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Development of Artificial Intelligence (AI)-Based Physics Learning Media Integrated with Bakpia: Expert Feasibility Test

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Abstract: This research aims to develop AI-based learning media integrated with the concept of bakpia in learning Physics on the topic of Temperature and Heat for students in senior high school. The research method used is the research and development (R & D) method with the 4D model modified into 3D, namely define, design, and develop because the main focus is the feasibility test. The integration of the bakpia concept with AI, Perplexity and ChatGPT, is in one phase of the syntax of the learning model that exists in each learning media. The resulting product has been tested and assessed through a feasibility test by 2 validators, namely lecturers who are material experts and media experts. The feasibility test results of learning media on the topic of Temperature and Heat in the form of E-Worksheet was 1.97, E-Module 1.84, and E-Book 2.01, all of which are in the feasible category. Based on this, it can be concluded that the AI-based learning media integrated with the bakpia concept on the topic of Temperature and Heat developed can improve the physics identity and 21st century skills of students in Senior High School as measured by questionnaires, observations, and written tests when this product is developed more widely.

Keywords: Artificial intelligence; Bakpia; E-book; E-module; E-worksheet; Physics identity

Introduction

In the 21st century, there has been great progress in science and technology throughout the world, including artificial intelligence (Rusilowati et al., 2016). The current globalization creates increasingly tight competition so that students must have 21st century skills (Turiman et al., 2012). Education is one of the areas of community life that is greatly influenced by advances in information and communication technology. The use of AI in education has also yielded good results. With AI, students can use technology correctly to find additional information about bakpia and the physics concepts contained therein.

One of the 21st century skills that need to be improved is critical thinking, science literacy, and problem solving skills (Algiranto et al., 2021). These abilities allow learners to analyze, evaluate, and formulate their opinions on how they understand complex physics concepts (Ubaidillah et al., 2023). However, in reality, students' critical thinking skills are still relatively low. Science literacy which is a combination of skills, values, attitudes, understanding, and knowledge about science is needed by students to develop investigations, problem solving, skills to interpret data and facts scientifically to understand learning concepts (Klucevsek, 2017). Facts in the field show that the science literacy skills of students in Indonesia are quite low. This is shown in the achievement of science literacy by the Program for International Student Assessment (PISA), Indonesia ranks 62 out of 70 participating countries (OECD, 2019).

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Students with good problem solving skills will have a better understanding of physics and show higher involvement in the learning process such as discussion and observation (Asiyah et al., 2021). However, most students still do not have good problem solving skills. For example, students fail to solve physics problems systematically, have difficulty understanding questions, have difficulty determining the theory, and have difficulty finding the formula used to solve physics problems (Markawi, 2015).

In addition to critical thinking skills, science literacy, and problem solving, students also need to build physics identity. Someone who has a high physics identity tends to feel challenged in learning things related to physics. Physics identity is related to interest, recognition from others, competence, and performance (Hyater-Adams et al., 2018). However, students' interest in learning physics is still low, which is indicated by the absence of students who actively ask questions about physics material explained by the teacher (Santika, 2024). The low interest of students can be caused by monotonous learning, less attractive learning media, and the lack of learning models used (Aswara et al., 2022). In addition, students' competence and performance are also still relatively low.

One of the causes of low critical thinking, science literacy, and problem solving skills possessed by students is the lack of teaching materials used in physics learning (Nurhasnah et al., 2020). Other indicators that indicate low critical thinking skills are in the ability to manage strategies and tactics, reasoning, and analysis (Azmi et al., 2024; Neswary et al., 2022; I. A. Rizki et al., 2025). In line with interest which is one of the keys to the success of physics learning from motivational factors and cognitive abilities (Amalina et al., 2025). Student interest can be increased through the right method (Septyowaty et al., 2023). The teaching materials provided for students in schools are limited in number and have not led to students' science literacy skills. In addition, students and educators consider that physics learning is one of the subjects that is difficult to understand. Therefore, more interesting learning media innovations are needed to increase interest in learning physics. Along with the development of technology in the world of education including AI, its use can provide several benefits that help students develop critical thinking skills, interest, motivation, and student involvement in learning and understanding physics concepts if accompanied by careful use (Fabio et al., 2025; Gontina et al., 2023; Harahap, 2024; Nurazreen et al., 2025). For this reason, proper AI integration is needed, including in learning media.

