EPISTEMA

Vol.4 No.2 2023 | e-ISSN: 2723-8199
https://doi.org/10.21831/ep.v4i2.66119

Article History
Received : 19 September 2023;
Revised : 19 October 2023;
Accepted : 25 October 2023;
Available online : 31 October 2023.

Developing Literacy and Numeracy-Based Mathematical Reasoning Question Items for High School Students

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Abstract:
This study aims to describe the process and the result of developing literacy and numeracy-based mathematical reasoning questions for high school students in Mojokerto that are valid, practical, and effective. The subjects of this study are 12th-grade students at the public senior high school of Gondang. The research instruments are observation sheets, interview guidelines, response questionnaires, and mathematical reasoning ability tests. At the same time, the data analysis in this study is qualitative and quantitative. The result of this research is (1) In The preliminary stage, students' mathematical reasoning abilities still needed to improve with evidence of difficulties in identifying and relating the information provided to conclusions. The researchers and teachers determine the research subjects and research time. In the formative evaluation stage, for self-evaluation, the researcher analyzed the material and curriculum. The third stage is prototyping, consisting of expert review, one-to-one, small group, and field tests. In the expert review, prototype II was produced, which was very valid, with an overall average of 4.24. Three students were tested in the one-to-one, and three prototypes were built. A trial was conducted in the small group, and a prototype IV was produced. The field test, testing, and production of mathematical modules met the valid, practical, and effective criteria. (2) The study's findings include numeracy and literacy-based mathematical reasoning problems that satisfy the validity criteria with proper categories and the practical requirements with extremely positive standards, in addition to achieving the efficacy criterion of the questions through students' mathematical reasoning.

Keywords: literacy, mathematical reasoning, numeracy, question

EPISTEMA
Vol.4 No.2 2023 | e-ISSN: 2723-8199
https://doi.org/10.21831/ep.v4i2.66119

INTRODUCTION

Mathematics is an essential subject at every level of school in every country. It is demonstrated by making mathematics the basic competency in PISA (Program for International Student Assessment), which 6000,000 pupils from 78 nations attended. PISA is a country's evaluation of its education system. PISA focuses on reading literacy, mathematics literacy, and scientific literacy. According to the 2018 PISA results, Indonesian pupils scored worse than the average OECD score in reading, mathematics, and science (OECD, 2019). It can be stated that students' reading and math skills in Indonesia still need to improve. Literacy and numeracy must, therefore, be improved.

Research results state that students' reading literacy and numeracy skills are still poor (Widiantari et al., 2022; Winata et al., 2021). Because many students often find the answers to the test from the internet and need to try to read the books first when doing assignments. In addition, when students face mathematical problems, they do not try to solve them according to their understanding.

Furthermore, the facts happening in Indonesia are associated with low literacy and numeracy skills; this condition has worsened with the COVID-19 pandemic, encouraging students to study from home. The teacher's lack of readiness in learning technology innovation, especially mathematics, the lack of learning support infrastructure owned by schools, and the availability of teaching materials. These all resulted in decreasing students' learning abilities (learning loss). The Freedom to Learn policy is a concrete action from the Ministry of Education and Culture to strengthen students' literacy and numeracy. Among the strategies to strengthen literacy and numeracy is developing the school ecosystem as a place of learning, providing a text-rich environment, and emphasizing reasoning and problem-solving modeling processes in learning (Dewayani et al., 2021).

In addition, reasoning has a vital role in improving students' literacy and numeracy abilities. According to Vebrian et al., (2021), reasoning ability is the ability that underlies students' mathematical literacy and numeracy processes by involving logical thinking processes to explore and connect parts of the problem in making conclusions, checking answers, or providing justification from reports/solutions that are obtained. Based on the researcher's observations at a Mojokerto high school, it was found that many of the 32 students who were given mathematical reasoning questions related to everyday life still had difficulty identifying and connecting the information provided to conclusions. So, it can be said that students can still not solve contextual questions requiring the ability to reason well. According to Fikriya et al. (2018), one of the reasons for this is that Indonesian students are not familiar with contextual problems. Its completion requires students' abilities to reason, argue, and be creative. These cause the mathematics achievements of Indonesian students not to be satisfactory.

