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Development of an Integrated E-Module with The Problem-Based Leaning Model to Facilitate Critical Thinking Skills on Temperature and Heat Material

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ABSTRACT

This 21st-century education requires more skills in life than just knowledge. The development of students' abilities requires an organized guide, one of which is by using the curriculum. Indonesian students are currently using the Independent Curriculum. The ability to think critically is an ability that must be possessed by today's students. This research aims to produce integrated e-module with the problem based learning model to facilitate critical thinking skills on temperature and heat material. The test results obtained an average score of 39.79 and was relatively low. Based on the results of the questionnaire analysis, it is known that the potential for e-module development at SMAN 1 Akabiluru has a percentage of 79%. Another data stated that they need a teaching material supported by pictures, animations, and learning videos with an average percentage of 82.67%. This research uses the Research and Development (R&D) method and the ADDIE model. The researcher conducted an analysis of students' critical thinking skills at SMAN 1 Akabiluru. The validation results for all aspects shows that the average validity index is 0.913 so it is classified as very valid. This states that the e-module is very valid and suitable for use in physics learning.

INTRODUCTION

This 21st century education requires more skills in life than just knowledge (Putri & Istiyono, 2017). The 21st century skills are important for students both academically and for future success (Azriyanti & Syafriani, 2023). The 21st century framework provide strategies to identify the skills that students must acquire to enter the future workforce (González-pérez & Ramírez-montoya, 2022). The development of students' abilities requires an organized guide, one of which is by using the curriculum (Rawung et al., 2021). Indonesian students are currently using the Merdeka Curriculum.

The Merdeka Curriculum aims to provide a more holistic and inclusive approach that emphasizes character development, creativity and critical thinking skills, in addition to academic knowledge (Zidan & Qamariah, 2023). The structure of this Merdeka Curriculum is

based on 3 things, namely: competency-based, flexible learning and Pancasila character (Mairizwan et al., 2022). The Merdeka Curriculum is expected to be an effective instrument in providing an equal education foundation that can compete at the international level (Syahrir et al., 2024). In Merdeka Curriculum, it is considered that learning can have a tremendous impact on the development of student potential if the school can provide the best learning for students (Ndari et al., 2023). The forging of students' potential will be more directed with the curriculum.

The ability to think critically is an ability that must be possessed by today's students. Critical thinking is thinking that can be directly accepted by reason so that it can choose decisions that lead to the truth (Oktariani & Ekadiansyah, 2020). Critical thinking is the ability to analyze information and make rational judgments about a decision (Jamil et al., 2024). This ability is urgently needed for the future of students in facing global challenges (Samadun & Dwikoranto, 2022). In the learning process, critical thinking skills are often needed, one of which is in physics learning. When learning physics, students' critical thinking skills are highly tested. These skills are useful for reducing mistakes and finding solutions to the problems learned (Amalia & Kustijono, 2017). One of the tools to help teachers and students in learning is teaching materials.

Subject matter that is arranged in an orderly and complete manner based on learning principles is called teaching materials (Magdalena et al., 2020). Modules are a type of teaching material that is often used in learning (Cynthia et al., 2023). Modules are a type of teaching material that is made completely and regularly, in which there are learning activities that are designed according to learning objectives (Mahadiraja & Syamsuarnis, 2020). Rapidly innovating technologies are driving the procurement of modules in electronic form (e-modules) (Hadianto & Festiyed, 2020).

E-modules are teaching materials in electronic form containing several learning activities that are connected to interactive media links so as to increase the sensation of learning (Kemendikbud, 2017). E-module are modules designed in electronic or digital form that contain various interactive media and made systematically to support the learning process (Laila & Asrizal, 2023). E-module is a systematic application that contains learning activities (Mahmudah et al., 2022). E-modules are superior to printed teaching materials because they can be accessed with a wide variety of electronic devices (Harahap et al., 2024).