Based on the results of interviews with teachers, physics learning has never integrated local wisdom in it, so students also often question the implementation of physics concepts into everyday life. Therefore, the right learning model is needed such as the Guided Inquiry model, Contextual Teaching and Learning (CTL) and cooperative type think pair share and learning media integrated with local wisdom so that students feel interested in participating in physics learning and can understand temperature and heat material well.

Integration of local wisdom is important so that students still know, maintain cultural heritage, and remain sensitive to physical phenomena that also exist in their local culture (everyday) (Sakti, et al., 2024). In order to be more contextual and maintain local cultural wisdom, there have been several local Indonesian wisdoms that have been integrated into physics such as Wonosobo's typical ongklok noodles, Magelang's typical crackers, Pekanbaru's Bolu Kemojo, and North Sumatra's Langkat Pottery in the material on temperature and heat (Lumbangaol et al., 2024; Nurjannah, 2024; I. N. Rizki et al., 2024; Trisnowati et al., 2023).

Until now, there has been no AI-assisted learning media integrated with the local wisdom of the Yogyakarta region, namely Bakpia. In fact, making bakpia involves several physics concepts. First, during the kneading process there is a physics concept of pressure and changes in shape. Second, during the baking and cooling process, there is a concept of temperature, namely increasing and decreasing temperature. Third, during the baking process there is a physics concept of increasing temperature and changing heat which is marked by conduction events when hot from the pan, convection when steaming the bakpia filling, and radiation from hot steam that hits the bakpia filling when steamed. Based on this phenomenon, it can be concluded that temperature and heat are physical concepts that are interrelated in the heat transfer process (Benzaama et al., 2025). However, because the learning media focuses on temperature and heat, the bakpia concept used is in the baking and cooling process which involves changes in temperature and heat transfer. There are various sources of literature that mention students' difficulties in understanding temperature and heat material such as difficulties in understanding concepts, learning motivation, and building scientific knowledge contextually so that it can hinder students' understanding and learning outcomes (Haryono et al., 2024; Salame et al., 2025; Siregar et al., 2024).

Several physical concepts in the bakpia making process can be found with critical thinking and scientific literacy skills to find information related to it. AI is present not only as a search engine, but also to present content that can produce structured solutions and help personalize learning materials according to the needs and learning speed of each student (Sirnoorkar et al., 2024). Although more attention is needed from

educators so that the use of AI technology can really improve the achievement of the material, is used with the right ethics, and does not cause dependency (Selwyn et al., 2025; Wiese et al., 2025; Zhang et al., 2025). For this reason, supervision will be easier if AI integration is carried out directly during learning through media. Integration is carried out using AI as a technology that presents more adaptive, informative, and interactive content regarding the physical phenomena that occur during the bakpia making process. The manifestation of media assisted by AI technology can be in the form of print or digital media that is adjusted to the learning objectives and student abilities to be measured (Ayuni et al., 2024). In relation to 21st century skills, modules, books, student worksheets, websites, IoT, and comics have been developed that measure aspects of scientific literacy, problem solving, and critical thinking using natural phenomena as physical aspects (Aris et al., 2024; Hidayati et al., 2023; Izzah et al., 2023; Maryani et al., 2022; Matsun et al., 2022; Safarati et al., 2023).