Other observations have resulted in learning activities in general. The question items used by the teacher were only taken from one textbook, namely the Buku Matematika Wajib Kelas XII (Compulsory Mathematics Book for Grade 12th published by Yudistira, which still lacked question items that encouraged reasoning ability in solving them. This book has limited questions that train mathematical reasoning abilities and very few questions based on literacy and numeracy. Even though sometimes the teacher creates question items, these questions are only given during the Mid Semester Assessment (PTS) or the Final Semester Assessment (PAS), so it is still necessary to develop question items to enrich teacher instruments related to reasoning, literacy, and numeracy.

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The alternative solution is to develop literacy-based mathematical reasoning question items. One way to train students' reasoning abilities is by giving them question items specifically designed (Rizta et al., 2013). In addition, Suriyani & Wahyuni (2021) stated that children who are used to handling these difficulties strengthen their reasoning thinking processes indirectly. These custom-developed questions are created with the context surrounding and concerning pupils in their daily lives. In order to promote numeracy literacy, the teacher or educator's evaluation technique must be acceptable and involve students' mathematical thinking. Feriyanto (2022) explains that one of the strategies to strengthen literacy and numeracy is to develop a text-rich environment, especially one that encourages reasoning and modeling skills in solving mathematical problems.

Several studies have been carried out related to the development of literacy and numeracy-based mathematical reasoning questions, including developing a mathematical reasoning instrument to stimulate students' numeracy skills in the context of my house, but limited to junior high school, which is the place of the research and did not link to literacy skills (Suriyani & Wahyuni, 2021). In addition, the research by (Susetyawati & Kintoko, 2022) developed question items of numeracy literacy as many as four valid and reliable questions but have not been linked to mathematical reasoning. Another study found that literacy and numeracy-based modules built to promote the critical thinking skills of high school students in Mojokerto helped enhance students' critical thinking skills (Feriyanto & Putri, 2020). As a result, it is critical to create literacy and numeracy-based mathematical reasoning challenges for Mojokerto high school pupils.

Then, the purpose of this study is to describe the process of developing valid, practical, and effective literacy and numeracy-based mathematical reasoning questions for high school students in Mojokerto, as well as the results of developing valid, practical, and effective literacy and numeracy-based mathematical reasoning questions for high school students in Mojokerto. The advantages of this research include the following: In theory, this research should be able to share new information on how developing mathematical reasoning questions based on numeracy literacy might benefit teachers, other researchers, and researchers themselves. In theory, this research should be able to share new information on how developing mathematical reasoning questions based on numeracy literacy might benefit teachers, other researchers, and researchers themselves.

METHOD

Study Design and Sample

This study's design is research and development, sometimes called R & D (Research and Development). This study uses this research approach to create literacy and numeracy-based mathematical reasoning questions for Mojokerto high school students and explain the development process. The subjects of this study are SMAN 1 Gondang class XII students. Regency of Mojokerto in the academic year 2022/2023.

The Research Procedure

While the Tessmer development model was used in this study, it is divided into two major stages: the preliminary and formative evaluation. According to Tessmer (1993), it includes self-evaluation, expert review, one-to-one, small group, and field tests. In the preliminary stage, the researcher chooses the place and research subjects and undertakes many school-related preparations, such as cooperating and scheduling research with class teachers. In the formative

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evaluation stage, for self-evaluation, the researcher analyzed the material and curriculum, which in this case is Curriculum 2013 revision and the COVID-19 emergency curriculum. Afterward, the researchers designed literacy and numeracy-based mathematical reasoning question items. While at the expert review stage, a review of the substance, construction, and language of prototype one was carried out. The validators were reviewed according to related expertise. So, prototype two is produced. At one stage, the researcher assigns prototype 2 to one of the pupils. The outcomes of student comments or suggestions about the prototype's clarity will be used as input material for refining the instructional materials that are being developed, and then prototype three will be generated. The researcher assigned prototype 3 to three students in the small stage group. Students for one-to-one and small group stages are students with equal abilities, namely high mathematical abilities. At this field test stage, the questions revised on prototype four were tested on a group of research subjects, namely 12th Mathematics and Science grade 3, totaling 30 students.