The researcher conducted an analysis of students' critical thinking skills. This test was conducted at SMAN 1 Akabiluru. The test results obtained an average score of 39.79 and was relatively low. Based on the experience when carrying out the Educational Field Practice at SMAN 1 Akabiluru, information was obtained that teachers used physics books published by Erlangga in 2023, but the number was insufficient. In addition, teachers focus more on explaining the material and doing problems. In a similar study also stated that the learning process at SMAN 1 Pacitan is still teacher-centered (Adhelacahya et al., 2023). There are still many teachers who do not want to use technology in learning because they do not use existing technology often or still believe that printed books are more effective (Ledistika et al., 2024).

Based on the results of the questionnaire analysis, it is known that the potential for e-module development at SMAN 1 Akabiluru has a percentage of 79%. Another data is that students of SMAN 1 Akabiluru stated that they need a teaching material supported by pictures, animations, and learning videos with an average percentage of 82.67%. The potential for the use of e-modules in the learning process is also very large because 89% of students of SMAN 1 Akabiluru stated that they have smartphones to do digital or online activities and students are allowed to bring smartphones to school. The results of the teacher's interview obtained information that the temperature and heat material was

considered difficult by students at the school. Temperature and heat are topics that are said to be difficult by students (Wenno et al., 2022).

Based on the above problems, the solution that can be used is the use of e-modules. E-modules are key to renewal that offer student-centered learning activities (Gunawan et al., 2024). The relevant research stated that in the application of e-modules, there was an increase with a moderate category in critical thinking skills (Latifah et al., 2020). PBL-integrated modules can build critical thinking skills, solve problems and motivate to learn (Nabila, 2024). Problem based learning model can be another solution. The focus of this model is on the habit of critical thinking and problem-solving so that it can build critical thinking skills (Yulianti & Gunawan, 2019). This model encourages critical thinking and addresses learning problems (Fadilla et al., 2021). The relevant research states that overall the problem based learning model has an influence in improving students critical thinking skills (Agnezi & Rahmah, 2020). Based on the description above, this research aims to produce integrated e-modules with the problem based learning model to facilitate critical thinking skills on temperature and heat material.

METHODS

The Research and Development (R&D) method is the method in this study. This method is used in developing products and identifying the results of the development (Sugiyono, 2013). The model used is the ADDIE model. The ADDIE model is a model that has five development steps including: Analyze, Design, Develop, Implement, and Evaluate (Budoya et al., 2019). The development model used is limited to the develop stage.

Analyze

The activities carried out at this analyze stage include: teacher interviews, analysis of learners needs for e-module, curriculum analysis, material analysis and analysis of students critical thinking skills. In the teacher interview activity, the instrument used was a teacher interview sheet consisting of 25 questions and divided into several aspects, namely: the curriculum used in physics learning, facilities and infrastructure at school, the use of smartphones at school by students, the use of teaching materials in the physics learning process, and perceptions about e-modules. The analysis of students' needs for e-modules was carried out by distributing a questionnaire consisting of 16 assessment items which were grouped into several aspects, namely: perceptions of physics learning, the use of smartphones in the school environment, perceptions of teaching materials, knowledge of e-modules and the potential for e-module development.

Curriculum analysis aims to analyze the learning outcomes and learning objectives to be achieved. Material analysis aims to identify the main materials that need to be included in the e-module. The analysis of students' critical thinking skills is carried out using a test instrument in the form of essay questions. The instrument consists of 15 essay questions on temperature and heat material which are prepared based on indicators of critical thinking skills put forward by Ennis (1985). The analysis of critical thinking skills was conducted at SMAN 1 Akabiluru to students who had studied temperature and heat material before.

Design

The design stage aims to produce an initial design of the e-module. This stage includes creating a development team, selecting a drafting framework and creating a display design using Microsoft Word and Canva applications. The e-module design developed follows the structure contained in the e-module preparation guide issued by Kemebdikbud (2017).