In line with Payadnya et al. (2025) findings on the lack of cultural integration integrated with AI and the absence of research that raises the concept of heat temperature in Yogyakarta's typical bakpia food in AI-integrated learning media, then based on the description above, the problem found in this study is the feasibility of various AI-based learning media integrated with the concept of bakpia in the 21st century learning model to improve 21st century abilities. Therefore, multimedia in the form of E-Worksheet with Guided Inquiry model to improve critical thinking skills and physics identity, E-module with CTL model to improve science literacy skills and physics identity, as well as E-book with Think Pair Share Cooperative model to improve problem solving and physics identity.

Method

Define, at this stage five steps are used, namely initial analysis, learner analysis, task analysis, concept analysis, and formulation of learning objectives. Initial analysis was conducted to identify problems in learning by observation and interviews with physics educators in one of Yogyakarta's high schools. Participant analysis was conducted to determine the characteristics and needs of students in participating in physics learning. Task analysis is carried out by detailing the outline teaching material content tasks found in schools that are adjusted to the learning objectives in the Merdeka Curriculum. Concept analysis is carried out to identify the main concepts contained in Temperature and Heat Physics material. Specification of learning objectives is carried out to determine the dependent variable of the media to be developed.

Define, this stage aims to determine the requirements and needs in learning. There are five steps used, namely initial analysis, learner analysis, task analysis, concept analysis, and formulation of learning objectives. Initial analysis was conducted to identify problems in learning by observation and interviews with physics educators in one of Yogyakarta's high schools. Learner analysis aims to determine the characteristics and needs of students in participating in physics learning. Task analysis is carried out by detailing the outline teaching material content tasks found in schools that are adjusted to the learning objectives in the Merdeka Curriculum. Concept analysis is carried out to identify the main concepts contained in Temperature and Heat Physics material. Specification of learning objectives aims to summarize the analysis that has been done previously which includes initial analysis, learner analysis, task analysis and concept analysis. The results at this stage are used for the preparation of learning activities and learning tools to be developed.

Because it focuses on development and feasibility testing, student analysis is carried out by recording qualitative data on student learning experiences that have been taken so far. Meanwhile, the concept of temperature and heat contained in each process of making bakpia is integrated by being applied in contextual materials and assignments. Measurement of critical thinking skills, scientific literacy, and problem solving are in the written test assignments available in each media.

Design, this stage is carried out by compiling research instruments, selecting products developed, selecting formats, and making preliminary designs. Therefore, in this study, multimedia was made in the form of E-Worksheet with Guided Inquiry model to improve critical thinking skills and physics identity, E-module with CTL model to improve science literacy skills and physics identity, and E-book with Think Pair Share Cooperative model to improve problem solving and physics identity.

The purpose of developing critical thinking skills is so that students have the ability to make judgments, analyze, and make logical conclusions (Syukri et al., 2023). Learners' science literacy skills are useful for creating a higher quality education. Problem solving skills can help students build new knowledge and support the physics learning process. Develop, at this stage, a product will be produced in the form of E-Worksheet, E-Modul, and E-Book integrated with the concept of bakpia. Some of the steps taken are assessing the feasibility and validation of products by experts. The assessment results in the form of comments and suggestions will be used as a reference to revise the product before conducting a limited trial on students, so that the final product will be produced.

The main focus of inquiry-based learning is to involve students in learning optimally, learning objectives include directed and systematic activities, and foster students' confidence in what is found during learning (Saputra et al., 2016). The CTL learning model is an approach that connects learning materials with real situations so as to encourage students to make connections between the knowledge they have and their daily lives (Afni et al., 2020). Meanwhile, the think pair share cooperative learning model prioritizes students to play an active role in learning activities with their group mates to solve problems presented by the teacher (Rukmini, 2020).