Data Collection Tools

Data collection techniques are techniques or methods used to collect data to be researched. This means that this technique requires strategic and systematic steps to obtain valid data in accordance with reality. The research instruments are observation sheets, interview guidelines, response questionnaires, and mathematical reasoning ability tests.

Data Analysis

The data analysis in this study is qualitative and quantitative; at the formative evaluation stage, qualitative data analysis is used on data gathered by interviewing experts and students about their perspectives on the modules prepared by the researchers. Meanwhile, quantitative data analysis is used for data obtained from questionnaires and literacy and numeracy tests to determine the feasibility of the questions being developed. This study's quantitative data analysis uses validity, practicality, and effectiveness (McKenney & Reeves, 2013). The question is valid if the score criteria show a valid or very valid category. The validity analysis was adopted Khabibah (2007) by calculating the average of each aspect and the average total validity using the following categories:

Table 1. Validity

No.	Scale	Category
1	$4 \leq V_a \leq 5$	Very Valid
2	$3 \leq V_a < 4$	Valid
3	$2 \leq V_a < 3$	Less Valid
4	$1 \leq V_a < 2$	Invalid

A V_a is the average total validity of the developed mathematical reasoning questions. The question is said to be an assessment from the validator on the validation sheet stating that the question can be used in learning with little or no revision. The question items are practical; they are developed and produced according to the desired goals by showing student responses in optimistic, very optimistic, or convenient categories and the level of students' mathematical reasoning abilities with excellent or perfect criteria (Riduwan, 2019).

Table 2. Qualification of The Results of The Response Questionnaire Adapted

No.	Percentage	Qualification	Description
1	$81\% - 100\%$	Very Good	Very Positive
2	$61\% - 80\%$	Good	Positive

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No.	Percentage	Qualification	Description
3	$41\% - 60\%$	Moderate	Quite Positive
4	$21\% - 40\%$	Less Good	Less Positive
5	$0\% - 20\%$	Not Good	Not Positive

Meanwhile, the results of the mathematical reasoning tests were assessed using the mathematical reasoning scoring rubric according to Hilaliyah et al. (2019) in Table 3.

Table 3. The Scoring Rubric of Mathematical Reasoning

No.	Indicator	Descriptor	Rubric
1	Possing an Assumption	Students write a Temporary Answer to the Problems given	0 if Descriptor is not Appear One of the Descriptor is Appear
		Write down the Information Obtained (Including the Steps Taken) based on the Problem given	0 if Descriptor is not Appear One of the descriptors appears, but it is Irrelevant to The Question Two if Descriptor Appears, and it is Relevant to the Question
2	Perform Mathematical Manipulation	Students do what they Feel Appropriate, Including using Calculation Operations or Adding/Removing a Part or all of what Students think is Necessary and Accordance with the Concept/Principle that has been Determined	0 if Descriptor is not Appear One of the descriptors appears, but it is Irrelevant to The Question Two if Descriptor Appears, and it is relevant to The Question
		Students Write Down The Steps to Solve the Problems (Carry out the Solution)	0 if Descriptor is not Appear One of the descriptors appears, but it is Irrelevant to The Question Two if Descriptor Appears, and it is relevant to The Question
3	Compile Evidence, Provide Reasons or Evidence for The Correctness of The Solution	Students test their Answers by Perform Mathematical Manipulations	0 if Descriptor is not Appear One of the Descriptors appears
		Students Argue in The Process of Solution	0 if Descriptor is not Appear One of the Descriptors appear
4	Drawing Conclusion from The Statement	Students give a Reason for their Solution	0 if Descriptor is not Appear One of the Descriptors appears
		Students Draw a Conclusion (Appropriate to what is Asked about) at the end of the Solution	0 if Descriptor is not Appear One of the Descriptors appears

Using the rubric above, the analysis results are then calculated classically using the completeness limit using the applicable Minimum Completeness Criteria and the percentage of completeness of mathematical reasoning abilities adapted from Widoyoko (2009) in Table 4.

