Development Of Statistics Teaching Modules For Improving Critical Thinking Abilities Of Grade XI

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Abstract

This research was motivated by the low critical thinking skills among eleventh-grade students at SMA Negeri 2 Pematangsiantar. Preliminary analysis showed that 61.1% of students were unable to recognize problems and identify the known and questioned information. The research method used was Research and Development (R&D), adapting the 4D model (Define, Design, Develop, Disseminate). The developed module meets the validation criteria from material and media experts. The module was declared highly practical, as indicated by the 90.4% positive response rate from students. The module was proven effective in improving students' critical thinking skills. The increase in students' critical thinking skills was in the high category, with an N-Gain score of 0.71. Furthermore, the classical learning mastery of students reached 94.4%, exceeding the minimum mastery criterion (80%).

Keywords: Teaching Module Development, Statistics, Critical Thinking Skills

INTRODUCTION

Mathematics is a science related to the process of thinking or reasoning using logic. Mathematics comes from the Greek word "mathematike," meaning to study. The word itself is derived from the word "mathema," meaning knowledge or science. Furthermore, "mathematike" also means to think. According to Susanto (2016), mathematics is a discipline that can improve thinking and argumentation skills, contributing to solving everyday problems and in the workplace (Susilowati, 2022).

According to Suriasumantri (Isma Nastiti Maharani & Niken Dani Safitri, 2024) mathematics is a tool for thinking, alongside language, logic, and statistics. Mathematics is a science that studies how to think rationally and logically. According to Nurhikmayati, mathematics is also a science that encompasses a collection of concepts in the form of operations, numbers, symbols, and definite patterns. Based on the opinions of the experts mentioned above, it can be concluded that mathematics is the study of calculations, analysis, and the use of reason and logical thinking skills (Savitri, Theresia Laksmi., Nurjaya, I Gede., Yasa, 2022)

Mathematics also has an important role in various disciplines and advances human thinking power as stated in the Minister of Education and Culture Regulation Number 22

of 2016, namely improving the quality of education is directed at improving the quality of Indonesian people as a whole through cultivating the heart, mind, and sports in order to have competitiveness in facing global challenges.

Critical thinking is a form of thinking that needs to be developed in every student. According to Simbolon et al. (Nugraheni, Siswanti, Ivet, Merdeka, & Penggerak, 2022) critical thinking is the process of searching, obtaining, evaluating, analyzing, synthesizing, and conceptualizing information as a guide to developing one's thinking with self-awareness, and the ability to use this information to increase creativity and take risks. Similar things were expressed by Hasibuan & Surya (2016) that critical thinking skills are the basis for analyzing arguments and can develop logical thought patterns. According to Tsui (Wafiroh, Fajrin, & Madura, 2024) critical thinking is important for the future of students, considering that it prepares students to face many challenges that will arise in their lives, careers, and at the level of their personal obligations and responsibilities.

Critical thinking is important in education according to the Permendiknas (Minister of National Education Regulation) because it helps students become more analytical, evaluative, and problem-solving individuals. This allows them to not only receive information, but also to process it deeply, assess its truth, and apply it in various life contexts. Critical thinking is important for building national character. Students are required to be able to start thinking critically, including in mathematics learning in the classroom, because mathematics can never be separated from our activities in our daily lives. With the increasing critical thinking of students today, it is hoped that critical thinking can be embedded in students and strengthen their own character (Ardiansyah et al., 2023).

Based on research conducted by Hamidah & Ain (2022) shows that students' critical thinking skills are still relatively low, low critical thinking skills can be seen from students' grades, out of 15 students there are 5 or 33.33% of students who are able to think critically, while 10 people or 66.67% of students are not yet able to think critically. From the data obtained based on interviews with homeroom teachers, the low critical thinking skills of students are caused by several factors including students lacking concentration and not focusing on the learning delivered by the teacher, in the learning process students must be encouraged by the teacher themselves to ask questions, students are more silent, sitting, listening, taking notes, and memorizing so that teaching and learning activities become uninteresting and fun. When students work on math problems given by the teacher, there are still many students who still cannot understand the meaning of the problem and how to solve it, students do not understand the concept of solving the problems given by the teacher and are less able to solve problems in the questions given and the level of student reasoning is also still lacking (Yiniar, Lovisia, & Yolanda, 2024).

In learning activities, teaching materials are crucial for both teachers and students. Teachers will struggle to improve the effectiveness of their learning without comprehensive teaching materials. Likewise, students will struggle to learn without them. If teaching materials are not readily available, then... Teaching materials essentially serve several roles for teachers, students, and learning activities (Afriandi, 2020). Therefore, teaching materials are crucial to develop as an effort to improve the quality of learning.