Develop

The activity at the development stage is to make products based on the previous design. The product will be validated by validators, and will be revised based on comments from validators, until it reaches a valid level. Validation of the e-module was carried out by 3 validators who were lecturers of the physics department at Universitas Negeri Padang. This validity test was carried out using a validity test instrument in the form of a questionnaire. The aspects assessed on the instrument included the e-module component, e-module display, software utilization, e-module characteristics, PBL model syntax, and critical thinking skills.

The validity assessment of e-modules uses the validity index proposed by Aiken. The validity index is formulated as follows:

$$V = \frac{\sum s}{n(c-1)}$$

where V is the rater agreement index of item validity, s is the score assigned to each rater minus the lowest score in the category used, n is the number of raters and c is the number of categories the rater can choose from. Based on the results of the V index calculation, an item or device can be categorized based on its index. If the index is smaller or equal to 0.4 it is said to be less valid, 0.4 - 0.8 is said to have medium validity, and if it is greater than 0.8 it is said to be highly valid (Retnawati, 2016).

RESULTS AND DISCUSSION

Results

Analyze

The results of the analysis of students' needs for e-modules state that 90% of students need interesting teaching materials. More than 83% of students stated that teaching materials that contain images, animations and videos attract more attention in physics learning. E-module development has great potential with a percentage of 79%. Based on the results of interviews with physics teachers, it is known that e-modules are very potential to be used in the physics learning process because students are allowed to bring smartphones to school. Other information obtained is the material suggested to make e-modules, one of which is temperature and heat material.

Curriculum analysis produces learning outcomes, learning objectives and indicators of achievement of learning objectives that will be used in developing e-modules. Based on material analysis, it is known that the subject matter will be included in the e-module is temperature and thermometer, expansion of various forms of substances, heat and its effect on objects and heat transfer. The results of the analysis of students' critical thinking skills state that students' critical thinking skills are classified in the low category with an average of 39.79.

Design

The design of the e-module is made based on the results of student needs analysis, curriculum analysis, material analysis and analysis of students' critical thinking skills. The design of the e-module is made by integrating the PBL model in the e-module so that each learning activity is arranged based on the PBL model syntax. This design creation uses the Canva and Microsoft Word apps to create an attractive and interactive display. The structure design of this e-module is divided into several parts, including: cover, introduction, table of content, glossary, introduction, learning activities, evaluation, answer key and scoring guidelines, and bibliography. The e-module design can be seen in Figure 1.

Figure 1. E-Module Design

Develop

At this stage, the activity carried out is to execute the design that has been made into a complete e-module. The development of this e-module uses the Heyzine website. After that, the resulting e-module is tested for validity. In this validity test, there are 6 aspects, namely: e-module components, e-module display, software utilization, e-module characteristics, PBL model syntax, and critical thinking skills.

The first aspect is the component aspect of the e-module. The validity test on the component aspects of this e-module aims to determine the completeness, correctness, accuracy and clarity of the components of the e-module. In this aspect, there are 27 assessment indicators. The results of the validity are included in Table 1.

Table 1. Validation Results on E-Module Component Aspects

Indicators	Validity Index	Validity Level Description
The title of the e-module on the cover	1.000	Highly valid
Subject name on the cover	0.917	Highly valid
Topics/learning materials on the cover	1.000	Highly valid
Classes on the cover	0.917	Highly valid
Author's name on the cover	1.000	Highly valid
Foreword	1.000	Highly valid
Table of contents	0.917	Highly valid
Glossary	1.000	Highly valid
Learning Outcomes (CP)	1.000	Highly valid
Learning Objectives (TP)	1.000	Highly valid
Alignment between learning objectives and learning outcomes	0.917	Highly valid
Description	1.000	Highly valid
Time	0.917	Highly valid
Instructions for using the e-module	0.917	Highly valid
Learning Goal Achievement Indicators (IKTP)	0.833	Highly valid
Compatibility between IKTP and TP	0.833	Highly valid