Table 4. The Completeness Criteria of Mathematical Reasoning Ability

No.	Percentage of Completeness	Criteria
1	$P > 80\%$	Very Good
2	$60\% < P \leq 80\%$	Good
3	$40\% < P \leq 60\%$	Moderate
4	$20\% < P \leq 40\%$	Less Good
5	$P \leq 20\%$	Not Good

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RESULT

In the preliminary stage, the researcher determined the school's location where the research was conducted, namely SMAN 1 Gondang. This school was chosen because of the recommendations from the implementation of Field Teaching Practice activities. The research subject is 12th mathematics and science grade students because, based on the findings of researchers' observations, students' mathematical thinking abilities were still insufficient, with evidence of difficulty in detecting and linking the information presented to make inferences. In addition, the school still uses K-13 revision, prioritizing student literacy and numeracy. The basic principles of numeracy literacy align with the mathematics scope in the 2013 curriculum. Therefore, the researchers can recommend the research to the Head of SMAN 1 Gondang Mojokerto, and then researchers work together with mathematics teachers to determine research subjects and research time. The research was conducted from November 7 to December 9, 2022.

In the formative evaluation stage, for self-evaluation, the researcher analyzed the material and curriculum, which in this case is the Curriculum 2013 revision of the COVID-19 emergency curriculum. By Kemdikbud (2018), the selected sequence and series material in class XI with basic competency 3.6. Generalizing number and amount patterns in Arithmetic and Geometry sequences and 4.6 Presenting and solving contextual problems (such as growth, decay, compound interest, and annuities) using arithmetic or geometric sequence patterns.

Table 5. The Validity Result of Prototype 1

No.	Judgment	Substance	Construction	Language
1	Validator per validator	4.16	4.36	4.22
Overall average		**4.24**		

According to Khabibah (2007), the average validity of mathematical reasoning questions based on literacy and numeracy development is 4.24, indicating that it is in the very valid group. The two validators revealed that the produced reasoning questions might be employed with a minor modification, namely the necessity to evaluate indicators of mathematical reasoning, particularly in compiling evidence and providing arguments for the soundness of the solution. After revisions were made, prototype two was produced. In one stage, the researcher asked a student with high mathematical ability to work on the problem and provide suggestions or comments. Problem number 1 is precise about what is meant, what is being asked, and the process for solving it. Question number 2 must be considered again when choosing words/sentences because there are ambiguous sentences regarding the difference between income from the beginning of the 185th month or only income from the 185th month. At the field test stage, the questions which were revised to become prototype four were tested on a group of students who were research subjects, namely class XII Mathematics and class 3 science, totaling 30 students. Students also work on a response questionnaire to determine the appropriateness of questions and provide comments. In question number 2, which is still difficult to understand, the suggestion is to use sentence editing. The results of the questionnaire analysis of students' answers to literacy and numeracy-based reasoning questions are presented in Table 6.

Table 6. The Result of Response Questionnaire Analysis on Mathematical Reasoning

No.	Number of Statement	The Number of Students				Practically
		Strongly Disagree	Disagree	Agree	Strongly Agree	
1	1	0	0	12	18	90%
2	2	0	0	19	11	84.17%

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No.	Number of Statement	The Number of Students				Practically
		Strongly Disagree	Disagree	Agree	Strongly Agree	
3	3	0	0	12	18	90%
4	4	0	0	9	21	92.5%
5	5	0	0	10	20	91.67%
6	6	0	0	7	23	94.17%
7	7	0	0	12	18	90%
8	8	0	0	17	13	85.83%
9	9	0	0	20	10	83.33%
10	10	0	0	12	18	90%
11	11	0	0	13	17	89.17%
Average						**89.17%**

The response above questionnaire analysis results yield an average of 89.17%. Based on the qualifications of the response questionnaire findings in Table 6, it is possible to conclude that the results are highly positive. As a result, the produced mathematical reasoning questions meet the practicality criterion. Table 6 shows the results of the mathematical reasoning ability test in the field test stage, which were assessed using the scoring rubric.

