellent	
$70\% \leq SR < 90$	Good	
$50\% \leq SR < 70$	Good enough	
$SR < 50\%$	Bad	
Total average		3.80

According to Table 3, Over the course of the three meetings, the average overall teacher assessment score was 3.80, so the percentage value was 96%, which shows the practicality of good learning tools. Student response surveys, observation sheets of student activities, and the comprehensiveness of student learning are used to analyze the efficacy of learning resources. The recapitulation uses the findings from student response surveys and observations of their activities in Table 4 and Table 5.

Table 4. Analysis of Student Activity Observation Results

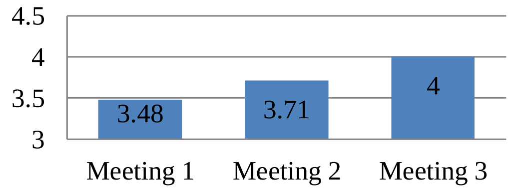
Value (P_s)	Category	Results of Observation of Student Activities
$90\% \leq SR$	Excellent	
$70\% \leq SR < 90$	Good	
$50\% \leq SR < 70$	Good enough	
$SR < 50\%$	Bad	
Total average		3.73

Table 4. displays the findings from the first to the third meeting's observation of student activities in a row is 3.48; 3.71 and 4, an average of 3.73 was obtained, so that the percentage value of student activity was 93% which showed that the value (Ps) was in the range of $90\% \leq Ps$ which showed the activeness of students had a very good category.

Table 5. Analysis of Student Response Results

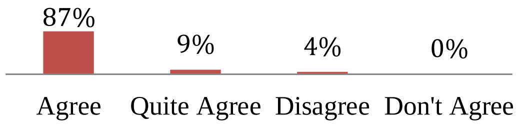
Value (P)	Category	Results of Student Response Questionnaire
$90\% \leq P$	Excellent	
$70\% \leq P < 90$	Good	
$50\% \leq P < 70$	Good enough	
$P < 50\%$	Bad	

Table 5. demonstrates that up to 96% of students do well when utilizing LSLC-based collaborative learning tools to learn about the composition function, so it is discovered that the proportion value of reactions from students is in the

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range of and has a very good category, while 17 out of 20 students achieve completeness, so that 85% of students are deemed finished. Considering the findings of the observations of student activities, student response questionnaires, and the completeness of the test of learning outcomes results, it was determined that LSLC-based collaborative learning tools were declared effective.

In the **dissemination stage**, learning tools that have fulfilled reliable, useful, and efficient standards can be disseminated. This learning tool was then socialized to teachers at SMA Unggulan Hafsa Zainul Hasan Genggong to be used in other classes. This learning device is printed and stored in the library of SMA Unggulan Hafsa Zainul Hasan Genggong. After the dissemination stage, experimental research was carried out to determine how learning devices affect students' ability to think critically. The experimental investigation was carried out by giving a pre-test before learning composition functions, as well as a post-test for both the experimental and control courses concluded after learning. Prior to conducting the hypothesis test, precondition tests, such as homogeneity and normality tests, were performed on the pre- and post-test data for the two groups. The following are the normalcy test results and the homogeneity of the pre- and post-test values, respectively, in Tables 6, 7, and 8.

Table 6. Pre-Test and Post-Test Values Normality Test Results

Test Normality		Kolmogorov-Smirnov		
	Class	Statistic	df	Sig.
Critical Thinking Skills	Pre-test experiment	.138	24	.200
.	Pre-test control	.129	24	.200
	Post-test experiment	.165	24	.092
	Post-test control	.109	24	.200

Table 7. Pre-test Homogeneity Test Results

Test of Homogeneity of Variance					
		Levene Statistic	df1	df2	Sig.
Critical Thinking Skills	Based on Mean	.023	1	46	.880
(Pre-test)	Based on Median	.027	1	46	.871
.	Based on Median and with adjusted df	.027	1	42.418	.871
	Based on trimmed mean	.028	1	46	.868

Based on Table 6, The experimental class pre-test sig value was 0.200 (> sig 0.05), the control class pre-test sig value was 0.200 (>0.05), the experimental class post-test sig value was 0.92 (sig >0.05), and the control class post-test sig value was 0.200 (sig >0.05), according to the results of the Kolmogorov-Smirnov normality test. It was determined that the pre-test and post-test values in the experimental class and control class were normally distributed.

Table 8. Post-test Homogeneity Test Results

Test of Homogeneity of Variance					
		Levene Statistic	df1	df2	Sig.

E-ISSN: 2656-5846
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Critical Thinking Skills (Post-test)	Based on Mean	.002	1	46	.966
	Based on Median	.002	1	46	.966
.	Based on Median and with adjusted df	.002	1	45.545	.966
	Based on trimmed mean	.001	1	46	.970

The pre-test value data for the experimental class and control class are homogenous, as shown by Table 7. sig value = 0.880 (sig >0.05) and Table 8. sig value = 0.966 (sig >0.05). This indicates that there is homogeneity between the post-test value data for the experimental and control classes. parametric test analysis of the data from the hypothesis test, specifically utilizing independent sample t-tests.

Table 9. Displays the findings of the t-test

	Levene's Test for Equality of Variances		t-test for Equality of Means				
			T	df	Two-Sided p	Mean Difference	Std. Error Difference
Equal variances assumed	.002	.966	2.813	46	.007	4.125	1.466

Table 9. shows that the value of sig = 0.007 (sig < 0.05), which indicates that the use of LSLC-based collaborative learning technologies has a major impact on students' ability to think critically. This success is influenced, among other things, by the creation of learning resources that are adapted to the learning model according to the requirements and learning goals of students in the Independent Curriculum. LSLC-based collaborative learning tools encourage students to be active in discussions, foster positive interdependence, and foster a caring attitude towards students. The stages of the collaborative learning model, namely engagement, exploration, transformation, presentation, and reflection, contained in the learning activities in the Teaching Module and the steps to complete the student worksheet, can direct students to collaborate well. These are the specific phases of collaborative learning, as shown in Table 10.

Table 10. Collaborative Learning Stage

Stage	Activity of Collaborative Learning
Engagement	1. Teachers analyze the level of ability and intelligence of each student. 2. Teachers form groups of 4-5 pupils in each group in which there are high, medium and low-skilled students.
Exploration	1. Teachers give LKPD that contains mathematical contextual problems 2. The students accepted the conditions of the discussion given in the subject. 3. Students dig information on the subject 4. Students formulate questions 5. Analyze information to gather solutions ideas

 E-ISSN: 2656-5846
P-ISSN: 2656-2286

Stage	Activity of Collaborative Learning
Transformation	1. Students in each group exchange ideas, ideas or opinions in solving the problem 2. Participants do each other's grades, accept and appreciate the opinions of each other 3. Interaction of mutual learning encourages students to clarify, describe and synthesize concepts as alternative solutions. 4. Each group finds a solution to each formula of the problem. 5. Each group prepares the answers to the discussions.
Presentation	1. Each group presents the results of its discussion, while the other group observes, contemplates, compares and responds to the presentations of other groups. 2. Ask an individual to respond to a group or group with a group about something not understood.
Reflection	Students analyze their ability to understand the materials taught and analyze the shortcomings and advantages of the learning process, as a material for teachers to plan more effective learning to learning goals.

Providing math problems based on contextual problems of composition function material in student worksheet requires students to think critically. Previous studies showing that problem-based learning may enhance critical thinking abilities corroborate this (Idris et al., 2020; Simanjuntak & Sudibjo, 2019; Suparya, 2020; Tanjung & Nababan, 2018). Through the processes of individually developing concepts, debating them, and picking up knowledge from one another, the LSLC-based collaborative learning approach assists students in developing their critical thinking abilities. Arguing on LSLC-based *collaborative learning* is not to compete with each other to be the most correct, but to achieve a common goal.

The ability of students to solve challenges demonstrates their capacity for critical thought (Satwika et al., 2018; Windari & Yanti, 2021). From the data from the analysis of written tests and interviews with students in experimental classes, it shows that there are students who meet all indicators of critical thinking abilities. Furthermore, with the introduction of collaborative learning technologies, critical thinking in the experimental class has improved more than critical thinking in the control class. Based on some of the points raised, it may be inferred that creating reliable, useful, and efficient teaching resources might help students become more adept at critical thinking.

4. Conclusions

The creation of LSLC-based collaborative learning tools satisfies the requirements of being valid, practical, and effective, according to the researchers' examination of the study's findings and the above-discussed debate. In addition, the hypothesis test using a parametric test, namely the independent simple t-test, shows that LSLC-based collaborative learning tools have a significant effect on students capacity for critical thought. Based on observations during learning, it

 E-ISSN: *2656-5846*
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was concluded that LSLC-based collaborative learning tools increase learning motivation, and student participation in debates should be encouraged.

Based on the conclusion, the outcome of creating collaborative learning tools based on LSLC is focused on fostering critical thinking skills in grade XI mathematics lessons of SMA Unggulan Hafsa Zainul Hasan Genggong and can be used as one of the teaching materials. The suggestion given is that there is a need to continue this research to develop collaborative learning tools that can enhance creative abilities, learning outcomes, learning motivation, and critical thinking skills in different materials and other subjects.

Author Contributions

The first and second authors contributed to creating the scientific articles and managing the publication process. The third, fourth, and fifth authors focused on collecting, processing, and analyzing the research data.

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Declaration of Competing Interest

The authors declare that there are no conflicts of interest.

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Mathematics Learning Using Japanese Multiplication Method (JAMED) Solving Multiple Problems Class III Basic Education Students

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ABSTRACT

This research examines whether the multiplication abilities of third-grade students in Pamekasan improve before, during, and after using JAMED media for mathematics instruction. The study aims to assess the students' multiplication skills across these three stages, analyzing any observed improvements. The research employs a single subject experimental method with an A-B-A design, using action tests for data collection. The subject is a third-grade student with the initials AW. Findings show that the student's multiplication ability was very low in the initial baseline (A1), improved to a sufficient level during the intervention (B), and reached a high level in the final baseline (A2). This indicates a significant positive impact of JAMED media on the student's multiplication skills.

1. Introduction

One of the K13 translations in mathematics is that students can perform mixed arithmetic operations, one of which is multiplication. The understanding of multiplication is the main mathematical concept that children should learn after they learn addition and subtraction. If the addition and subtraction operations have been introduced in the first grade in elementary school, multiplication operations are usually introduced in the second grade in elementary school. Multiplication is repeated addition. Instilling the concept of multiplication, that is, as in planting the concept of addition and subtraction, planting the concept of multiplication of natural numbers needs to be done by providing students with as many experiences with concrete objects as possible. Activities that use concrete

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objects as learning tools should characterize all learning activities. According to the results of the introductory interview on September 19-20 2022 with the homeroom teacher for class III with the initials RA, it was found that one of the students with the initials AW, aged 10 years, was male. in doing multiplication given by the teacher, children can only do basic multiplication even though according to basic competencies children are expected to have mastered multiplication. The multiplication ability of students is only up to the basic multiplication and the media used by the teacher is with media objects around them.

Problems experienced by students require immediate handling/solving because if not addressed then the problem of students' inability in multiplication will continue at the next grade level. Handling students with multiplication counting problems requires learning media that is suitable according to the needs of students, namely by using JAMED media.

The research problem: 1. Can the ability to operate multiplication in class III students in Pamekasan increase before using JAMED media in teaching mathematics? 2. Can the ability to operate multiplication in class III students in Pamekasan increase when JAMED media is used in teaching mathematics? 3. Can the ability to operate multiplication in class III students in Pamekasan increase after using JAMED media in teaching mathematics? 4. Is there a picture of an increase in the ability to operate multiplication using JAMED media seen from results of an analysis between conditions before, during and after being given treatment to class III students in Pamekasan? So that the objectives to be achieved are: 1. How is the multiplication operation ability of class III students in Pamekasan before using JAMED media. 2. How is the ability to operate multiplication in the use of JAMED media in class III students in Pamekasan in teaching mathematics on multiplication material. 3. How is the multiplication operation ability of class III students in Pamekasan increased after using JAMED media. 4. What is the description of the increase in the ability to operate multiplication using JAMED media based on the results of analysis between conditions before, during and after being given treatment to class III students in Pamekasan.

Mathematics has a practical function and can make it easier for children to think as stated by Abdurrahman (Siagian 2017: 61) "Mathematics is a symbolic language whose practical function is to express quantitative and spatial relationships so that its theoretical function is to facilitate thinking". So Mathematics is a science that examines abstract objects arranged using the language of symbols to express quantitative relationships and is useful for solving problems in everyday life. Learning mathematics can also provide reasoning pressure in the application of mathematics. According to Uno (2007: 130) suggests that the purpose of learning mathematics is: Mathematics helps someone so that it is easy to solve problems, because mathematics provides truth based on logical and systematic reasons and can facilitate problem solving because the process of working mathematics is passed sequentially which includes stages observation, guessing, testing hypotheses, looking for analogies, and finally formulating theorems. So that students are able to skillfully use mathematics. In addition, learning mathematics provides reasoning in the application of mathematics. And can provide truth that makes sense and can help children in solving problems.

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Multiplication is actually also repeated addition. According to Damayanti (2012: 126) "stated that: Multiplication is the main basic arithmetic operation that children should have learned after they learned the arithmetic operations of addition and subtraction. Therefore, to understand the concept of multiplication, one must first master the concept of addition. The symbol used in multiplication is a cross (x). But in reality students have not been able to do in accordance with the existing curriculum. In this study, the ability to operate multiplication is the score obtained by the test results which show the subject's ability to perform multiplication operations involving natural numbers using JAMED media.

According to Bovee (Asyhar 2011: 4), it is used because of the function of the media as an intermediary or delivery of a message from the sender (sender) to the recipient of the message (receiver). In addition, according to Gagne and Sadiman (Barus 2015: 6), "learning media are various types of components in the student's environment that can stimulate them to learn". That learning media is a tool given by the teacher so that it can be used to attract students' interest and attention in improving their learning outcomes to be more effective.