The learning media created are differentiated based on learning objectives, 21st century skills being measured, and the learning model used. The first media, E-book, is used to measure problem-solving skills through the cooperative think pair share model, with one of its phases being pair by matching the answers from the discussion results and information obtained through Chat GPT. The second media, E-Module, is used to measure science literacy skills with the contextual teaching and learning model, with one of its phases being inquiry so that students as media users are able to observe and try to identify the types of thermometers as temperature measuring instruments with Perplexity AI. In the third media, E-Worksheet, which is used to measure critical thinking skills with the guided inquiry model, the use of Chat GPT is in phase 5, namely analyzing data to confirm the results of the analysis of several temperature and heat phenomena presented contextually. The concept of temperature and heat contained in each process of making bakpia is integrated into the material and assignments as contextual examples of physical events that occur in the student's environment. The following is a picture of the research flow diagram:

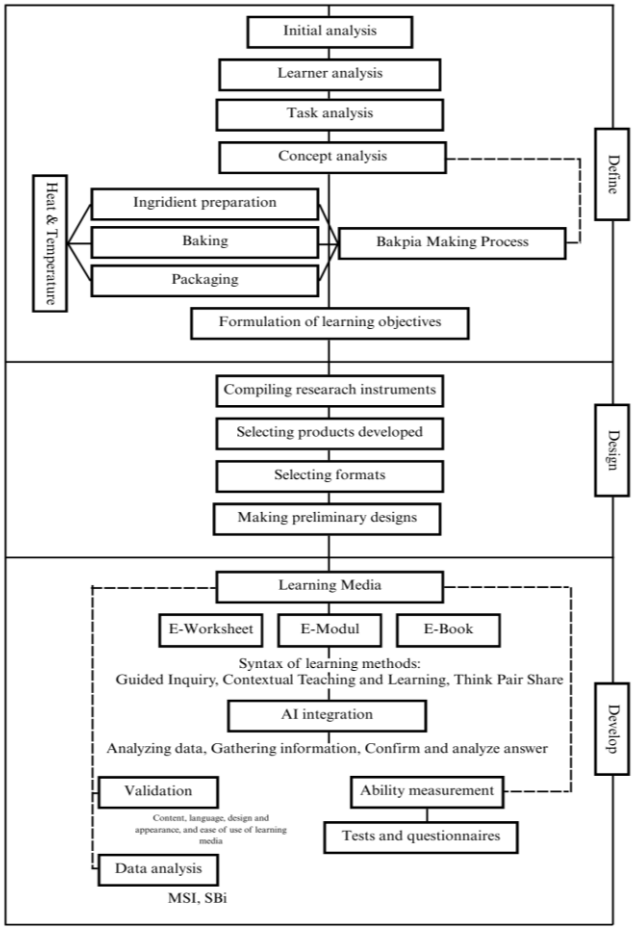
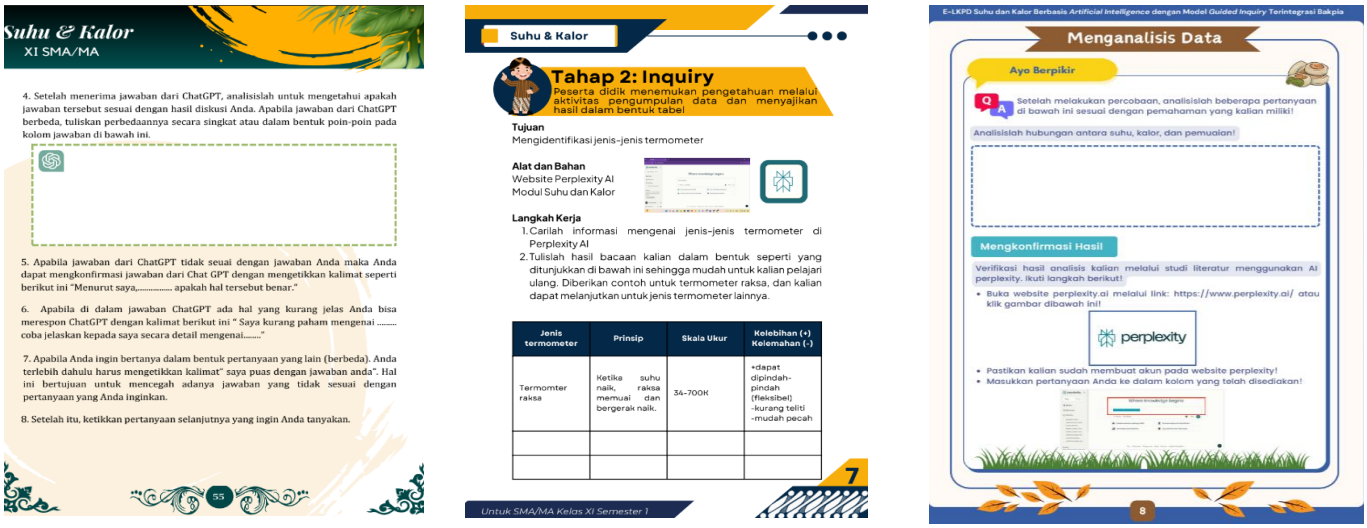


