Journal on Mathematics Education
Volume 15, No. 1, 2024, pp. 173-190

Developing mathematics teaching materials using maritime context for higher-order thinking in junior high school

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Received: 13 June 2023 | Revised: 23 October 2023 | Accepted: 30 October 2023 | Published Online: 19 November 2023

Abstract

Mathematics learning using high-order thinking skills is crucial for students. High-order thinking skills can be developed through learning materials with contexts relevant to the student's environment. This research aims to: produce maritime context mathematics teaching materials for higher-order thinking in Junior High Schools that are valid, practical, and have a potential effect on analytical and evaluation skills. The subjects of this study were 7th-grade students at SMP Tamansiswa Palembang, SMP Tamansiswa Mariana, and SMP Tamansiswa Sungai Buah. Data collection techniques include walkthroughs, interviews, observations, documentation, and tests. Data analysis is conducted qualitatively through descriptive methods. The research development of maritime context mathematics teaching materials for higher-order thinking at Junior High Schools has been validated based on content, construct, and language by expert reviews. During one-to-one interactions, students demonstrated their comprehension of the teaching materials and their ability to analyze and evaluate the student worksheets (SW) and questions. Practicality was observed during small group interactions, as students encountered no difficulties in solving problems on the SW and questions using analytical and evaluative skills. Furthermore, the field test demonstrated that the maritime context mathematics teaching materials have the potential to enhance students' analytical and evaluative abilities. In conclusion, this research has produced valid, practical, and potentially effective maritime context mathematics teaching materials for higher-order thinking at Junior High Schools, which can enhance students' analytical and evaluative abilities.

Keywords: Context, Design, Development, High-Level Thinking Skills, Maritime, Teaching Materials

How to Cite: Malalina, Putri, R. I. I., Zulkardi, & Hartono, Y. (2024). Developing mathematics teaching materials using maritime context for higher-order thinking in junior high school. *Journal on Mathematics Education, 15*(1), 173-190. http://doi.org/10.22342/jme.v15i1.pp173-190

The use of teaching materials can improve the quality of learning (Ariza Muñoz et al., 2023; Sujiono et al., 2023). In addition, teaching materials make a large and important contribution to learning (Dólera-Almaida & Carrillo-Gallego, 2023; Latifah et al., 2023). Thus, to improve the quality of learning, it is necessary to develop appropriate and relevant teaching materials that suit the needs of students. However, the main problem that often emerges in learning is uninteresting material because it has not emphasized the use of context that relates the subject matter to problems of daily life or situations that they are familiar with. This makes mathematics not seem difficult and abstract (Zulkardi, 2005). Other problems are the minimal availability of teaching materials and the preparation of teaching materials not considering the needs of learning objectives (Arsanti, 2018; Cahyadi, 2019). Wibowo and Pratiwi (2018) have investigated teaching materials used by students and revealed that, to date, the teaching

materials are less interesting and difficult to understand by students. Teaching materials contain information, tools, and texts or any form of material needed for learning planning and implementation (Prastowo, 2012).

On the other hand, developing teaching materials can improve learning processes and students' learning outcomes (Nuryadi et al., 2023). Teaching materials become crucial in the learning process (Hidayat et al., 2022), improve students' thinking skills (Abdelrahman & Wang, 2023), and enable the learning process to run effectively (Hermawan et al., 2019). The structure of systematically arranged teaching materials refers to the learning objectives to achieve (Baskor et al., 2015). The intended teaching materials are the main materials used in the learning process (Majid, 2008). Teaching materials in the form of reading materials, workbooks, or videos can increase students' knowledge (Kosasih, 2021). It is obvious various teaching materials could improve the quality of learning processes and learning outcomes.

Teaching materials can use daily life contexts (Indriyani, 2019; Johnson, 2011). On the other hand, teaching materials should be presented in accordance with the students' world (Ulya et al., 2010). Therefore, the developed teaching materials can be related to the learners' environmental life or directly related to their life contexts, for example, maritime activities in river waters as daily activities.

Putri and Zulkardi (2020) explain that learning materials can use students' live contexts. It's because this field is closely related to daily life (Prahmana & D'Ambrosio, 2020). Learning mathematics can be initiated by exploring phenomena in the surrounding environment (Prahmana et al., 2021; Prahmana & Istiandaru, 2021). Furthermore, teachers can use environmental contexts to teach the materials because the context can link the students' real knowledge with their formal knowledge (Putri & Zulkardi, 2017; Susanta et al., 2023). Therefore, the mathematical context used in learning can continue to develop.

The results of previous studies are related to the environmental contexts used in learning mathematics; for example, Palembang context helps students understand algebraic arithmetic operations (Putri et al., 2022; Aini et al., 2023). The results showed that this study produced mathematical problems similar to PISA in the context of form and space with the context of Historical Buildings in Karawang that are valid, practical, and have the potential to affect mathematics learning. Putri et al. (2021) research resulted in a learning trajectory that could help grade VII students complete counting operations in the context of obesity. These contexts exist in the environment and enable teachers to teach materials of algebra, arithmetic, and geometric shapes to students.