Japanese Multiplication Methode (JAMED) is a multiplication method created by Professor Fujisawa Rikitarou (1900) from Tokyo University. This method is known in Indonesia as the Cross-Line multiplication method, which is a geometry-based multiplication method with two parallel auxiliary lines, vertical and horizontal (Grain, 2018). For example multiplication 21 x 23, we simply draw 2 lines and space 1 line below with a sufficient distance from the 2 previous lines horizontally. Then draw a vertical line that collides with a horizontal line as many as tens and the units are 2 lines and 3 lines. after that, calculate the point on the bottom right for the unit result. The number of dots in the lower left and upper right to find out the tens results. For hundreds, add up the dots on the top left. And it is true that the result of 21 x 23 = 483 as in figure 1.

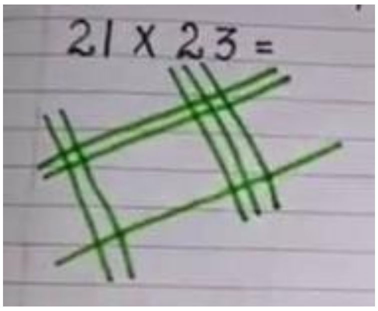

Figure 1. Japanese Multiplication Methode (JAMED)

Strengths and Weaknesses a. Strengths 1. Easy to find answers 2. It only takes a short time 3. No deep knowledge of multiplication is needed 4. Can balance the brain b. Disadvantages 1. It takes a large space to do it.

2. Method

The quantitative approach is a research approach whose specifications are systematic, planned and clearly structured from the outset to the creation of a research design. According to t Sugiyono (2013: 13), "quantitative research methods can be interpreted as research methods based on the philosophy of positivism, used to research on certain populations or samples, sampling techniques are generally carried out randomly, data collection uses research

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instruments, data analysis quantitative/statistical in nature with the aim of testing the established hypothesis".

The intended quantitative approach is to determine the increase in the multiplication operations ability of class III students in Pamekasan with before and after the application of Media JAMED.

The research type is a single subject experimental research (single subject research). Sunanto, et al (2005: 41) stated that SSR, or "single subject research," describes study methods that are specifically created to record behavioral changes in single people.

The purpose of the Single Subject Research (SSR) research method is to gather data by examining the effects and efficacy of a treatment in the form of using JAMED media to improve the class III students' ability to operate multiplication before receiving treatment (baseline 1/A1), during treatment (Intervention/B), and after treatment (baseline 2/A2), as well as analysis prior to and following treatment.

Research variable is a basic term in experimental research including single subjects which provides an overview of how this research is carried out. Sunanto (2005: 12) "Variable is an attribute or characteristic about something in the form of objects or events that can be observed". Thus the research variable is everything determined by the researcher to be studied and researched in order to obtain information about it. Based on these problems, this research has one variable that is studied, namely "multiplication operation ability" using JAMED media which is expected to improve students' multiplication operation ability.

This study used an A-B-A design, a three-phase study that aims to assist in overcoming the challenges the subject faces. As stated by Sunanto (2005: 54), the single subject research design that is employed is Withdrawal and Reversal with the Constellation A–B–A. This three-phase research design compares the baseline conditions before and after the intervention in order to determine the extent of the effect that a treatment has on an individual. Three phases comprise Design A – B – A: A1 (baseline 1), B (intervention), and A2 (baseline 2). The following steps will be completed in this study: A1 (baseline 1), which entails determining the multiplication operations ability profile and development of children prior to receiving treatment. Natural therapy is administered to the subjects without any outside intervention. "Prior to any kind of intervention, baseline refers to the situation in which target behavior is measured in its natural state (Sunanto, 2005: 54). The research subjects' state throughout treatment, specifically through the use of JAMED media, is referred to as B (intervention)." Over the course of several sessions, this intervention was repeated. To determine how the intervention affected students' multiplication operation skills, data collection on the subject's ability to do multiplication was done. "When an intervention is provided, the target behavior is measured under these circumstances (Sunanto, 2005: 54). c. A2 (baseline 2), which is the recurrence of baseline conditions to gauge how much the intervention is impacting the person. According to Sugiono (2007), computations known as descriptive statistics are utilized to assess data by characterizing or characterizing the obtained data in its original form.

The A-B-A design has three stages, namely A1 (baseline 1), B (intervention), and A2 (baseline 2). Pictures of the A-B-A design display can be seen in the following figure 2.

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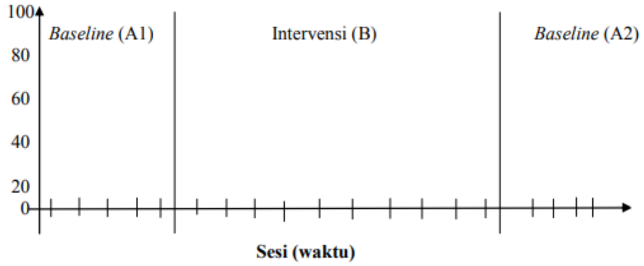

Figure 2. Display graphic design A – B – A

Data Collection Techniques: The form of the test used is a form of action test ordered by the researcher himself and given to a condition (baseline). In this study the measurement of the multiplication operation using JAMED media targets (target behavior) was carried out repeatedly for a certain period of time, namely per day. Comparisons were made on the same subject with different (baseline) conditions. Baseline is a condition where the measurement of target multiplication operations is carried out in natural conditions before intervention is given. Intervention conditions are conditions when an intervention has been given and the target behavior is measured under the conditions.

The instrument used to collect data in this study was an action test in multiplication operations using JAMED media which was compiled based on what was applied in the learning process to determine students' multiplication operations abilities before, during and after being given treatment on JAMED media. The assessment criteria were that students were not able to operate the abacus according to the number of questions given a score of 0, students were able to operate JAMED according to the number of questions given a score of 1. Each wrong answer was given a score of 0 while the correct answer was given a score of 1. It can be written as follows (Arikunto, 2006:19).

$$Result\ value = \frac{Obtained\ score}{maximal\ score} \times 100 \quad (1)$$

The result value of multiplication operations using JAMED media is calculated in the following categories.

Table 1. Multiplication Operation Ability Category

No	Inteval	Category
1	80-100	Very High
2	66-79	High
3	55-65	Enough
4	41-45	Low
5	<41	Very Low

(Arikunto, 2006:19)

Scores and percentages will be applied to the testing results from each phase, which are baseline-1 (A1), baseline-2 (A2), and intervention. According to Sunanto(2005) " By multiplying the total likelihood of an event by 100%, the percentage indicates the frequency of a behavior or event".

Percentages (%) are used in calculations while handling data. Sunanto (2006) explains that "the percentage indicates the number of occurrences of a behavior or event compared to the overall likelihood of the occurrence of the event

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multiplied by 100%". The researcher will compute the score of the student's ability in the Multiplication Operation before and after receiving the treatment (intervention), which is why percentages are used. The right answer for each student was divided by the overall score, then multiplied by 100.

3. Results and Discussion

Data interpretation under the following circumstances: baseline 1 (A1), baseline 2 (A2), and intervention (B). the multiplication operation ability of class III students at SDN Pamekasan was combined into one or entered in a format, the results can be seen as follows:

Table 2. Data Multiplication ability results Baseline 1 (A1), Intervention (B) and Baseline 2 (A2)

Sesion	Maximun Score	Score	Mark
	***Baseline* 1 (A1)**		
1	10	3	30
2	10	3	30
3	10	3	30
4	10	3	30
5	10	3	30
	***Intervence* (B)**		
6	10	5	50
7	10	5	50
8	10	6	60
9	10	6	60
10	10	6	60
11	10	6	60
12	10	6	60
13	10	7	70
14	10	7	70
15	10	8	80
	***Baseline* 2 (A2)**		
16	10	7	70
17	10	7	70
18	10	8	80
19	10	8	80

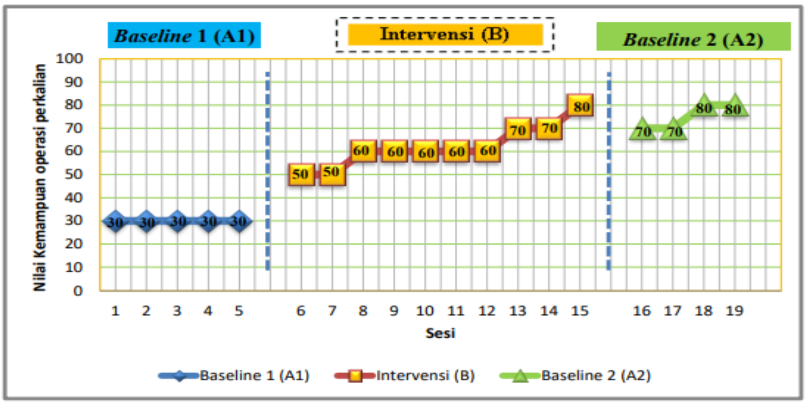

Figure 1. Multiplication Operation Ability of Class III Children at SDN Pamekasan in Baseline 1 (A1), Intervention (B) and Baseline 2 (A2) Conditions

 E-ISSN: *2656-5846*
P-ISSN: *2656-2286*

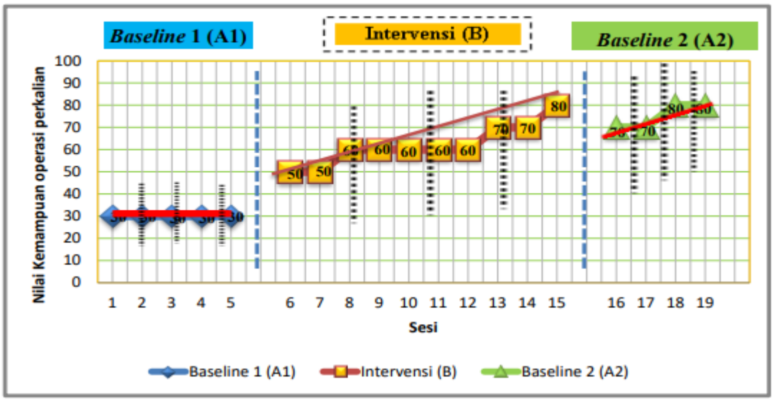

Figure 2. Trends in the Direction of Multiplication Operation Capability in Baseline 1 (A1), Intervention, and Baseline 2 (A2) Conditions

Table 3. Results of Visual Analysis in the Multiplication Operation Capability Condition Baseline 1 (A1), Intervention (B) and Baseline 2 (A2) Multiplication Operation Capability.

Condition	A1	B	A2
Condition-Length	5	10	4
Directional Trend Estimate	(=)	(+)	(+)
Stability Trends	Stable 100%	Variable 50%	Stable 100%
Data Trace	(=)	(+)	(+)
Stability Level and Range	Stable 30 - 30	Variable 50 - 80	Stable 70 – 80
Level change	Stable (0)	Variable (+30)	Stable (+10)

Explanation of the table of visual analysis results in the following conditions:

a) Baseline 1 (A1) conditions had five sessions per condition, Intervention conditions (B) had ten sessions, and Baseline 2 (A2) conditions had four sessions.
b) The data on the subject's capacity to operate the AW from the first to the fifth session has the same value, 30, as indicated by the lines in the above table, indicating that the tendency in the Baseline 1 condition (A1) is to be flat. The data on the subjects' capacity to operate multiplication from the sixth to the fifteenth session rose in value, as indicated by the trend of the line in the Intervention condition (B). However, in baseline condition 2 (A2), the direction tends to grow, indicating an improvement or increase in the AW subjects' multiplication operation ability from session sixteen to session nineteen (+).
c) The data collected indicates stability as the tendency for stability in Baseline 1 (A1) settings was calculated and the findings were 100%. The data acquired is unstable (variable) since the Intervention condition (B) has a 50% inclination toward stability. Baseline 2 (A2) has a 100% trend of stability, indicating that the data is stable.

 E-ISSN: 2656-5846
P-ISSN: 2656-2286

d) The data trail's explanation matches the preceding trend direction (point b). Conditions at baseline 1 (A1), baseline 2 (A2), and intervention (B) ultimately increased.
e) Under Baseline 1 (A1) settings, data tends to be flat with a range of 30 to 30, under Intervention conditions (B) data tends to increase with a range of 50 to 80, and under Baseline 2 (A2) conditions data tends to increase or increased (+) stably with a range of 70 to 80.
f) The data, specifically (=) 30, remained unchanged after the explanation of the level change in Baseline 1 (A1). A change in level, namely an increase of (+) 30 was seen in the Intervention condition (B). Meanwhile, there was a change in Baseline 2 (A2), with the level now being (+) 10.

The components of the analysis between conditions can be seen in the following table.

Table 4. Results of Analysis between Multiplication Operation Capability Conditions

Comparison of Conditions	A1/B	B/A2
Number of variables	1	1
Changes in trend direction and their effects	(=) (+) Positive	(+) (+) Positive
Changes in Stability Trends	Stable to Variable	Variable to Stable
Level change	(30 - 50) (+20)	(80 - 70) (-10)
Percentage of Overlap	0%	0%

The following provides an explanation of the visual analysis results between conditions:

a) One variable, from Baseline 1 condition (A1) to Intervention (B) and from Intervention condition (B) to Baseline 2 (A2), is the only one that has changed.
b) The trend direction between the Intervention circumstances (B) and Baseline 1 conditions (A1) shifts from flat to rising. This suggests that following the Intervention (B), things may improve or turn out better. There is a tendency for the Intervention condition (B) with Baseline 2 (A) to increase steadily.
c) Variations in the stable to variable trend between Baseline 1 (A1) and Intervention (B) conditions. On the other hand, the variable became steady in the Baseline 2 (A2) to Intervention condition (B). This occurred as a result of the AR subjects' multiplication operation abilities receiving different values in the Intervention condition (B).
d) There was a (+) 20 improvement or increase in level between Baseline 1 (A1) and Intervention (B) conditions. Conversely, there was a drop or modification in level (-) of 10 between Baseline 2 (A2) and Intervention conditions (B).
e) Data overlap is 0% between Baseline 1 (A1) and Intervention (B) conditions and 0% between Baseline 2 (A2) and Intervention conditions (B). The results of the growth in the graph show that giving Intervention (B) still has an impact on the target behavior, which is the capacity to perform multiplication. Accordingly, Intervention (B) will have a greater impact on the target behavior (target behavior) the lower the percentage of overlap.

E-ISSN: 2656-5846
P-ISSN: 2656-2286

Multiplication Operations Ability is a part that should have been mastered by every grade III student. However, based on the initial assessment carried out, it was found that third grade students in Pamekasan experienced multiplication problems where students were only able to do basic multiplication. This condition is found in the field so that researchers take this problem. This study uses JAMED media as a way to have a positive influence in improving students' multiplication operations skills, because students are more interested in visual media that has colors that are attractive to students. Therefore, the use of media in the learning process is very important because the presence of media can enhance and support student success in learning. Can provide a concrete understanding of the material provided and the use of JAMED media in learning mathematics multiplication operations. For this reason, the intervention in this study was carried out through JAMED media with modified steps adapted to the characteristics of the AW subject.