Based on observations of the modules currently in use, several fundamental weaknesses were found. Existing modules tend to be less than visually appealing. Hartog

(1967) stated that the physical appearance of a module needs to pay attention to readability through formatting, font size, spacing, and the use of images or colors that can generate interest and ease understanding (., ., & ., 2017).

Furthermore, the module's content only provides a summary of information without a subject overview, introduction, learning activities, exercises, exercise guides, summaries, formative tests, and answer keys. The module, however, serves as a guide for teachers in implementing structured and systematic learning, facilitating student independent learning, saving teachers time and energy, and serving as a reference for comprehensive lesson planning (., ., Dr. Ketut Agustini, S.Si, & ., Gede Saindra Santyadiputra, S.T., 2017).

Statistics is knowledge related to data collection methods, data processing, analysis, and drawing conclusions based on data collection and the analysis carried out.

According to the Ministry of Education and Culture (Kemendikbud), statistics are essential in education as an evaluation tool, a basis for accurate policy-making, improving education quality through data analysis, and facilitating research and development of teaching methods. Statistics help educators and policymakers understand data in a structured way to make better decisions, thus making the educational process more efficient and effective (Mahmudah, Nisa, & Masruroh, 2024).

Furthermore, this statistics material is also material whose application is very close to students' real lives, so mastery of this material is very important for students to have. A preliminary survey of students in grades XI-6 at SMA Negeri 2 Pematangsiantar on statistics material with descriptive questions showed that many students were still unable to master statistics material.

One of the students' answers to the following question: In a math test in a class, the average class score is 58. If the average math score of male students is 65, while the average score of female students is 54, then the ratio of the number of male and female students is

Based on the results of one of the students' answers above, it can be seen that the student has not been able to solve the problem given by the researcher properly and correctly. This shows that the student has not been able to solve the problem. There are 4 indicators of problem solving according to Edward Glaser, the indicators of critical thinking are as follows: (a) recognizing the problem, (b) finding ways that can be used to deal with the problems, (c) collecting and organizing the necessary information, (d) recognizing unstated assumptions and values (HAQ, 2023).

Based on the problem solving indicators, the results of the students' answers are grouped as follows: Students who have not been able to identify the problem: what is being asked and what data is being provided (22 students out of 36 students or 61.1%) Students who have not been able to find a solution to handle the problem (6 students out of 36 students or 16.6%) Students who have not been able to solve the problem and re-examine the steps used (3 students out of 36 students or 8.3%)

Based on the description above, it is necessary to develop a statistics teaching module that improves critical thinking skills with the title "DEVELOPMENT OF A STATISTICS TEACHING MODULE TO IMPROVE CRITICAL THINKING ABILITIES OF GRADE XI STUDENTS OF SMA NEGERI 2 PEMATANGSIANTAR"

METHOD

In this study, the type of research used is Research and Development (R&D). According to Sugiyono (2014: 297), research and development is a research method used to produce a particular product and test its effectivenes (Ramadhanty, Permana, Fauzia, & Rakhmawati, 2021)s.

According to Ali (2014: 105), development or research and development (R&D) is a process in developing and validating certain devices that become products, which from an industrial perspective is the development of a product prototype before mass production. From the two expert opinions above, the researcher concluded that development research is a process that develops and validates devices that can be accounted for.

According to Punaji (Syafruddin & Jeranah, 2020) the aim of development research is to assess changes that occur over a certain period of time.

This research was conducted at SMA NEGERI 2 PEMATANGSIANTAR. This research was conducted in the even semester of the 2025/2026 academic year in class XI on the subject of STATISTICS by requesting validation from one lecturer and one mathematics teacher at the high school. The reason the researcher chose this school was that similar research had never been conducted at the school. The subjects in the development of the module to improve mathematical problem solving skills were class XI students of SMA NEGERI 2 PEMATANGSIANTAR.

The object of research on developing modules to improve students' critical thinking skills is teaching materials in the form of modules on STATISTICS material (Nurlatifah & Purniati, 2025).