Figure 1. Research flow diagram

Below are examples of AI features found in each media:



(a) (b) (c)

Figure 2. AI Integration on each media (a) E-worksheet, (b) E-module, (c) E-book

This research was only carried out until the development stage because the type of research used was development research. The purpose of development research is to produce a product which will then be tested for feasibility or validity of the product that has been developed. Validation was carried out to 2 expert lecturers using a media feasibility sheet. The aspects measured on the 3 learning media are aspects of content, language, design and appearance, and ease of use of learning media. Quantitative data obtained in the form of product feasibility scores that have been developed. All questionnaire data obtained is still ordinal data, so it needs to be converted into interval data using the Method of Succsesif Interval (MSI). After being converted, the data is analyzed using the ideal standard (Sbi) with the following assessment criteria.

Table 1. Feasibility Criteria Using SBi

Score range	Category
$\bar{X} > \overline{Xi}$ + 1.5 SBi	Very feasible
$\bar{X}i$ + 1.5 SBi $\geq \bar{X} \geq \bar{X}i$	Feasible
$\bar{X}i > \bar{X} \geq \bar{X}i$- 1.5 SBi	Less feasible
$\bar{X}i$ - 1.5 SBi $> \bar{X}$	Very less feasible

Ordinal data in the form of eligibility score results (5, 4, 3, 2, 1) from all validators have hierarchical properties but do not have an equal distance between categories (very feasible to very unfeasible). MSI is used to overcome this limitation by transforming the data into an interval scale that meets the assumptions of parametric statistics. The method is to accumulate ordinal scores from validators on each aspect of eligibility and then convert them to percentages by comparing them to the ideal maximum score which is an objective criterion for evaluating learning media products or referred to as SBi (Ideal Standard Standard).

Results and Discussion

Define

The needs analysis stage of students conducted at SMAN 5 Yogyakarta then produced several findings such as students felt that Physics subjects were quite difficult to understand, one of which was on the topic of Temperature and Heat. Therefore, students expressed the need for learning media innovations that can support Physics learning. Meanwhile, students also revealed that learning Physics on the topic of Temperature and Heat is related to everyday life. However, there is no learning media that integrates Physics learning with real life or even integration with local wisdom.Based on this, there is a need for learning media innovations that utilize technological developments and are integrated with local wisdom. The media developed are E-Worksheet, E-Modul, and E-Book. Each media developed is based on Artificial Intelligence (AI) on the subject of Temperature and Heat with a 21st century learning model integrated with the concept of bakpia.

Based on this, a product in the form of AI-based Temperature and Heat E-Worksheet on Guided Inquiry integrated with the concept of bakpia to improve critical thinking skills and physics identity, AI-based Temperature and Heat E-Module on Contextual Teaching and Learning model integrated with the concept of bakpia to improve science literacy skills and physics identity, and AI-based E-Book on Think Pair Share Cooperative model integrated with the concept of bakpia to improve problem solving and physics identity of high school students.