This research was conducted while it was divided into three conditions, namely Baseline 1 (A1), Intervention (B), and Baseline 2 (A2). This was indicated by a significant increase in the ability to operate multiplication before and after the treatment, as seen from Baseline 1 (A1) the data obtained was stable, so the researcher stopped giving the test.

In the Intervention (B) the researcher gave the treatment, the multiplication operation ability of the AW subject in the Intervention condition (B) increased. This can happen because JAMED media is given, so that the multiplication operation ability of the AW subject has increased. Whereas at baseline A2 (after being given treatment) the scores obtained by students appeared to decrease and finally the scores obtained by students experienced an increase, when compared to baseline 1 (A1) the value of the multiplication operation ability test. Some of the research results that are relevant to this research are research conducted by Grain (2018) using JAMED to improve students' multiplication arithmetic operations. Nur Hidayah's research shows the effect of using the JAMED formula in class III SD which shows progress towards understanding multiplication in class III SD. And also based on similar research by Zharfa Nur fajrina in 2018 it resulted that using this formula can help develop students' mathematical representation abilities. So that a JAMED method is produced as a solution in learning multiplication of mathematics.

Based on the results of the analysis of data processing that has been carried out and presented in the form of line graphs, using the A-B-A design for the target behavior can improve the multiplication operations ability, the abacus media has a positive effect on increasing multiplication operations on students. Thus it can answer the formulation of the problem in this study, namely that the use of JAMED media can improve the multiplication operations ability of class III students in Pamekasan.

4. Conclusions

Based on the results of the research and data analysis, it was concluded that: 1. The ability to operate multiplication in class III students in Pamekasan before being given the intervention (baseline 1/A1) obtained the same value and was included in the very low category. 2. The multiplication operation ability of class III students in Pamekasan when the intervention (B) was carried out through the abacus media was unstable or variable. There was an increase in the level change

E-ISSN: *2656-5846*
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due to the influence of JAMED media and it was included in the sufficient category. 3. The multiplication operation ability of grade III students in Pamekasan after being given intervention through JAMED media in condition (Baseline 2/A2) has increased compared to baseline condition 1 (A1), obtained a stable value and is included in the high category. 4. The ability to operate multiplication in class III students in Pamekasan is based on the results of an analysis between conditions, namely before being given an intervention (Baseline 1 (A1) the ability to operate multiplication in students is very low, increasing to the sufficient category in conditions when given intervention (B), and from conditions when given the Baseline 2 (A2) intervention increased to the high category.Based on these data, it can be concluded that the use of abacus media can improve the ability to operate multiplication in class III students in Pamekasan.

Author Contributions

The model was constructed with assistance from the first and second authors. The theoretical analysis and result interpretation were assisted by the first and third authors. The analysis and numerical simulations were assisted by the fourth and fifth authors. The manuscript was amended by the corresponding author, the first author, based on feedback from journal editors and reviewers. Each author offered insightful criticism and contributed to the development of the study, analysis, and manuscript.

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Declaration of Competing Interest

No potential conflict of interest was reported by the author(s).

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Design of Android-Based Learning Media "MathArt" on Simple Interest, Discounts, and Taxation at the Lower Secondary Level of Education

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ABSTRACT

This study aims to design and evaluate the effectiveness of the MathArt application, an Android-based learning media focused on simple interest, taxes, and discounts for lower secondary education at SMPN 17 Bengkulu City. The research adopts a four-stage Research and Development (R&D) method: 1) research, 2) planning, 3) development, and 4) product trials. Data were collected qualitatively via Google Forms, targeting data form students and teachers. Questionnaires assessed MathArt's practically and effectiveness. Responses showed strong positive reception on MathArt, with 87.32% from students and 87.54% from teachers. This indicates its high suitability as a social arithmetic learning resource.

1. Introduction

The current development of education is closely intertwined with technological advancements. Education and technology play significant roles in human life, as famously noted by Toffler (1980) that the greatest power in the world lies in technology and knowledge. Consequently, in contemporary times, no aspect of human life, including education, can be detached from technology. Presently, the use of gadgets is not limited to specific individuals but is widely embraced by

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school-aged children (Pankaj S., et al., 2015). An example of such technological usage is through gadgets, which facilitate human communication (Sakina, et al., 2021). Over time, the utilization of gadgets across all age groups has proliferated, encompassing devices like mobile phones, televisions, laptops, tablets, computers, smartphones, and many others (Subarkah, 2019).

The development of gadgets has both positive and negative impacts on children. The positive aspect lies in how gadgets ease the acquisition of necessary information, especially when learning through play or vice versa (Sakinah, et al., 2021). Gadgets help save time and costs in the learning process. However, excessive gadget use can result in negative effects on children's daily behaviors. One such negative impact is that students may lack meaningful learning experiences (Suminar, 2019). Consequently, educators need to address these negative impacts by integrating technological media with teaching methods to provide students with enriching learning experiences while saving time and costs.

Utilizing gadgets as teaching materials is not as straightforward as envisioned. Educators must be proficient in the materials to apply them in teaching effectively. Learning media is crucial in supporting structured and varied learning processes, attracting students' interest (Riyan, 2021). Student interest in learning can be fostered by employing engaging learning models and encouraging student participation. Naturally, student interest in learning activities will lead to improved learning outcomes (Metaputri, et al., 2016). An example of utilizing gadgets in learning media is the use of Android-based mathematics learning applications.

A relevant study concerning the use of Android-based mathematics learning applications is "Development of Android-Based Learning Media on Social Arithmetic Material Using a Scientific Approach Assisted by Construct 2 Software in Grade VII of SMPN 137 Jakarta". The research yielded a validation score of 88.77% from validators, indicating a high level of validity. From this research, it is concluded that the use of Android-based mathematics learning applications is highly suitable for mathematics education.

Based on these research findings, we became interested in creating a similar learning media but using different software. In this study, we utilized iSpring Suite and Website APK Builder to develop the MathArt application. The purpose of this research is to design and evaluate the effectiveness of MathArt, an Android-based learning media focusing on simple interest, taxes, and discounts for lower secondary education. In this paper, we will present student and teacher responses to the application, gathered through qualitative data collection and analysis, to assess its practicality and effectiveness in enhancing the learning experience in social arithmetic.

2. Method

The type of research conducted is Research and Development (R&D). Research and Development is a series of product development, aimed at perfecting a product (Sukmadinata, 2012). In this study, the product developed is an Android application named MathArt, created using iSpring Suite and Website APK Builder. The development model used in this research is the Borg and Gall development model, which consists of ten development stages (Winarni, 2018).

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2.1 The Four Stages of R&D

2.1.1 Research and Information Gathering

Research and information gathering involve collecting initial information for product development. This stage includes literature review to gather initial information about what will be created and how it will be developed.

2.1.2 Planning

Planning involves formulating the objectives of the product to be created and determining what will be needed in the product development process. In this stage, we have formulated to create a mathematics learning application covering the topics of single interest, discounts, and taxes. Before creating the learning application, the initial step we took was to identify the basic competencies, indicators, and student classes for the material used in this application. The National Education Standards Body (BSNP) states that social arithmetic is a mathematics subject for Grade VII of junior high school in semester II. The basic competencies and competency achievement indicators are shown in Table 1.

Table 1. Basic Competencies and Competency Achievement Indicators

No.	Basic Competencies	Competency Achievement Indicators
3.9	Understanding social arithmetic (discounts, simple interest, taxation)	Determining the amount of discount Determining the amount of simple interest and tax
4.9	Analyzing various social arithmetic situations (discounts, simple interest, taxation)	Solving story problems related to discounts Solving story problems related to simple interest and tax

The next step is to determine the components that will be included in the application. These components consist of materials, quizzes, and instructional videos. To fulfill the components that will be included in the application, we have designed and created storyboards for instructional videos. Additionally, we have chosen a name for our product, which is the MathArt Mathematics Learning Application. Storyboard Creation Interface for Video Production in the MathArt Application. This storyboard was created using Microsoft PowerPoint 2010 software as shown in figure 1.

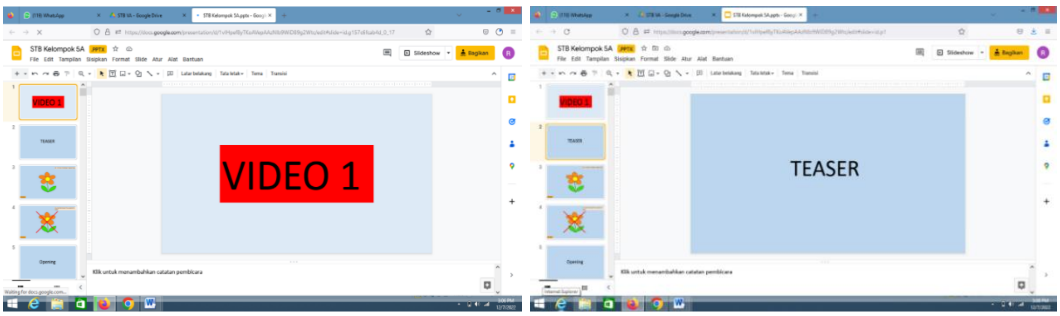

Figure 1. Storyboard Creation Interface

2.1.3 Product Format Development

The development of learning media involves leveraging various software tools, such as Ispring Suite, Website APK Builder, Microsoft PowerPoint, and CapCut, to ensure effectiveness and engagement. Alvin Toffler's quote, 'The illiterate of the 21st century will not be those who cannot read and write, but those who

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cannot learn, unlearn, and relearn' (Toffler, 1980), underscores the commitment to harnessing modern technology for educational advancement. These platforms enable the creation of dynamic and interactive learning materials tailored to students' needs, with Microsoft PowerPoint utilized for storyboarding and CapCut for refining video content, ensuring clarity and coherence in educational material presentation.

Figure 2. Initial Interface of the MathArt Application and Second Page Interface of the MathArt Application

Figure 2 illustrates the initial interface of the MathArt application. The initial interface features the developer's logo, the title of the application's content, and the name of the learning module. On the right side of figure 2 depicts the second page of the MathArt application. On this page, users can find the menu options available in the MathArt application. These options include instructional guidelines, learning objectives, learning materials, instructional videos, and quizzes designed to enhance students' skills.

Figure 3. Second Page Interface of the MathArt Application and Interface of the Objectives Feature in the MathArt Application

Figure 3 showcases the second page interface of the MathArt application, emphasizing the importance of clarifying learning objectives in education. Inspired by contemporary educational thought, the interface echoes the sentiment that "Education is not preparation for life; education is life itself" (Dewey, 2013). By aligning with John Dewey's timeless philosophy, the interface aims to elucidate the purpose behind students' learning journeys, fostering

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deeper engagement and comprehension. This approach, coupled with Benjamin Franklin's adage, "Tell me and I forget, teach me and I may remember, involve me and I learn," emphasizes the importance of actively involving students in their educational endeavors (Franklin, 2014). Thus, through a clear articulation of objectives, the MathArt application cultivates enriched learning experiences, driving students towards academic excellence.

Figure 4. Interface Display of the Objectives and Instructional Videos Features in the MathArt Application

On the left side of Figure 4 is the interface display of the Objectives feature in the MathArt application. This display contains information about the objectives of the learning process, aiming to help students understand the purpose behind their learning journey. On the right side of Figure 4 is the interface display of the Instructional Videos feature in the MathArt application. This feature provides instructions on how to use the feature and access instructional videos, with the goal of enhancing students' understanding of the learning material through the availability of instructional videos within the application.

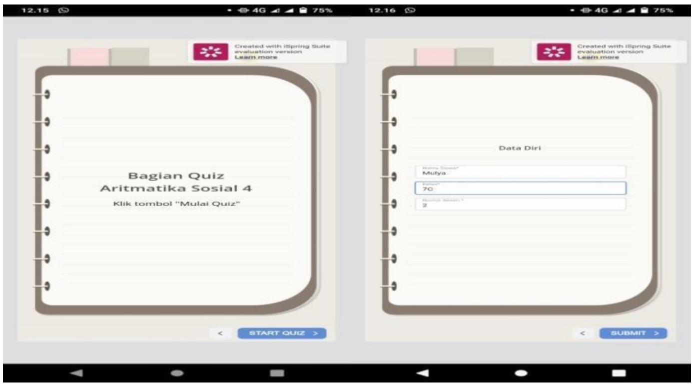

Figure 5. Interface Display of the Quiz Feature in the MathArt Application

Figure 5 displays the interface of the quiz feature in the MathArt application. The initial page of this feature contains the quiz title or introduction, followed by subsequent pages with columns for student personal data. Once students fill in their personal information, they are directed to the quiz instruction page. Here, students can proceed to take the quiz based on the provided instructions. Subsequent pages present quiz questions, allowing students to directly answer by clicking on options A, B, C, and D.

E-ISSN: 2656-5846
P-ISSN: 2656-2286

2.1.4 Field Testing
The field testing for this research was conducted at SMPN 17 in Bengkulu City, involving 34 participants, comprising 29 student respondents and 5 teacher respondents. The field testing falls within the moderate scale, with qualitative data obtained. Qualitative data were collected through questionnaires distributed via Google Forms for student respondents and paper forms for teacher respondents. These questionnaires included three indicators: the content of the learning application, language, and material. The data collected from the questionnaires will be analyzed according to the specific objectives using Likert scale analysis.

2.2 Data Collection Instruments
The instruments used in this study consist of validation questionnaires regarding the MathArt application, which are filled out by teachers and students. The distributed questionnaires assess teachers' and students' evaluations of the MathArt application regarding its content, language, and material. These questionnaires are intended for mathematics teachers and seventh-grade students at SMP N 17 in Bengkulu City. The questionnaires distributed to students and teachers are closed-ended, with four response options: strongly agree, agree, disagree, and strongly disagree.

2.3 Data Analysis Techniques
The research data obtained from student and teacher responses are analyzed using a Likert scale test. The steps of data analysis are as follows.

2.3.1 Data Presentation
In this step, the obtained data will be grouped according to the observed aspects. Subsequently, scoring will be conducted using Likert scale assessment calculations with a point range of 1 - 4.

