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Development of Physics E-Module Integrated with PBL Model and Ethnoscience to Improve Students' 21st Century Skills

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Abstract: The 21'st century learning should be able to build students' abilities comprehensively. Students are expected to have 21'st century learning skills known as 4C skills, namely critical thingking, creative thingking, collaboration and communication. Meaningful learning is needed to improve students' 21st century skills, such as integrated physics learning with ethnoscience. Ethnoscience related to local cultural concepts integrated into e-module can be used as a learning resource. The purpose of this study is to describe the results of the preliminary research and development stages of the physic e-module integrated with PBL model and ethnoscience to improve students' 21 Century skills. This study is a research and development (R&D) type and the Plomp model. The instruments used were teacher and student interview sheets, self-evaluation sheets, validity and practicality questionnaires. Based on data analysis, the results of validity testing in the valid category with an average value 0.94. Then, the results of practicality testing in the very practical category with an average value 90.09. It can be concluded, the physics e-module integrated with PBL model and ethnoscience to improve students' 21st century skills is valid and practical for use in the learning process.

Keywords: Ethnoscience; PBL model; Physic e-module; Students' 21st century skills

Introduction

The 21'st century learning should be able to build students' abilities comprehensively including knowledge, attitudes, skills and mastery of ICT (Aabla, 2017; Afandi et al., 2019; Malik, 2018). This comprehensive ability is needed by students to think and act well in their lives (Abaniel, 2021; Ang, 2018; Malik, 2018). The 21'st century skills are a person's abilities broadly including knowledge, skills, work habits, attitudes, character to achieve success (Luka et al., 2019; Proud et al., 2020; Semilarski et al., 2021). Students are required to have new skills that are more adaptive as competency standards that students must have so that they are able to be successful in facing work and life in the future, known as 21st century skills (Asrizal et al., 2018; P21, 2019). Student's 21'st century learning skills known as 4C skills, namely critical thinking, creative thinking, collaboration and communication (Indarta et al., 2022).

Critical thinking is the ability to reach the right conclusions based on systematic and reasoned thinking so as to be able to provide many alternatives for each result of one's thoughts (Ariyana et al., 2018). Critical thinking is the skills to carry out various analyses, assessments, evaluations, reconstructions, decision making that lead to rational and logical actions (King et al., 2010). The indicators of critical thinking skills are elimentri clarification, basic support, inference, and advanced. Critical thinking skills are one of the keys to success in both education and work (Sukma et al., 2023).

Creative thinking is a skill for finding new things that have not existed before, being original, developing various new solutions for each problem, and involves the ability to produce new, varied and unique ideas (Leen et al., 2014). The creative thinking indicators used consist of four indicators, namely: fluency, flexibility, originality, and elaboration (Harisuddin, 2019).

Communication is a skill to express new thoughts, ideas, knowledge, or information, both in writing and orally (Greenstein, 2012). Indicators assessed on

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communication skills are in the form of conveying opinions and ideas appropriately (Husna, 2012), inferring information, using correct and effective sentences, and using appropriate punctuation marks (Amala et al., 2019; Nazifah et al., 2022).

Collaboration is the skill of working together effectively and showing respect for diverse team members, exercising fluency and willingness to make decisions needed to achieve common goals (Greenstein, 2012). Collaborating with others includes being able to work effectively and respecting different team members, demonstrating flexibility and a desire to be useful in making compromises to achieve common goals, and taking responsibility in collaborative work and assess each individual's contribution within the team (P21, 2011).

The essential principles of 21st century learning are that learning should be student-centered, collaborative, have context, and be integrated with society. The 21st century learning paradigm emphasizes students' ability to find out from various sources, formulate problems, think analytically and work together and collaborate in solving problems (Shidiq, 2016). 21st century learning also emphasizes students to form their skills independently. Education in this era also demands knowledge and technology in the development of students who will become human resources in the future.

