Jurnal Elemen, 10(2), 289-304, May 2024
https:/doi.org/10.29408/jel.v10i2.25157

e- ISSN: 2442 - 4226

Developing RME-based module in statistics to improve problem-solving skills for higher education students

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Abstract

In university learning, it is important to use learning resources that can facilitate students' thinking skills. So it is necessary to develop teaching materials for learning material in class, So it is necessary to develop teaching materials that can help students understand the concepts of the material. This research aims to develop a statistics teaching module based on a realistic mathematical approach to foster student problem-solving. This research and development uses a 4-D model in four stages, namely: definition, design, development, and dissemination. Product trials are carried out in three stages, namely: a validity test, a limited test, and a wide-scale test. The test subjects in this research were students from the mathematics education study program at three universities in Bengkulu. The research instruments were questionnaire sheets and problem-solving tests on basic statistical material. The research results show that the RME statistics teaching module meets the criteria of being valid, practical, and effective in terms of students' problem-solving abilities. The suggestion from the research results is that it is important to present a context that is relevant to the student's environment in the use of RME teaching materials.

Keywords: problem-solving; research and development; RME; statistics teaching module

How to cite: Susanto, E, Susanta, A, Irsal, N. A., & Stanggo, P. D. (2024). Developing RME-based module in statistics to improve problem-solving skills for higher education students. *Jurnal Elemen*, *10*(1), 289-304. https://doi.org/10.29408/jel.v10i2.25157

Received: 23 January 2024 | Revised: 28 March 2024
Accepted: 11 May 2024 | Published: 1 Juni 2024

Introduction

The 21st-century skills that students must master include creativity, metacognition, problem-solving, and communication (Muhali, 2019; Trilling & Fadel, 2009). Students in higher education require this ability as a learning achievement in class. These skills provide provisions for college graduates in facing the era of Society 5.0 (Arsanti et al., 2021). Higher education has a role in preparing graduates to be competent and able to enter the jobs needed in the world today. To achieve this, the Indonesian government implemented an independent curriculum in universities. This application requires students to form independent, critical character and good social sensitivity (Kemendikbud, 2022).

We highlight learning at higher education and the achievements required for learning are getting higher as time passes. Through the implementation of a curriculum in higher education that focuses on developing innovation and creativity (Kemendikbud, 2022); critical thinking, problem-solving, communication, and collaboration (Mardhiyah et al., 2021). So learning in higher education needs to present these abilities in learning. College graduates must master competencies according to their field to compete in the world of work (Susanto & Susanta, 2022). Improving student skills, one of which is problem-solving ability, is one of the focuses of higher education learning.

Problem-solving is an important skill for everyone in their life, therefore every student need to master it. Problem-solving requires the integration of the application of knowledge, understanding, and skills (Santia, 2015). This shows that mastery of abilities at each cognitive level. Problem-solving ability is the main aspect of implementing the curriculum which is needed by students to apply and integrate concepts and skills and make decisions (Tambychik & Meerah, 2010). So problem-solving abilities must be made one of the goals of every lesson. In achieving this, educator competence plays an important role, especially in designing teaching materials to achieve learning success (Hariyati & Rachmadyanti, 2022). In developing students' abilities to carry out innovative learning (Susanta et al., 2022). Through innovative teaching materials, students' thinking abilities can be achieved. Even though learning today cannot be separated from learning resources that can be accessed via the Internet, the availability of printed teaching materials in the classroom still plays an important role.

The problems that occur in classroom learning vary for each student and face different challenges. We observe that learning outcomes, especially in Indonesia, from school to university levels, are still a special concern. Especially in learning at universities, we observe that student learning outcomes still need to be improved. For example, the results of research by Susanta et al., (2020) show that the average achievement of student statistics learning outcomes only reached a score of 68.54. When compared with standard scores, students get very good scores in the range of 85-100. This shows that it is necessary to increase student learning outcomes, especially in basic statistics courses.