Design

All Guided Inquiry syntax on E-Worksheet contains Temperature and Heat material integrated with the concept of bakpia, critical thinking ability indicators, and physics identity. At the Orientation stage there are narrative features, pictures, and videos about the process of making bakpia so that it can increase the interest of students. At the Problem Formulation stage, learners can raise questions by formulating problems with the help of KWL Chart so as to increase physics identity in the competence aspect. At the stage of formulating hypotheses, students are encouraged to formulate hypotheses based on the formulation of the problem so as to increase physics identity in the competence aspect. At the stage of collecting data, students can improve performance by conducting simple experiments (Saputra et al., 2016). At the stage of analyzing data Perplexity AI is used by students to analyze data. Finally, at the stage of formulating conclusions, students are directed to make conclusions with the help of KWL Chart so that they can improve the competence aspect (Agustina et al., 2020).

AI-based Temperature and Heat E-Module on Contextual Teaching and Learning Model Integrated with Bakpia Concept to Improve Science Literacy and Physics Identity. The E-Module developed has been adapted to the needs of students with the Contextual Teaching and Learning model. At the constructivism stage, students are provided with problems through videos of making bakpia so that students can identify the phenomenon of Temperature and Heat and increase aspects of interest. At the Inquiry stage, students are guided to formulate problems, collect data through activities, analyze and present data so as to improve the performance aspect (Nurhasnah et al., 2020). At this stage, students are also directed to use Perplexity AI as a tool in gathering information (Supriadi et al., 2022). At the Questioning stage, students are directed to ask

questions about the material they want to know so that they can improve the interest aspect. At the learning community stage, students will be formed into small groups to discuss material, share and work together to exchange information so that they can improve their physics identity ability on the competence indicator.

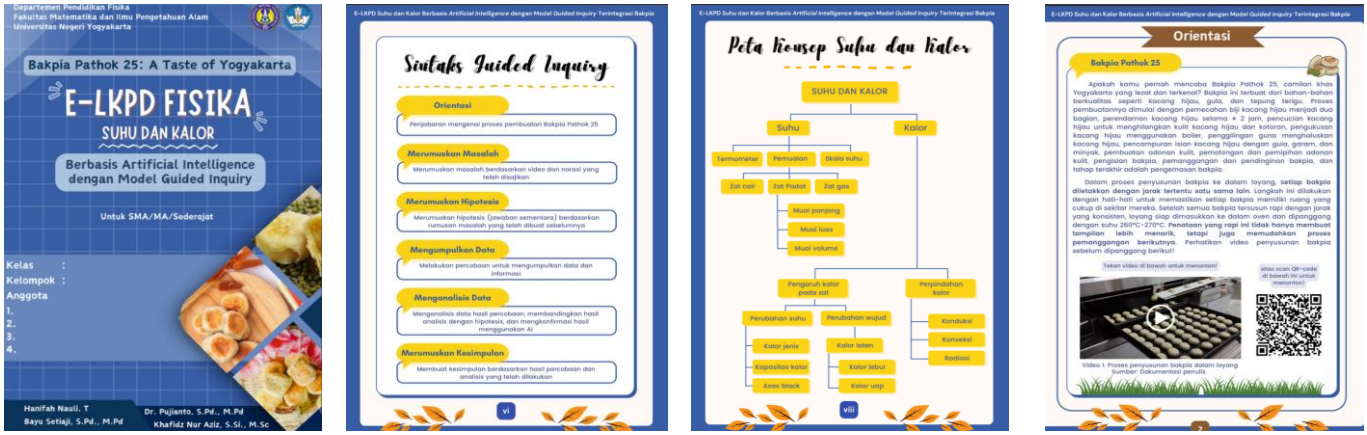


Figure 3. Display of the e-worksheet

The syntax of the fifth stage, namely modeling, students are guided by demonstrating a knowledge related to the material. Learners can observe videos or application narratives that have been provided. This can improve scientific literacy skills on indicators of analyzing scientific physics problems that apply the concepts of temperature and heat. The sixth stage syntax is reflection, students are given the opportunity to think back about what has been learned so that it can improve science literacy skills on indicators of analyzing scientific physics problems that apply the concepts of temperature and heat and physics identity on competence indicators. The seventh syntax is authentic assessment, students are directed to work on evaluation questions about temperature and heat material so that they can improve competence indicators and science literacy skills on indicators of analyzing scientific physics problems that apply temperature and heat concepts.