The 21'st century learning is relevant to the implementation of the independent curriculum. Implementation of the independent curriculum is one of the government's efforts to improve the quality of learning so that it can improve students' 21st century skills. The implementation of the new learning paradigm in the independent curriculum must be able to ensure that learning practices are student-centered (Azis et al., 2022; Murron et al., 2023). In learning, students are actively involved in constructing their abilities by reading, solving problems, investigating, collecting information, analyzing information, and so on. In an independent curriculum, learning must also pay attention to the abilities, interests and talents, and needs of students by implementing differentiated learning. The implementation of the independent curriculum also supports the use of digital technology equipment in the learning process in the form of multimedia tools as a medium for delivering learning material to create fun, interesting, creative and innovative learning (Ananda et al., 2023).

In the 21st century, all fields have experienced rapid development, especially the field of ICT. In the field of education, the use of digital teaching materials can facilitate the learning process (Prayogi et al., 2023). E-modules are one of the easiest learning resources to use, because they can be studied anywhere and at any time, are more interesting, interactive, and can improve learning outcomes. E-modules were also chosen because they are teaching materials that students can use in independent learning, have complete descriptions of learning materials, exercises and evaluations that provide feedback on student learning. Electronic teaching materials such as an e-module can provide students with the opportunity to study learning materials in their own homes (Asrizal et al., 2022). Another advantage of e-modules is that they can be connected to the internet and directly present videos, thus encouraging increased student interest and motivation to learn (Sari et al., 2021).

The use of modules can be collaborated with models, methods and approaches in learning, one of which is the PBL model. The PBL (Problem Based Learning) model is problem-based learning that can improve students' 21st century skills (Suharyat et al., 2022). Several researchers have implemented the PBL model to improve students' thinking skills in science (Adhitya et al., 2023; Mahardika et al., 2022; Mareti et al., 2021). Other researchers investigated the influence of the PBL model on students' creative thinking skills in science subjects ('Adiilah et al., 2023; Murdiasih et al., 2022).

E-module development is also integrated with ethnoscience. Ethnoscience is an activity to transform society's original science into scientific science. Ethnoscience has an important role in learning because it encourages teachers to teach science based on culture, local wisdom, and problems that exist in society to create more meaningful learning (Nuralita, 2020). The ethnoscience approach is a process of scientific reconstruction original that develops in society to be transformed into scientific knowledge (Khoiri et al., 2018).

Incorporating ethnoscience into education, students will be encouraged to explore and appreciate their own cultural heritage, as well as the diversity of surrounding cultures (Hasibuan et al., 2023). Ethnoscience is considered appropriate to support science learning in the 21st century and an independent curriculum. Physics learning e-modules integrated ethnoscience can improve students' learning outcomes and motivation (Asra et al., 2021).

Research relevant to this research is Research relevant to this study is first, research by Sukma et al. (2023), which states that learning using the ethnoscience-based PBL-Networked learning model can increase students' interest in entrepreneurship and Understanding of Concept. Second, research by Nurhayati et al. (2023) which states that the PBL model can improve students' 4C skills. Third, research by

Pratama et al. (2023) which states that the implementation of the ethno-science approach in science learning is effective in increasing various abilities and skills of students such as thinking skills, problem-solving skills, process skills and scientific literacy. Fourth, research by Andani et al. (2020) which states that the use of ethnoscience-based worksheets can increase student creativity in processing material.

Based on the background stated, researchers are interested in developing an integrated science E-module with PBL and ethnoscience models to improve students' 21st century skills. The advantage of this development is the birth of teaching materials in the form of E-modules in physic learning that are valid, practical and effective for improving students' 21st century skills.

Method

This study is a research and development (R&D) type that is development teaching material in the form of physic e-module integrated with PBL model and ethnoscience to improve students' 21 Century skills. The development model used in this study is the Plomp model, which has three stages, namely preliminary research, prototyping stage, and assessment phase (Plomp et al., 2013). First preliminary research, which is to collect information about problems in the field and design the product to be developed. Second, development or prototyping phase a formative evaluation is carried out on the product being developed, formative evaluation activities are carried out through self-evaluation, expert review, one-to-one evaluation, and small group. Third, Assessments Phase is carried out in the field test phase, aiming to determine the practicality and effectiveness of the physic e-module developed in improving students' 21 Century skills.