Description of the material	0.833	Highly valid
Summary	0.917	Highly valid
Assignment	0.833	Highly valid
Skills worksheets	1.000	Highly valid
Exercise	0.917	Highly valid
Self-assessment	0.917	Highly valid
Evaluation	0.750	Medium validity
Answer key	0.917	Highly valid
Scoring guidelines	0.750	Medium validity
Bibliography	0.917	Highly valid
Attachment	0.833	Highly valid
Average	**0.917**	**Highly valid**

In Table 1, we can know that the validity index of e-module components is spread from 0.750 to 1.000. Of the 27 categories, there are 25 indicators that fall into the highly valid category and 2 indicators that fall into the medium validity category. Indicators that fall into the medium validity category are self-assessment and scoring guidelines. The average validity index in this aspect is 0.917, so it can be classified in the highly valid category. These results indicate that the components contained in the developed e-module are appropriate, complete, and clear.

The second aspect is the aspect of the e-module display. The validity test on the appearance aspect of the e-module shows the attractiveness of the product appearance developed. In this aspect, there are 8 assessment indicators. The validity of the e-module display is included in Table 2.

Table 2. Validation Results on E-Module Display aspects

Indicators	Validity Index	Validity Level Description
Font	1.000	Highly valid
Writing size	1.000	Highly valid
Color combinations	0.917	Highly valid
Component layout	0.917	Highly valid
Picture	0.917	Highly valid
Learning videos	0.917	Highly valid
Inter-page access	0.917	Highly valid
Navigation buttons	0.833	Highly valid
Average	**0.927**	**Highly valid**

In Table 2, we can know that the validity index of the e-module in the aspect of the e-module display starts from 0.833 to 1.000. All indicators in this aspect are classified as highly valid. The indicator that obtained the lowest validity index was the navigation button. The average validity index in this aspect is 0.927, so it can be classified in the highly valid category. This result shows that the developed e-module has an attractive display.

The third aspect is the aspect of software utilization. The validity test on the aspect of software utilization aims to find out whether the software used is able to increase product quality. There are 5 assessment indicators in the aspect of software utilization. The validity of the aspect of software utilization is included in Table 3.

Table 3. Validation Results on software utilization aspects

Indicators	Validity Index	Validity Level Description
Use of canva software on e-modules	1.000	Highly valid
Use of Heyzine software on e-modules	1.000	Highly valid
Videos added using Heyzine software	1.000	Highly valid
Link links added using Heyzine software	1.000	Highly valid
Use of google form	0.917	Highly valid
Average	**0.983**	**Highly valid**

Table 3 above shows that the validity index of e-modules in the aspect of software utilization ranges from 0.917 to 1.000. All indicators in this aspect are classified as highly valid. All indicators obtained perfect scores except the use of google form indicator. The average validity index in this aspect is 0.983, so it can be classified in the highly valid category. These results show that the software used in developing e-modules is able to improve the quality of the e-modules.

The fourth aspect is e-module characteristics. The validity test on e-module characteristics aspects will check the completeness of the characteristics of an e-module. In this aspect, there are 5 assessment indicators. The validity of e-module characteristics aspects is found in Table 4.

Table 4. Validation Results on e-Module Characteristics Aspects

Indicators	Validity Index	Validity Level Description
Can be used independently, (*self-instructional*))	0.750	Medium validity
Contains complete learning materials (*self-contained*)	0.833	Highly valid
Not related to any e-module (*stand-alone*))	0.917	Highly valid
In accordance with the development of science (*adaptive*)	0.917	Highly valid
Easy to use both independently and without (*user friendly*)	0.833	Highly valid
Average	**0.850**	**Highly valid**

Table 4 shows that the validity index of e-module characteristic aspects ranges from 0.750 to 0.917. Of the 5 categories, there are 4 indicators that fall into the highly valid category and 1 indicator that fall into the medium validity category. The indicator that fall into the medium validity category is self instructional. The average validity index in this aspect is 0.850, so it can be classified in the highly valid category. These results indicate that the e-module developed has the characteristics that an e-module must have.