Table 2. Likert Scale for Assessment

Answer Options	Score
Strongly Agree	4
Agree	3
Disagree	2
Strongly Disagree	1

(Sugiyono, 2015)

2.3.2 Calculation of the Percentage Score
For each aspect on the observed questionnaire using the formula:

$$Score\ Percentage = \frac{\sum Acquired\ score}{\sum Maximum\ score} \times 100\% \quad (1)$$

In this crucial phase, the processed data will undergo meticulous calculation facilitated by Microsoft Excel software, ensuring accuracy and efficiency in deriving meaningful insights. The acquired score, pivotal in assessing the effectiveness of the MathArt application, embodies the summation of individual scores garnered across various indicators within the questionnaire.

As articulated by Sugiyono (2015), "The process of quantitative data analysis

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requires meticulous attention to detail, especially in compiling and aggregating scores obtained from diverse sources." Concurrently, the determination of the maximum achievable score is emblematic of the comprehensive evaluation framework, delineating the upper bounds of potential attainment. Drawing from best practices elucidated by experts in educational research, such as Creswell (2014), this phase underscores the significance of methodological rigor in ensuring the reliability and validity of the assessment process. Thus, through robust data computation and rigorous validation, this endeavor aims to furnish actionable insights conducive to informed decision-making in educational contexts.

2.3.3 Conversion of the Average Percentage Score of the Questionnaire into Qualitative Values Based on the Level of Validity.

Table 3. Categories of Data Validity Levels

Percentage (%)	Answer Options	Justification
80 < score ≤ 100	Highly Valid	No Revision
60 < score ≤ 79	Valid	No Revision
40 < score ≤ 59	Sufficiently Valid	Partial Revision
20 < score ≤ 39	Less Valid	Revision
0 < score ≤ 19	Highly Invalid	Revision

(Riduwan, 2008)

The product is considered suitable and beneficial for use if the validity level of the achieved data results attains a minimum average questionnaire score percentage of not less than 61%, categorized as good.

3. Results and Discussion

3.1 Result

The field trial results aim to determine the success of the MathArt learning application product in achieving its objectives and gather information for enhancing the MathArt learning application product and for the purposes of improvement in the subsequent stages. The outcome of this field trial is as follows:

Table 4. Percentage Interpretation of Student Scores

Aspect	Percentage (%)	Criteria
Learning Application Content	87,50%	Very Strong
Language	86,45%	Very Strong
Material	88,01%	Very Strong

Based on the table provided, the MathArt learning application demonstrates strong performance across various aspects. Specifically, the content of the application achieved a percentage of 87.50%, indicating a robust level of comprehensiveness and relevance. Similarly, the language aspect attained a percentage of 86.45%, suggesting a high standard of linguistic clarity and effectiveness. Moreover, the material aspect scored 88.01%, reflecting a highly substantial and informative content structure. Overall, these results underscore the commendable quality and effectiveness of the MathArt learning application across all evaluated dimensions.

E-ISSN: 2656-5846
P-ISSN: 2656-2286

Table 5. Percentage Interpretation of Teacher Scores

Aspect	Percentage (%)	Criteria
Learning Application Content	86,82%	Very Strong
Language	87,00%	Very Strong
Material	89,00%	Very Strong

Based on the provided table, it is evident that the MathArt learning application excels across various aspects as evaluated by teachers. Specifically, the content of the application scored 86.82%, indicating a highly robust and comprehensive coverage. Similarly, the language aspect achieved a percentage of 87%, reflecting a commendable level of linguistic clarity and effectiveness. Moreover, the material aspect attained an impressive score of 89%, underscoring the substantial and informative content structure of the application. Overall, these results affirm the exceptional quality and effectiveness of the MathArt learning application, as perceived by teachers, across all assessed dimensions.

The result show, the MathArt learning application demonstrates strong performance across various dimensions, with content, language, and material aspects scoring impressively at 87.50%, 86.45%, and 88.01%, respectively. These results highlight the application's comprehensive and relevant educational content, linguistic clarity, and substantial material structure. Similarly, teacher evaluations affirm MathArt's excellence, with high scores across all aspects, underscoring its effectiveness in delivering engaging and informative learning experiences.

3.2 Discussion

After the product is completed, it will be tested on seventh-grade junior high school students and mathematics teachers to assess its suitability. The trial is conducted by students from SMPN 17 in Bengkulu City and mathematics teachers in Bengkulu City. From the trial conducted with 29 student respondents and 5 mathematics teacher respondents, the interpretation percentage scores are obtained as follows: learning application content 87.50%, language 86.45%, and material 88.01% based on student respondents. Thus, from the percentage results obtained from student respondents, it can be concluded that our product excels in the material indicator. This is because in the MathArt application, the material provided is explained briefly, concisely, and clearly, making it easy for students to understand (Sugiyono, 2015).

Meanwhile, based on teacher respondents, interpretation percentage scores are obtained as follows: learning application content 86.82%, language 87.00%, and material 89.00%. Thus, from the percentage results obtained from teacher respondents, it can be concluded that our product excels in the material indicator. This is because in the MathArt application, the material provided is explained briefly, concisely, and clearly, making it easy for students to understand, according to teachers (Creswell, 2014).

Based on the results from both student and teacher respondents, the highest percentage for the MathArt application is in the material indicator. This is because the MathArt application presents material in a structured manner, starting from the understanding of the material, formulas accompanied by symbol explanations, instructional videos, example problems, and quizzes given

E-ISSN: 2656-5846
P-ISSN: 2656-2286

at the end. Below is a further explanation of the material indicator in the MathArt application:

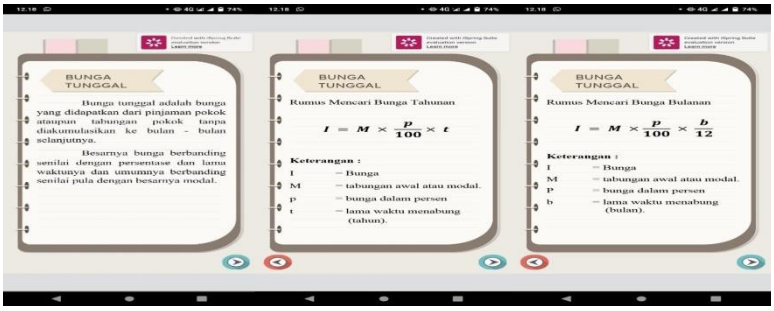

Figure 6. Display Image of Material I

In Figure 6, depicts the initial view of the single interest material page, explaining single interest. Subsequently, on the second and third pages, the formula for single interest is displayed alongside explanations of the formula's symbols. Hence, students can better grasp the material and understand the simple interest formula presented in the MathArt application.

Figure 7. Display of Material I Video Page

Figure 7 depicts the second view of the material page containing a video on single interest. On this page, users are directed to access the instructional video link. Thus, with the presence of this instructional video, students can better comprehend the explained material. In the instructional video, the learning material will be directly explained by the presenter, and it also includes images or real examples of the material, making it less monotonous than text alone.

Figure 8. Display of Material II

Figure 8 displays the page on the discount material. On the first page of the material, the definition of discount is provided, using language that is easily understood by students. Subsequently, on the second and third pages, the

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formula for discount is presented along with explanations of the formula's symbols. This enables students to better comprehend the material and understand the discount formula presented in the MathArt application.

Figure 9. Image Display of the Video Page for Material II

Figure 9 depicts the video page for the discount material. On this page, users are directed to access the instructional video link. Thus, with the presence of this instructional video, students can better understand the explained material. Because in the instructional video, the learning material is explained directly by the presenter, and the video content is not monotonous text but also includes images or real-life examples of the material.

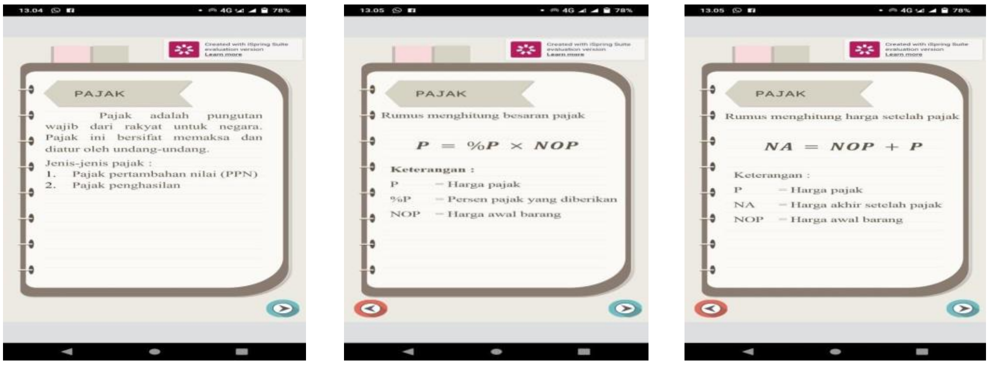

Figure 10. Display of the Page on Material III

Figure 10 illustrates the page layout for the tax material. On the initial page of the material, the definition of tax is provided, employing easily understandable language for students. Subsequently, the second and third pages display the tax formulas accompanied by explanations of the formula symbols. Thus, students can better comprehend the material and understand the tax formulas presented in the MathArt application.

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Figure 11. Display of the Video Page on Material III

Figure 11 depicts the video page on tax material. On this page, users are directed to the instructional video link. Consequently, with the presence of these instructional videos, students can better understand the explained material. These videos provide direct explanations from the presenter and are not solely reliant on text, but also include images or real-life examples of the material.

Aligned with similar research on Android-based learning media using Construct 2 software, it was found that the highest percentage regarding the listed indicators in the application was the suitability of the learning media content, with a percentage of 99.12% (Anisah, et al., 2019). This indicator is a crucial aspect of the success of Construct 2 learning applications, as it encompasses important aspects of the learning process, including learning material. In line with this, the MathArt application has fulfilled the crucial aspect of the learning process, namely learning material, as evidenced by the highest percentage obtained from respondents lying in the material indicator. Thus, it can be said that the MathArt application is highly suitable for use in the learning process of single interest, discount, and tax materials.

4. Conclusions

This study finds that the MathArt application received positive responses, with percentages of 87.32% from students and 87.54% from teachers. Therefore, this application is highly recommended for teachers to use as a learning tool and for future researchers to further develop into an even better learning medium.

Author Contributions

The author contributions for this article are as follows: Ratnah Lestary served as the primary author, responsible for conceptualization, methodology, and validation. Mulya Sarti Apriani contributed to data curation, investigation, and formal analysis. Rizki Putri Kesuma participated in software implementation, visualization, and writing the original draft. Riko Dwi Cahyo provided resources, supervised the project, and reviewed and edited the manuscript. Teddy Alfra Siagian contributed to project administration, funding acquisition, and critical review and revision of the article. All authors read and approved the final version of the manuscript.

Declaration of Competing Interest

As the author of this article, I declare any potential competing interests that may influence the impartiality or interpretation of the study. These interests encompass financial or personal affiliations, rivalries, or religious convictions. It is important to note that there are no conflicts of interest related to this research. There are no financial relationships or agreements with any organization mentioned in the study. The manuscript was not written under any remuneration, and there are no competing interests that could impact the objectivity of the work or the views expressed herein.

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Development of Problem-Based Senior High School Mathematics Learning Tools with a Culturally Responsive Teaching Approach

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ABSTRACT

This development research aims to produce valid, practical, and effective senior high school mathematics learning tools through problem-based learning with a Culturally Responsive Teaching approach. The research employed a 4-D model, consisting of the Define, Design, Develop, and Disseminate stages. The research subjects were 36 students in Class X-4 of SMAN 3 Lumajang for the 2022/2023 academic year. The learning tools outcomes included teaching modules, students' worksheets (LKPD), student activity observation sheets, and test questions. The established criteria revealed that the learning tools outcomes were valid, effective, and practical. Hopefully, further research could develop more varied learning tools regarding materials, learning models, and integrated culture.

1. Introduction

One of the branches of knowledge studied by students at school is mathematics. Mathematics cannot be modified because it is a science whose truth is absolute and based on pure deduction, an essential part of mathematical proof. The deduction system explains that a statement is considered valid if the underlying axioms or postulates are also valid (Sinaga et al., 2021). Mathematics is still one of the subjects that is considered difficult by students in elementary and middle school. The learning material is abstract, and the teacher still uses expository methods during the learning process, resulting in some students being unable to understand the material well because of their concrete thinking.

Setiyawan (2017) states that mathematics learning should start by introducing problems or posing real-world problems. Masril et al. (2020) reveal

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that problem-based learning aims to help students develop thinking, problem-solving and intellectual skills, learn how to participate in real-world experiences, and become independent learners.

Interviews with Class X mathematics teachers at SMAN 3 Lumajang showed that teachers experienced difficulties developing problem-based learning tools integrated with culture. Many students also experienced difficulties solving mathematical problems related to data concentration measurement material. In addition, the lack of active participation of students and the unconducive classroom environment during the learning process could make learning activities in the classroom ineffective and inefficient. It made teachers need to facilitate students by using learning models that could actively engage students during the learning process. Learning activities must also be able to explore students' competencies, both in the cognitive, psychomotor, and affective domains. To overcome these problems, teachers can use a problem-based learning model with a *culturally responsive teaching* approach.

The problem-based learning model is a learning model that applies elements of authentic assessment (real or concrete reasoning) comprehensively because it contains elements of finding problems or problem posing as well as solving them (Indrianawati & Wahjudi, 2014). To solve these problems, students will gain knowledge and skills related to the studied material. According to Lubis & Azizan (2018), the problem-based learning model is a learning model that requires students to be more creative, critical, and actively participate in the learning process, especially in solving problems. In line with this, Djonomiarjo (2019) highlights that the problem-solving approach positions the teacher as a facilitator, which focuses on student learning activities. Active learning that engages students, individually and in groups, will be more meaningful because students gain much experience in the learning process. The characteristics of problem-based learning include the application of contextual learning, the presentation of problems that can motivate students to learn, integrated learning (integrity) with unlimited problems, active engagement of students in learning, collaborative cooperation, as well as the development of skills, experience, and concept (Fauzia, 2018).