Research instruments are essential components of research because they serve to collect data relevant to the research objectives (Zaenal, 2017). This research was conducted by the researcher herself under the guidance of a supervisor, who then validated it by experts. To validate the module, an instrument in the form of an assessment sheet is required. This assessment sheet in research and development will be used to assess the product created by the researcher (SUGIARTI & Oktaviani, 2022). The validator will provide an assessment by completing a checklist for each assessment item and providing input or suggestions for product evaluation. The researcher prepared several instruments based on a pre-designed guide to obtain the necessary data. These instruments include a validation sheet, an observation sheet, a test to assess problem-solving abilities, and a student response questionnaire (Novalianti, Susilawati, & Ã¢â, ¬ËœeArdhuha, 2021).

RESULTS AND DISCUSSION

Development Results

The results of this research and development (RnD) study resulted in a mathematics learning module on statistics to improve critical thinking skills. This research and development was conducted at SMA Negeri 2 Pematangsiantar to assess the validity and effectiveness of the developed mathematics learning module (Ndae & Widyaningrum, 2020).

Module Effectiveness

Table 1. Critical Thinking Ability Test Results

No	Critical Thinking Aspects	Pretest		Posttest		Gain
		Average	%	Average	%	

1	Formulating the problem	4.8	60.0%	7.2	90.0%	0.75
2	Providing Arguments	4.4	55.0%	7.0	87.5%	0.72
3	Making Deductions	4.2	52.5%	6.8	85.0%	0.68
4	Performing Induction	4.6	57.5%	7.1	88.8%	0.73
5	Conducting an Evaluation	4.0	50.0%	6.6	82.5%	0.65
	Overall Average	**4.4**	**55.0%**	**6.94**	**86.8%**	**0.71**

Based on the gain criteria (gain > 0.7 = high category), the increase in students' critical thinking skills is included in the **High category** with a gain value of 0.71.

Table 2. Student Learning Completion

Value Category	Number of Students	Percentage	Information
90 – 100 (A)	15	41.7%	Completed
80 – 89 (B)	16	44.4%	Completed
75 – 79 (C)	3	8.3%	Completed
< 75 (D)	2	5.6%	Not Completed
Total	**36**	**100%**	
Classical Completion	**34**	**94.4%**	**Completed**

Based on the completion criteria (80% ≤ KB ≤ 100% = complete), the classical learning completion of 94.4% shows that learning using the developed module is **effective** .

Table 3. Student Response Questionnaire Results

No	Aspect	Percentage of Positive Responses
1	Material	89.6%
2	Presentation	91.2%
3	Language	87.5%
4	Benefit	93.1%
	Average	**90.4%**

 Based on the student response criteria (≥ 80% = positive), the student response to the developed module was **very positive** with a percentage of 90.4%.

discussion

Validity of Statistics Teaching Module

Validation results by two experts indicate that the developed statistics teaching module has very good validity with an average score of 4.5 on a scale of 5.0. This indicates that the module has met the criteria for appropriateness of content, presentation, language, and graphics according to BSNP (2010) standards.

The highest validity was found in the aspects of material suitability to learning objectives and formula suitability to material, each receiving a score of 5.0 (very valid). This indicates that the module content aligns with the expected learning outcomes in the Independent Curriculum (Inggriyani & Fazriyah, 2018).

The level of agreement between validators reached r-0.85, which is considered very high. This value indicates that both validators consistently assessed the quality of the developed module. This result aligns with research by Nababan & Aminah (2018), which

stated that a high level of validator agreement indicates that the developed product is of good quality and trustworthy (Ni'matuzzahroh, 2020).

The module's cover and content design also received excellent reviews. The module's use of contrasting colors, illustrations appropriate to the material, and attractive layout are all key strengths. This is important because, according to Prastowo (2014), an attractive module layout can increase student motivation and facilitate comprehension.

Practicality of Statistics Teaching Module

The practicality of the module is assessed from two aspects, namely the teacher's ability to manage learning and student activity during learning.

Teachers' Ability to Manage Learning

Observations showed that teachers' ability to manage learning using the developed modules was considered good, with an average score of 3.82. The highest scores were found in the aspects of material mastery, interaction and communication, providing feedback, and appropriateness of activities to the module design, each of which received a score of 4.0.

Teachers' learning management skills improved from the first to the third meeting. This indicates that the developed module facilitated teacher implementation due to its clear instructions and structured learning activities.

These results support Hadiansah's (2022) statement that a good teaching module should be able to assist teachers in developing effective and efficient lesson plans. The developed module has fulfilled its function as a guide for teachers in implementing systematic and structured learning.

Student Activeness in Learning

Observations of student activity showed an average percentage of 84.2%, which is considered very high. Student activity also increased from the first meeting (79.8%) to the third meeting (88.5%) (Benyamin, Qohar, & Sulandra, 2021).