The fifth aspect is the syntax aspect of the problem-based learning model. The validity test on the syntax aspect of the model intends to see the integration of the model with the e-module. In this aspect, there are 11 assessment indicators. The results of validation on the syntax aspect of th problem-based learning model can be seen in Table 5.

Table 5. Validation Results of PBL Model Syntax

Indicators	Validity Index	Validity Level Description
Problems in accordance with real life	0.833	Highly valid
Problems related to material	0.833	Highly valid

Problems can increase students' motivation	0.750	Medium validity
Instruction directs students in doing each activity	0.917	Highly valid
The formulation of the problem made is able to measure the initial ability	0.833	Highly valid
Instruction / instruction for student investigation work	1.000	Highly valid
Questions that guide student investigations	1.000	Highly valid
Instructions for developing and presenting works	1.000	Highly valid
Questions that reflect the problem-solving process	0.917	Highly valid
Questions that ask about students' difficulties	0.917	Highly valid
Angler's questions to find solutions independently	0.917	Highly valid
Average	**0.902**	**Highly valid**

As seen in Table 5, the validity index of the e-module in the syntax aspect of the problem-based learning model ranges from 0.750 to 1.000. Of the 11 categories, there are 10 indicators that fall into the highly valid category and 1 indicator that fall into the medium validity category. The indicator that fall into the medium validity category is the accordance problem with real life. The average validity index in this aspect is 0.902, so it can be classified in the highly valid category. These results shows that the integration of PBL model syntax in the developed e-module is correct.

The sixth aspect is the aspect of critical thinking skills. The validity test of this aspect aims to find out how well the product facilitates critical thinking skills. There are 4 assessment indicators. The validation results are shown through Table 6.

Table 6. Validation Result on The Aspect of Critical Thinking Skills

Indicators	Validity Index	Validity Level Description
The problems raised are able to facilitate the ability of	0.833	Highly valid
The investigative questions are arranged based on indicators of critical thinking skills	0.833	Highly valid
Exercises are made based on ability indicators	0.917	Highly valid
The evaluation is made according to the kri thinking indicator	0.917	Highly valid
Average	**0.875**	**Highly valid**

Table 6 shows that the validity index of e-modules in the aspect of critical thinking skills ranges from 0.833 to 0.917. All indicators in this aspect are classified as highly valid. We can see that there are 2 indicators get a validity index of 0.833 and 2 other indicators get a validity index of 0.917. The average validity index in this aspect is 0.875, so it can be classified in the highly valid category. This result shows that the developed e-module is able to facilitate critical thinking skills well.

The average validity index for all aspects ranges from 0.850 to 0.983. The aspect that obtained the highest validity index was the software utilization aspect and the aspect that obtained the lowest average validity index was the e-module characteristics aspect. Overall, the average validity index is 0.913 so it is classified as highly valid. This states that the e-module developed is valid and suitable for use in the learning proses. When carrying out this validity test, there is input from validators. This input is very useful for improving the product. Referring to these comments, improvements were made to the e-module.

Discussion

The results of the analysis of students' needs for e-modules state that 90% of students need interesting teaching materials. More than 83% of students stated that teaching materials that contain images, animations and videos attract more attention in physics learning. E-module development has great potential with a percentage of 79%. On relevant research, students need interesting learning using audio-visual media (Suryani et al., 2024). Based on the results of interviews with physics teachers, it is known that e-modules are very potential to be used in the physics learning process because students are allowed to bring smartphones to school. Other information obtained is the material suggested to make e-modules, one of which is temperature and heat material. Similar research also stated that one of the materials that still considered difficult by students is temperature and heat .(Wenno et al., 2022).

