Design of Realistic Mathematics Education Approach to Improve Critical Thinking Skills

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Abstract Critical thinking skills are skills needed in the modern era, especially in the industrial era 4.0, as today, having critical skills will facilitate students in solving problems in life. The purpose of this study is to design statistical material for RME-based teaching materials to improve students' critical thinking skills. The method used in this study is ADDIE. In the ADDIE method, there are five stages; (1) Analysis, (2) Design, (3) Development, (4) Implementation, and (5) Evaluation. This research is only limited to analysis and design. The subjects in this study were seventh-grade students at Patuk 4 Public Middle School. Data collection instruments include observation sheets and interview guidelines and validation sheets. The results of this study indicate that the design of teaching materials has been adapted to the characteristic of students using the ADDIE method. The design includes cover, preface, concept map, Core Competencies (KI), Basic Competencies (KD) and Competency Achievement Indicators, table of contents, module activities, evaluation, and summary. Teaching material in statistical learning is based on RME steps to improve students' critical thinking skills. This research can be continued at the development, implementation, and evaluation stages in learning.

Keywords ADDIE, Critical Thinking, E-Module, Realistic Mathematics Education

1. Introduction

Critical Thinking is a process that involves reasoning and analysis to conclude [1][2]. Critical thinking skills are needed in the development of students because they can influence the development of thinking [3]. Critical thinking is one of the foundations of the 21st century's closeness. 21st Century skills are a set of skills that must be possessed by individuals, especially students because it will help

succeed in college, work, and life in the information age [4], in this case, schools can become facilitators to instill 21st-century skills. Prepare students for mathematical literacy is equipping them with 21st-century competence [5]. 21st Century skills are also used by students in Thailand in the process of vocational-technical education and training, 21st-century makes students more mature in dealing with problems in the real world [6]. Mathematics is needed in calculations and thinking. The process required individuals to solve problems [7][8]. Besides, mathematics is a universal language that allows humans to think, record, communicate ideas about elements, and quantity [9]. The importance of thinking skills will have an impact on life because to survive and adapt to the environment is highly dependent on human thinking skills [10]. The skills that can be developed at school are critical thinking. Critical thinking has a great influence in determining one's success in the future compared to IQ [11]. With critical thinking skills, students are expected to think rationally and logically when solving a problem. The lack of critical thinking skills will make it difficult for students to solve High Order thinking Skill (HOTS) type problems. The following skills can identify critical thinking skills: (1) Interpretation, (2) Analysis, (3) Evaluation, and (4) Taking Conclusion [12]. However, the fact that student's critical thinking skills in Indonesia are still relatively low. It can be seen from the results of the 2015 PISA (Program for International Student Assessment). The PISA shows that Indonesia ranks 63 out of 72 participating countries, with a mathematical grade of 386 out of 500 (international value standard) [13]. The cause of the low skills of students in solving problems is the lack of emphasis to develop critical thinking skills in learning mathematics when at school [14]. The teacher has not been able to make learning devices that can make students accustomed to higher-order thinking skills [15]. Based on the results of observations made by researchers, the cause of low critical thinking skills of students, especially in class VII in Patuk Gunung Kidul

Middle School can be found. There were several results obtained. Learning is still centered on the teacher so that students become passive. Researchers give the test. The resulting test shows that some students have not been able to analyze the questions and make conclusions due to the lack of learning strategies. The teaching theory that supports thinking skills during the learning process is one of the factors that affect low critical thinking skills. If students do not immediately fix this, they will have difficulty in solving questions with type HOTS. Learning difficulties of students caused by learning disabilities are internal factors, namely neurological dysfunction, and other causes are external factors, including incorrect learning strategies, learning management activities that do not encourage children's learning motivation [16]. Some of the results of the study above state that the critical thinking skills of mathematics from junior high school students who get innovative mathematics learning are better than the critical thinking skills of students who obtain conventional learning. 21st Century skills are needed by students in Thailand in the process of vocational education and technical training [17]. A mathematical model or approach is needed and encourages students to think critically. One approach that can be used is realistic mathematics education. Both the form of teaching theory and learning models are important steps in teaching mathematics. Realistic mathematics education (RME) will make mathematics learning more meaningful and justification. RME brings fundamental changes in the teaching and learning process of mathematics in the classroom. The teacher no longer provides information directly but provides problem assistance and activities. This problem assistance and activities can be used by students to build an understanding of mathematical concepts that lead to the creation of formal mathematical knowledge and empathy. The main principles in RME, namely: (1) Guided discovery, (2) progressive mathematics, (3) Didactic phenomenology, and (4) Self-developed models. In implementing learning, RME provides five principles, namely: (a) use of contexts (b) progressive mathematical (c) contribute to students, (d) interactions, and (e) interrelation. From the principles and characteristics of RME, learning can be made in realistic mathematics learning activities as follows: (a) understanding real problems, (b) solving real problems, (c) comparing and discussing the answers (d) concluding [18]. Although "realistic" in this approach means the "real world" situation at RME, the word itself has a broader meaning [19]. Although "realistic" in this approach means the "real world" situation at RME, the word itself has a broader meaning. This illustrates the problem that students can imagine RME emphasizing learning mathematics, which is ideal by doing mathematics itself. Freudenthal saw mathematics as a human activity. In the learning process, students are expected to rediscover the mathematical concepts learned. Thus, the emphasis on learning is the process. RME-based teaching theory will be