The research was conducted in the first semester of the 2023/2024 academic year. The subjects of this study were students of class X at SMAN 4 Padang. The purpose of this study is to describe the results of the development of the physic e-module integrated with PBL model and ethnoscience to improve students' 21 Century skills in valid and practical criteria.

The design of physic e-module integrated with PBL model and ethnoscience must be validated first by experts before being tested. The aim is to determine the consistency of its component. The validity test carried out by three expert validators using an expert review sheet with 6 aspect, namely material substance, visual communication, learning design, software usage, PBL model, and ethnoscience assessment. The analysis used to test the validity is a proposed by Aiken (Syaifuddin, 2014). The assessment is done by assigning a number between 1 (ie very unpresentative or very irrelevant) to 5 (ie very representative or very relevant). The value of aiken v is obtained by using Equation 1.

$$V = \frac{\Sigma s}{[n(c-1)]} \tag{1}$$

Information:
s = r – I_o
I_o = The lowest value of validity assessment (lowest number = 1)
c = The highest value of validity assessment (highest number = 5)
r = Number given by validator

The results of Aiken's calculations range from 0 to 1 and the the validity category of an instrument can be seen in Table 1.

Table 1. Category of Instrument Validity Level (Retnawati, 2016)

Value	Category
V ≤ 0.80	Valid
0.4 ≤ V < 0.80	Currently
V < 0.40	Less Valid

Then the equation (2) for calculating practicality is:

$$\%\ \text{Practicality} = \frac{Total\ score}{Maximum\ score}\ x\ 100 \tag{2}$$

The results of practicality category of an instrument can be seen in Table 2.

Table 2. Practicality Category (Yanto, 2019)

Value	Category
81-100	Very Practical
61-80	Practical
41-60	Practical Enough
21-40	Less Practical

Result and Discussion

Preliminary research is the initial stage carried out in develops a product. The objectives of the initial research stage are to get information about the situation in the field provide an overview related to the product developer who will be designed. The activities carried out at this stage are needs analysis, student analysis, analysis of learning outcome, and analysis of learning settings. Information at this stage was obtained by observing several schools in Padang city. Then also collected initial data related students' 21st century skills.

The first analysis is problems in learning, namely students still experience difficulties in learning physics. The causal factors come from internal and external factors. Internal factors that have quite an influence on students' difficulties in learning physics are the motivation aspect in learning physics, which is 56.74%. External factors have quite an influence on students' learning difficulties in the aspects of learning resources and learning media, namely 67.14%.

The second analysis is the problem of using ICT in schools. In this analysis, a questionnaire instrument was used which was given to four physics teachers to identify teachers' difficulties in integrating ICT into teaching materials or electronic teaching materials. Analysis of teacher difficulty on the use of ICT in teaching material can be seen in Table 3.

Table 3. The Analysis of Teacher Difficulty on the Use of ICT in Teaching Material

Teacher Difficulty on the Utilization of ICT in Teaching Material	Value
Difficulty in creating E-teaching materials	78.13
Difficulty in mastering E-teaching material	82.81
Difficulty in mastering software	84.38
difficulty in creating E-teaching material use software	85.94
Difficulty using E-teaching materials in learning.	79.69

Based on Table 3, it can be seen that teachers experience difficulties in using ICT in teaching materials. According to the data from the analysis of teachers' difficulties in creating E-teaching materials and difficulties using E- teaching materials in learning, the respective scores are 78.13 and 79.69, which are in the range of 61-80 in the high category. Meanwhile, teachers' difficulties in mastering E-teaching materials, difficulties in mastering software, and difficulties in creating E-teaching materials using software show scores of 82.81, 84.38, and 85.94 respectively, which are in the 81-100 range in the very high category. From the data obtained, it can be concluded that teachers feel constrained and have difficulty in utilizing ICT in teaching materials.