Another problem that occurs in learning in higher education is limited teaching materials. The absence of specially designed teaching materials that suit student characteristics and learning objectives is a contributing factor to the low achievement of learning outcomes. Based on the results of a survey of the teaching material needs of mathematics education students at

the Faculty of Teachers Training and Education, Bengkulu University. It was concluded that up to 80.00% of students provided learning resources that were most accessed via the Internet. This shows that the availability of online learning resources is very large. However, the selection of learning resources needs to be adjusted to student characteristics and the use of very general and irrelevant contexts can make it difficult for students to understand concepts. So it is necessary to design teaching materials that can facilitate students' independent or guided learning in discovering concepts.

Previous research has shown that Realistic Mathematics Education (RME) provides learning experiences that are appropriate to the student's context. In the RME learning process, students use their knowledge to solve real problems in everyday life (Yuliani, 2016). Hence lecture teaching materials in the form of learning modules that are integrated with RME is offered to the problems that have been described Because in mathematics learning, it is stated that RME can strengthen it as an important process in learning (Laurens et al., 2017). So it is important to present the RME context in learning. RME also facilitates developing students' creative and critical thinking (Rifandi et al., 2021); and building knowledge for problem-solving (Palupi & Khabibah, 2018).

The use of RME contexts in teaching materials for classroom learning has been proven to support students' thinking skills. Research conducted by Rifandi et al., (2021) found that RME plays a supporting role in solving problems, explaining ideas, and mathematical relationships between real objects, images, graphs, and algebra. The RME approach has been proven to be better in improving problem-solving (Mukaromah et al., 2023; Windari & Winarti, 2019). RME that uses a cultural context supports the achievement of learning outcomes (Susanto et al., 2021). Therefore, it is important to develop teaching materials for higher education using deep context RME to support students' problem-solving abilities. Most of the previous research was carried out in secondary education and has not been widely developed in university teaching materials, especially basic statistics. Apart from that, the realistic problems we use refer to everyday problems in the student environment, namely problems in the Bengkulu context. The research emphasis that needs to be carried out is designing RME in learning modules, especially in statistical learning. This research aims to develop teaching materials in the form of statistics modules RME approach to support student problem-solving.

Methods

This research aimed to develop statistics modules using the RME approach. The type of this research is Research and Development (R&D). This development research was focused on problem-solving-oriented RME statistics teaching materials. The development model used was a 4-D model with stages: (a) define, (b) design, (c) develop, and (d) disseminate (Thiagarajan et al., 1974). The choice of this model was due to the sequential stages so that it followed the research objectives, namely producing RME statistics teaching materials that were valid, practical, and effective in supporting student problem-solving. The 4-D model stages are more appropriate in product development, especially RME modules. This is because at the define stage problems can be studied and development needs analyzed, at the design stage an initial

product design is carried out which is then assessed and tested at the development stage. In the diversity of data sources for this research, the product test subjects were spread across three universities. The research was carried out on students of the mathematics education study program at Bengkulu University, Faculty at Islamic State University Fatmawati Sukarno Bengkulu, and Institut Agama Islam Negeri (IAIN) Curup. The subjects of the small group test (practicality test) from each campus were 9 students selected from low, medium, and high ability levels. Meanwhile, field tests (effectiveness tests) were carried out on whole classes selected from each university. The distribution of product trial subjects in the research is in Table 1.

Table 1. Product trial subjects

University	Expert	Small Group	Field test
Bengkulu University	2	9 students	31 students
UIN Fatmawati	1	9 students	25 students
IAIN Curup	1	9 students	18 students

The procedure for implementing this development research begins with the define stage, namely as a reference for initial product design. At the define stage, three analyses are carried out, namely: (1) curriculum and material analysis, (2) analysis of student abilities and characteristics, and (3) RME context analysis. The second stage is the design stage, at this stage an initial draft of problem-solving-oriented RME statistics teaching materials is produced. The next stage is development which focuses on product testing which consists of (1) expert testing, (2) small-scale testing, and (3) wide-scale testing. The final stage is dissemination, at this stage teaching materials are disseminated to other lecturers on the campus which is the target of the research.