easy to understand and attract student's interest because they relate to everyday life, and the tools used are available in the surrounding environment and provide direct benefits to life [20]. Teachers can also use the development of teaching theory that is close to RME as a guide in teaching and effective in improving student's mathematical reasoning [21]. The use of realistic mathematical models can guide students to understand the concepts in solving problems gradually [22]. Also, the use of RME learning models can significantly improve student's mathematical critical thinking compared to conventional learning [23]. The results of another determination also mentioned that the development of learning tools that use realistic mathematics education approaches could improve student's critical thinking skills [24]. Also, realistic mathematics education helps teachers to teach mathematics to students and successfully refine math skills [25]. Some relevant findings regarding the analysis of the characteristics of critical thinking skills and learning with the RME approach provide predictions that learning with the RME approach plays a good role in improving student's critical thinking skills.

With the problems that have been outlined in the background, analyzing the needs of teaching theory that are suitable for students, designing teaching theory that is in line with the RME learning model, and being able to foster student's critical thinking skills. The second is to produce a design of teaching material that is suitable for use.

2. Materials and Methods

This type of research is development research. The product that will be developed in this research is for improving student's critical thinking skills for class VII, namely designing learning modules based on Realistic Mathematics Education (RME). This research model uses the ADDIE development model. The ADDIE model consists of five stages, namely: Analysis, Design, Development, Implementation, and Evaluation Model (ADDIE), which includes five steps, namely analysis, design, development, implementation, and evaluation [26-32]. The ADDIE model can be seen in Figure 1

Figure 1. ADDIE Model [25]

Writing is limited to the design phase to determine module design based on Realistic Mathematics Education (RME) to improve student's critical thinking skills. Data collection techniques use observation, interviews, questionnaires, and literature studies. Observation guidelines are used to retrieve data about the student's needs for learning media and find out what the teacher uses learning models. Interview guidelines are used to determine the use of learning media during the learning process and student's critical thinking skills. A literature study is conducted to find indicators of creative thinking skills and learning models of Realistic Mathematics Education (RME). The subjects of this study were students of class VIII SMP N 4 Patuk 2018/2019 school year.

2.1 Analysis Phase

Curriculum analysis of mathematics subjects for seventh-grade junior high school students refers to the 2013 curriculum as contained in the attachment to Permendikbud No. 21 of 2016. Some aspects are analyzed, namely Core Competency (KI), Basic Competence (KD), indicators of competency achievement (GPA), and learning materials. The analysis is used as a guideline in the preparation of teaching materials in the form of an E-Module approached Realistic Mathematics Education to improve critical thinking skills. The lack of teaching materials that integrate critical thinking also becomes one of the causes of the lack of critical thinking in students. Based on the results of interviews with mathematics teachers and some students at SMPN 4 Patuk Gunung Kidul, the writer obtained some data. When explaining the material, the teacher uses teaching materials that are used in the form of books that are already in school and uses conventional methods during the learning process. In terms of the curriculum of teaching materials available are following KI, KD, along with indicators of their achievement, but the teaching materials used do not emphasize the realistic concept. As a result, students do not understand the concepts being taught. The researchers gave questionnaires to 13 students with instructions to fill in the material that was felt to be the most difficult to

understand. The result is that statistical material is the most chosen material by students. This can be seen in table 1:

Table 1. Difficulty level Math theory

No	Theory	Many choose
1	Comparison	1
2	Social arithmetic	2
3	Lines and angles	3
4	Squares and triangles	2
5	Statistics	5

Lack of understanding of concepts, especially in statistical material, has an impact on student's scores. The average value of statistics material is lower than other materials. This is obtained from interviews with teachers. Furthermore, an analysis of students is conducted. Students still find mathematics difficult. As a result, students cannot focus on learning and even have a chat when learning takes place. Students only hear the explanation from the teacher without being actively involved when learning takes place. Based on the results that have been found, researchers provide a solution that is by providing a model or approach that can encourage students to be active, explore, find ideas, learn independently and improve critical thinking skills. From the analysis of material requirements and learning models from the interview above, it generates an idea that an E-Module with RME approach is needed. With the steps on the RME, the real approach will help students understand material concepts so students can develop critical thinking skills.

2.2. Design

The author makes a module design that is composed of cover, preface, table of contents, to a bibliography. The design of this module is based on indicators of practicality and validity. The author decides the module with the RME approach to improve student's critical thinking skills. The design can be seen in Figure 2.

Figure 2. The relation of the syntax of RME and student activities in Module to the indicators of critical thinking

The syntax that has been presented in Figure 2 shows five stages, namely: the use of context, progressive mathematics, student contribution, interactions, and interrelation. In the use of context, the teacher gives problems relating to the real world and the activities of students observing what is conveyed by the teacher so that in this process, there will be analysis activities by students. In progressive mathematics, mathematics was built through models. With this activity, students try to solve problems through models created or developed as mathematization so that they can foster analysis activities in the process. In student contributions, the students play an active role in the learning process. That means that all thoughts or ideas of students are considered. The activities of students can be in the form of discussion in the process of students who will foster interpretation. In interactions, there are interactions between teachers and students as well as students with students as well as students. The student interaction occurs in the form of comparing answers and others. At this stage, an evaluation process occurs to evaluate the credibility of the statement. In interrelation, the aim is to address the linkages between topics and the teacher who guides students to exploit, so that the learning process is meaningful. In this case, the activities of students are to made conclusions.

2.2.1. Cover

The cover is the outside, which consists of a title, author's name, and the image that represents the contents. The following is the cover design, which can be seen in Figure 3.

Figure 3. Design cover

2.2.2. Preference

The introduction contains a statement of thanks to those who have helped complete the student worksheet. The introduction can be seen in Figure 4.

Figure 4. Preference

2.2.3. Concept Map

The concept map contains an outline of the mapping of material to be studied. The concept map can be seen in Figure 5

Figure 5. Concept Maps

2.2.4. Basic Competencies (KD) and Core Competencies (KI)

KD and KI contain indicators about what students should get. Worksheets for Basic Competency (KD) and Core Competence (IC) students can be seen in Figure 6.

Kompetensi Inti	
	<ol style="list-style-type: none"> 1. Menghargai dan menghayati ajaran agama yang dianutnya. 2. Menghargai dan menghayati perilaku jujur, disiplin, tanggungjawab, peduli (toleransi, gotong royong), santun percaya diri, dalam berinteraksi secara efektif dengan lingkungan sosial dan alam dalam jangkauan pergaulan dan keberadaannya. 3. Memahami pengetahuan (faktual, konseptual, dan prosedural) berdasarkan rasa ingin tahunya tentang ilmu pengetahuan, teknologi, seni, budaya terkait fenomena dan kejadian tampak mata. 4. Mencoba, mengolah, dan menyaji dalam ranah konkret (menggunakan, mengurai, merangkai, memodifikasi, dan membuat) dan ranah abstrak (menulis, membaca, menghitung, menggambar, dan mengarang) sesuai dengan yang dipelajari di sekolah dan sumber lain yang sama dalam sudut pandang/teori.
Kompetensi Dasar	
	<p>3.10 Menganalisis data berdasarkan distribusi data, nilai rata-rata, median, modus, dan sebaran data untuk mengambil kesimpulan, membuat keputusan, dan membuat prediksi.</p> <p>4.10 Menyajikan dan menyelesaikan masalah yang berkaitan dengan distribusi data, nilai rata-rata, median, modus, dan sebaran data untuk mengambil kesimpulan, membuat keputusan, dan membuat prediksi.</p>
Indikator Pencapaian Kompetensi (IPK)	
	<ol style="list-style-type: none"> 1. Menganalisis data berdasarkan distribusi data untuk mengambil kesimpulan 2. Menganalisis data berdasarkan distribusi data untuk membuat keputusan 3. Menganalisis data berdasarkan distribusi data untuk membuat prediksi