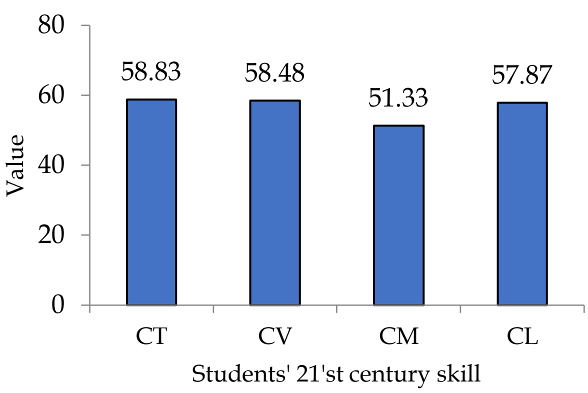

Figure 1. Students' 21st century skills in preliminary research

The third analysis is about students' 21st century skills. Component of 21 century skills are Critical Thinking (CT), Creative Thinking (CV), Communication (CM), and Collaboration (CL). Based on the test sheet instruments and performance assessment sheets given to students, the result of the analysis of students' 21 century skills in preliminary research can be seen in Figure 1.

Based on Figure 1 shows that students' 21st century skills still look low. Critical thinking skills are at the level of 58.83%; creative thinking 58.48%; communication 51.33%; and collaboration 57.87%. Based on this data, the average for each indicator of students' 21st century skills is in the low category and overall the average percentage of students' 21st century skills level is only 56.63%.

These findings indicate that there are problems in physics learning. Real conditions in the field show that students' 21st century skills are still low. To answer the challenges of the 21st century, physics learning should be carried out more adaptively and dynamically so that it can keep up with the transformation of education in this digital era. Current learning should integrate ICT in the learning process. To make learning more interesting so that it can increase students' motivation and interest in learning, but still improve students' scientific reasoning. One possible solution is to develop a physics e-module integrated with PBL models and ethnoscience to improve students' 21st century skills.

In the Development and Prototyping Phase, a formative evaluation of the product is carried out. Activities in this phase aim to design solutions to problems raised in the initial observation phase. Based on the results of the analysis, the solution provided is the development of physics teaching materials in the form of physic e-module integrated with PBL model and ethnoscience to improve 21st century thinking skills of class X students on global warming material. This e-module designed based on an e-module structure which consists of: Cover, Foreword, Instructions for Using the E-module, Learning Achievements and Objectives, Learning Activities, Student Worksheets, Exercises, Evaluation and Bibliography. The following is the appearance of the developed e-module.

Figure 2. Cover and menu of the e-module

Figure 2 shows that initial appearance of the e-module namely cover and menu. The cover displays the material title, author's name, affiliation, student grade level. Meanwhile, in the menu section there are menus contained in the e-module which serve as navigation in using the e-module. This e-module can be accessed online by students via the link provided by the teacher.

This e-module is integrated with the PBL or problem based learning model, as shown in Figure 3.