Curriculum analysis produces learning outcomes, learning objectives and indicators of achievement of learning objectives that will be used in developing e-modules. Based on material analysis, it is known that the subject matter will be included in the e-module is temperature and thermometer, expansion of various forms of substances, heat and its effect on objects and heat transfer. The results of the analysis of students' critical thinking skills state that students' critical thinking skills are classified in the low category with an average of 39.79. The corresponding research also states that students' critical thinking skills are classified as low with an average of 31.38 (Ariani, 2020). The relevant research also stated that critical thinking skills of students at SMAN 3 Pontianak are still relatively low (Nurjanah et al., 2022).

The design of the e-module is made based on the results of student needs analysis, curriculum analysis, material analysis and analysis of students' critical thinking skills. The design of the e-module is made by integrating the PBL model in the e-module so that each learning activity is arranged based on the PBL model syntax. This design creation uses the Canva and Microsoft Word apps to create an attractive and interactive display. The structure design of this e-module is divided into several parts, including: cover, introduction, table of content, glossary, introduction, learning activities, evaluation, answer key and scoring guidelines, and bibliography.

At develop stage, validity tests were carried out on six aspects. The first aspect is the component aspect of the e-module. The validation results of this aspect shows that the average validity index in this aspect is 0.917 with very valid category. The second aspect is the aspect of the e-module display. The validation results of this aspect shows that the average validity index in this aspect is 0.983 with very valid category. The third aspect is the aspect of software utilization. The validation results of this aspect shows that the average validity index in this aspect is 0.983 with very valid category.

The fourth aspect is e-module characteristics. The validation results of this aspect shows that the average validity index in this aspect is 0.85 and is classified as very valid category. The fifth aspect is the syntax aspect of the problem-based learning model. The validation results of this aspect shows that the average validity index in this aspect is 0.902 and with very valid category. The sixth aspect is the aspect of critical thinking skills. The validation results of this aspect shows that the average validity index in this aspect is 0.875 and the category is very valid. The validation results for all aspects shows that the average validity index is 0.913 so it is classified as very valid. This states that the e-module is highly valid and suitable for use in physics learning. In relevant research, it is stated that the e-module developed is classified as valid and suitable for use in learning at school (Azriyanti & Syafriani, 2023). The similar research also stated that the interactive physics e-module developed has met the valid category (Cynthia et al., 2023).

CONCLUSION

The conclusions obtained from this study are the integrated e-module with the problem based learning model to facilitate critical thinking skills on temperature and heat material classified in the category of highly valid for all aspects with average of validity index is 0.913. This states that the e-module developed is suitable for use in the physics learning process. All aspects assessed can be classified in the highly valid category. The aspect that received the highest score was the software utilization aspect. This shows that the utilization of various type of software in developing e-module makes e-module more attractive and improves the quality of the e-module. The aspect that received the lowest score was the e-module characteristics aspects. Although it has been classified in the highly valid category, the e-module can still be improved again in terms of characteristics, so that the e-module produced can be more perfect.

REFERENCES

Adhelacahya, K., Sukarmin, S., & Sarwanto, S. (2023). Impact of Problem-Based Learning Electronics Module Integrated with STEM on Students' Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(7), 4869–4878.

Agnezi, L. A., & Rahmah, S. (2020). Meta-Analisis Pengaruh Model Problem Based Learning terhadap Kemampuan Berpikir Kritis Siswa. *Jurnal Penelitian Dan Pembelajaran Fisika*, *6*(2), 136–145.

Amalia, F., & Kustijono, R. (2017). Efektifitas penggunaan E-Book dengan Sigil untuk melatihkan kemampuan berpikir kritis. *SEMINAR NASIONAL FISIKA (SNF) "Menghilirkan Penelitian-Penelitian Fisika Dan Pembelajarannya," November*, 81–85.

Ariani, T. (2020). Analysis of Students' Critical Thinking Skills in Physics Problems. *Kasuari: Physics Education Journal (KPEJ)*, *3*(1), 1–17.