The data in this research was collected through questionnaires and problem-solving tests. The data collection instrument consists of (1) a validity sheet, (2) a practicality sheet, and (3) problem-solving questions. The measurement indicators of problem-solving questions are understanding the problem, devising a plan, carrying out the plan, and looking back. Apart from checking the data source, to ensure the validity of the research data, an assessment of the quality of the research data collection instruments is also carried out. Each instrument has gone through the expert assessment and checking to ensure suitability in terms of construction, materials, and language. The problem-solving instrument consists of 4 descriptive questions which are assessed for conformity with the basic competency of basic statistical material. In terms of content, the problem-solving instrument was analyzed using the Aiken index with the results of the analysis of the four questions having an index value of more than 0.5 (Retnawati, 2014). So that the instrument meets the valid criteria. Apart from that, reliability calculations are carried out through trials on Faculty of Education University Bengkulu students who have taken basic statistics courses. This analysis uses Cronbach's alpha with a calculated value of 0.67 is a reliable criterion (Priyatno, 2013). These two basic analyses show that the research instrument in the form of problem-solving questions is suitable for use as a research data collection tool.

Analysis of data obtained from validity, practicality, and problem-solving test instruments through descriptive statistics consisting of mean, mode, minimum, maximum, and standard

deviation of data. This analysis is to describe data on students' statistical problem-solving abilities. Construct validity analysis uses Aiken Index analysis with valid criteria if the Aiken index value is more than 0.5 (Aiken, 1980; Retnawati, 2016). The practicality analysis is based on a questionnaire given to students with 8 question items with a score of 1-4 which focuses on aspects of ease of use such as presentation of information, images, symbols, language, and systematic presentation of material in teaching materials. The teaching materials in this research are practical if the student's assessment scores are good to very good. The research product practicality score criteria range from 1.00 to 1.80 (very poor); 1.81-2.60 (less); 2.61-3.40 (good); and 3.41-4.00 (excellent).

Analysis of product effectiveness data in this research was analyzed based on tests of students' problem-solving abilities in large-scale trials. Product effectiveness analysis was also carried out using descriptive statistics to describe students' problem-solving abilities using the criteria in Table 2.

Table 2. Problem-solving criteria

Interval	Criteria
0-33	Low
34-66	Middle
67-100	High

The product in this research is effective if the percentage of student mastery in solving statistical problems reaches 60.00%.

Results

The define stage results

Curriculum and material analysis

Curriculum and material analysis was carried out through identifying semester learning plans (in Indonesia RPS) for basic statistics courses. The results of the analysis of the RPS show that the learning stages are carried out conventionally by presenting the material. The delivery of the material does not specifically use realistic problems that are better known to students. The use of teaching materials as learning resources is still in the form of general basic statistics books and ppt handouts from lecturers. So the learning design contained in the teaching materials is not specifically intended to improve problem-solving abilities.

Furthermore, the results of material studies based on the curriculum are focused on data concentration measures. The sub-materials used as study material as a basis for preparing teaching materials consist of mean, median, and mode. Based on the results of material analysis through the distribution of material requirements questionnaires, data concentration measures are material that is difficult for students to master, especially in solving real problems. So it requires learning with a special design to be carried out.

Student analysis

At the define stage, we also carry out an analysis of student needs. The results of the analysis of students' initial abilities by giving problem-solving ability questions concluded that in general students' abilities were still very low. Based on the results of working on problem-solving questions related to data concentration measures for 20 students, in Table 3.

Table 3. Students' initial ability test achievements of problem-solving skills

Problem-Solving Aspect	Students	Percentage (%)
Understand the problem	12	60.00
Plan a solution	9	45.00
Solve the problem	6	30.00
Looking back	2	10.00

The results of student abilities in Table 3 show that the level of understanding of the problem only reached 60.00%. This means that students understand the problem as well as being asked what they know. The data also shows that only 2 students were able to review the results of problem-solving (10.00%). Analysis of the need for developing teaching materials was also reviewed by students by exploring information about the use of learning resources in the classroom. Analysis of the availability of teaching materials for 20 students through questionnaires. The results of the analysis questionnaire are in Table 4 below.