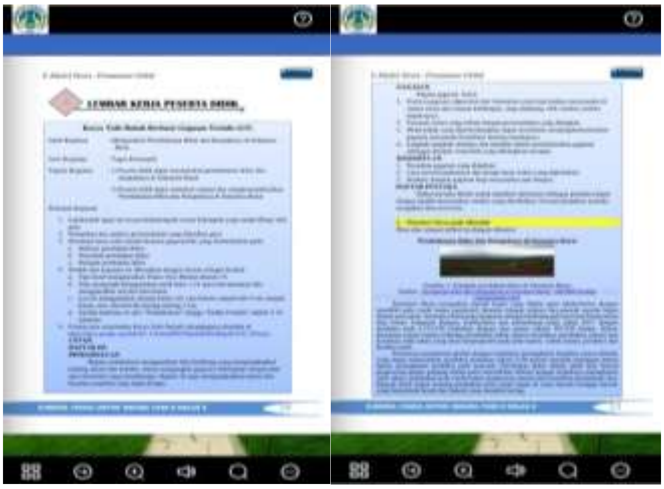

Figure 3. Integrated PBL model in e-module

Figure 3 shown that part student worksheets contained in the e-module. This section follows steps of the PBL learning model, namely student orientation to the problem, organize students to study, guiding individual or group investigations, develop and present work results, and evaluate the solution process problem. PBL is designed to help students: 1) build a broad and flexible knowledge base, 2) develop effective problem solving skills, 3) develop skills learn independently, think critically and be directed throughout life, 4) become effective collaborator; and 5) being intrinsically motivated to learning. Model PBL (Problem Based Learning) is problem-based learning that can improve skills 21st century students (Suharyat et al., 2022). Apart from the PBL model, this e-module also integrated with ethnoscience, as shown in figure 4.

Figure 4 shows that this e-module is integrated with ethnoscience, for example in the explanation of global warming material. Ethnoscience is integrated in the form of local wisdom of the people of West Sumatra in protecting nature, such as "forbidden forests". This is one of the efforts to prevent global warming. Ethnoscience has an important role in learning because it encourages teachers to teach science based on culture, local wisdom, and problems that exist in society to create more meaningful learning (Nuralita, 2020; Sari et al., 2021). Ethnoscience learning has an influence on learning, namely a positive influence in the form of appreciation for regional culture will emerge if the learning at the school being studied is in line with students' everyday cultural knowledge. This kind of learning process is called inculturation learning, student-centered learning will run effectively, due to the process of assimilation and accommodation of students' learning (Khoiri et al., 2018). Ethnoscience is considered appropriate to support science learning in the 21st century. This is in line with the the result of systematic literature review on 152 ethnoscience articles conducted by (Fahrudin et al., 2023), which states that the impact of ethnoscience in science learning can improve several skills, one of which is critical thinking skills.

Figure 4. Integrated ethnoscience in e-module

The first step that will be taken after making product is self-evaluation. self-evaluation, namely revising the designed E-module yourself. The instrument used at the self-evaluation stage is a self-evaluation sheet. The purpose of carrying out this self-evaluation is to check for possible errors that still exist in the E-module being developed before it is validated by experts. Some of the revisions resulting from the evaluation itself include correcting typos, language corrections, and revisions to images and layout. Next, the results of the self-evaluation will be analyzed and then the product will be revised to become prototype 1.

The second step that will be taken is an Expert review. Expert review is consulting and discussing the product that have been designed with experts. The results of the E-module design, which has been carried out by self-evaluation, are given to experts for validation. The e-module validation test in this research was carried out by 3 experts, namely FMIPA UNP lecturers. In this analysis, a questionnaire instrument was used which was given to three lecturers to identify validity of the e-module. Analysis of validity e-module can be seen in Table 4.

Based on the data in Table 4 that the six components of validation on the value V>0.8 in the valid criteria. This states that the physics e-module integrated with the PBL model and ethnoscience is feasible and can be used to assist learning activities. These six components, namely material substance, visual communication, learning design, software utilization, PBL model and ethnoscience are in the valid category with an Aiken's V value range of 0.86 to 0.97. The average result of the Aiken V analysis based on six components is 0.94 in the valid category. This shows that the validity of the physics e-module integrated with PBL models and ethnoscience on global warming material is in the valid category and suitable for use in learning.

Tabel 4. The Validity of Physic E-Module Integrated with PBL Model and Ethnoscience

Component	Validity's Value	Category
Material Substance	0.94	Valid
Visual Communication	0.96	Valid
Learning Design	0.95	Valid
Software usage	0.97	Valid
PBL Model	0.97	Valid
Ethnoscience	0.86	Valid
Average	0.94	Valid

Indicator of the material substance components consist of truth, material coverage, up-to-dateness, and readability. The validation results for each indicator are correctness 0.97, material coverage 0.92, contemporary 0.92, and readability 0.97. Visual communication component indicators consist of navigation, letters, media, color, animation, and layout. The validation results for each indicator are navigation 1.00, letters 1.00, media 1.00, color 0.92, animation 0.92, and layout 0.92.