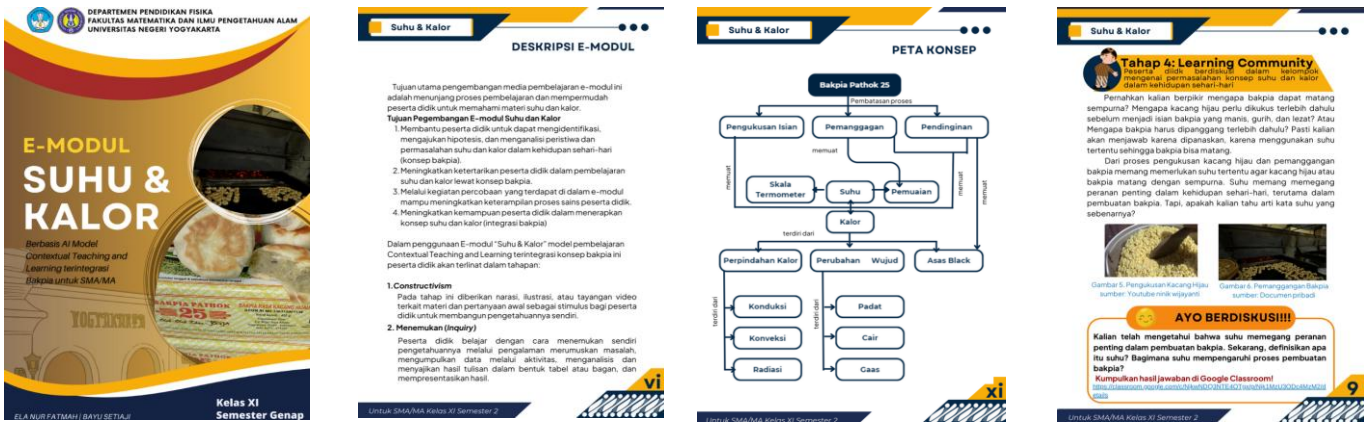


Figure 4. Display of the e-module

AI-based E-Book on Think Pair Share Cooperative model integrated with bakpia concept to improve problem solving and physics identity of high school students. The first syntax is Think presented a problem regarding the process of making bakpia. Then students are asked to solve the problem so that it can improve one of the problem solving indicators, namely problem identification and determining physics concepts. In addition, at this stage it can also improve one of the physics identity indicators, namely competence and interest (Sari, 2018). In the Pair stage, students are directed to discuss the problems in the previous stage. Chat GPT is used by learners to confirm and analyze answers. In addition, at the Pair stage, learners are asked to carry out experimental activities so as to improve problem solving indicators of determining physics concepts, applying physics concepts, and drawing conclusions as well as indicators of competence, interest, and performance. At the Share stage, students are directed to present the results of the discussion that has been obtained. At this stage, it is able to improve physics

identity indicators, namely interest and performance (Suwarno, 2020).