This research will develop teaching materials using the maritime context for mathematics learning that contain higher-order thinking skills (HOTS). This is expected to increase students' interest and understanding of mathematics while improving higher-order thinking skills in contexts relevant to everyday life. It is important to familiarize learners to learn higher-order thinking skills well (Ramdiah et al., 2019; Retnawati et al., 2018). Higher-order thinking skills are an important aspect to be developed in learning (Ahmad et al., 2017; Wilson & Narasuman, 2020). To date, only a few studies have developed mathematics teaching materials using the maritime context in river waters. This is because the progress of the times causes a decrease in the life activities of maritime people on the river. After all, the life of people on the river switches to land. In fact, life contexts in the river indirectly contain mathematical concepts for students and enable them to learn mathematics at school. Malalina et al. (2020a, 2020b, 2022) assert that activities in waters can be used as a context to learn mathematics. Activities in the waters are related to maritime affairs, such as shipping and trading activities centered in waters, one of which is on rivers (Lapian, 2017; Subiyakto, 2020; Yuliati, 2014; Singh, 2012; Asnan,

2018; Pradhani, 2018; Susilowati, 2017). Therefore, this research aims to: produce maritime context mathematics teaching materials for higher-order thinking in Junior High School that are valid, practical, and have a potential effect on analytical and evaluation skills.

METHODS

This research employed a development design method to develop valid, practical, and potentially influential mathematics teaching materials using maritime contexts. The results of the teaching materials developed in this study are in the form of *Lembar Kegiatan Peserta Didik* (student worksheets), reading materials, learning videos, and questions with levels of analysis and evaluation ability.

This research started with observing maritime activities in the Musi River of Palembang and the Batanghari River of Jambi. Then, maritime activities in this river were analyzed and served as a context to develop mathematics teaching materials for junior high schools. Zulkardi (2002) explains that a development design must follow research objectives. In this study, the development design consisted of two stages: preliminary design and formative evaluation. In the preliminary design stage, the research analyzed maritime activities, reviewed literature, and designed mathematics teaching materials using maritime activities on rivers, such as shipping and trading on the Musi River of Palembang and the Batanghari River of Jambi. After the preliminary study stage, the formative evaluation was conducted and consisted of a self-evaluation, prototype design, and field test (Tessmer, 1993; Zulkardi, 2002). The researchers conducted a self-evaluation to analyze the results of the research product. Expert review and one-to–one stage were also employed to obtain the validity of the research product. The research product was reviewed by four expert lecturers from UIN Raden Fatah Palembang, Universitas PGRI Palembang, and Universitas Sarjanawiyata Yogyakarta. The results of the expert-reviewed product were then validated to ensure the content, construct, and language of the product. Meanwhile, one-to-one stage was carried out by three students with high, medium, and low mathematical abilities at SMP Tamansiswa Palembang. At the small group stage, the students' mathematical abilities were investigated to find out the practicality of the developed product.

The small group stage involved 6 students at SMP Negeri 43 Palembang and 6 students at SMP Negeri 3 Pemulutan Selatan. Those students had math skills. In the last stage, a field test was conducted to find out the potential effects of the developed teaching materials. The research subjects were 30 students of class VII from SMP (junior high school) Tamansiswa Palembang, SMP Tamansiswa Sungai Buah, and SMP Tamansiswa Mariana.

Data collection techniques used at each stage included interviews, validation sheets, documentation, observation, and tests. Interviews were conducted directly with people actively working in the Musi River and the Batanghari River. The interviews were conducted during the development of teaching materials and consisted of expert review, one-to-one stage, small group stage, and field tests. These interviews aim to obtain comments and input related to problems in the student activity sheets and test questions. Observations were conducted to explore community's activities in the Musi River and the Batanghari River as well as students' activities when using teaching materials. The observations were supported by validation sheets of comments and suggestions from experts. Documentation was carried out to capture the community's activities in both rivers according to the context and students' activities in using the teaching material. Documentation enabled this research to reveal students' mathematical abilities, difficulties, and solving problems during learning processes

using teaching materials. Data analysis techniques were useful to analyze descriptive qualitative results from the development stage.

RESULTS AND DISCUSSION

This study aims to develop mathematics teaching materials using maritime contexts for junior high schools. These contexts include shipping and trading, such as exchange/barter trading, mobile trading, and floating stall trading. In the development stage, two phases were involved, namely preliminary design and formative evaluation. The detailed explanation of these phases is as follows.

Preliminary Design

At the preliminary design stage, the researchers analyzed maritime activities, namely shipping and trading in the Musi River of Palembang and the Batanghari River of Jambi. Figure 1 shows a map of maritime activities, shipping, and trading, in the Musi River.