Indicators in the learning design component consist of Title, learning outcomes, learning objectives, material, practice, evaluation, work steps, compiler and references. The validation results for each indicator are title 1.00, learning outcomes 1.00, learning objectives 0.96, material 0.92, exercises 0.92, work steps 0.83, organizer 1.00, and references 1.00.

Indicators for software usage components consist of writing software, development software, supporting software, interactivity, and originality. The validation results for each indicator are writing software 1.00, development software 1.00, supporting software 1.00, interactivity 0.92, and originality 0.92. Indicators in the PBL Model assessment component consist of orienting students to problems, and organizing students to learn, guiding individual/group investigations, developing and presenting work results, and analyzing and evaluating the problem solving process. Indicator analysis results the PBL model assessment component ranges from 0.92-1.00.

The ethnoscience assessment has a validation value of 0.86 with a valid category. Overall, the e-module has integrated ethnoscience well. Based on suggestions from validators, ethnoscience integration must be further improved to get optimal results, then ensure that evaluation instruments can measure students' 21st century skills well. After obtaining a validation score of 0.94 in the valid category and after being revised according to the validator's suggestions, the product became prototype 2.

The third step that will be carried out is One-to-one evaluation. One-to-one evaluation is carried out by asking for suggestions from product users, namely students, to assess the product that has been designed. This stage was carried out by three students with three different abilities. These three abilities include students who have high ability, medium ability, and low ability. The three students will be asked to provide responses and suggestions for the designed E-module. The purpose of the one-on-one evaluation is to see the practicality of the electronic teaching materials being developed. Some improvements to the e-module at this stage are adding pictures and learning videos, changing the colors on some pages, and adding a place to collect student assignments in the e-module. The revised result of this stage is called prototype 3.

The next step that will be taken is small group or micro evaluation carried out by applying the E-module designed to a group of students. The purpose of the small group evaluation is to see the practicality of the E-module being developed. This stage was carried out on nine students with three different abilities. These three abilities, namely three people representing high ability, three people representing medium ability, and three people representing low ability. The instrument at this stage is an e-module practicality questionnaire. The practicality results in small groups are shown in table 5.

Table 5. The Practicality of Physic E-module Integrated with PBL Model and Ethnoscience in Small Group

Component	Practicality's Value	Category
Usable	88.44	Very Practical
Easy To Use	87.11	Very Practical
Appealing	92.89	Very Practical
Clear	92.22	Very Practical
Low Cost	89.78	Very Practical
Average	90.09	Very Practical

Based on Table 5, it can be seen that the level practicality of the integrated physics e-module with PBL models and ethnoscience in small groups is average score 90.09 in the very practical category. The physics e-module was then revised according to respondents' suggestions and the design was perfected so that it became a prototype 4 or final product to then be applied in the physics learning process to improve students' 21st century skills.

Conclusion

Based on the results of the development of physics e-module integrated with PBL model and ethnoscience to improve students' 21st century skills can be used by teachers and students using their respective smartphones or other digital devices anywhere and anytime. The validity of the physic e-module integrated with PBL model and ethnoscience are in the valid category with an average value 0.94. Then, the practicality of the physic e-module integrated with PBL model and ethnoscience in small group evaluation are in very practical category with an average value 90.09. So, the physics e-module integrated with PBL model and ethnoscience to improve students' 21st century skills is valid and practical for use in the learning process.

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Author Contribution
A.D.F contributes to conceptualizing the research ideas, developing products, collecting data, analyzing data, and writing articles. A., a supervisor who managed this research activities from conceptualizing the research ideas to writing, reviewing and editing articles.

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Conflicts of Interest
The authors declare that there is no conflict of interest regarding the publication of this article.

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