The highest activity was found in the writing activity sub-variable, specifically the indicator for taking notes on lesson material, with a percentage of 94.3%. This indicates that the developed module encourages students to actively record and document their learning process. This high level of writing activity aligns with the module's characteristics, which provide space for students to write down their thoughts, problem-solving processes, and reflections.

The lowest level of activity was found in the oral activities sub-variable, specifically the willingness to ask questions (64.0%) and express opinions (65.7%). Although this is still considered high, it indicates that students need to be encouraged to be more active in asking questions and expressing opinions. However, there was a significant increase from the first to the third meeting, indicating that modules designed with critical thinking activities can increase students' courage in expressing their opinions.

Student engagement in peer discussions reached 86.0%, indicating that the module successfully fostered positive interactions among students. This aligns with the collaborative learning principles implemented in the module through group activities and discussions (Navitasari, 2019).

These results align with research by Asminah et al. (2022), which states that learning using well-designed modules can increase student engagement in the learning process. This

high level of student engagement indicates that the developed modules are practical and easy to use in learning.

Effectiveness of Statistics Teaching Module

The effectiveness of the module is assessed from three aspects, namely increasing students' critical thinking skills, classical learning completion, and students' responses to the module.

Improving Students' Critical Thinking Skills

The results of the critical thinking ability test showed a significant increase from the pretest to the posttest. The average pretest score was 4.4 (55.0%), increasing to 6.94 (86.8%) in the posttest. The gain value obtained was 0.71, which is included in the high category (gain > 0.7).

The highest improvement occurred in problem formulation, with a gain of 0.75. This indicates that the developed module is highly effective in training students to identify and formulate problems in the form of appropriate questions. Activities in the module that encourage students to analyze problem situations before solving them have been shown to successfully improve this skill (Kusmianty, Widiyanto, & Kusuma, 2020).

The aspects of providing arguments and conducting induction also experienced significant improvements, with gains of 0.72 and 0.73, respectively. This indicates that the module exercises requiring students to provide logical reasoning and draw conclusions from specific cases to general issues successfully improved students' critical thinking skills.

The lowest increase occurred in the evaluation aspect, with a gain of 0.65, although it is still in the moderate category (0.3 ≤ gain < 0.7). This indicates that the ability to evaluate an argument still requires more intensive practice. However, there was a significant increase from 50.0% to 82.5%.

These results align with research by Wicaksanti (2023), which states that the use of specially designed learning modules can improve students' critical thinking skills. The modules developed in this study include activities that explicitly train the five aspects of critical thinking according to Ennis (2016), so the improvements achieved encompass all aspects of critical thinking skills (Rachmantika & Wardono, 2019).

This improvement in critical thinking skills is also supported by the module's characteristics, which present contextual problems related to students' real lives. According to Simbolon et al. (2017), learning with relevant contexts can help students develop critical thinking skills because they can see the direct application of the concepts they learn.

Classical Learning Completion

Posttest results showed that 34 out of 36 students (94.4%) achieved the minimum passing grade (≥75). This classical passing grade far exceeds the minimum criterion of 80%. This indicates that the developed module is highly effective in helping students achieve their learning objectives.

The distribution of student scores shows that:

1. 15 students (41.7%) obtained an A (90-100), indicating excellent understanding.
2. 16 students (44.4%) obtained a grade of B (80-89), indicating good understanding.
3. 3 students (8.3%) obtained a grade of C (75-79), indicating sufficient understanding.
4. 2 students (5.6%) obtained a grade of D (<75), indicating that understanding was still lacking.

The high percentage of students who obtained A and B grades (86.1%) shows that the module is not only effective in helping students achieve minimum mastery, but is also able to increase students' understanding to a high level.

The two students who had not yet completed the course showed significant progress from pretest to posttest, although they did not reach the Minimum Competency (KKM). This indicates they require additional guidance or a remedial program. The developed module also provides a remedial section for students who require additional assistance.

These results support the findings of Hawa et al. (2021), who stated that the use of well-designed learning modules can improve student learning outcomes and learning completion. The module's systematic structure, gradual presentation of material, and varied practice questions help students better understand the material.

Student Responses to the Module

The results of the student response questionnaire showed a positive response rate of 90.4%, far exceeding the minimum criterion of 80%. This indicates that students responded very positively to the developed module.

The highest positive response was in the benefits aspect (93.1%), indicating that students directly benefited from using the module in their learning. Students felt that the module helped them better understand statistics material, increased their motivation to learn, and developed their critical thinking skills.

