Validity of Physics E-Modules Based on an Inquiry Model Integrated with the Science, Environment, Technology, and Society Approach to 21st Century Skills

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Abstract. Education for the 21st century combines knowledge, abilities, and attitudes with a command of information and communication technologies. The role of education is very important as part of an effort to build national character and produce millennials who are innovative, creative, and ready to face global challenges. 21st-century skills are one of the skills that students must have to face global challenges. 21st century skills include critical thinking, creativity, collaboration, and communication, otherwise known as "4C skills." 21st-century skills are also very much needed in learning physics. One of the best teaching materials for enhancing students’ 21st-century skills is an e-module built on the inquiry model and the science, environment, technology, and society (SETS) approach. The goal of this study was to establish the validity, practicability, and efficacy of e-modules created using the SETS approach integrated inquiry model in increasing students' 21st century competencies. This type of research is called development research (R&D). This development procedure refers to the Plomp development model, which has three stages: preliminary research, prototyping, and assessment. E-module validation is reviewed from four aspects: the substance of the material, the learning design, the appearance, and the use of the software. The average score obtained for the substance component of the material, the learning design, the appearance, and the use of the software is in a very valid category. Based on these data, it can be concluded that the inquiry model-based e-module integrated with the SETS approach is in the "very valid" category.

Keywords: E-module, Inquiry, SETS, 21st century skills

Citation: Wati, W.W. & Syafriani. 2023. Validity of physics e-modules based on an inquiry model integrated with the science, environment, technology, and society approach to 21st century skills. JIPI (Jurnal IPA dan Pembelajaran IPA), 7(2):133-144.

Introduction

The role of education is very important as part of an effort to build national character and produce millennial generations that are innovative, creative, and ready to face increasingly advanced global challenges, especially in the 21st century (Fitri et al., 2019). The 21st century is a century with very rapid developments in science and technology (Mahardika et al., 2022). The development of science and technology affects all aspects of life, including the world of education. The implication is that every nation, including Indonesia, must adapt to the demands of the times (Pratama et al., 2019). Education can be used to increase knowledge and technology, character, and skills to be able to adapt to various aspects of life in the future (Margunayasa et al., 2019).
The principle of learning in the 21st century is blended learning, which combines knowledge, thinking skills (critical, innovative, problem-solving), technology, and research (Pratama et al., 2019). The 21st century demands education prepare students who are able to face global competition (Pratiwi et al., 2019). Frydenberg and Andone (2011) stated that to face global competition in the 21st century, everyone must have 21st-century skills. 21st century skills are known as "the 4C skills," which include critical thinking skills, creativity, collaboration, and communication (Mahmudah et al., 2022). 4C skills are fundamental skills recommended by a team of experts in the New World of Work in the 21st century. 4C's abilities as a solution to global challenges through critical thinking in contributing new ideas as creative individuals capable of solving real-world problems and working together and collaborating in teams (Pratama et al., 2019).

21st-century skills are also very much needed in learning physics because learning physics is not only limited to studying facts, concepts, principles, and laws but also learning how to obtain information, apply technology, work scientifically, and have thinking skills (Aji et al., 2017). Learning physics is a process of integrating various components and activities carried out to investigate various natural phenomena using the steps of the scientific method, which will help students build their knowledge. One of the goals of learning physics is to develop the ability to think inductively and deductively by using the concepts and principles of physics to explain various natural events and solve problems both qualitatively and quantitatively. After studying physics, it is hoped that students' thinking skills can develop properly (Nurdiyanti et al., 2020).

The importance of 21st-century skills for students learning physics can be seen from the explanation above. However, the fact is that students' 21st-century skills are still relatively low. This is evidenced by the results of an initial survey conducted in the field and supported by the results of preliminary studies conducted in the last 5 years of research. The factors that cause students' 21st-century thinking skills to be low are: First, the teaching materials used by teachers in the learning process are still fixated on textbooks as the only source of learning, so the teaching materials used cannot improve students' 21st-century skills. Second, the learning models and approaches used are not optimal for improving and training students' 21st-century skills.