The *culturally responsive teaching* approach recognizes and accommodates cultural diversity in an environment. Indeed, this approach recognizes and embeds the culture of fellow students in the school curriculum and builds meaningful relationships with the culture of the community. The *culturally responsive teaching* approach is designed to empower students by using meaningful cultural relationships to convey academic social knowledge and attitudes. Maryono et al. (2021) convey that the *culturally responsive teaching* approach involves all students actively participating during learning, a fundamental element of effective teaching. This approach motivates students to learn actively and also encourages them to become independent, namely being able to learn independently, being responsible, tolerant, and respecting differences with other students. Integrating learning and culture in the learning process will create a meaningful learning atmosphere. Arif et al. (2021) also revealed that the culturally responsive teaching approach was a learning method that emphasized the equal rights of every student to receive teaching without distinguishing between their cultural backgrounds. In their research results, Masruroh & Fathani (2024) revealed that mathematics learning tools based on the ethnomathematics of the traditional house of the Osing Tribe of Banyuwangi showed that these learning tools could increase student participation in learning activities.

Based on the description above, it is necessary to develop problem-based senior high school mathematics learning tools with a *culturally responsive teaching* approach. The problem-based learning model requires students to play an active role in solving problems. In addition, the culturally responsive teaching-learning approach recognizes and accommodates cultural diversity in the learning environment. The use of this model is expected to increase students' interest and ability in understanding and solving mathematical problems. This research focused on developing problem-based senior high school mathematics learning tools with a *culturally responsive teaching* approach, including teaching modules, students' worksheets, student activity observation sheets, and test questions. Therefore, this research aims to produce valid, practical, and effective mathematics learning tools through problem-based mathematics learning with a culturally responsive approach.

2. Method

This research employed development research methods. The research was carried out in the even semester of the 2022/2023 academic year at SMAN 3 Lumajang. The research subjects were 36 students in class X-4. This development research used a development model consisting of four development stages: *define*, *design*, *develop*, and *disseminate* (Thiagarajan et al., 1974).

The research instruments included teaching modules, student worksheets, student activity observation sheets, and test questions. The validators involved in this research consisted of a mathematics education lecturer and a mathematics teacher. The data analysis technique was descriptive statistical analysis. Data was analyzed based on suggestions and input from validators, which were used as improvement material during the learning tool revision stage. Data analysis was also carried out on students' test results after completing the learning.

Furthermore, the validity level of an instrument was determined by modification outcomes, as mentioned by Hobri (2010), who suggested the steps for determining the V_a value as follows:

a. The validator evaluated each aspect of the research instrument and then determined the average scores of the validation results from the validator for each aspect with the formula:

$$I_i = \frac{\sum_{j=1}^{n} V_{ji}}{n} \quad (1)$$

Where:
I_i : average score of validation results from the validator for each -i aspect
V_{ji} : *j*- validator score data for the -i aspect
n : number of validators

b. Calculating the total average score for each V_a aspect with the formula:

$$V_a = \frac{\sum_{i=1}^{n} I_i}{n} \quad (2)$$

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Where:
V_a: total average score for each aspect
I_i: average score of validation results from the validator for each -i aspect
i: rated aspect
n: number of aspects

c. Determining an instrument's validity level based on the instrument validity level category (modified from Hobri, 2010).

Table 1. Instrument Validity Level Categories

V_a Value	Validity Level
$1 \leq V_a < 1.5$	Invalid
$1.5 \leq V_a < 2$	Less valid
$2 \leq V_a < 2.5$	Fairly Valid
$2.5 \leq V_a < 3$	Valid
$V_a = 3$	Very Valid

The minimum research instrument has met the V_a value with a valid category; thus, it could be used. If the instrument does not meet the valid category, it must be revised and retested until it meets the valid criteria.

Data was analyzed based on the results of student observations and tests after completing each learning cycle. Adopted from Ngalim Purwanto (1992), a formula for analyzing data from student activity observations can be seen below:

$$Observation\ Results\ Score\ (NHO) = \frac{Obtained\ Score}{Maximum\ Score} \times 100\% \quad (3)$$

Based on the percentage value obtained from observations of student activities, interpretation was carried out using the following interpretation categories.

Table 2. Success Level Criteria

Percentage of Student Activities (%)	Category
$85 \leq NHO < 100$	Excellent
$70 \leq NHO < 85$	Good
$55 \leq NHO < 70$	Sufficient
$45 \leq NHO < 55$	Less
$0 \leq NHO < 45$	Poor

Source: modified from Satriani (2016)

The success of student learning outcomes could be measured from those who reached the *Minimum Completeness Criteria* (KKM) of 70 with a minimum classical completeness level of 75% of students who reached the specified KKM (Depdiknas, 2004). The formula for calculating the level of classical learning completeness can be defined as follows:

$$Completeness\ of\ Classical\ Learning = \frac{Total\ of\ Passed\ Students}{Total\ Students} \times 100\% \quad (4)$$

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3. Results and Discussion

A mathematics education lecturer and a mathematics teacher tested the validity of the research instrument. After both validators filled out the validation sheet, the validation results were analyzed using the validation formula and produced a total average score for all aspects (V_a). Furthermore, the total (V_a) values for all aspects categories were given based on Table 1, and the validity level was determined. Based on the results of the validity test, the teaching module was declared valid with a (V_a) value of 2.71, which was in the interval $2.5 \leq V_a < 3$ and the interpretation category was valid. Thus, the teaching module could be implemented. Student worksheets were also declared valid with (V_a) value of 2.81, which was in the interval $2.5 \leq V_a < 3$ and the interpretation category was valid; hence, it could be implemented.

The results of the validity test of the student activity observation sheet obtained a (V_a) value of 2.79, which was in the interval $2.5 \leq V_a < 3$ and the interpretation category was valid so that it could be used for data collection. The results of the validity test of the test questions obtained a (V_a) value of 2.88, which was in the interval $2.5 \leq V_a < 3$ and the interpretation category was valid. Thus, it could be used for data collection. Observations were carried out to perceive students' activities during the learning process. The observation results of students' activities in Class X-4 are:

Table 3. Observation Results of Student Activities

Percentage	Category
94%	Excellent

In addition, student learning outcomes were tested after applying learning tools to data concentration measurement material. The students' learning outcomes in Class X-4 are presented below:

Table 4. Students' Learning Outcomes

Total Students	Total Scores	Average Score	Number of Passed Students	Number of Unpassed Students	Classical Completion Percentage	Classical Achiev-ement (75%)
36	3023	83.97	31	5	86%	Passed

This research employed a 4-D development model that consisted of four stages: *define*, *design*, *develop*, and *disseminate* stages. The definition stage aims to determine and define the requirements needed for learning by analyzing the objectives and limitations of the device material being developed. The process of developing learning tools in this research began with observing and searching for information about mathematics learning carried out in schools. The results of interviews with mathematics teachers showed that teachers experienced difficulties in developing problem-based learning tools that were integrated with culture. Based on the results of initial observations in class, students experienced difficulty in solving mathematical problems related to data concentration measurement material. Therefore, in developing this learning tool, mathematical problems would be given to students through student worksheets, which would be worked on in groups. The learning tool development aims to help students understand the concept of data concentration measures, especially group data

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mode material, as well as improve their ability to solve mathematical problems.

Meanwhile, the *design* stage aims to design a learning device prototype. Preparing tests was the first step in connecting the *define* stage and *design* stage. The tests were prepared based on indicators of competency achievement and were used as a measuring tool for changes in students' behavior after the learning process. The researcher chose a problem-based learning model with a culturally responsive teaching approach in Class X-4 with a particular class and student characteristics. The learning media was PowerPoint, while the research development format would be teaching modules, student worksheets, learning media, and test questions. Teaching modules were prepared using a problem-based learning model with a culturally responsive teaching approach. The students' worksheets contained a brief description of the data concentration measurement (mode) material as well as several problems that students discussed during learning. Meanwhile, the preparation of assessments took the form of test questions, which were given at the end of the lesson to determine student learning outcomes.

In addition, *develop* stage aims to modify the learning device prototype. In this research, the validity of the research instrument was tested by a mathematics education lecturer and a mathematics teacher at SMAN 3 Lumajang. Based on the results of the validity test, the teaching module was declared valid with a (V_a) value of 2.71, which was in the interval $2.5 \leq V_a < 3$ and the interpretation category was valid so that the teaching module could be implemented. Student worksheets were also declared valid with (V_a) value of 2.81, which was in the interval $2.5 \leq V_a < 3$ and the interpretation category was valid. Hence, it could be implemented. However, the student activity observation sheet was also declared valid with (V_a) value of 2.79, which was in the interval $2.5 \leq V_a < 3$ and the interpretation category was valid. Hence, it could be used for data collection. Finally, the test questions were also declared valid with a (V_a) value of 2.88, in the interval $2.5 \leq V_a < 3$ and the interpretation category was valid; thus, it could be used for data collection. Based on previously established effectiveness criteria, the learning tools produced in this research were included in the excellent category. It was due to the fact that 86% of the students who took the exam in class achieved scores of over 70, with an average class score of around 83.97. Besides that, the learning tools outcomes were also stated to be practical because the observation results of student activities showed a percentage of 94%, indicating that the learning implementation in this research was excellently committed.

After going through the field trial stage, the final learning tools, consisting of teaching modules, student worksheets, student activity observation sheets, and test questions, have been successfully developed. Then, *disseminate* stage intended that the learning tools would be distributed through outreach to the MGMP Mathematics forum at SMAN 3 Lumajang. Hopefully, mathematics teachers who are members of the forum can implement these learning tools in mathematics learning based on the material being taught.

This research only discussed data concentration measurement material at the senior high school level. However, the results of the validation and learning device tests showed that the learning devices that had been created met the criteria of being valid, effective, and practical based on established standards. Hopefully, the research results can contribute to the development of more

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effective and relevant mathematics learning tools for students' cultures. They can increase teachers' and students' awareness of the importance of integrating local culture into mathematics learning at school. Similar research has also been carried out by Masruroh & Fathani (2024), where their research results revealed that the mathematics learning tools based on the ethnomathematics of the traditional house of the Osing Banyuwangi Tribe that had been created met the criteria of being valid, practical, and effective.

4. Conclusion

In short, this research concluded that:

1. The problem-based mathematics learning tool with a culturally responsive teaching approach that has been developed in this research was considered valid. The learning tools consisted of teaching modules, student worksheets, student activity observation sheets, and test questions.
2. The practicality and effectiveness of problem-based mathematics learning tools with a culturally responsive teaching approach that had been developed in this research were considered excellent. It can be seen in student learning outcomes and student activities during learning.

In this research, researchers provided several recommendations as follows:

1. The learning tools that have been created still need to be tested in other schools that have different conditions in order to produce quality learning tools.
2. The learning tools created in this research only discussed material measuring data concentration at the senior high school level. Hopefully, future research can develop more varied learning tools in terms of integrated material, learning models, and culture.

Author Contributions

The first author focused on collecting, processing, and analyzing the research data. The second author contributed to creating the scientific articles and managing the publication process.

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Declaration of Competing Interest

The authors declare that there are no conflicts of interest.

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E-Module for Problem-Based Learning Integrating Batak Toba Culture (PBL BTC) to Improve Problem-Solving Ability

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ABSTRACT

This research aims to analyze: 1) the validity, practicality and effectiveness of the PBL e-module based on Batak Toba Culture (PBL BTC) which was developed to increase students' problem-solving abilities at SMP Negeri 1 Simanindo; 2) increasing students' problem-solving abilities through the developed e-module. This research is using the ADDIE. From the tested of class IX 2 was obtained: 1) the PBL BTC e-module have the criteria of being valid, effective, and practical; 2) Increased problem-solving abilities using the PBL BTC e-module as seen from the N-gain value is 0.506, it is in the "medium" category. This research recommendations might be made the E-Module with mathematical problem-solving tasks on the topic of congruency should be continued for future effectiveness evaluations.

1. Introduction

Education is a legitimate endeavor to generate exceptional individuals, hence it contributes to an important role in defining a nation's existence. Understanding the significance of education motivates everyone, particularly legislators and educators, to strive for the greatest education possible. Throughout Indonesia, the intention of developing top-notch human resources is still being actively pursued. Indonesia's mathematics score is still below the global average,

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according to the PISA (Program for International Student Assessment) results. PISA is an international survey program that evaluates students' literacy in reading, mathematics, and science at the age of fifteen. Indonesia is placed 69 out of 81 participating nations in the 2022 PISA inquiries, with a common score of 366, whilst the average score for all countries is 472 (*PISA 2022 Results (Volume I)*, 2023). It is anticipated that the national education system will bring about change and support students in acquiring problem-solving, adaptive, and learning skills.

It is necessitate to teach mathematics at all educational levels, including elementary, middle, high school, and college. This is so that learners can be ready for their future employment, as mathematics is a fundamental subject. In the twenty-first century, sophisticated thinking skills are the primary concern of the teaching of math in schools. When non-routine problem-solving is incorporated into mathematics evaluations, students' HOTS are stimulated, leading to a variety of solutions to fundamental technical problems that cannot be solved just by conventional approaches. One should not undervalue the significance of being able to answer non-routine mathematical issues. In the twenty-first century, it is becoming more and more important to be able to handle non-routine cases, which are those that require analysis, synthesis, and creativity and are incapable of being resolved using previously established strategies or formulas (Azid et al., 2022).

That is, a challenge involving a circumstance for which one or more suitable solutions have not yet been developed for the person or group involved. Fundamentally, for children to be resilient in the face of continuously changing circumstances in life and the outside world, mathematics education in schools must prepare them to think critically, logically, carefully, honestly, and successfully. In elementary and secondary education, students should be able to: (1) utilize patterns as hypotheses in solving problems and get competent to reach interpretations based on existing conditions or details; (2) use rational thought on things, carrying out logical manipulations both in simplifying as well as analyzing previous parts in addressing issues; and (3) explain concerns, logical thinking, and compiling statistical proof thru written representations, graphs, charts, or any other means to clear tasks or specific situations. This is stated in Indonesian Education and Culture Regulation Number 58 of 2014 as the objectives of mathematics education.

Four steps for problem-solving processes were proposed by Polya (Fitriani et al., 2022): working backward, drawing a figure, generalization, analogy, and trial-and-error. Students would gain from practicing these procedures since it encourages them to analyze problems, make and carry out strategies, and determine whether or not the strategy produces the desired results. Students could effectively address mathematical and practical problems using this technique. Previous research revealed that employing the Polya stage in solving a problem is very useful for students. When students reach the understanding stage of the problem, they can recognize and comprehend the known elements of the problem. When a plan is being created, the subject has a method for handling the issue. In the following step, the subject applies the previously created plan to tackle the problem. In order to confirm the outcomes, the subject reexamines them in the final step (Murtiyasa & Wulandari, 2022).