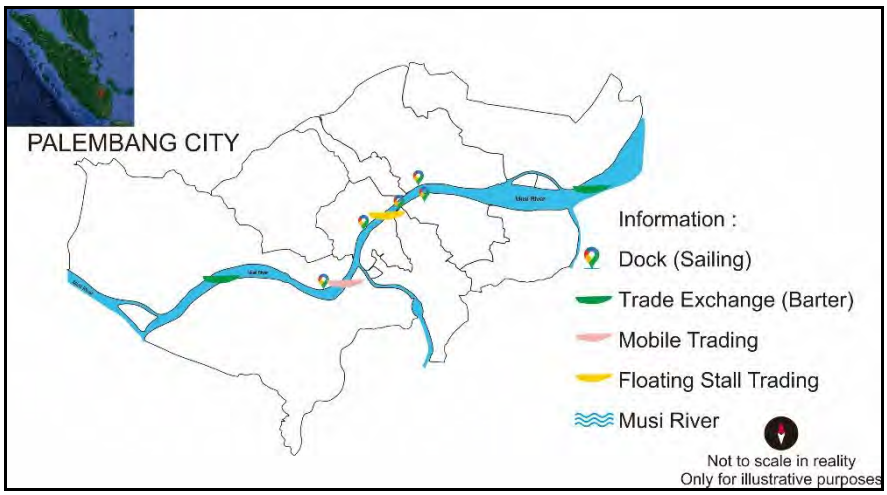


Figure 1. Map of Shipping and Trading in the Musi River of Palembang (made with Corel Draw)

Furthermore, Figure 2 shows maritime activities of shipping in Batanghari River of Jambi.

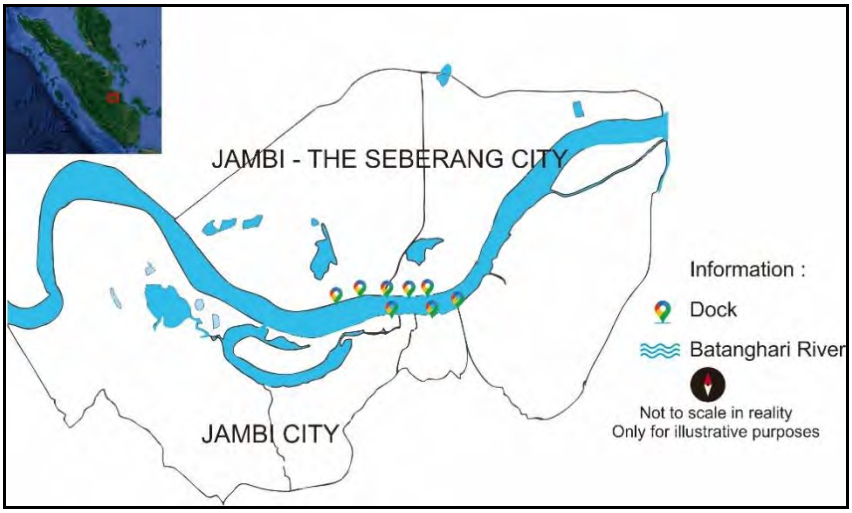


Figure 2. Map of the Boat Route in Batanghari River Jambi (made with Corel Draw)

The collected data show the maritime shipping and trading activities in the Musi River of Palembang and the Batanghari River of Jambi. The researchers analyzed to identify the mathematical concepts associated with shipping and trading activities. Shipping activities use a *ketek* boat (see Figure 3).

Figure 3. Sailing Activities Using *Ketek* Boats

Figure 3 shows the shape of *ketek* boats used in shipping activities in the Musi River of Palembang and the Batanghari River of Jambi. Trading activities include bartering, mobile trading, and floating stall trading (see Figure 4).

Figure 4. Trading Activities

Figure 4 depicts trading activities in the Musi River using boats, which have been designed according to their functions, namely, to facilitate trading. The findings from shipping and trading activities were developed into mathematics material in accordance with the curriculum for seventh grade.

Prototyping Stages

At the Prototyping stage, a formative evaluation was carried out and included self-evaluation, expert review, one-to-one stage, small group stage, and field tests. A detailed explanation of these stages is as follows:

Self-Evaluation Stages

The self-evaluation stages were carried out by evaluating and revising the teaching materials developed by the researchers. Evaluation and revision aim to find errors and deficiencies in the teaching materials before they are assessed by the validator. This study tested three student activity sheets (SW) and four questions at the end of the meeting. SW 1 uses the context of shipping, SW 2 uses the context of exchange trading (barter), and SW 3 uses the context of mobile trading and floating stall trading. Meanwhile, the test questions consist of four questions. The first and second questions

use the shipping context while the third and fourth questions use the trading context. All activities on SW and questions filled with a high-level ability (HOTS), namely analysis and evaluation levels.

Expert Review and One-to-One Stage

The expert review stage was carried out to validate teaching material products, construction, and language use. This validation process was carried out both offline and online. Table 1 summarizes experts' suggestions and comments on the developed mathematics teaching materials using maritime contexts.