Figure 6. Syllabus

2.2.5. Learning Activities Based on Realistic Mathematics Education

In learning activities, some activities adjust to the syntax of RME. The use of context or realistic problems is used as a starting point for learning. Context is something that can be imagined by students. The goal is that the concepts conveyed can be understood. Figure 7 is an example of a part of the contexts.

Modus and Median

Modus and Median

Have you ever played dice with your friends? Suppose you and your friend play roll the dice repeatedly to determine the highest number. Have you ever noticed the dice eye which often appears when playing? what do the dice eyes often appear? in statistics, the eye of the dice that often appears is called the modus. Modus is a measure of the centralization of data. To better understand the modus and one other measure of centralization of data that is the median, do and discuss the following activities, then present the results of the discussion in front of the class with your group!

Use of Context

Figure 7. Example part of Context

In progressive mathematical, which is building mathematics through models, the use of models is regarded as a link from real-world knowledge to the world of mathematics. Figure 8 is an example of a part of a progressive mathematical model.

5. Look at the point flow diagram in step 4) then discuss it !

a) What is the size of the shoe that has the most points?
Answer:

b) What is the weight of the student who has the most points?
Answer:

6. Discuss with your group then draw a line to divide the data in a point flow chart into two equal parts, then determine!

a) What size shoes are located in the centerline?
Answer:

b) What is the weight on the midline?

Interactivity

Figure 8. Example part of Progressive mathematics

In the contribution of students, students are allowed to develop various informal strategies that are used in the process

of solving problems. In realistic mathematics, learning mathematics is a social activity. Listening to what others find and discussing the findings, students will get ideas for solving their problems. Figure 9 is an example of a part of the results of student construction and interactivity.

Figure 9. Example part of Contribute to Student and Interactivity

Next, to show the relationship, the teacher plays an important role in directing students to gain knowledge. Figure 10 is an example of part of the interrelation.

Figure 10. Example part of Interrelation

2.2.6. Table Content

Table of contents is the page that is a guide to the contents in the book along with the appropriate page number. The table of contents can be seen in Figure 11.

Daftar Isi	
Identitas Modul	i
KATA PENGANTAR	ii
DAFTAR ISI	iii
KOMPETENSI INTI	iv
KOMPETENSI DASAR	iv
PETUNJUK PENGGUNAAN Modul	iv
Penjelasan simbol pada Modul	v
PETA KONSEP	vi
Statistika	1
Rata-rata	4
Kegiatan 1	6
Modus dan Median	9
Kegiatan 2	9
Contoh Soal	12
Latihan	13
Ukuran Penyebaran Data	13
Kegiatan 3	14

Figure 11. Table of content

2.2.7. Summary

The summary contains conclusions about the statistical material in a nutshell. The summary can be seen in Figure 12.

Rangkuman

- ❖ Statistika adalah cabang ilmu matematika yang mempelajari metode pengumpulan, pengolahan, penafsiran, dan penarikan kesimpulan dari data yang berupa angka-angka.
- ❖ Dalam statistika, data dapat disajikan dalam bentuk tabel dan berbagai diagram agar lebih mudah dibaca dan dianalisis pembaca
- ❖ Rumus menentukan rata – rata (*mean*):

$$\text{Rata – rata (Mean)} = \frac{\text{jumlah nilai seluruh data}}{\text{banyak data}} = \frac{x_1 + x_2 + \dots + x_n}{n}$$
- ❖ Modus adalah nilai yang paling sering muncul pada data.
- ❖ Median adalah nilai tengah setelah data diurutkan. Median dari statistik peringkat: $x_1, x_2, \dots, x_n$ dengan $x_1 < x_2 < \dots < x_n$ dapat ditentukan dengan formula:

$$\text{Median } (M_e) = \begin{cases} \frac{x_{n+1}}{2} & ; n \text{ ganjil} \\ \frac{x_{\frac{n}{2}} + x_{\frac{n}{2}+1}}{2} & ; n \text{ genap} \end{cases}$$
- ❖ Jangkauan dapat ditentukan dengan rumus $= X_{\max} - X_{\min}$
- ❖ Kuartil adalah nilai yang membagi data menjadi empat bagian yang sama
- ❖ Kuartil terdiri atas kuartil bawah (Q_1), kuartil tengah atau median (Q_2), dan kuartil atas (Q_3). Q_1 , diperoleh dengan membagi data di sebelah kiri dari median menjadi dua bagian yang sama. Q_2 adalah median. Q_2 diperoleh dengan membagi data di sebelah kanan dari median menjadi dua bagian yang sama.
- ❖ Jangkauan antarkuartil dapat ditentukan dengan rumus: $H = Q_3 - Q_1$

Figure 12. Summary

2.2.8. Evaluation

The aim is to evaluate the learning outcomes of students in understanding the material that has been learned. The evaluation in this study can be seen in Figure 13.

Evaluasi

A. Pemahaman Konsep

- Dari 12 siswa yang mengikuti tes matematika diperoleh data sebagai berikut: 9, 6, 8, 7, 6, 5, 6, 4, 7, 3, 6, 4. Modus dari data tersebut adalah

a. 6
c. 7

b. 6,5
d. 7,5
- Tabel berikut adalah data hasil ulangan matematika siswa kelas VIIIA

Nilai	4	5	6	7	8	9	10
Frekuensi	2	6	10	6	4	1	1

Banyak siswa yang mendapat nilai lebih dari nilai rata-rata adalah

a. 8 orang
c. 12 orang

b. 10 orang
d. 22 orang

- Hasil ulangan matematika tercantum pada tabel berikut ini.

Nilai	Frekuensi
9	4
8	7
7	10
6	12

Figure 13. Evaluation

2.3. Develop Phase

Table 2. Comments / input Expert media

No	Comments / Suggestions	Follow-up
1.	Cover colors are too flashy, fonts that are used too large should be made simple	Cover repaired by reducing the color of the blocking color
2	The layout should be paid more attention to make it more presentable and attractive	Layout improved
3.	The background is too colorful, so it prevents text material in teaching material.	Background replaced

The author designs a design. The design is developed,

and a media expert validates the design. Some suggestions are obtained. The researcher improves by the advice given by the expert. The list of improvements that have been given by media experts can be seen in Table 2.

After getting comments/suggestions from experts, the researchers then followed up on improving teaching theory, so that they would be better in the learning process, the following improvements have been made;

2.3.1. Cover

Repairing the cover that is too flashy, the font used by the cover, to make it more comfortable when viewed, can be seen in Figure 14.

Figure 14. Cover improvements

2.3.2. Layout

Correcting the layout of the module that is not suitable, the improvement results can be seen in Figure 15

Figure 15. Layout improvements

2.3.3. Background

Fix background that is too flashy. The improvement results can be seen in Figure 16

Before

After

Figure 16. Background improvements

The research data obtained were converted into qualitative values by comparing scores from media experts with ideal scores calculated using the provisions in Table 3:

Table 3. Ideal Score

Average	Criteria
$X > 4.2$	Very good
$3.4 < X \leq 4.2$	Good
$2.6 < X \leq 3.4$	Enough
$1.8 < X \leq 2.6$	Less
$X \leq 1.8$	Very Less

The results of the questionnaire assessment by media experts can be seen in Table 4.

Table 4. Questionnaire assessment results

No	Name	Position	Score	Criteria
1	M.Fahrul Styawan	Teacher	4.5	Very Good
2	Agung Dwi Ratna	Teacher	4.7	Very Good
	Total		4.6	Very Good

Based on the results that have been obtained, it can be seen that teaching theory is declared feasible by getting an average grade of 4.6 with very good criteria.

3. Conclusions

This study resulted in the design of modules based on Realistic Mathematics Education (RME). Module design based on the Realistic Mathematics Education (RME) model to improve student's critical thinking skills with the method used is ADDIE. The results of the research in the design phase consist of several components arranged in a module, at the beginning, namely (cover, preface, table of contents, instructions for use, concept map, IC and basic competency), content section (learning and evaluation activities) and closing (glossary and bibliography). The development of critical thinking skills is found in problem training and evaluation. The module contains steps for RME and indicators of critical thinking skills. Furthermore, the module design is validated and then repaired according to the advice given by the validator so that the product can be declared valid and is suitable for use.

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