One of the efforts that can be made to improve students' 21st-century skills is to develop teaching materials in the form of an inquiry-model-based physics e-module integrated with the science, environment, technology, and society (SETS) approach to improving students' 21st-century thinking skills. The selection of appropriate teaching materials, models, and approaches will have a tremendous impact on the smooth running of learning activities and can help achieve learning objectives. Suryani et al. (2022) conducted research that explains that good quality, appropriate, and appropriate teaching materials will facilitate the achievement of learning objectives. As well as the research conducted by Lovisia et al. (2017), it also explains that without teaching materials, learning activities cannot be carried out properly, as well as the use of models and approaches in learning activities.

The act of defining and looking into a problem is called inquiry. The act of inquiry can also be seen as a means of learning something new. The goal of the inquiry-based learning model is to gather knowledge through observation or experimentation in order to solve an issue by applying critical and logical thinking abilities. According to the characteristics of 21st century learning, the inquiry model requires students to seek out information from a variety of learning sources, be able to think critically, be inventive in problem solving, be able to integrate technology in learning, and have good communication and collaboration skills (Sormin et al., 2019). The SETS approach, on the other hand, combines learning into four areas: science, environment, technology, and society (Fitri et al., 2019).
The e-module based on the inquiry model integrated with the SETS approach is the best teaching material and is very suitable for improving students' 21st century skills because it is in line with the demands of 21st century learning and has also been shown to improve students' 21st century skills. This is demonstrated by one of the findings of a study done by Yerimadesi et al. (2022), which states that the e-module based on the inquiry model combined with the SETS approach is proven to be able to develop students' 21st century skills, specifically their capacity for creative thinking. The outcomes of testing utilizing the T test provide evidence for this claim.

The developer of the e-module based on the SETS integrated inquiry model has been developed by previous researchers, but there are still some limitations from this research, including First, the researcher only develops e-modules based on the SETS approach. Second, there has been no development of teaching materials in the form of e-modules based on inquiry models that are integrated with the SETS approach to critical thinking skills and collaboration skills. Third, few researchers have created inquiry-model-based E-modules that are integrated with the SETS approach to 21st-century students' physics learning skills. The goal of this study was to establish the validity, practicability, and efficacy of e-modules created using the SETS approach integrated inquiry model in increasing students' 21st century competencies.

**Methods**

The type of research used in this study is known as research and development (R&D). This process of development uses the Plomp model, which comprises three stages: initial research, prototype, and evaluation. The subjects in this study were validators (expert lecturers), teachers, and students of MIPA I, SMA Negeri III, Bukittingi, for field trials. The object of this research is an E-module based on an integrated inquiry model with the SETS approach on material for mechanical waves, traveling waves, and stationary class XI MIPA. The instrument used in this study was a validation questionnaire developed by experts.

![Plump research procedure](image)

**Figures 1.** Plump research procedure.
The results of the validation of the physics e-module based on the integrated inquiry model of the SETS approach on the material of mechanical waves, traveling waves, and stationary waves are calculated using the validity formula according to Akbar (2012). The validity formula according to Akbar (2012) will be used to calculate the average of each validity component based on the validator's value:

\[ V - ah = \frac{T}{Th} \times 100 \% \]  

(1)

Keterangan:

- \( V - ah \) = Expert index validation
- \( T \) = Total empirical score achieved (based on expert judgment)
- \( Th \) = Expected total score

The \( V - ah \) results obtained using equation 1 will be analyzed based on the validity criteria proposed by Akbar (2012) in Table 1.