The presentation aspect also received a high positive response (91.2%), indicating that the module design with attractive colors, appropriate illustrations, and a neat layout successfully attracted students' attention. According to Hartog (1967), the physical appearance of the module needs to pay attention to readability through format, font size, spacing, and the use of images or colors that can arouse interest and ease of understanding.

The material aspect received a positive response of 89.6%, indicating that the material presented in the module is relevant to students' needs, easy to understand, and includes relevant examples. The gradual presentation of the material, from simple to complex concepts, helps students build a strong understanding (Prayogi & Muhali, 2025).

The lowest positive response was for the language aspect (87.5%), although it still fell into the very positive category. Several students provided feedback that some technical terms needed simpler explanations. This feedback will be taken into consideration for future module improvements.

These results align with research by Nababan & Aminah (2018), which showed that positive student responses to the developed teaching materials can improve student motivation and learning outcomes. This high level of positive response also indicates that the developed modules meet the needs and characteristics of 11th-grade students.

Advantages and Disadvantages of the Module Developed

Module Advantages

Based on the results of validation, trials, and input from validators and students, the developed module has several advantages:

Specifically Designed to Enhance Critical Thinking

This module not only presents statistical material, but explicitly trains the five aspects of critical thinking skills according to Ennis (2016) through structured activities such as "Let's

Think Critically" and guiding questions that direct students to analyze, evaluate, and conclude (Aprina, Fatmawati, & Suhardi, 2024).

Attractive Visual Design

The use of bright colors with modern gradations, illustrations that match the material, and a neat layout make the module attract students' attention and increase their learning motivation.

Contextual Material

The examples of questions and problems presented are related to students' real lives, such as YouTuber data, social statistics, and everyday phenomena that make learning more meaningful.

Complete and Systematic Structure

The modules are equipped with all the necessary components for learning, from learning objectives, materials, sample questions, exercises, and evaluations. This structure facilitates independent learning for students.

Encouraging Independent Learning

With clear instructions, example problems with detailed discussions, and space for students to write down their thoughts, this module facilitates students' independent learning.

Integrating Technology

The module introduces the use of Microsoft Excel to create scatter diagrams, equipping students with technology skills relevant to 21st century needs.

Equipped with Multilevel Assessment

Assessments in the module include diagnostic, formative, and summative with questions varying from easy to difficult levels, so they can accommodate the diversity of student abilities.

Module Deficiencies

Even though it meets the criteria of being valid, practical and effective, the module that was developed still has several shortcomings:

1. **Limited Material Coverage**

This module only covers scatterplots, correlation, and simple linear regression. Other statistical topics, such as measures of central tendency, measures of dispersion, and probability distributions, are not covered (Anugraheni & Sartono, 2022).

2. **Not equipped with learning videos**

The module is not yet equipped with a QR code that leads to a learning video, which can help students who prefer to learn through audio.

3. **Limitations of Practice Questions**

Although it is equipped with practice questions with various levels of difficulty, the number is still limited so students who want more practice may need additional resources.

4. **Use of Technical Terms**

Some technical statistical terms still need to be explained in simpler language to make them easier for students to understand.

5. **Limitations of the Trial**

The trial was conducted in only one class at one school, so the generalizability of the research results is still limited. A broader trial is needed in other schools and classes with different characteristics.

Research Implications

Theoretical Implications

This research contributes to the development of mathematics learning theory, in particular:

1. **Development of Critical Thinking-Based Teaching Materials**

This research shows that a teaching module specifically designed with critical thinking aspects in mind can significantly improve students' critical thinking skills. This reinforces constructivism theory, which emphasizes the importance of students actively constructing their own knowledge through higher-order thinking processes.

2. **Validation of the 4-D Model in the Context of the Independent Curriculum**

This study proves that the 4-D development model remains relevant and effective when used in the context of the Independent Curriculum, with slight adaptations to the teaching module components that are adjusted to the structure of the Independent Curriculum teaching module.

3. **Contextual Learning and Critical Thinking**

The results of the study show that the use of real-life contexts in statistics learning can improve students' critical thinking skills, which is in line with Ausubel's theory of meaningful learning.

Practical Implications

Practically, this research provides implications for:

1. **Math teacher**
   1. The developed module can be used as a reference in developing teaching materials that encourage students' critical thinking skills.
   2. Teachers can adapt the activities in the module to apply to other mathematics materials.
   3. Teachers gain an idea of how to design learning that increases student activity.