Table 1. Validation Comments on Questions

Validators	Institutions	Suggestion
Dr. Sri Adi Widodo, M.Pd.	Universitas Sarjanawiyata Tamansiswa Yogyakarta	1. The cover must show the identity of the teaching material. Who and what level of students use the teaching material? 2. The word *ketek* boat should be written in italic. 3. Sentences should be written using more understandable language for readers. 4. In Activity 2, the context of the voyage should explain more in width and length. Use area units if the word area is used. 5. Reading materials are necessarily added. Therefore, if the materials are tested on Javanese students, they will understand the context of the question.
Dr. Sujinal Arifin, M.Pd.	Universitas Islam Negeri Raden Fatah Palembang	1. The presentation between images should be adjusted and presented with the concept that students will learn. 2. Reading materials should be added to facilitate students to recognize the situation.
Dr. Nyiayu Fahriza Fuadiah, M.Pd.	Universitas PGRI Palembang	1. Learning objectives should be added. 2. Reading materials about sailing should be added. 3. Activity 2 should be replaced with an image of a dock, which more clearly shows its shape. 4. Activity 3 should be replaced with a clearer picture of a *ketek* boat. 5. Activity 4 should be replaced with another map so that it is not the same as Activity 1.
Mardiana S.Pd., M.Pd.	Universitas PGRI Palembang	1. The use of Indonesian grammar, diction, and punctuation in sentences should be improved. 2. The word "Anda" should be used rather than the word "mu". 3. The word "students" should be used rather than the word "students".

Table 1 summarizes validators' or experts' comments or suggestions on teaching materials. The comments and suggestions conclude three points. First, the teaching materials should use clear language without double meanings. Second, the quality of the images should be improved. Third, the context should be adjusted with the problem. Furthermore, Table 2 presents the result of validating the developed questions.

Table 2. Validation Comments on Questions

Validators	Comments
Dr. Sri Adi Widodo, M.Pd.	Question indicators and scoring rubrics should be improved.
Dr. Sujinal Arifin, M.Pd.	Contexts used in the teaching material have already supported learning activities and followed the problems to solve.
Dr. Nyiayu Fahriza Fuadiah, M.Pd.	Contexts used in the teaching material are in accordance with the math questions at the HOTS level.
Mardiana S.Pd., M.Pd.	The use of Indonesian grammar, diction, and punctuation in sentences should be improved.

Table 2 presents the validators' comments and suggestions about the level of analysis and evaluation abilities developed by the researchers. These comments and suggestions are employed to improve the ability level of analysis and evaluation.

Translation: The picture above is Mudung Laut Dock which is located in Jambi - The Seberang City, with an area of 32 meters. If the width of the ketek boat is 1.5 m. How many small boats can lean on the dock. a. Write down any information in the image above b. Sketch the above information in picture form c. Explain how you think the solution will be	Translation: The picture above is Mudung Laut Dock which is located in Jambi Kota Seberang, with an area of 32 square meters. If the width of the ketek boat is 1.5 meters. How many small boats can lean on the dock. a. Write down what information is in the picture above? b. Sketch the above information in picture form? c. Explain how to complete activity 2 in your opinion!

Figure 5. Before Revision (Left) and After Revision (Right) to Activity 2 about Sailing Contexts

Furthermore, in the one-to-one stage, three students with high, medium, and low math abilities were selected. The one-to-one stage was carried out directly by researchers and students to find out the difficulties experienced by the students when using teaching materials. The one-to-one stage has

revealed several comments. First, the students do not know the location of Batanghari River. Second, the place for filling in answers is too small. Third, the students find it difficult to imagine the shape of the dock in activity 2. The followings are pictures showing changes from the first prototype to the second prototype.

Figure 5 shows changes in the pictures before and after the revision based on the validators' comments on SW for activity 2 about shipping contexts. The picture was revised to avoid the students' misperception of the shape of the dock.