<table>
<thead>
<tr>
<th>No</th>
<th>Percentage (%)</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>80 ≤ V ≤ 100</td>
<td>Very valid or usable without improvement</td>
</tr>
<tr>
<td>2</td>
<td>60 ≤ V &lt; 40</td>
<td>Valid or usable but minor improvement</td>
</tr>
<tr>
<td>3</td>
<td>40 ≤ V &lt; 25</td>
<td>Less valid, less effective, less complete, needs major improvement, recommended not to use</td>
</tr>
<tr>
<td>4</td>
<td>0 &lt; V ≤ 25</td>
<td>Invalid or unusable</td>
</tr>
</tbody>
</table>

Based on Table 2, the e-module based on the integrated inquiry model SETS approach is said to be very valid if the values obtained are in the range 80 ≤ V ≤ 100, and valid if they are in the range 60 ≤ V < 40, less valid if they are in the range 40 ≤ V < 25 and invalid if it is in the range 0 < V ≤ 25 (Akbar, 2012).

**Results and Discussion**

**Preliminary research stages**

The stages of research carried out are as follows: 1) making preliminary study instruments in the form of questionnaires and test questions; 2) conducting initial observations and interviews with physics teachers regarding the learning system applied and what teaching materials are used during the learning process; 3) conducting critical thinking ability tests and distributing questionnaires on creativity, collaboration, and communication skills to students in class XI MIPA at SMA Negeri Bukitinggi; 4) Analyzing data from the results obtained in the field, both in terms of the teaching materials used, the learning system applied, and initial data on the 21st century skills of students at school. Based on the findings of the preliminary research, problems were identified at the school, including: first, the teaching materials used by teachers in the learning process are still fixated on textbooks as the only source of learning, so the teaching materials used cannot
improve students' 21st century abilities. Second, the learning models and techniques used are not the best to improve and prepare students to have 21st-century skills. Third, as seen in Table 2, the average score for 21st century skills is at the middle level.

**Table 2. The Average Score For 21st Century Skills**

<table>
<thead>
<tr>
<th>No</th>
<th>21st century skills</th>
<th>The average score (%)</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Critical thinking skill</td>
<td>58.49</td>
<td>Moderate category</td>
</tr>
<tr>
<td>2</td>
<td>Creativity skill</td>
<td>59.32</td>
<td>Moderate category</td>
</tr>
<tr>
<td>3</td>
<td>Collaboration skill</td>
<td>65.18</td>
<td>Moderate category</td>
</tr>
<tr>
<td>4</td>
<td>Communication skill</td>
<td>69.70</td>
<td>Moderate category</td>
</tr>
</tbody>
</table>

Based on Table 2, it can be seen that the average score value on each 21st century skill. Critical thinking skills have an average score value of 58.49 with a sufficient category. Creativity skills have an average score of 59.32 with a moderate category. Collaboration skills have an average score of 65.18 with a moderate category. Communication skills have an average score of 69.70 with a moderate category. These results show that the 21st century skills of students at school are still relatively low. One of the talents students need to have in order to tackle global difficulties is a 21st-century skills, which is consistent with Frydenberg & Andone's (2011) assertion that everyone needs a 21st-century skills in order to compete globally in the 21st century (Herayanti et al., 2017).

A group of experts has recommended the key skills known as the "4Cs" for the New World of Work in the twenty-first century. Using critical thinking, creativity, the ability to handle real-world problems, and teamwork, the 4C talents can help address the world's concerns (Munawwarah et al., 2020). The 21st century education model is described by BNSP (2010) as having the following characteristics: utilizing educational technology; learner-centered learning; using creative learning methods; learning that is related to the real world and students' daily lives; and using a curriculum that can help students reach their full potential.

Nine learning criteria that are capable of instilling 21st-century abilities were developed by RAND corporation in 2012. The nine criteria are: curriculum that is pertinent to students' daily lives; learning that involves multiple disciplines; developing lower and higher order thinking skills; applying the knowledge gained to other areas or other disciplines that intersect with students' daily lives; teaching students how to learn; countering misconceptions in learning; learning in teams; using technology to support learning; and fostering students' creativity (Mayasari et al., 2016). Teachers who understand the value of education in meeting contemporary needs in the age of the global economy will undoubtedly work to provide their students the skills required for the twenty-first century. In order to survive and prosper in the increasingly ferocious competition in the age of globalization, learners need these skills (Anggraeni et al., 2018).