2. **Student**
   1. Students have an alternative learning resource that is interesting and easy to understand for independent learning.
   2. Students are trained to think critically in solving mathematical problems, which is useful not only in learning but also in everyday life.
   3. Students are more motivated in learning mathematics, because the material is presented in an interesting and contextual way.

3. **School**
   1. Schools have valid, practical, and effective teaching materials that can be used in mathematics learning.
   2. Schools can use this module as a reference for developing learning modules in other subjects.
   3. The results of this study can be used as consideration in procuring or developing teaching materials in schools.

4. **Further Research**
   1. This research can be a reference for research into the development of similar teaching materials on other materials or subjects.
   2. The development model and research instruments that have been prepared can be adapted for similar research.

3. The results of this study open up opportunities for broader and more in-depth further research.

Research Limitations

The researcher realizes that this study has several limitations:

1. Limitations of Research Subjects

This study only involved 36 students from one class at a school, so the results of the study cannot be generalized to a wider population.

2. Trial Time Limitations

The trial was only conducted in 3 meetings (6 lesson hours), so the long-term effects of using the module on students' critical thinking skills could not be observed.

3. Material Limitations

The module developed only covers part of the statistics material for class XI, so it does not cover all the competencies that students must master in one semester.

4. Instrument Limitations

The critical thinking ability test instrument used only consists of 10 descriptive questions, so it cannot measure students' critical thinking abilities comprehensively.

5. Limitations of Research Design

This study did not use a control group, so the effectiveness of the developed module cannot be directly compared with conventional learning.

However, these limitations do not reduce the value and benefits of this research, because the main objective of development research is to produce valid, practical, and effective products for certain contexts, not for broad generalization.

Comparison with Relevant Research

The results of this study are in line with several relevant studies that have been conducted previously:

1. **Nababan & Aminah's (2018)** research showed an increase in critical thinking skills with an average gain of 0.32. This study showed higher results with a gain of 0.71. This difference is likely due to the module developed in this study being specifically designed with explicit activities to train critical thinking, while Nababan & Aminah's research focused on a problem-based learning model.

2. **Wicaksanti (2023)** research shows that the Problem-Based Learning model can improve students' critical thinking skills. This research complements these findings by showing that specially designed learning materials (modules) can also improve critical thinking skills, with even higher gains.

3. **Asminah et al. (2022)** found that problem-based learning tools can improve learning outcomes and critical thinking skills. This study reinforces these findings by demonstrating that valid, practical, and effective teaching modules can achieve classical completion rates of up to 94.4%.

4. **Hawa et al. (2021)** research emphasized the importance of teaching materials that support independent learning and critical thinking skills. This study aligns with these findings and provides concrete examples of modules that can facilitate independent learning, with a positive student response rate of 90.4%.

Overall, this research provides a new contribution by producing a statistics teaching module product that is specifically designed to improve students' critical thinking skills by using the 4-D learning model in the context of the Independent Curriculum.

CONCLUSION

Based on the results of research and development (R&D) that have been carried out using the 4D model (Define, Design, Develop, Disseminate) regarding the Mathematics Learning Module on the Subject of Statistics to Improve Critical Thinking Skills of Grade XI Students of SMA Negeri 2 Pematangsiantar, the following conclusions can be drawn: Module Validity: The Mathematics Learning Module on the Subject of Statistics that was developed was declared Very Valid. This is based on the recapitulation of expert validation results with an average overall score of 4.5 on a scale of 5.0, as well as the level of agreement between validators which is in the Very High category (R = 0.85). Module Practicality: The developed module is declared Practical for use in learning. The teacher's ability to manage learning is in the Good category with an average overall score of 3.82.

Student activity during the trial was in the Very High category with an average percentage of 84.2%. Student responses to the developed module were Very Positive with an average percentage of 90.4%. Module Effectiveness: The developed module was declared Effective in improving students' critical thinking skills and learning completeness. The improvement in students' critical thinking skills was in the High category with an N-Gain value of 0.71. Students' classical learning completeness reached 94.4%, which indicates that the module was effective in achieving learning objectives.