Table 4. Student response to learning

Question items	Percentage
Use of lecture materials from general statistics books	18 Students [90.00%]
The use of problem examples in lectures uses real context	11 Students [55.55%]
Use of realistic contexts known to students in lectures	5 Students [25.00%]

Based on the data in Table 4, it can be concluded that in general lectures still use general basic statistics books. Lecturers have not specifically developed teaching materials that use real contexts that are real for students. It can be seen that of all the students who responded, only 25.00% of the students responded to lecturers in lectures using realistic problems.

RME context analysis

Several results were obtained from the analysis of the realistic context that was used as a problem in the development of statistical teaching materials, namely: the context of the Bengkulu traditional market which can be linked to the average concept. The Bengkulu tourism context is the average number of visitors to Long Beach, Covid-19. Context of agricultural output in Bengkulu to explain the average. The context of typical Bengkulu food explains the median queue of visitors to buy bay tat cake (a typical Bengkulu cake). The results of the RME context analysis of the Bengkulu problem are in Table 5 below.

Table 5. Results of RME context analysis

Context	Material
Bengkulu tourism context, COVID-19 in Bengkulu	Mean data
Bengkulu agricultural products	Mean data and mode
Typical Bengkulu Food	Median

Based on the results of the analysis of the material, students, and the RME context, it was concluded that it was necessary to develop statistical teaching materials that could support students' problem-solving abilities. The results of the analysis of statistical material, namely data concentration measurement material, require contextual problems so that problems are conveyed to students. To support statistics learning in higher education, teaching materials with realistic problems based on problem-solving are needed. The statistics teaching materials developed are in the form of modules consisting of realistic problems, materials, problem-solving activities, and strengthening exercises.

Design phase results

At the design stage, teaching materials were designed in the chapters on data presentation and measures of central tendency. The selected teaching material design includes aspects of material presentation, layout, and discussion (BSNP, 2008) and an emphasis on realistic problems. We consider that in compiling the RME statistics module it is necessary to design problems that are relevant to the material and more familiar to students. This stage also produces how the teaching materials are presented so that they are easy to read. In its presentation, the teaching materials are arranged sequentially, namely realistic problems, material, and strengthening exercises. In the design stage, data collection instruments are also produced, namely validity sheets, practicality sheets, and the preparation of problem-solving tests. The results of the design of statistics teaching materials are characterized by the presence of realistic problems in each introductory material. The following is an example of realistic problem design in teaching materials.

A. MEAN

Realistic Problem

Look at the following figure!

Figure. Illustration of the Covid Handling Command Post

In dealing with the spread of Covid-19, checkpoints have been established at every border in the Bengkulu area. In every 15 minutes, the Bengkulu provincial health team checks the body temperature of 60 people driving both cars and motorbikes on average. The results of measuring each person's body temperature will be different and may be the same. The team records and will present the average body temperature of the riders.

Figure 1. Example of realistic problem design (in English)

Development stage results

Expert test

The products that have been developed are assessed by experts consisting of two lecturers from the University of Bengkulu and one lecturer from the State Islamic University of Fatmawati Bengkulu. In its implementation, the expert test begins with conducting a forum group discussion (FGD). Next, each expert is given teaching materials and a validity sheet. Assessments are carried out on aspects of material, presentation techniques, language, and use of RME context. The results of the analysis are based on validator data as in Table 6.

Table 6. Validation of textbook products

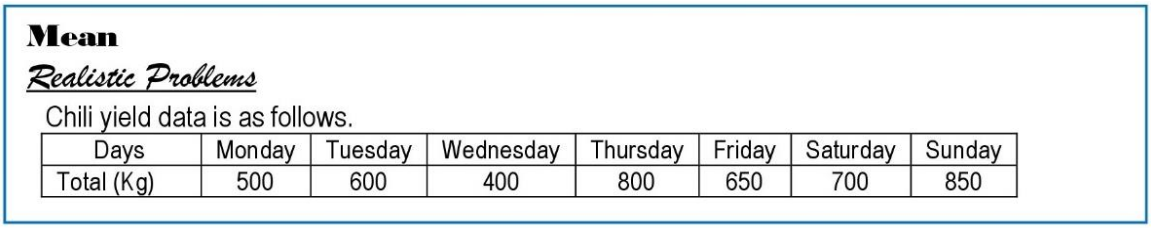
Aspect	Aiken Index	Criteria
Material suitability	0.58	Valid
Material accuracy	0.65	Valid
Presentation technique	0.78	Valid
Sequence of presentation flow	0.56	Valid
Presentation of communicative language	0.76	Valid
RME context appropriateness	0.80	Valid