**Prototyping Phase stages**

The prototyping stage aims to design solutions to problems that have been identified at an early stage. The problem-solving design will later produce a work plan or written plan that will be realized in the form of an e-module based on an integrated inquiry model of the SETS approach to students' 21st-century skills using the Flip PDF corporate application. The stages carried out in the prototyping phase are:

a. Create an e-module based on an integrated inquiry model with the SETS approach to students' 21st-century thinking skills. The format of the e-module based on the integrated inquiry model with the SETS approach has several components, namely: 1)
The main menu contains the table of contents, a glossary, an introduction, learning activities, and a bibliography. 2) The introduction contains general and specific instructions for using e-modules, components of the inquiry model, and the SETS approaches, basic competence (KD) and competency achievement indicators (IPK), as well as learning materials and learning objectives. 3) Learning activities contain material descriptions, learning activities, learning videos, simulations, sample questions, and evaluation. 4) bibliography. The design view of the e-module can be seen in Figures 2, 3, 4, 5, and 6.

**Figures 2.** Displays the main menu on the e-module

**Figures 3.** Show Introduction to the electronics module
Figures 4. Display of Learning Activities on e-modules

Figures 5. Display of student activity sheets based on the inquiry model integrated with the SETS

Figures 6. Evaluation display on interactive e-modules

b. Develop product validation instruments that include material substance (correctness, depth, contemporary, and readability), learning design (titling, SK, KD, indicators, material, sample questions, evaluation, and references), display (navigation, typography, media, color, animation, and simulation), and software utilization (interactive, native).
**Stages Assessment Phase**

Product validation test

The assessment stage aims to evaluate the prototype by conducting a product validation test to determine the evaluation of the product design or teaching materials by experts. The evaluation aspect of the validity test consists of four components: the substance of the material, the learning design, the appearance, and the use of the software (Ministry of National Education, 2010). The assessment of the physics e-module based on an integrated inquiry model with the SETS approach was carried out by three experts, namely physics lecturers with doctoral degrees. Based on the results of the data analysis performed on the e-module, the validity test results were obtained, which can be seen in Table 3.

**Table 3. Data Analysis Results of Validity Test**

<table>
<thead>
<tr>
<th>No</th>
<th>Aspects assessed</th>
<th>Average of aspects</th>
<th>V – ah</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Substance of the material</td>
<td>86</td>
<td>87</td>
<td>Very valid</td>
</tr>
<tr>
<td></td>
<td>a. Correctness of the material</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. Depth of the material</td>
<td>82</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. Contemporary</td>
<td>77</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>d. Readability</td>
<td>92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Learning design</td>
<td>90</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Display</td>
<td>91</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Software utilization</td>
<td>91</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Based on the results of the data analysis from the validity test conducted in Table 3 above, the average validation value is obtained from the substance aspect of the material, which includes truth, depth, originality, and readability in the e-module based on the integrated inquiry model. The SETS approach is 84, with a very valid category. The truth in the substance aspect of the material in the developed e-module contains explanations that are made not to deviate from the truth of science, such as compliance with scientific principles that have been tested, the fact that the material presented is based on facts, and the fact that the material presented is logical or rational. The depth aspect of the substance of the material contains the suitability of the depth of the material being studied, which includes the completeness of the material, the development of the material, and the integration of the material with other materials. Currently, the substance aspect of the material contains compatibility with the development of science; this can be seen in terms of material that is applied in real or contextual life and can bring up new things that are influenced by the development of science and technology. Readability in the substance aspect of the material contains the use of standard grammar and is easy to understand (Depdiknas, 2010).

This explanation is also supported by research conducted by Yanuarti et al. (2022), which explains that the characteristics of e-modules as independent learning materials greatly affect the quality of writing and preparation. Systematic e-modules consist of units of learning activities that stand alone and can sometimes be studied non-linearly. Writers must use standard and easy-to-understand grammar as well as motivating and interactive
sentences so that e-module readers feel involved with the material being studied and as if the author is explaining it directly to the user. Therefore, the substance of the material in the e-module is quite important because it contains an explanation of the main points of learning and strategies for using the module for self-learning and self-evaluation (reflective).