REFERENCE

. K. A. P., ., Dr. Ketut Agustini, S.Si, M. S., & ., Gede Saindra Santyadiputra, S.T., M. C. (2017). Pengembangan E-Modul Berbantuan Simulasi Berorientasi Pemecahan Masalah Pada Mata Pelajaran Komunikasi Data (Studi Kasus : Siswa Kelas Xi Tkj Smk Negeri 3 Singaraja). *Kumpulan Artikel Mahasiswa Pendidikan Teknik Informatika (Karmapati)*, *6*(1), 40. Https://Doi.Org/10.23887/Karmapati.V6i1.9267

. K. A. P., . D. K. A. S. S. M. S., & . G. S. S. S. T. . M. C. (2017). Pengembangan E-Modul Berbantuan Simulasi Berorientasi Pemecahan Masalah Pada Mata Pelajaran Komunikasi Data (Studi Kasus : Siswa Kelas Xi Tkj Smk Negeri 3 Singaraja). *Kumpulan Artikel Mahasiswa Pendidikan Teknik Informatika (Karmapati)*, *6*(1), 40. Https://Doi.Org/10.23887/Karmapati.V6i1.9267

Anugraheni, I., & Sartono, E. K. E. (2022). *Analisis Kemampuan Berpikir Kritis Matematis Berbasis Realistik*. 244–249.

Aprina, E. A., Fatmawati, E., & Suhardi, A. (2024). Penerapan Model Problem Based Learning Dalam Mengembangkan Keterampilan Berpikir Kritis Pada Mata Pelajaran Ipa. *Jurnal Kependidikan*, *13*(1), 981–990. Https://Doi.Org/10.31004/Irje.V4i3.832

Ardiansyah, A. S., Dewi, N. R., Junaedi, I., Efrilianda, D. A., Mulyono, M., Astuti, C. R. H. Y., … Hasaroh, E. F. (2023). Pelatihan Digitalisasi Modul Ajar Kurikulum Merdeka Bagi Guru Smp Negeri 2 Tulung. *Jurnal Pengabdian Kepada Masyarakat Indonesia (Jpkmi)*, *3*(3), 21–28.

Benyamin, B., Qohar, A., & Sulandra, I. M. (2021). Analisis Kemampuan Berpikir Kritis Siswa Sma Kelas X Dalam Memecahkan Masalah Spltv. *Jurnal Cendekia : Jurnal Pendidikan Matematika*, *5*(2), 909–922. Https://Doi.Org/10.31004/Cendekia.V5i2.574

Haq, A. (2023). Pelatihan Nasional Penyusunan Modul P5 Menggunakan Kreasi Ide Media Serbaneka Pada Kepala Sekolah Dan Guru. *Jurnal Abdi: Media Pengabdian Kepada Masyarakat*, *8*(2), 217–226. Https://Doi.Org/10.26740/Abdi.V8i2.21157

Inggriyani, F., & Fazriyah, N. (2018). Analisis Kemampuan Berpikir Kritis Siswa Dalam Pembelajaran Menulis Narasi Di Sekolah Dasar. *Jurnal Pendidikan Dasar*, *9*(2), 30–41. Opgehaal Van Http://Journal.Unj.Ac.Id/Unj/Index.Php/Jpd/Article/View/9498

Isma Nastiti Maharani, & Niken Dani Safitri. (2024). Pengembangan Instrumen Evaluasi Kurikulum Merdeka Jenjang Sd. *Decode: Jurnal Pendidikan Teknologi Informasi*, *4*(2), 621–632. Https://Doi.Org/10.51454/Decode.V4i2.347

Kusmianty, D., Widiyanto, B., & Kusuma, M. (2020). Efektivitas Model Pembelajaran Sets Metode Praktikum Pada Materi Pemanasan Global Dalam Meningkatkan Kemampuan Berpikir Kritis. *Cakrawala: Jurnal Pendidikan*, *14*(1), 41–51. Opgehaal Van Cakrawala.Upstegal@Gmail.Com

Mahmudah, W., Nisa, R., & Masruroh, L. (2024). Pelatihan Pembuatan Modul Ajar Dan Media Pembelajaran Berbasis Artificial Intellegence. *Community Development Journal: Jurnal Pengabdian Masyarakat*, *5*(5), 9038–9043. Https://Doi.Org/Https://Doi.Org/10.31004/Cdj.V5i5.34629

Navitasari, Y. A. (2019). Keefektifan Etnomatematika Melalui Benda Konkret Terhadap Kemampuan Berpikir Kritis Peserta Didik Kelas Iii Materi Pecahan. *Karya Ilmiah Mahasiswa Progdi Pendidikan Guru Sekolah Dasar Fkip*, *3*(2).

Ndae, M. A., & Widyaningrum, D. A. (2020). Pengaruh Model Pembelajaran Recripocal Teaching Pair Share Dengan Media Gambar Terhadap Kemampuan Berpikir Kritis Siswa Sma. *Quagga: Jurnal Pendidikan Dan Biologi*, *12*(1), 76–84.