Table 6 shows that each component assessed has valid criteria with an Aiken V index of more than 0.5. This shows that expertly the teaching materials fulfill a theoretical perspective. Suggestions given by the assessment include the presentation of material which must be sequential as well as realistic problems for each sub-material. The validator suggests that each material presented begins by presenting a contextual problem. Realistic problems must have image captions added. Summary of suggestions from the assessment in Table 7

Table 7. Expert reviewer assessment results

Expert	Suggestion
Expert 1	▪ The presentation of material must be more consistent by providing examples of questions and solutions ▪ The use of realistic problems must be based on concepts and contexts that are close to students
Expert 2	▪ It is best for realistic problems to be given real pictures to support students in understanding the problem ▪ Strengthening exercises must be adapted to the material and refer to problem-solving abilities
Expert 3	▪ Include images of realistic problems ▪ Check the writing of symbols and language for any incorrect writing

The results of the assessment by the reviewer were used as a reference in product revisions in this research. One example of the results before and after revision is the presentation of realistic problems in teaching materials as in Figure 2.



(a)

Mean

Realistic Problems

Figure. Chile Harvest Results

A farmer in Rejang Lebong Regency recorded the chili harvest in one week. The chilies are sent to Bengkulu City every day to be sold. The harvest results are recorded as in the following table.

Days	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Total (Kg)	500	600	400	800	650	700	850

(b)

Figure 2. (a) before revision, (b) after revision

Small scale trials

Products that have been validated and revised based on suggestions from validators are then carried out in limited trials to determine the practicality of the teaching materials. Practicality tests were carried out on mathematics education study program students who took statistics courses. The trial was carried out on 9 students from low, medium, and high levels of knowledge. The highest average student assessment results were that the language component was easy to understand so that in terms of language the textbook was presented well. Meanwhile, the lowest average value is found in image display and color presentation of textbook material. Based on this, improvements are focused on the appearance or layout of the presentation of teaching materials so that they are attractive to users.

The results of the practicality test where assessments from product users, namely students, are used as a reference in improving the readability and ease of use of the product. The following is a summary of the practicality assessment results from small-scale tests in Table 8.

Table 8. Product practicality test results

Aspect	Average	Criteria
Appearance (image, color)	3.50	Very good
Font type and size	3.45	Very good
Layout and sequence of dishes	3.56	Very good
Language used	3.39	Good
Presentation of real context problems	3.23	Good
Presentation of material and exercises	3.39	Good
The problem is easy to understand	3.00	Good
Realistic problems with the student environment	3.04	Good

Field test

The field testing phase was carried out on 74 students from three universities. In this trial, learning was carried out by the lecturer using RME statistics teaching materials. Before the implementation of teaching lecturers, an FGD was carried out regarding the systematic

implementation of learning and the final tests carried out. Learning was carried out during two meetings which focused on data concentration measurement material. After learning, a test is carried out to measure students' statistical problem-solving abilities.

Table 9. Students' statistical problem-solving

Interval	Score
Mean	70.05
Max	80.25
Min	25.04

The results of the description of students' satistical problem-solving abilities in Table 9 show that on average students have a high category ability, namely 70.05. This means that in general students have mastered problem-solving skills with mastery reaching 70 percent. Students can be understanding the statistics problems, be making a plan, solve the statistic problem, and look back on the problem-solving process. Next, student ability data is divided into three levels, namely low, medium, and high. The results of the analysis of students' problem-solving ability tests are in Table 10.