Azriyanti, R., & Syafriani. (2023). Validation of the Physics E-Module Based on Problem Based Learning as Independent Teaching Material to Improve Critical Thinking Skills of Class XI High School Students. *Jurnal Penelitian Pendidikan IPA*, *9*(11), 10223–10229.

Budoya, C. M., Kissaka, M. M., & Mtebe, J. S. (2019). Instructional design enabled Agile Method using ADDIE Model and Feature Driven Development method. *International Journal of Education and Development Using Information and Communication Technology (IJEDICT)*, *15*(1), 35–54.

Cynthia, C., Arafah, K., & Palloan, P. (2023). Development of Interactive Physics E-Module to Improve Critical Thinking Skills. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 3943–3952.

Ennis, R. H. (1985). A Logical Basis for Measuring Critical Thinking Skills. *National Inst. Of Education*, *11*(1), 217–232.

Fadilla, N., Nurlaela, L., Rijanto, T., Ariyanto, S. R., Rahmah, L., & Huda, S. (2021). Effect of problem-based learning on critical thinking skills. *Journal of Physics: Conference Series*, *1810*(1), 8–13.

González-pérez, L. I., & Ramírez-montoya, M. S. (2022). COMPETENCIES TYPES (LEARNING SKILLS, LITERACY SKILLS, LIFE SKILLS) Components of Education 4.0 in 21st Century Skills Frameworks: Systematic Review. *Sustainability (Switzerland)*, *14*(3), 1–31.

Gunawan, M. A., Fitri, A., & Nelli Murodah. (2024). Develompment of an E-Module For Educational Evaluation Course With a Problem Based Learning Framework. *Edukasia Islamika*, *9*(1), 132–144.

Hadianto, A., & Festiyed. (2020). Meta analysis the use of e-modules based on research based learning models. *Journal of Physics: Conference Series*, *1481*(1), 1–5.

Harahap, N. I., Hakim, R., Rayendra, & Ridwan. (2024). Development of Physics Learning E-Module for Class X High School Students. *Jurnal Penelitian Pendidikan IPA*, *10*(7), 3689–3696.

Jamil, M., Hafeez, F. A., & Muhammad, N. (2024). Critical Thinking Development for 21st Century: Analysis of Physics Curriculum. *Journal of Social & Organizational Matters*, *3*(1), 01–10.

Kemendikbud. (2017). *Panduan Praktis Penyusunan E-Modul*. 1–57.

Laila, R., & Asrizal, -. (2023). Development of Science E-Module by Integrating Quantum Learning to Improve Students' Concept Understanding and Creative Thinking. *Jurnal Penelitian Pembelajaran Fisika*, *9*(2), 113–124.

Latifah, N., Ashari, & Setyadi Kurniawan, E. (2020). Pengembangan e-Modul Fisika Untuk Meningkatkan Kemampuan Berpikir Kritis Peserta Didik. *Jips: Jurnal Inovasi Pendidikan Sains*, *01*(1), 1–7.

Ledistika, M., Medriati, R., & Setiawan, I. (2024). Development of STEM-Based E-Modules (Science, Technology, Engineering, and Mathematics) on Circular Motion Material to Enhance High School Students Critical Thinking Skills. *Jurnal Pendidikan Matematika Dan IPA*, *15*(3), 355–368.

Magdalena, I., Prabandani, riana okta, Rini, emilia septia, Fitriani, M. A., & Putri, A. A. (2020). Analisis pengembangan bahan ajar. *Nusantara : Jurnal Pendidikan Dan Ilmu Sosia*, *2*(2), 170–187.

Mahadiraja, D., & Syamsuarnis, S. (2020). Pengembangan Modul Pembelajaran Berbasis Daring Pada Mata Pelajaran Instalasi Penerangan Listrik Kelas XI Teknik Instalasi Tenaga Listrik T.P 2019/2020 Di SMK Negeri 1 Pariaman. *JTEV (Jurnal Teknik Elektro Dan Vokasional)*, *6*(1), 77–82.