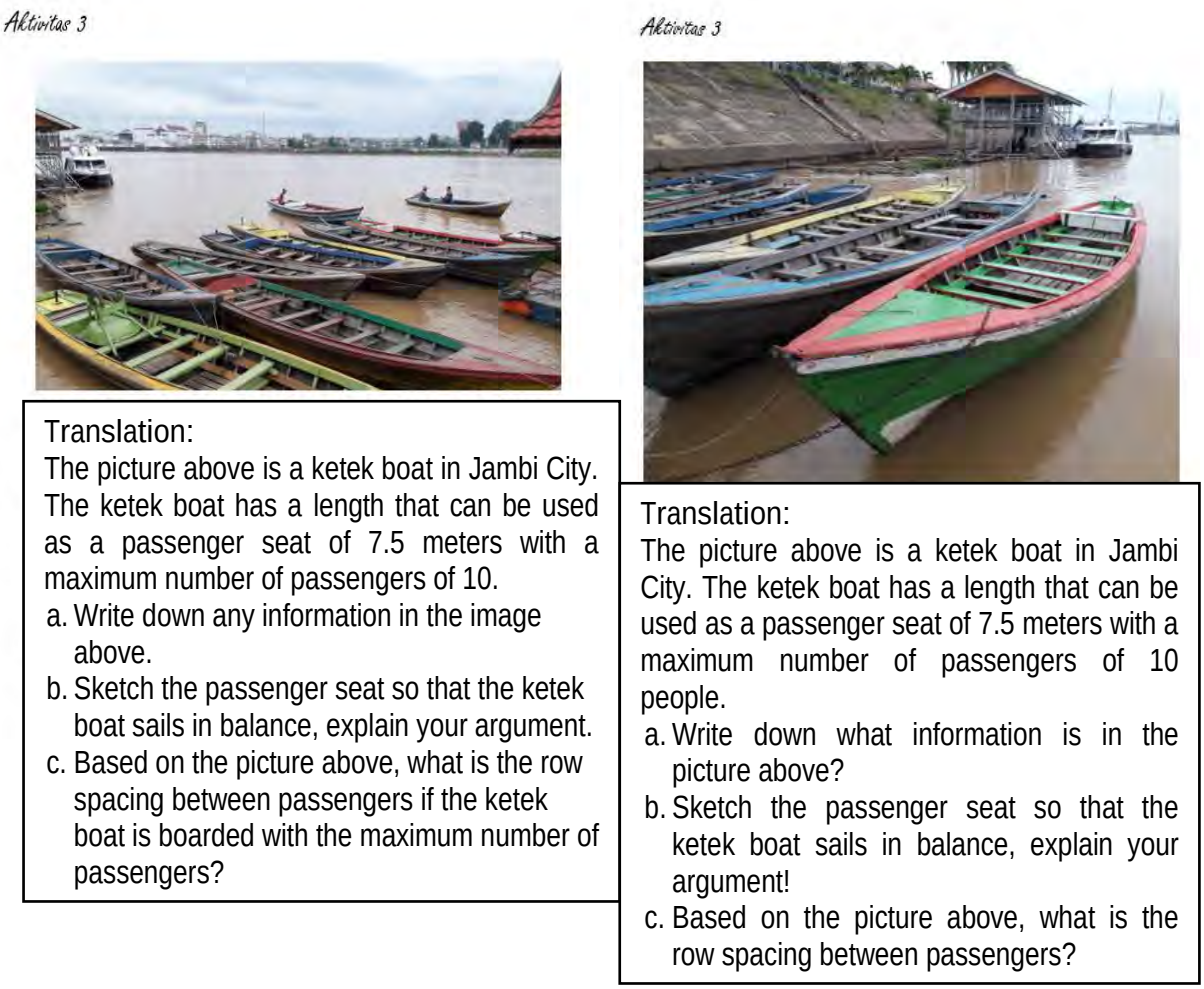


Figure 6. Before Revision (Left) and After Revision (Right) to Activity 2 about Sailing Contexts

Figure 6 shows changes in the pictures before and after the revision based on the validators' comments on the picture of the *ketek* boat, especially the seats. The image was revised to avoid errors when counting the number of rows of passenger seats in the *ketek* boat. Comments and suggestions from expert reviews and one-to-one stage were employed to improve the teaching materials and produce a second prototype.

Small Group Stage

The small group stage was carried out by involving six students with high, medium, and low mathematical abilities in small groups. The students were selected based on the recommendations of the mathematics teacher. The small group stage was conducted at SMP Negeri 43 Palembang and

SMP Negeri 3 Pemulutan Selatan. At the small group stage, students had understood the reading material before completing the SW. The SW was completed in groups. Students discussed the results of their work in their respective groups and then determined the conclusions of the answers written on the answer sheet. After conducting group discussions, each group presented their results.

The results of analyzing students' answer sheets conclude that the students could complete the SW and questions by analyzing and evaluating the problems. However, in the small group stage, this study found several notes to revise, especially related to the use of small font sizes and images in reading materials. The small group stage concludes that mathematics teaching materials using maritime contexts for junior high school students are practical.

Field Tests

The field test is the final stage in the development of teaching materials using maritime contexts for junior high schools. After obtaining valid and practical teaching materials, a field test was carried out. At this stage, the research subjects consisted of 30 students from three schools: SMP Tamansiswa Palembang, SMP Tamansiswa Sungai Buah, and SMP Tamansiswa Mariana.

At the field test stage, small group discussions consisting of 4-6 students, and large group discussions, namely class discussions, were conducted. Researchers acted as facilitators in field test activities to achieve learning objectives. The field test stages are as follows.

The meeting began with greetings "*salam dan bahagia*" (special greetings from Tamansiswa Family), introductions, and checking the attendance list. The students were asked to read the reading material in SW and watch the learning videos. Afterward, the researchers asked questions related to the information obtained from the reading materials and videos. This step aims to enable students to understand that mathematics is related to maritime contexts in rivers. The researchers explained the learning objectives for solving mathematical problems in maritime contexts. The result of students' answer sheets in the first activity is shown in Figure 7.