Table 10. Level of problem-solving abilities

Interval	Criteria	Total	Percentage
0-33	Low	3	4.05 %
34-66	Middle	23	31.08 %
67-100	High	48	64.86 %

Based on Table 10, students who have a high level of problem-solving ability are 64.86%. This means that it can be concluded that students' problem-solving abilities after learning with RME statistics teaching materials are on average in the high category.

Dissemination stage

The dissemination stage was carried out by providing teaching materials to lecturers teaching statistics courses at the universities where the research was conducted. Distribution is also carried out online so that students can access the teaching materials developed.

Discussion

The results of the Aiken index analysis of the expert assessment data show that each aspect of the module meets the valid criteria. This means that, in terms of construct, the module has been prepared to meet the criteria of material, presentation techniques, language, and use of RME context. Validation results help accuracy in designing teaching materials (Suparti et al., 2015). The validation results are not only in the form of assessment numbers but there are suggestions for improvements given by experts to the product. So that the product consistently meets the development goals and materials. Apart from that, this teaching material also meets the aspect of ease of use. This aspect must be fulfilled because it is related to how users can easily understand the concept of the material through the modules being developed. Teaching materials are good if they are readable, such as images, symbols, and presentations are

displayed very clearly. Practical teaching materials can be used by students to be more effective and efficient (Sunismi & Fathani, 2016). Ease of use of teaching materials is the main aspect of practicality. In line with this, teaching materials can be said to be practical if students use the teaching materials without problems (Akbar, 2016). Apart from that, an attractive appearance is needed to stimulate students' interest in learning and use it as a learning resource (Kurniawati et al., 2015).

Our findings in this research are that the emphasis on real context in problems in teaching materials has an impact on student responses to learning. The use of this context is necessary because it facilitates students in problem-solving. The use of real context influences problem-solving abilities (Kadir & Masi, 2014). The importance of real problems in learning is also shown from the results of research conducted by Susanta et al., (2023) which proves that learning using local context mathematics tasks can support literacy skills which include the ability to solve problems. Assignments using context can motivate students to complete assignments (Clarke & Roche, 2018). So the context used in this statistics teaching module has an impact on the learning process.

The results of the analysis of students' problem-solving abilities show that on average they are in the high category after learning using the developed module. The results of the analysis of the effectiveness of teaching materials show effective criteria. This means that the RME teaching materials developed are effective in supporting students' problem-solving abilities. Through the application of realistic problems in teaching materials, it will support students in solving the problems given. This is following the opinion which states that a device is said to be effective if it produces the desired results (Plomp, 2007).

The results in this study follow the findings of previous research which found that RME-based learning is effective in improving mathematical problem-solving abilities (Anggraini & Fauzan, 2020; Musdi et al., 2023; Widana, 2021). Other research also shows that problem-solving abilities with RME learning are better than conventional (Mukaromah et al., 2023). The increase in problem-solving abilities as a result of RME teaching materials is because students have the opportunity to rediscover and construct mathematical concepts to help solve problems (Susanti, 2017). Apart from that, systematic procedures in solving problems are an aspect of supporting student abilities. This follows the opinion of Laurens et al., (2017) who stated that the key to RME learning is related to problem-solving procedures. We show one of the student stages in solving problems in this research in Figure 3.