Ni'matuzzahroh, I. (2020). Model Pembelajaran Novick Dengan Media Origami Terhadap Kemampuan Berpikir Kritis Siswa. *Jurnal Riset Pembelajaran Matematika*, *2*(April), 7–10.

Novalianti, K. E., Susilawati, S., & Ã¢Â, ¬ËœArdhuha, J. (2021). Pengaruh Model Brain Based Learning Berbantuan Brain Gym Terhadap Kemampuan Berpikir Kritis Ditinjau Dari Motivasi Belajar Fisika Peserta Didik. *Jurnal Pijar Mipa*, *16*(1), 49–56. Https://Doi.Org/10.29303/Jpm.V16i1.1397

Nugraheni, D., Siswanti, H., Ivet, U., Merdeka, K., & Penggerak, S. (2022). Implementasi Kurikulum Merdeka Di Sekolah Penggerak Sd Negeri 2 Pogung Kabupaten Klaten. *Jurnal Pendidikan Ipa Veteran*, *6*, 53–61.

Nurlatifah, P. A., & Purniati, T. (2025). *Systematic Literature Review : Penerapan Game Edukasi Untuk Meningkatkan Motivasi Belajar Matematika*. *4*(1), 115–127.

Prayogi, S., & Muhali, M. (2025). Pengembangan Model Pembelajaran Aktif Berbasis Inkuiri (Abi) Untuk Mengembangkan Keterampilan Berpikir Kritis Mahasiswa. *Prisma Sains : Jurnal Pengkajian Ilmu Dan Pembelajaran Matematika Dan Ipa Ikip Mataram*, *3*(1), 21. Https://Doi.Org/10.33394/J-Ps.V3i1.1074

Rachmantika, A. R., & Wardono. (2019). Peran Kemampuan Berpikir Kritis Siswa Pada Pembelajaran Matematika Dengan Pemecahan Masalah. *Prosiding Seminar Nasional*

Matematika, 2(1), 441.

Ramadhanty, V. D., Permana, R. I., Fauzia, B. R. S., & Rakhmawati, N. A. (2021). Analisis Faktor Penggunaan Dompet Digital Di Kalangan Mahasiswa Perguruan Tinggi Surabaya. *Jurnal Teknik Informatika Dan Sistem Informasi*, *8*(1), 312–322. Https://Doi.Org/Https://Doi.Org/10.35957/Jatisi.V8i1.584

Savitri, Theresia Laksmi., Nurjaya, I Gede., Yasa, I. N. (2022). Kemampuan Menulis Teks Narasi Ekspositoris Siswa Kelas Vii Smp. *Jurnal Bahtra*, *12*(4), 459–468.

Sugiarti, S., & Oktaviani, N. (2022). Analisis Kepribadian Tokoh Dalam Novel Trauma Karya Boy Candra (Tinjauan Psikologi Sastra). *Seulas Pinang: Jurnal Pendidikan Bahasa Dan Sastra*, *4*(1), 1–12. Https://Doi.Org/10.30599/Spbs.V4i1.1523

Susilowati, E. (2022). Implementasi Kurikulum Merdeka Belajar Pada Mata Pelajaran Pendidikan Agama Islam. *Al-Miskawaih: Journal Of Science Education*, *1*(1), 115–132. Https://Doi.Org/10.56436/Mijose.V1i1.85

Syafruddin, F., & Jeranah, J. (2020). Efektivitas Penerapan Model Quantum Learning Dengan Pendekatan Realistic Mathematics Education (Rme) Terhadap Hasil Belajar Siswa. *Al Asma : Journal Of Islamic Education*, *2*(2), 224. Https://Doi.Org/10.24252/Asma.V2i2.17487

Wafiroh, H., Fajrin, N. D., & Madura, U. T. (2024). Analisis Kesulitan Guru Dalam Mengembangkan Modul Ajar Kurikulum Merdeka Di Sdn Banyuajuh 2 Analisis Kesulitan Guru Dalam Mengembangkan Modul Ajar Kurikulum Merdeka Di Sdn Banyuajuh 2. *Media Akademik (Jma)*, *2*(2).

Yiniar, Y., Lovisia, E., & Yolanda, Y. (2024). Pengembangan Modul Ajar Kurikulum Merdeka Topik Usaha Energi Berbasis Inkuiri Terintegrasi Keterampilan Kolaborasi. *Magneton: Jurnal Inovasi Pembelajaran Fisika*, *2*(2), 129–138. Https://Doi.Org/10.30822/Magneton.V2i2.3539