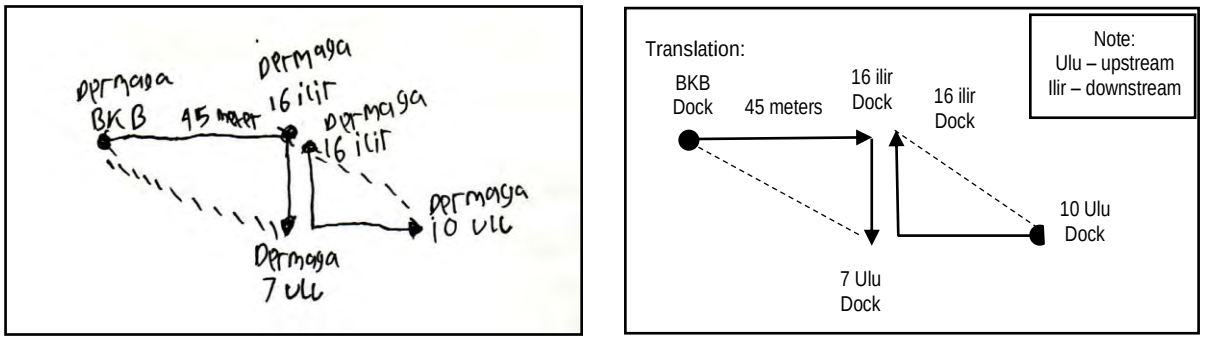
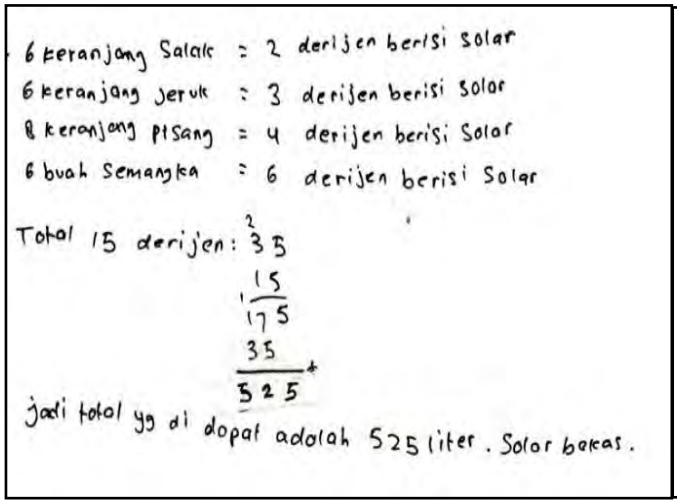


Figure 7. Answers of Student ASN

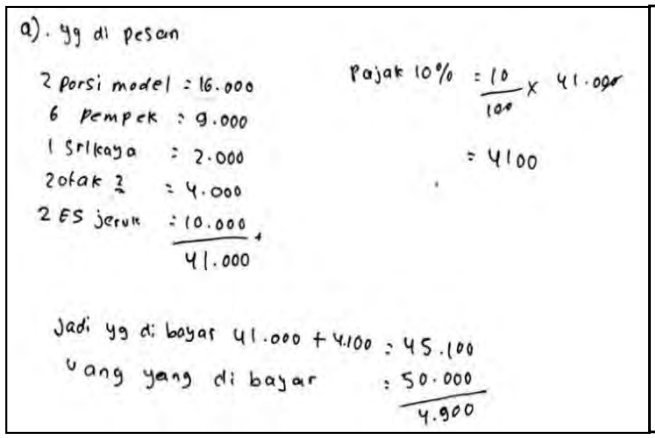
Figure 7 shows the answer sheet of a student, namely ASN. The student's drawing sketch for activity 1 of the first meeting shows that she can analyze problems. Moreover, she has already had the analytical skills to understand the problems in the SW, namely there are two *ketek* boats. The first *ketek* boat sails straight from the starting point to the east (to the right) then 90^o (perpendicular) to the south (down). Meanwhile, the second *ketek* boat sails straight from the starting point to the west (to the left) then 90^o (perpendicular) to the north (up). Meanwhile, Figure 8 shows the answer of student NF.



Translation:
6 baskets of snake fruit = 2 jerrycans filled with diesel
6 baskets of oranges = 3 jerrycans filled with diesel
8 banana baskets = 4 jerrycans filled with diesel fuel 6 watermelons = 6 jerrycans filled with diesel fuel
The total of 15 jerry cans:
(35x15=175+35=525)
So, the total obtained is 525 liters of used diesel

Figure 8. Answers of NF Student

Figure 8 shows the student's answer sheets about the material of integer operations. Next, the students analyzed the question by comparing the number of baskets changed with jerry cans filled with diesel fuel. After that, the students counted the total liters of used diesel fuel obtained from the change. Furthermore, Figure 9 shows the answer of student RA.