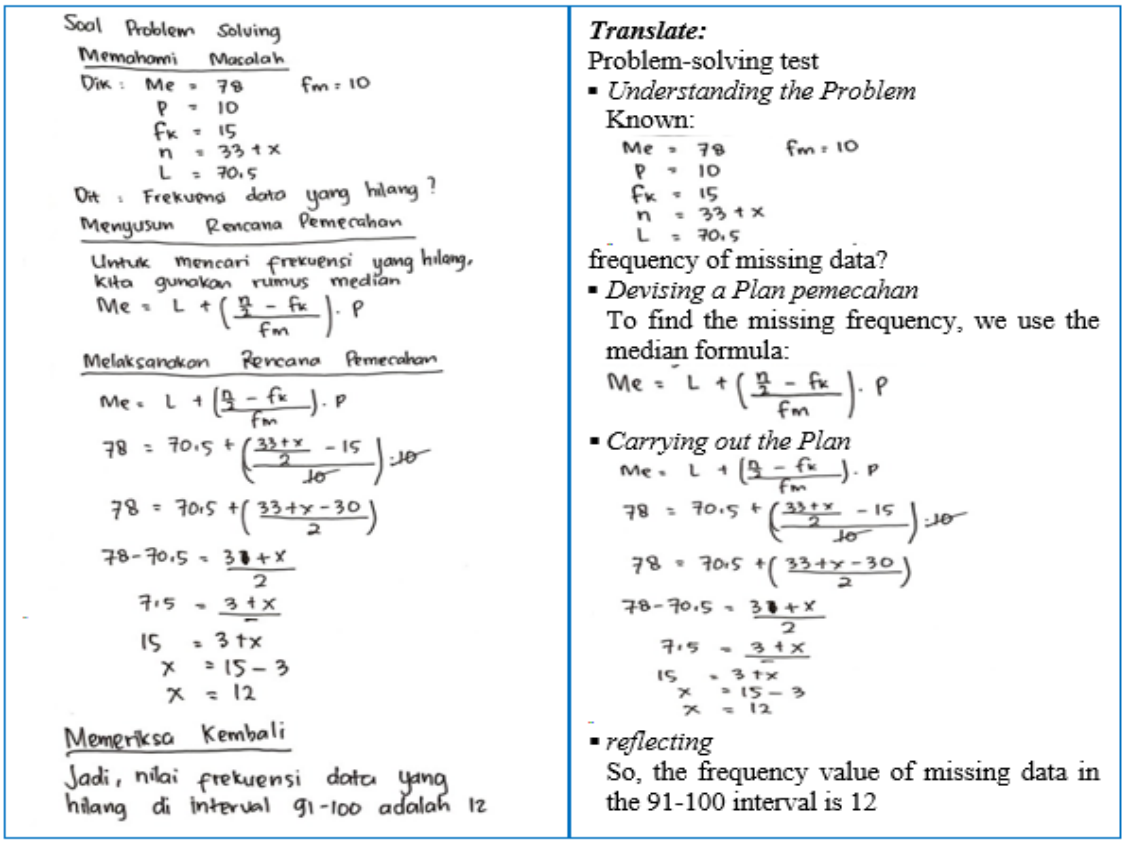


Figure 3. Example of student completion

The results of the analysis of student answers in Figure 3 show that students have been able to solve problems using problem-solving stages. At the completion stage, it can be seen that students can use the median formula to calculate the frequency in a class. Students are also able to apply existing problems in mathematical equations. So it is concluded that students have high problem-solving abilities. So that the use of the developed RME module can support students' problem-solving skills in studying basic statistics in college. The RME statistics teaching materials a research output can be downloaded at the link **https://shorturl.asia/HpRVO**

Conclusion

The RME statistics teaching materials oriented toward problem-solving abilities meet valid and practical criteria. The research results in the form of RME statistics teaching materials are effective on students' statistical problem-solving abilities. The suggestion from this research is that when developing teaching modules in higher education, one needs to pay attention to the characteristics and environment of students as problems in conveying the material concept

The limitation of this research is that the focus of the skills achieved from using the module is problem-solving abilities. Future research can expand the focus on student skills such as communication skills, reasoning, and statistical literacy. Another limitation of the research is the implementation time so that only three basic statistical subchapters were developed, even though the material could be developed more widely. The implication of this research is to

develop students' problem-solving abilities by applying teaching materials using a context that is realistic and familiar to students

Acknowledgment

The authors would like to thank the Institute for Research and Community Service or the Institute for Research and Community Service or LPPM Bengkulu University for the financial support of the research so that the study can be carried out.

Conflicts of Interest

The authors declare no conflict of interest.

Funding Statement

This research was funded by the Institute for Research and Community Service or Institute for Research and Community Service (LPPM) Universitas Bengkulu with contract number**: 4886/UN30.7/LT/2021**

Author Contributions

Edi Susanto: Conceptualization, Writing, and Original Draft; **Agus Susanta**: Formal analysis and Methodology; **Nur Aliyyah Irsal**: Validation and Supervision, **Pratiwi Disha Stanggo**: analysis

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