Aspects of learning design, which include titles, SK, KD, indicators, material, sample questions, evaluation, and references to e-modules based on integrated inquiry models with the SETS approach, obtained an average value of validation by experts of 90 with a very valid category. The physics e-module based on the integrated inquiry model of the SETS approach that was developed already includes all design aspects recommended by the Ministry of National Education (2010), which include titles, SK, KD, indicators, materials, sample questions, evaluations, and references. The components of this learning design design lie in the introductory part and the e-module learning activities. The developed e-module will also emphasize students' being able to discovery on their own, lean on their own, and practice critical thinking and collaboration skills that are in line with the demands of today's 21st-century learning.

21st-century learning is learning that can develop competence as a whole. Proficiency and skills are needed to face the challenges of the 21st century. The summary of the international framework for 21st-century competencies formulated by the assessment and teaching of 21st century skills (ATC21S) Project includes: (1) ways of thinking, consisting of creativity and innovation, critical thinking, problem-solving, and decision-making; (2) ways of working, consisting of communication and collaboration; (3) learning tools, consisting of information literacy and ICT literacy; and (4) living in the world, consisting of local and global citizenship, life and career skills, and personal and social responsibility (Anggraeni, et al., 2018).

This explanation is also supported by research conducted by Munawarah et al. (2020) who explain in their article that skills are very important to pay attention to, learn, and understand, especially 21st-century skills. 21st-century skills include critical thinking skills, collaboration, communication, and creativity. Critical thinking skills are one of the skills required for 21st-century learning, so one's thinking skills must be constantly honed so that critical thinking develops and improves at a higher level, or higher order thinking skills. Students who can think critically will be able to solve problems effectively and make good decisions (Munawarah et al., 2020).

Display aspects, which include navigation, typography, media, color, animation, and simulation in the e-module based on the SETS approach integrated inquiry model, obtained an average validation value of 91 from experts with a very valid category. The developed e-module contains navigation buttons that make it easier for students to use the e-module; in each sub-point, there is a button that can be pressed and directed to the intended page, and in the developed e-module, there is a home button that makes it easier for students to return to the previous page. The developed e-module also contains simulations according to the material presented, making it easier for students to understand the material and also motivating them to engage in independent learning. The explanation above is also supported by research conducted by Suryani et al. (2022), which explains that display quality, which includes navigation, typography, media, color, animation, and simulation, is a very influential part of students' motivation to learn as a whole. independent. The characteristics of e-modules as self-study materials greatly affect the quality of their writing and preparation.

The aspect of software utilization, which includes interactiveness and originality in the developed e-module based on the integrated inquiry model, received an average value of validation by experts of 91 with a very valid category. The use of software in the
The development of e-modules is very important and greatly influences the role of e-modules in learning and helps achieve the learning objectives themselves. This explanation is also supported by Wahyuni et al. (2022), which explain that e-modules will be more interesting to be used as independent study material if they are supported by the right technology and according to the needs of students.

The e-module developed in this study is interactive in order to increase efficiency, motivation, and the ability to facilitate student learning in order for students to be more active in learning and consistent with student-centered learning in order for students to learn even better (Sari et al., 2022). Based on the overall results of e-module validation based on an integrated inquiry model with the SETS approach in Table 3, an average value of 87 is obtained with a very valid category. Riduwan (2012) revealed that teaching materials are said to be feasible and can be applied if 61% is obtained.

**Conclusion**

The following conclusions may be drawn from the data that has been analyzed in this study: 1) E-modules based on the inquiry model integrated with the SETS approach are appropriate for use as teaching materials on mechanical waves, traveling waves, and stationary waves for class XI MIPA SMA. 2) E-modules based on the inquiry model integrated with the SETS approach have all been proven to be effective in terms of content, learning design, appearance, and software use.

**References**