Translation:
a) which is ordered

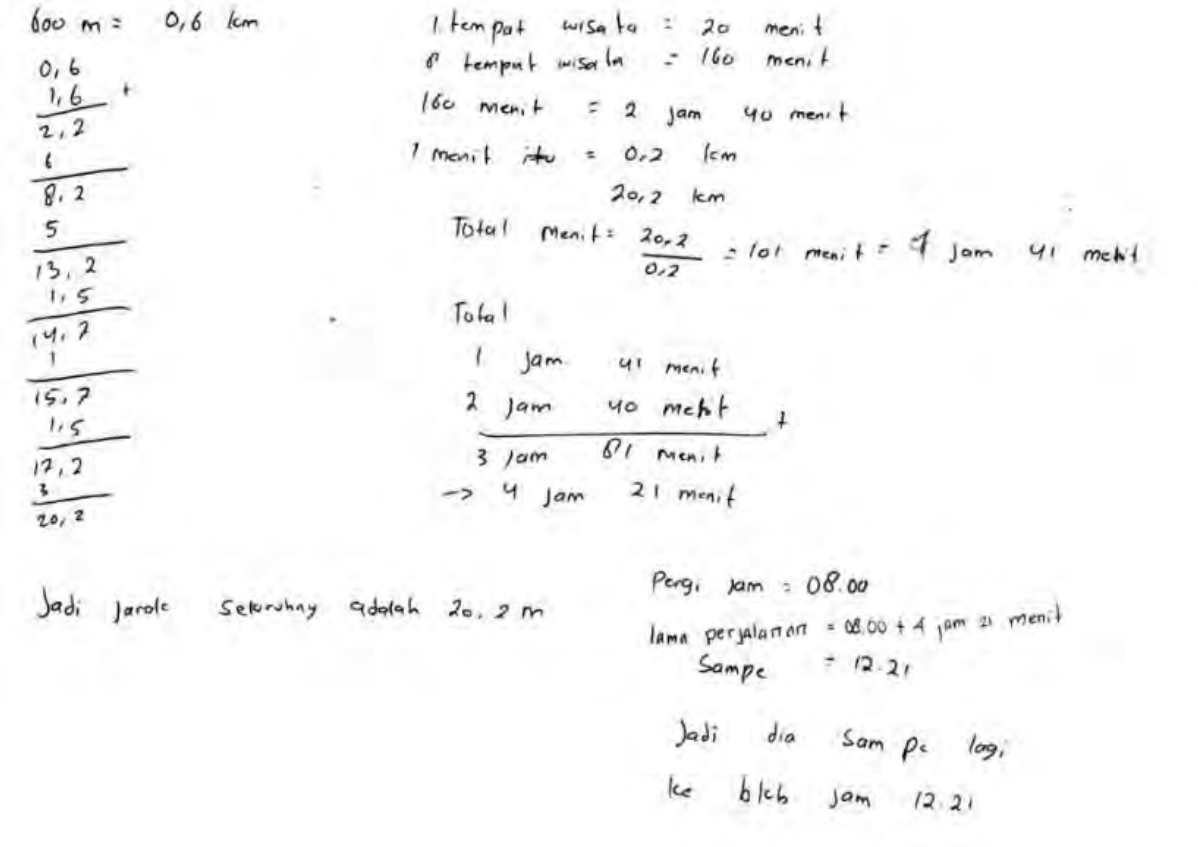
2 portions of models	= 16,000
6 pempek	= 9,000
1 srikaya	= 2,000
2 otak-otak	= 4,000
2 orange ice	= 10,000 +
	41.000

10% Tax = (10:100)x41.000 = 4.100

so what is paid is 41.000 +4.100=45.100
Cash for paying =50.000
4.900

Figure 9. Answers of Student RA

Figure 9 explains the student's answer sheet for activity 4 at the third meeting. Figure 9 also shows that the student can present an answer related to the material and present the data with social arithmetic. The student's working process began with presenting data from consumer orders. Then, he calculated the amount of payment and added taxes from the amount of payment. Furthermore, he calculated the amount of change paid by consumers. At meeting 4, the shipping context was presented. ARZ student's answer is presented in Figure 10.



Translation:

600 m = 0.6 km
0.6 +
2.2
1 +
8.2
5 +
13.2
1.5
14.2
1 +
15.7
1.5 +
17.2
3 +
20.2

so the total distance is 20.2 m

1 tourist attraction = 20 minutes
8 tourist attractions = 160 minutes
160 minutes = 2 hours 40 minutes
1 minute = 0.2 km
20.2 km
Total in minutes = (20.2:0.2) = 101 minutes = 7 hours 41 minutes

Total
1 hour 41 minutes
2 hours 40 minutes +
3 hours 81 minutes
→4 hours 21 minutes

Leave time = 08.00
Length of journey = 08.00 + 4 hours 21 minutes
Arrive time = 12.21
So he will come back to BKB at 12.21

Figure 10. Student ARZ's Answer for Question Number 1

Figure 10 shows the answer of student ARZ when solving question number 1. Figure 10 shows that student ARZ could analyze the distance needed by a *ketek* boat to sail from one tourist spot to another by adding up the distances to the tourist attractions visited. Then, student ARZ analyzed question 1 by explaining that if going to a tourist attraction took 20 minutes, going to eight tourist attractions would

take 160 minutes. Student ARZ also changed the words 160 minutes to 2 hours and 40 minutes. After that, student ARZ divided the overall distance of the tourist attractions, namely 20.2 KM., with the time required by a boat to sail for 1 minute. And the answer is 0.2 minutes. Thus, the answer to sailing time for the eight tourist attractions has been obtained. Afterward, student ARZ evaluated what time the tourists would return to their original place. In addition, student ARZ could evaluate the time and distance needed to get to and surround the tourist attractions until the tourists returned to the initial dock by adding up the time while sailing and visiting tourist attractions. His answer for this evaluation is 4 hours and 21 Minutes. The results of the field test conclude that teaching materials potentially influence students' HOTS abilities, namely the levels of analysis and evaluation.