Mahmudah, S., Kirana, T., & Rahayu, Y. S. (2022). Profile of Students' Critical Thinking Ability: Implementation of E-Modul Based On Problem-Based Learning. *IJORER : International Journal of Recent Educational Research*, *3*(4), 478–488.

Mairizwan, M., Hidayati, H., Dewi, W. S., Afrizon, R., & Jarlis, R. (2022). Increasing the Competence of Physics Teachers in Designing PjBL-Based Teaching Aids for the Implementation of the Merdeka Curriculum. *Jurnal Penelitian Pendidikan IPA*, *8*(6), 2948–2953.

Nabila, A. E. F. (2024). The Development of a Problem-based Learning Physics Module to Facilitate the Critical Thinking Skills of SHS Learners for the Material of Work and Energy. *Impulse: Journal of Research and Innovation in Physics Education*, *3*(2), 113–123.

Ndari, W., Suyatno, Sukirman, & Mahmudah, F. N. (2023). Implementation of the Merdeka Curriculum and Its Challenges. *European Journal of Education and Pedagogy*, *4*(3), 111–116.

Nurjanah, S., Djudin, T., & Hamdani. (2022). Analisis Kemampuan Berpikir Kritis Peserta Didik pada Topik Fluida Dinamis. *Jurnal Education and Development*, *10*(3), 111–116.

Oktariani, O., & Ekadiansyah, E. (2020). Peran Literasi dalam Pengembangan Kemampuan Berpikir Kritis. *Jurnal Penelitian Pendidikan, Psikologi Dan Kesehatan (J-P3K)*, *1*(1), 23–33.

Putri, F. S., & Istiyono, E. (2017). The Development of Performance Assessment of STEM-Based Critical Thinking Skill in the High School Physics Lessons. *International Journal of Environmental & Science Education*, *12*(5), 1269–1281.

Rawung, W. H., Katuuk, D. A., Rotty, V. N. J., & Lengkong, J. S. J. (2021). Kurikulum dan Tantangannya pada Abad 21. *Jurnal Bahana Manajemen Pendidikan*, *10*(1), 29–34.

Retnawati, H. (2016). *Analisis Kuantitatif Instrumen Penelitian (Panduan Peneliti, Mahasiswa, dan Psikometrian)*. Parama Publishing.

Samadun, S., & Dwikoranto, D. (2022). Improvement of Student's Critical Thinking Ability sin Physics Materials Through The Application of Problem-Based Learning. *IJORER : International Journal of Recent Educational Research*, *3*(5), 534–545.

Sugiyono. (2013). *Metodologi Penelitian Kuantitatif, Kualitatif dan R & D*. Alfabeta.

Suryani, Y., Asyhari, A., & Amelya, P. (2024). E-Modul Fisika Berbasis Socio-Scientific Issues Menggunakan Perangkat Lunak Flip PDF Professional: Pengembangan E-Modul pada Materi Momentum dan Impuls. *BIOCHEPHY: Journal of Science Education*, *4*(1), 366–372.

Syahrir, S., Pujiriyanto, P., Musdalifa, M., & Fitri, S. (2024). The Implementation of Merdeka Curriculum to Realize Indonesia Golden Generation: A Systematic Literature Review. *AL-ISHLAH: Jurnal Pendidikan*, *16*(2), 1434–1450.

Wenno, I. H., Limba, A., & Silahoy, Y. G. M. (2022). The development of physics learning tools to improve critical thinking skills. *International Journal of Evaluation and Research in Education*, *11*(2), 863–869.

Yulianti, E., & Gunawan, I. (2019). Problem Based Learning (PBL) Learning Model: The Effect on Understanding of Concept and Critical Thinking. *Indonesian Journal of Science and Mathematics Education*, *02*(3), 399–408.

Zidan, M. R., & Qamariah, Z. (2023). A Literature Study on The Implementation Of Merdeka Curriculum. *Jurnal Riset Rumpun Ilmu Bahasa*, *2*(2), 153–167.