Digital textbooks and modules significantly improve education by giving learners and educators fresh perspectives. The main purpose of creating

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electronic math learning materials is to enhance HOTS, alternative learning resources, and mathematical literacy for today's learners (Wijaya et al., 2022). This e-module learning media is allowed by the National Education Standards Regulation Number 19 Article 19 (1) of 2005 of the Indonesian Government, which suggests it implementing in schools should be interactive, inspiring, fun, and challenging, with students encouraged to participate actively.

Designing teaching materials that are appropriate to the local cultural context is an alternative source of student learning. E-modules will assist students in recognising culture and diversity because they may be presented more attractively through instructional videos, audio, visual aids, and appealing designs. As a result, e-modules must be built with both display design and convenience of access in mind in order to pique students' interest and motivate them to learn (Latif & Talib, 2021).

According to several research, junior high school students can improve from adopting e-modules that employ Flip Pdf Professional software to learn mathematics (Aulia & Prahmana, 2022; Tania & Siregar, 2022; Yunianta et al., 2023). The outcomes of his investigation, the created mathematics e-module product was legitimate and appropriate for use in the classroom. For that reason about it to be useful utilized as a substitute for other learning tools for mathematics. With the help of Flip PDF Professional, you can create interactive flipbooks with chapters that include images, questions, flash, MP4, audio, and YouTube videos, among other types of information (Seruni et al., 2020).

Mathematics and culture are intimately intertwined. D'Ambrosio developed Ethnomathematics as a solution based on the way mathematics has been taught in schools and his reflections on how mathematics evolved. Ethnomathematics is a means of learning and integrating concepts, methods, and approaches that have been created and employed by people from many sociocultural backgrounds (Prahmana et al., 2021). Conforming to Borba, ethnomathematics is the application of mathematical ideas unique to a culture to the relational and spatial facets of daily life (Yeni D. Fonataba et al., 2023). Previous research verified the effectiveness of integrating cultural lessons into mathematics education (Latif & Talib, 2021; Wahyu Sintiya et al., 2021). Research on the development of culture-based e-modules on mathematical lessons showed positive outcomes for junior high school students (Nurfadilah et al., 2023; Utami et al., 2018).

The electronic module with the PBL anchored in Batak Toba Culture is expected to serve space of learners with educating and cultivating the way they learn, with the hope that change the paradigm from teacher-centered learning to student-centered instruction. Based on Batak Toba culture, this research creates digital teaching materials (e-modules) that will be implemented in Ambarita Village, Samosir Regency, North Sumatra Province.

2. Method

The subjects in this research were students of SMP Negeri 1 Simanindo class IX 1 for development trial and students of class IX 2 for implementation. After students have finished learning with the lesson plan, the quality of their learning outcomes is evaluated using the learning ability test instrument. The problem-solving skills of the participants were assessed using essay-style questions as the learning capacity test in this research.

The reasons and considerations for going for the subjects of this study were based on Piaget's concepts of levels of intellectual development, with children aged 11 and up having entered the formal operational stage. The object of the current research is a digital module (e-module) regarding similarity and congruence material.

This form of research is Research and Development, thereby implements the ADDIE. The steps of the ADDIE process are explained in the chart below.

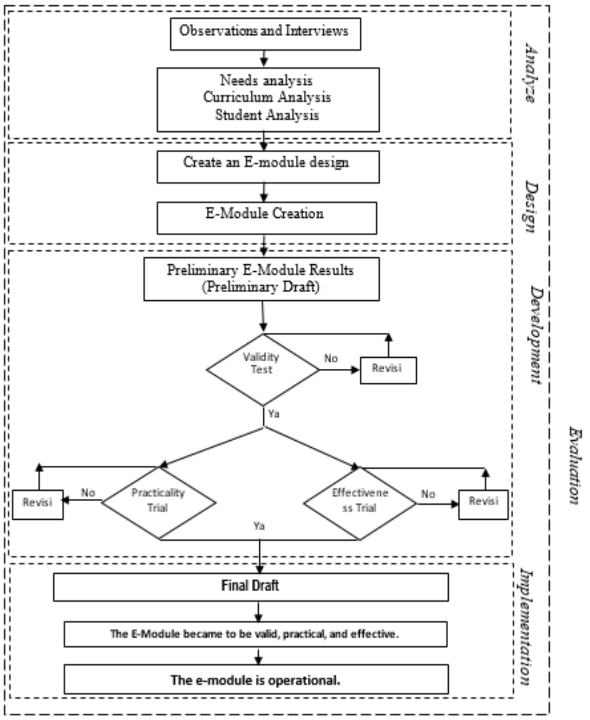

Figure 1. The ADDIE Methodologies for Research

Instruments for research can be classified into three categories: validity, practicality, and e-module effectiveness. Expert Validation will conduct two types of analysis: media analysis from one validator who is an ICT instructor and content analysis (material) from two validators who are mathematics lecturers. With the criteria according to (Sagala & Widyastuti, 2021), as shown in Table 1.

Table 1. The Criteria of Validity

No	Quality score	Statement quality aspect validitas
1.	$3,26 < \bar{x} \leq 4,0$	most valid
2.	$2,51 < \bar{x} \leq 3,26$	Valid
3.	$1,76 < \bar{x} \leq 2,51$	Adequate
4.	$1,00 < \bar{x} \leq 1,76$	Less

Validity methods for data analysis are carried out if the PBL BTC e-module generated has a minimum level of validity achieved validity level is valid ($2,51 \leq Va < 3,26$). The process of calculating the learning implementation observation score is as follows:

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P-ISSN: 2656-2286

$$O_k = \frac{\sum_{j=1}^{m} P_i}{m} \quad (1)$$

with: O_k= average learning implementation observation score
P_i= average score of learning implementation observations at each meeting
m = number of meetings

After collecting the data, the average total score is established by the results of observations of learning implementation. The value of ($\boldsymbol{O_k}$) with categories as in Table 2.

Table 2. Learning Implementation Level Criteria

No.	Level of Learning Implementation	Criteria
1.	$1 \leq O_k < 2$	not implemented
2.	$2 \leq O_k < 3$	not well implemented
3.	$3 \leq O_k < 4$	well implemented
4.	$O_k = 4$	very well implemented

The PBL BTC e-module is considered practical if its average learning implementation falls within the 'Well executed' category (3 ≤ O_k < 4). The BTC PBL e-module fits the effective category in terms of: (1) Classical achievement of students requirements specifically a minimum of 85% of students who participate in the learning can achieve a score ≥75; (2) 80% of students responded positively to the BTC PBL e-module.

In this research, the growth in students' problem-solving skills may be analyzed as follows:

$$n - gain = \frac{score\ postest - score\ pretest}{score\ ideal - score\ pretest} \quad (2)$$

The values of Equation 2 have categories as in Table 3.

Table 3. Learning Implementation Criteria

No.	Value of Learning Implementation	Level
1.	$g > 0.7$	high
2.	$0.3 < g \leq 3$	medium
3.	$g \leq 0.3$	low

3. Results and Discussion

3.1. Results

Data analysis and study outcomes from each development step are described here.

3.1.1. Analyze

Several issues were identified based on the requirements analysis data, encompassing: 1) Students in class IX at SMP Negeri 1 Simanindo have poor problem-solving skills; 2) Students are less active in following lessons, because teachers tend to apply the lecture method during learning; 3) Inadequate use of technology in mathematics education, causing students to struggle with complex concepts; 4) Students' textbooks are difficult to understand whilst learning maths.

 E-ISSN: 2656-5846
P-ISSN: 2656-2286

Curriculum analysis data is assessed as part of the instructional lesson plan. In the section on learning activity phases, the teacher does not differentiate between teacher and student activities in depth. According to interviews, teachers claimed that they have not yet constructed courses of action based on students' requirements or traits, resulting in learning activities that are not ideal. Some ideas, such as instructing pupils to learn to find out, have not been properly applied, and teachers are the sole source of learning. This is the focus that researchers must pay attention to in order to identify the scope of material coverage that is appropriate to the conditions that exist and are implemented by the school.

Based on cultural background, pupils of SMP Negeri 1 Simanindo are predominantly Batak Toba. All students live in the Batak Toba tribe's villages of Ambarita, Tomok, Unjur, and Tuktuk. Several different classifications apply to a variety of tangible manifestations of Batak Toba culture: (1) mentifact: *dalihan na tolu*, *suhi ni ampang na opat*, Batak script, Batak numbers, kinship, *partururan* (a greeting custom based on genealogy), *turi-turian* (regional stories), Batak songs (*O Tano Batak*), the Batak tribe's life goals (*hamoraon-hagabeon-hasangapon*), *umpasa* (rhymes), *umpama* (garnish), and *lapet* (tradisional food); (2) sociofacts include *tarombo* (genealogy), Batak language, *marsiadapari* (cooperative work), *tortor* Batak (dance), *marria raja* (democracy); (3) artefacts: Ruma Batak or *Ruma Bolon* (traditional house), *tugu* (king's monument), *sigale-gale* (puppet), *ulos* (woven cloth), *sor tali*, *gorga* (calligraphy), *uning-uningan* (Batak drum), *rere* (woven seating/mats), and *tandok* (woven for rice containers).

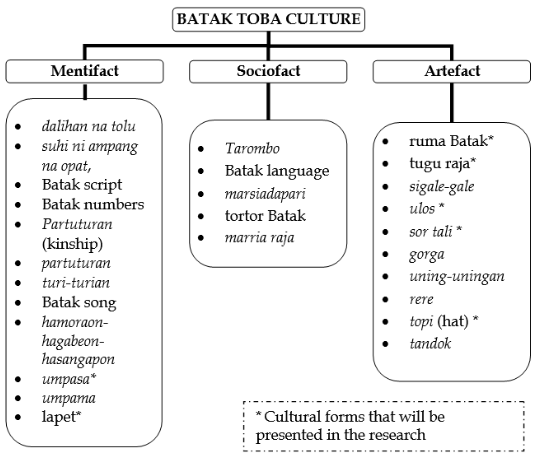

Figure 2. Batak Toba Culture

3.1.2. Design

The main components of the PBL BTC e-module are the cover, concept map, usage instructions, learning activities, and bibliography. Based on the analytical findings from the analyze stage, the PBL model e-module based on Batak Toba culture appears. The Canva application was used to design the cover of the Batak Toba culture-based PBL model e-module, which was then programmed in the Flip Book Professional application. The designed cover features several illustrations related to the material of congruence and similarity in the context of the Toba Batak tribe, as well as the title of the material. This is to make sure that the e-module's learning subjects engage students.

E-ISSN: 2656-5846
P-ISSN: 2656-2286

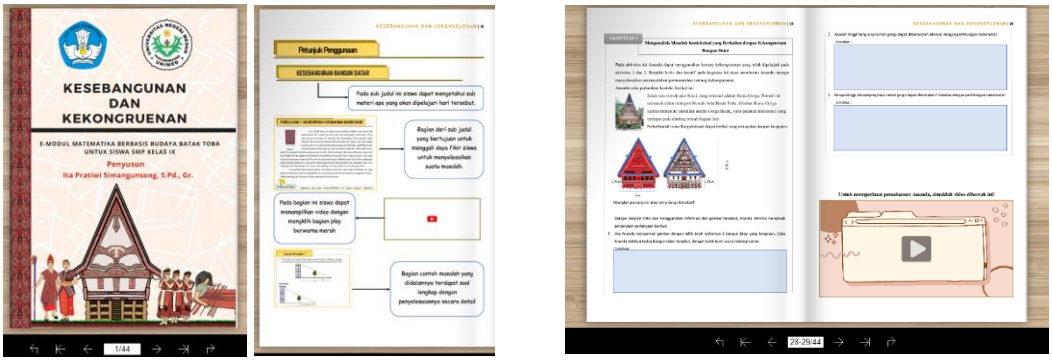

Figure 3. E-module Mathematics with Batak Toba Culture Context

3.1.3. Development

Research tools and student e-modules are verified by practitioners and subject-matter experts. The average value of the results obtained from practitioners and professionals validating e-modules and research instruments is: 1) E-modules have a score of 3.97; 2) Tests of problem-solving skills have met the standards for reliability and validity as evaluation.

Table 4. Validity of Problem-Solving Ability Pre-test Question Items

Items	R_{xy}	t_{count}	t_{table}	Interpretation
1	0,814	7,422	2,048	Valid
2	0,684	4,958	2,048	Valid
3	0,638	4,385	2,048	Valid
4	0,575	3,720	2,048	Valid

Table 5. Validity of Problem-Solving Ability Post-test Question Items

Items	R_{xy}	t_{count}	t_{table}	Interpretation
1	0,529	3,302	2,048	Valid
2	0,729	5,627	2,048	Valid
3	0,847	8,421	2,048	Valid
4	0,856	8,749	2,048	Valid

The reliability of the pre-test mathematical problem solving ability is 0.618 (high category) and the post-test mathematical problem solving ability is 0.741 (very high category). Following an analysis of the learning implementation, the average score was 2.93, falling into the category of not well implemented ($2 \leq O_k < 3$). This score falls short of the requirements for proving the e-module's feasibility in terms of learning implementation. Trial 1's classical completion of the students' problem-solving abilities came up with a score of 40,63%, which was insufficient to satisfy the requirements for classical completeness. With 93.34% of responds, the average student reaction fell into the "positive response" category. These served as the trial 1 efficacy indicators. Data that pointed out that the students' e-modul could not be deemed to be useful and effective was acquired after trial I's e-modul analysis. For this reason, the e-module was modified.

When completing first trial, adjustments were made to create an e-module that met all of the practical and effective criteria established. The findings of the adjustments by first trial were then retested on the same students, with a focus on areas of practicality and effectiveness that had not been met. The outcomes

E-ISSN: 2656-5846
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results of trial II were: The average observation score for learning implementation was 3.33 in the "well implemented" category. The total of 90,625% students completed the classical completeness. As a result, it was determined that a final draft was valid, practical, and effective to implement in class IX-2.