The teaching material has been revised by referring to the validators' comments and suggestions. Moreover, the validators declare that the content, constructs, images, readability, and language use of these teaching materials are valid. This claim is in accordance with Putri and Zulkardi (2018) who opine that validity can be obtained from the comments of experts. The validators' comments also agree with Zulkardi and Kohar (2018) as well as Zulkardi and Putri (2020) who state that teaching material must use a clear image and use readable language. Comments and suggestions provided from expert reviews and one-to-one on content, constructs, and language can be used to produce a valid second prototype (Hiltrimartin et al., 2022).

The students' answer sheets in the one-to-one and small group stages show that the developed teaching materials are practical. Kamus Besar Bahasa Indonesia (Big Indonesian Dictionary) defines the word practical as the easiness to use based on the results of practice. The developed materials are declared practical because teachers and students can easily use them (Gravemeijer, 2014). In addition, practicality is also shown from learning observations and students' answer sheets as the students can understand problems in SW (Effendi et al., 2019). Practicality is also indicated by the absence of difficulty when teachers, students, and other users use a developed product (Nieveen, 1999). It is confirmed that the developed teaching materials are practical because the students can easily use them and understand the problems.

The field test stage concludes that the developed teaching materials potentially affect the high-level abilities of students, especially their level of analysis and evaluation to complete SW and questions. Students completed SW by observing pictures or tables followed by understanding the questions in the problem. These steps are supported by Zulkardi et al. (2020) who state that before solving problems by observing pictures, and understanding tables and also questions. The use of contexts is pivotal because contexts enable students to easily understand mathematics from an abstract concept to a real concept (Putri & Zulkardi, 2020). In this research, the students could understand mathematics through questions using the contexts of their environment to improve their analysis and evaluation levels.

The curriculum emphasizes the use of HOTS in mathematics learning, daily life contexts, and collaborative learning (Meryansumayeka et al., 2019; Zulkardi & Putri, 2020). Therefore, learning mathematics using maritime contexts has a potential effect because these contexts can be connected to students' environment to produce SW and HOTS (Higher Order Thinking Skills) questions.

CONCLUSION

This research produces valid and practical maritime context mathematics teaching materials for higher-order thinking in Junior High School. Valid can be seen from the expert review stage, namely assessing

content, constructs and language in lesson plan, SW and higher-order thinking skills. In one to one, based on the findings on the answer sheet on SW and higher-order thinking skills questions show that students are able to understand the problems in teaching materials as seen from being able to analyze and evaluate SW problems and problems. At the small group stage, it is stated to be practical based on the results of SW trials and questions show that during the learning process carried out in groups, students do not experience obstacles to solve problems in SW and questions. From the field test stage, it was obtained that maritime context mathematics teaching materials for high-level abilities in Junior High School have a potential effect on analytical and evaluation skills. The potential effect is seen in the ability of students to be able to analyze and evaluate problems that exist in SW and Questions.

Acknowledgments

The researchers would like to thank all parties who supported and assisted in the completion of this research. The researchers would like to thank the people who had direct activities in the Musi River of Palembang and the Batanghari River of Jambi as well as staff at the Education and Culture Office of Palembang City, the Education and Culture Office of Banyuasin Regency, the Office of National Unity and Politics of Palembang City for the permission. The gratitude is also delivered to expert reviewers, headmasters, teachers, and students of SMP Negeri 43 Palembang, SMP Negeri 3 Pemulutan Selatan, SMP Tamansiswa Palembang, SMP Tamansiswa Mariana, and SMP Tamansiswa Sungai Buah who have provided facilities and infrastructure to conduct this research. It is expected that this research can provide a major contribution to the field to other researchers.

Declarations

Author Contribution : M: Created the concepts, collected data, designed the methodology, wrote drafts, analyzed the data, reviewed the products, as well as wrote and edited the revised results

RIIP: created the concept, designed the methodology, analyzed data, as well as reviewed, validated, and monitored the product.

Z: reviewed the product, edited the draft, analyzed the data, and monitored the product.

YH: created the concepts, designed methodologies, reviewed the product, edited the draft, analyzed the data, reviewed the product, and supervised the research process.

Funding Statement : This research did not receive a special grant from a funding agency, either from a government or private agency.

Conflict of Interest : The authors declare no conflict of interest.

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