Table 7. The Result of Mathematical Reasoning Test

No.	Student's Name	Score for Question		Conversion Score	Criteria
		1	2		
1	A	9	8	77.27	Complete
2	B	8	9	77.27	Complete
3	C	8	9	77.27	Complete
4	D	11	11	100	Complete
5	E	3	4	31.81	Incomplete
6	F	5	7	54.54	Incomplete
7	G	6	8	63.64	Incomplete
8	H	10	11	95.45	Complete
9	I	10	9	86.36	Complete
10	J	9	10	86.36	Complete
11	K	7	7	63.64	Incomplete
12	L	5	6	50	Incomplete
13	M	2	4	27.27	Incomplete
14	N	7	5	54.55	Incomplete
15	O	9	8	77.27	Complete
16	P	9	9	81.82	Complete
17	Q	11	10	95.45	Complete
18	R	6	7	59.09	Incomplete
19	S	10	10	90.91	Complete
20	T	11	11	100	Complete
21	U	7	8	68.18	Incomplete
22	V	9	9	81.82	Complete
23	W	8	10	81.82	Complete
24	X	10	7	77.27	Complete
25	Y	8	9	77.27	Complete
26	Z	10	10	90.91	Complete
27	AA	11	10	95.45	Complete
28	AB	8	5	59.09	Incomplete
29	AC	8	9	77.27	Complete
30	AD	3	2	22.73	Incomplete

Table 7 above shows that 19 out of 30 students scored more than the passing grade, namely 77. So, it can be concluded that the completeness of mathematical reasoning ability is

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https://doi.org/10.21831/ep.v4i2.66119

63.33% in the excellent category and meets the criteria for effectiveness. Based on the research results above, literacy and numeracy-based mathematical reasoning questions are valid, practical, and effective.

DISCUSSION

Revisions are made based on these suggestions/comments, and prototype three is produced. At the small group stage, the researcher gave prototype 3 to three students with heterogeneous mathematical abilities to try out. The results are that students with low math skills are making mistakes in solving number 1, especially point b. This is because the two students are less careful in reading the information in the questions. In addition, students with low math skills cannot solve problem number 1 point b. Based on additional interviews, question number 1 points to students with medium and low math abilities, who stated that they had not thoroughly worked on the problem. The results of this interview are reinforced by research results (Ario, 2016); students' mathematical reasoning errors occur due to a lack of accuracy in understanding the questions, doing calculations, and forgetting formulas. Whereas in question number 1 b, students with low math abilities stated that they were still confused about solving the problem because they were not used to it. This is by Lestari et al., (2018). In general, students make mistakes in mathematical reasoning because they are not used to working on questions based on mathematical reasoning.

CONCLUSION

Based on the findings, it is possible to conclude that (1) the development process begins with the preliminary stage, SMAN 1. Because of the recommendations from the Field Teaching Practice implementation, Gondang was chosen as the focus of this research. Moreover, based on the results of observations that researchers had made, it was found that students' mathematical reasoning abilities were still lacking, with evidence of difficulties in identifying and relating the information provided to conclude. Therefore, the researchers can recommend the research to the Head of SMAN 1, Gondang Mojokerto, and the mathematics teacher. In the formative evaluation stage, for self-evaluation, the researcher analyzed the material and curriculum. The selected sequence and series material in class XI with basic competency 3.6. Generalizing number and amount patterns in Arithmetic and Geometry sequences and 4.6. Using arithmetic or geometric sequence patterns, they presented and solved contextual problems (such as growth, decay, compound interest, and annuities).

The third stage is prototyping, which includes expert review, one-to-one, small group, and field tests. In the expert review, the prototype II was said to be valid. In the one-to-one setting, three students were tested, and three prototypes were created. A trial was undertaken on the small group, and a prototype IV was created. The field test, testing, and production of mathematical modules that met the valid, practical, and effective criteria followed. (b) The study's findings are numeracy and literacy-based mathematical reasoning problems that meet the validity requirements with valid categories and meet the practical criteria with a very positive criterion. In addition to achieving the effectiveness criterion for the questions, students' mathematical reasoning.

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https://doi.org/10.21831/ep.v4i2.66119

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