3.1.4. Implementation

The observation findings of the learning implementation exercise were 3.64, indicating a "well implemented" category. The outcomes of tested in class IX-2 revealed the following efficacious indicators: 1) The second trial's problem-solving skills of the students received a classical completeness score of 87.5% (being able to the criterion "have met classical completeness"); 2) The average student respond to was 94.62% of the total, falling into the "positive response" category. The average N-gain obtained during implementation in class IX-2 was 0.506, it means medium criteria.

3.1.5. Evaluation

Various unavoidable limitations, such as the following, mean that this research has imperfections and limitations. When discussion groups are formed, only gender and the distribution of upper, middle, and lower groups are taken into consideration. Because researchers neglected to consider student compatibility, group interactions between students were hindered. The e-module in this study are exclusively appropriate for use with students who belong to the Batak Toba ethnic tribe.

Table 6. Level of Reaching in Mathematical Problem-Solving Ability

Classification	*Pre-test* quantity of students	*Pre-test* Classical Achievement Percentage	*Post-test* quantity of students	*Post-test* Classical Achievement Percentage
Complete	6	18,75%	28	87,50%
Incomplete	26	81,25%	4	12,50%
Total	32	100%	32	100%
Class Average	54,55		77,53	

According to the classical student accomplishment criterion, at least 85% of students who took the problem-solving ability test achieved a score of ≥75. Thus, the results of the pre-test and post-test of mathematical problem-solving ability met the traditional achievement requirements. As a result, the application of the PBL B3T model e-module developed meets the classical achievement needs.

3.2. Discussion

According to the results of a pre- and post-test assessment of those capabilities in class IX-2, skills in solving mathematical problems have improved. The average scores that students received for their pre- and post-test problem solving demonstrate this growth in their problem solving skills. The average score for pupils' problem-solving skills increased from 54.55 to 77.53. The average normalized gain was also used to measure the increase in problem solving ability scoring 0.506 ($0.30 < \text{n-gain} \leq 0.70$). The results also reveal that students' ability to solve mathematical problems increased as a result of using a e-module PBL

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BTC.

In order encourage students to accurately identify the various facets of Batak Toba culture, this research sets up e-modules to teach about tugu (traditional monuments), Ruma Gorga/Ruma Bolon (traditional dwellings), ulos, hats, sortali (traditional apparel), and lapets (typical food). Because the issues were applicable to their everyday lives, students were willing to face the obstacles posed by the local cultural setting in this study, which enhanced their capacity for problem-solving. Other problem given in this e-module is the roof design concept for Ambarita Harbor, which bases its design on the roof of Ruma Bolon. The Ambarita Harbor point arose from the harbor's proximity to the domiciles and schools of SMP Negeri 1 Simanindo children, who are familiar with the appearance of the harbor's roof.

Instructor scaffolds allow them to dynamically support students' requirements for motivation. Established task value, mastery objectives, belonging, emotion management, expectancy for success, and autonomy are the six goals that should be promoted by motivation-enhancing scaffolds in PBL, all of which are backed by motivation theories (Belland, et. al, 2013). Similarly, instruction utilizing the e-module PBL BTC supports similar direction. Scaffolding and work examples help with e-modules. Every meeting, students are required to present the outcomes of their group discussions and problem-solving efforts, and the teacher offers constructive criticism. In addition, the e-module offers substitute problem solving on sample topics that might serve as an example for solitary study.

The outcomes of the post-test showed that students who received instruction through problem-based learning possessed high competencies in problem-solving. Participants who are able to accurately and fully translate spoken language into mathematical language are able to demonstrate that they comprehend the problem by answering the questions in the problem. The approach selected for alternate responses is noted by students in the indicator of planning to solve the problem. Next, using a rigorous and logical approach, students can formulate solutions, perform precise calculations, and reach conclusions regarding the probability of properly handling the problem. The application of this PBL approach validates all problem-solving indicators, (Saragih & Habeahan, 2014), who found that PBL learning produced superior student response patterns than conventional instruction.

Increasing students' problem-solving abilities cannot be separated from the Toba Batak culture-based PBL model used. The learning activities follow Dewey's and Bruner principles (Rézio et al., 2022). An alternative way to learning is to apply the Problem Based Learning model (I. P. Simangunsong et al., 2022; I. T. Simangunsong et al., 2023). PBL focuses on two concepts: John Dewey's autonomous learning, which emphasizes learning in response to real-life situations, and Jerome Bruner's concept of epistemic motivation, which is an internal force that helps people comprehend things better. In order to develop their problem-solving skills, students learn by working through mathematics issues within their cultural environment.

According to their traditional wisdom, students working in groups must encourage one another: "*tinaon* barakbak, *dapotsa papaluan; lehet masioloan, unang masipamaluan*" translates to "support each other, don't embarrass your friends." In addition, "*bisuk songon ulok, marroha songon darapati*," or "be as clever as a snake

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and wise as a dove," was another piece of advice from the Batak *umpasa*. All of these ancestor messages are beneficial for raising bright, morally upright offspring. "*Manat unang tartuktuk, dadap unang tarrobung*" (slow down so as not to trip, be careful so as not to fall) is an example of *umpasa*, or Batak Toba cultural values reminding pupils to work carefully when given an assignment to solve a problem. The phrase "*manatap tu jolo, manaili tu pudi*"—which translates to "looking to the future but don't forget the past"—is repeated to students after every accomplishment. It is emphasized to students that looking back at past events can help them solve difficulties in the future.

The findings of this investigation are consistent to (Saragih et al., 2017), who found that using instruments for advanced mathematical thinking skills in conjunction with student-centered learning grounded in local cultural models is a valid and effective approach for teaching mathematics in junior high schools. (Putri et al., 2023) mentioned in their study that e-module PBL with local cultural quite effective to assist students in improving their problem-solving abilities. Mathematics based on social arithmetic materials. This study also closely aligns with the other assertion that the Plomp development model produced valid, useful, and efficient findings when used to construct a problem-based learning model based on Batak culture (PBL-BC) (Sinaga, 2014). The Batak Toba cultural system *dalihan na tolu* is integrated into mathematics education through Bornok Sinaga's research. In the meantime, tugu (monuments), Ruma Gorga/Ruma Bolon, ulos, hats, sortali, and lapets are the part of Batak Toba cultures that is covered by this research. The current study is the outcome of Bornok Sinaga's research employing the ADDIE model, which has been modified for the demands of 21st-century digitalization. The Batak tribe produces digital textbook products (e-modules) that can be used in the environment by Toba junior high school students with a Batak Toba cultural context.

The PBL BTC e-module can be utilized as a guide when integrating it into other teaching resources to help students at the same or various educational unit levels enhance their ability to solve mathematical problems. Additionally, other academics can utilize this e-module product, which is based on Batak Toba culture, as a reference for developing e-modules with a particular cultural context.

4. Conclusions

Primarily conclusions from the above discussion, it is possible to conclude that the e-module PBL BTC is valid (supported by research instruments and e-module validation results), practical (supported by learning implementation observation results), and effective (supported by positive student responses and the ability to be problems solver). The research's conclusions and findings allow for the formulation of the following recommendations: 1) All classes and schools should continue to use the E-Module that was tested; 2) It is recommended to proceed with the E-Module containing mathematical problems on congruency in order to conduct additional effectiveness evaluations.

Author Contributions

Building the e-module media and gathering the information were contributions made by the first author. The other two authors evaluated the appropriateness of the descriptions of the assessment outcome. The fourth author in order to help

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refine it.

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Declaration of Competing Interest
All authors confirm that this research is writing that does not have the potential to cause problems both scientifically and socially.

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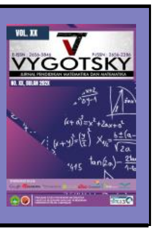

Mathematical Literacy as a Key Competency for Maritime Education: Systematic Review of Cadet Competencies

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ABSTRACT

This study discusses the role of mathematical literacy as the main competency that cadets need to have in the field of maritime education. Through a systematic literature review (SLR), the mathematical literacy competencies needed by cadets in the maritime field are navigation, problem solving, use of modern technology, operational management, critical and logical thinking, and accurate data-based decision making. This systematic review provides an illustration of literacy mastery Mathematics not only supports cadets' understanding of basic maritime concepts, but also improves cadets' abilities in dealing with challenges or unexpected situations on board ships and while at anchor. Therefore, developing mathematical literacy must be a priority in cadet education and training programs to produce graduates who are competent and ready to face the complexity of the global maritime industry.

1. Introduction

Mathematical literacy is one of the key competencies in various fields, including the maritime sector (Veloo et al., 2015). In the era of globalization and industrial revolution 4.0, this ability is increasingly vital for professionals in the increasingly complex maritime industry. Maritime education has a vital role in preparing cadets to face challenges in the complex and dynamic maritime world. Therefore, maritime education as a forum for producing superior human resources in the maritime field requires special attention to develop the

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mathematical literacy of cadets.

Cadets are said to have mathematical literacy skills in the era of the industrial revolution 4.0, if cadets are able to estimate, interpret information and even solve problems in various realistic ways so that they can provide reasons in numeracy, graphic and geometric situations and communicate using mathematics(Azmi et al., 2020). Therefore, mathematical literacy not only includes basic numeracy skills, but also involves the ability to analyze, reason, and communicate ideas effectively when identifying, formulating, and solving mathematical problems in various contexts. Mathematical literacy not only includes basic numeracy skills, but also involves the ability to analyze, reason and communicate ideas effectively when identifying, formulating and solving mathematical problems in various contexts (OECD, 2019).

Mathematical literacy not only involves understanding basic concepts, but also the ability to apply this knowledge in problem solving, decision making, and technological innovation (Jablonka, 2003). In the maritime context, mathematical literacy plays an important role in various aspects such as navigation, logistics management, weather and ocean current analysis, as well as the operation of modern maritime technology. These skills enable cadets to understand, interpret, and apply mathematical concepts in real situations, which is critical to safety and operational efficiency at sea. Good mathematical literacy also helps in making quick and accurate decisions in emergency conditions, reducing the risk of accidents and improving overall operational performance. Therefore, the urgency of study related to mathematical literacy in maritime education is becoming increasingly important along with the complexity of maritime operations and rapid technological developments.

The relationship between mathematical literacy and maritime education is very close, because mathematics is the core of various maritime activities. For example, ship navigation requires an understanding of geographic coordinates, distance and time calculations (Akbar, 2017), and the use of maps and navigation tools (Ningrum et al., 2015). In addition, engine operations and ship maintenance require accurate calculations to maintain efficiency and prevent damage. Mathematical skills are also important in logistics and resource management, such as fuel planning and inventory management. Cadets who have good mathematical literacy will be better prepared to face these challenges and contribute significantly to the success of ship operations.

The mathematical literacy competencies required by cadets include understanding basic mathematical concepts such as algebra, geometry and trigonometry, as well as the ability to apply them in a maritime context. They must also be able to use software and technology that relies on mathematics, such as ship management systems and electronic navigation tools. In addition, data analysis skills and interpretation of quantitative information are essential for making evidence-based decisions in operational situations. Cadets also need to develop logical, analytical, systematic, critical and creative thinking skills, as well as the ability to collaborate (Napitupulu, 2008; Syarif, 2016). This is the basis for effective problem solving in the field and is a characteristic of 21st century learning (Jaenudin et al., 2020).

Several studies have shown a positive correlation between the level of mathematical literacy and academic and professional performance in the maritime sector. For example, study reveals the importance of mastering mathematical symbols and graphs in solving maritime problems (Veloo et al., 2015). Meanwhile, findings related to mathematical literacy abilities of 86% of cadets are in the proficient and proficient category in mathematics lectures (Lusiani & Suprianto, 2024). This shows that mathematical literacy is very important. However, although mathematical literacy is very important, there is still a gap between the needs of the maritime industry and the level of mathematical literacy of maritime education graduates. One of the study results identified that many cadets still experience difficulties in applying mathematical concepts in practical maritime contexts, especially in the operation of modern navigation technology (Purba, 2022).

The novelty of this study presents a new contribution by highlighting mathematical literacy as a fundamental competency in maritime education, which has not been discussed comprehensively in the maritime context. This is due to a gap, namely the lack of in-depth empirical research related to the implementation of mathematical literacy in maritime education, especially for cadets. Although much literature emphasizes the importance of mathematical literacy, very little examines how this literacy is applied practically in the context of maritime training and education.

Therefore, a comprehensive study is needed regarding the mathematical literacy competencies required by shipping cadets, as well as how to integrate the development of these competencies into the maritime education curriculum. This study aims to review the latest literature regarding the importance of key mathematical literacy competencies for shipping cadets, as well as formulate recommendations to improve the development of these competencies in maritime education.

2. Method

This study uses a systematic literature review (SLR) method. This study of articles using the SLR method uses Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Fachrudin & Juniati, 2023; Moher et al., 2009; Page et al., 2021). The steps used are as follows:

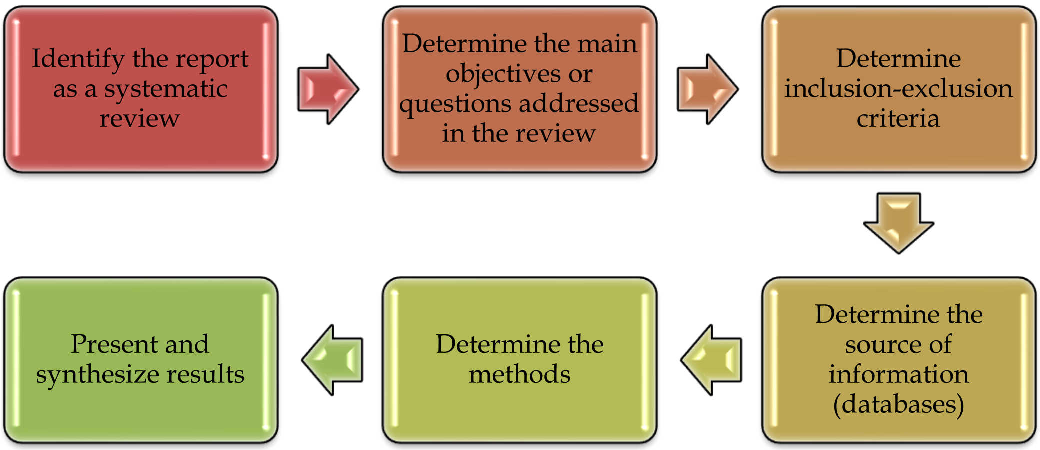

Figure 1. Flowchart of This Study

Based on Figure 1, this study procedure includes: a) identifying systematic reviews; b) determine the main aims and research questions addressed in this

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review; c) determine inclusion and exclusion criteria for conducting such review; d) determine the source of information or database used to identify studies and the search date for each study article; e) determine the methods used to assess the risk of bias in the included studies; and f) present and synthesize the results.

This study conducted an extensive and comprehensive search for articles in digital databases using the "Publish or Perish" software to search for relevant information regarding the mathematical literacy competencies of maritime education cadets. Keywords used in searching for articles from journals and conferences based on the inclusion and exclusion criteria shown in Figure 2 are "mathematical literacy", "maritime education", and "cadet competency".

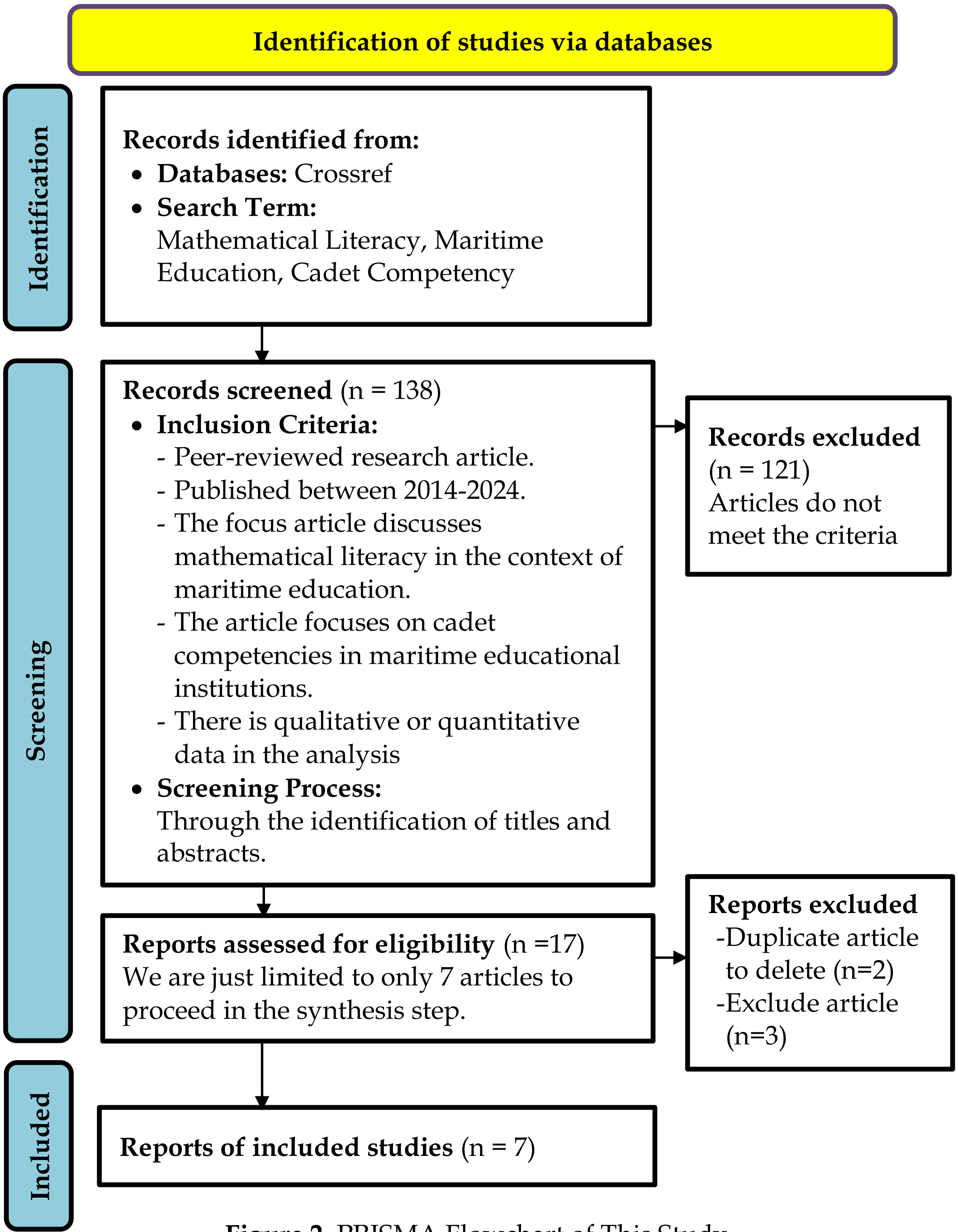

Figure 2. PRISMA Flowchart of This Study

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The criteria for article publication years used in this SLR method are 2014 to 2024. The number of articles obtained in the initial stage was 138 with only 7 titles passing according to the stages of the systematic review process. There were 121 article titles excluded. This was because they did not meet the inclusion and exclusion criteria and limits that the researchers had determined. Some of the article findings that researchers then excluded were study that did not focus on students or cadets, prospective teachers, and discussions that did not focus on articles that did not provide a framework or indicators regarding mathematical literacy.

3. Results and Discussion

Based on the publication data that the researcher obtained, the following are the characteristics of the study that the researcher found. These findings include mathematical literacy at high school, vocational high school, and higher education levels. By examining various important roles related to mathematical literacy that can be associated with the field of maritime education, researchers carried out a synthesis stage. At the synthesis stage, the researcher only selected 7 articles for in-depth analysis which discussed the role of mathematical literacy as shown in Table 1 as follows.

Table 1. Synthesis Results of Research Articles on Mathematical Literacy

Author	Year	Title	Explanation
Tatjana Stanivuk, et al.	2017	Mathematics as a Science and Marine Activity Follow Each Other Throughout History (Stanivuk et al., 2017)	Mathematical literacy enhances maritime safety by aiding in navigation accuracy, cost optimization, and overall efficiency, ensuring safer voyages and operations in the shipping industry.
Chumachenko Mariia Mykolaivna	2023	Contemporary Methods of Mathematical training of Future Navigators (Mykolaivna, 2023)	Mathematical literacy is crucial for maritime education, ensuring future navigators can manage modern technical means, make quick decisions, and navigate in various situations, enhancing their professional competence.
Gabriel Senanu Akakpo	2016	The Role and Relevance of Mathematics in the Maritime Industry (Akakpo, 2016)	Mathematical literacy is crucial in Maritime Education due to its application in ship construction, space management, and port operations, enhancing problem-solving skills and industry performance.
S. P. M. Pillai, et al.	2017	Comparative Studies of Mathematical Literacy/ Education: A Literature Review (Pillai et al., 2017)	Mathematical Literacy plays a crucial role in Maritime Education by enabling learners to apply mathematical concepts in real-world maritime scenarios, enhancing their problem-solving skills and decision-making abilities.
Jinhyun Hong ,	2020	The Role of Numeracy	Mathematical literacy plays a

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Author	Year	Title	Explanation
et al.		and Financial Literacy Skills in the Relationship between Information and Communication Technology use and Travel Behaviour (Hong et al., 2020)	crucial role in influencing ICT use and travel behavior, suggesting its significance as a key competency for various fields, including maritime education.
Anis Syafiqah Sohaimi, et al.	2022	Analysis of Mathematics Literacy Ability (Sohaimi et al., 2022)	Mathematical literacy is crucial for education. The study shows students struggle with math, highlighting the importance of enhancing mathematical abilities, including in maritime education for competency development.
Lusiani & Suprianto	2024	Kemampuan Literasi Matematis pada Taruna Ketatalaksanaan Pelayaran Niaga dalam Perkuliahan Matematika (Lusiani & Suprianto, 2024)	Mathematical literacy is very important for cadets because it not only supports cadets' academic success, but also prepares them for future challenges in cadets' maritime careers.

In the context of maritime education, mathematical literacy plays a very important role in forming cadet competencies who are ready to face global challenges in the maritime industry. Based on the results of the SLR analysis in Table 1, various mathematical literacy competencies required by cadets are identified, which include aspects of navigation, decision making, use of technology and operational management. The following is a further description of these competencies:

a. Mathematical Navigation Ability
Navigation at sea is one of the crucial aspects of maritime operations, and mathematical literacy plays a central role in this. Mathematical navigation skills involve the calculations necessary to determine a ship's position, speed, direction, and estimated travel time. One study result emphasizes that mathematics is used to ensure shipping safety through accurate and efficient navigation (Stanivuk et al., 2017). Cadets need to understand how to apply mathematical equations to determine optimal trajectories, avoid hazards, and set arrival times with high precision. Mistakes in calculations can have fatal consequences, so mathematical literacy is a competency that cannot be ignored in maritime education.

b. Problem Solving and Decision Making
The maritime industry often faces situations that demand quick and correct decisions, especially in unforeseen conditions such as bad weather or technical breakdowns. This highlights that cadets' ability to solve mathematics-based problems is very important to support decision making in the field (Mykolaivna, 2023; Pillai et al., 2017). This competency involves the application of mathematical concepts in practical contexts, such as determining the optimal load of a ship to maintain stability, planning fuel use, and evaluating risks during shipping operations. Thus, mathematical

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literacy not only helps in better decision making but also in reducing risks and increasing the efficiency of maritime operations.

c. Use of Modern Navigation Technology
Technological developments in the field of maritime navigation require cadets to have strong mathematical literacy skills in operating and interpreting data from various modern navigation devices, such as GPS, radar and ship traffic management systems. Cadets must be able to use mathematics-based software to analyze data and make accurate predictions regarding conditions at sea (Hong et al., 2020; Mykolaivna, 2023). This technology not only helps in navigation but also in more efficient route planning and operational cost savings. Therefore, strong mathematical literacy enables cadets to maximize the benefits of modern navigation technology and improve the safety and efficiency of operations at sea.

d. Management and Optimization of Maritime Operations
Mathematical literacy also plays an important role in maritime operations management, which includes logistics planning, ship space management and port operations. The study results underline the importance of mathematics in making decisions regarding ship load distribution, storage space arrangement, and shipping route optimization to minimize costs and time (Akakpo, 2016; Pillai et al., 2017). This capability is critical to ensuring maritime operations run smoothly and efficiently. Cadets who have these competencies will be able to manage resources more effectively, ultimately contributing to the productivity and profitability of the maritime industry.

e. Critical and Logical Thinking
Critical and logical thinking supported by strong mathematical literacy is essential for cadets in identifying potential problems and developing effective strategies. Mathematical literacy is very important for cadets because it not only supports cadets' academic success, but also prepares cadets to face future challenges in maritime careers. Critical and logical thinking skills supported by mathematical literacy enable cadets to analyze complex situations and make the right decisions, which is key in facing various operational challenges in the maritime world (Lusiani & Suprianto, 2024).

f. Data Analysis and Data-Based Decision Making
In today's digital era, data plays an increasingly large role in decision making. Cadets need to have the ability to interpret numerical data which is then analyzed and use the results of the analysis to make data-based decisions that are accurate and relevant. The study results show that many cadets still face difficulties in understanding and applying mathematical concepts in the maritime context (Sohaimi et al., 2022). This emphasizes the need to strengthen mathematical literacy in marine education. Cadets who have good data analysis skills will be better able to respond to changing situations at sea, such as weather changes, fluctuations in fuel supplies, and ship traffic dynamics.

Based on the study results above, this study contributes to understanding the role of mathematical literacy for cadets in maritime education. However, as with every research, there are several advantages that add value and

E-ISSN: *2656-5846*
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disadvantages that need to be considered for further development. The following is a discussion of the advantages and disadvantages of this study which are shown in Table 2.

Table 2. Advantage and disadvantage of this study

Advantage	Disadvantage
a. **Strengthening Essential Competencies:** This study emphasizes the importance of mathematical literacy as a fundamental competency in maritime education, so as to increase awareness of the importance of strengthening this aspect in the maritime education curriculum. b. **Relevance to the Maritime Industry:** By highlighting the relationship between mathematical literacy and the skills required in the maritime industry, this study provides a strong theoretical foundation to ensure that cadet education is relevant to real needs in the field. c. **Systematic Approach:** The use of the Systematic Literature Review (SLR) method allows this study to present comprehensive and structured findings, providing a clear picture of the existing literature and ensuring that the conclusions drawn are based on in-depth and critical analysis. d. **Basis for Further Research:** The results of this study can become a basis for further research that focuses on developing mathematical literacy in maritime education, thereby providing a further contribution to the development of cadet competencies.	a. **Data Source Limitations:** This study is only based on seven primary articles, which may not be enough to describe the entire context of mathematical literacy in maritime education. This could limit the generalizability of the findings. b. **Limited Focus:** This study focuses only on mathematical literacy without considering other literacies that are also important in maritime education, such as technological literacy or language literacy, which may also play an important role in cadet education. c. **Limitations of Practical Implementation:** Although this study offers strong theoretical insights, practical implementation of the results of this study in educational curricula may face challenges, such as resistance to curriculum change or resource limitations. d. **Lack of Empirical Data:** This study is based on a literature review and may be lacking in empirical data that could strengthen the findings or provide concrete evidence about the effectiveness of mathematical literacy in the context of maritime education.

Therefore, it is hoped that understanding the advantages and disadvantages described above can become a reference for improving and developing research in the future, in order to strengthen and enrich the contribution of mathematical literacy to education and the maritime industry in a more comprehensive manner.

4. Conclusions

Based on the results and discussion through Systematic Literature Review (SLR) analysis, it can be concluded that mathematical literacy is a fundamental competency that must be possessed by every cadet in maritime education. This competency includes precise navigation skills, effective problem solving, use of sophisticated modern technology, efficient operational management, critical and logical thinking, and accurate data-based decision making. By mastering these

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competencies, cadets will be better prepared to face challenges in the increasingly complex and dynamic maritime industry. Therefore, strengthening mathematical literacy in the maritime education curriculum is very necessary to ensure the readiness and success of cadets in their future careers. In addition, this study can be a basis for conducting further relevant study related to the development of mathematical literacy in the context of maritime education and sustainable professional.

Author Contributions

The first, second, and third authors designed the study concept and methodology. All authors performed an initial literature search and screening of articles. The first and third authors performed data extraction and study quality assessment. All authors contributed to the analysis and interpretation of the data. The first and second authors wrote initial drafts of the manuscript. All authors made critical revisions to the intellectual content. The second and third authors provided substantial input into the final writing. All authors have read and approved the final published version of the manuscript.

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Declaration of Competing Interest

The author declares that this study has no conflicts of interest reported in this article.

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