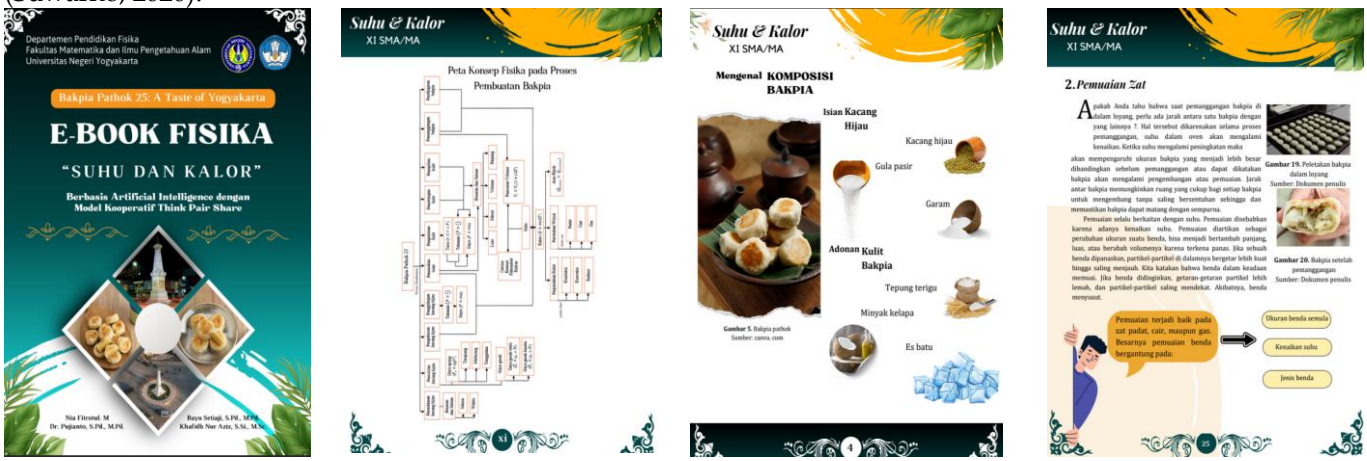


Figure 5. Display of the e-book

Develop

The feasibility of AI-based learning media integrated with the concept of nakpia was validated by 2 validators consisting of 2 expert lecturers. Validation was carried out by providing a validation questionnaire containing questions regarding the suitability of the preparation of learning media on the aspects measured.

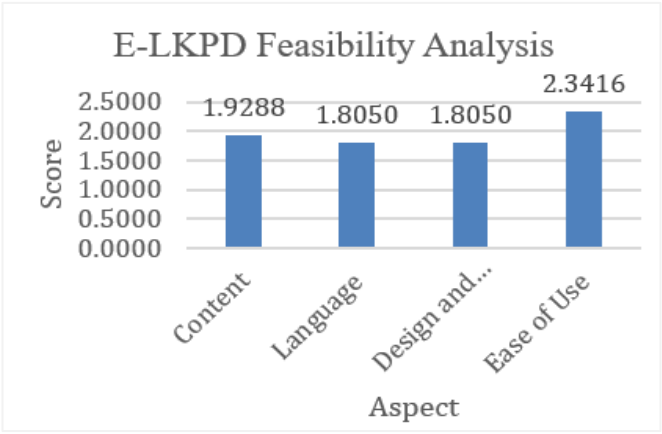


Figure 6. E-worksheet feasibility test results

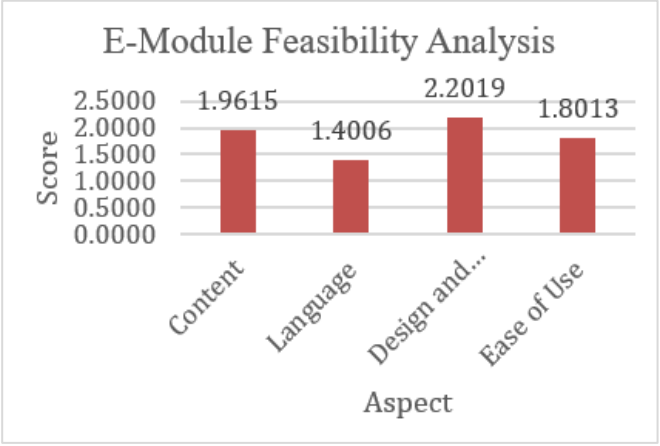


Figure 7. E-module feasibility test results

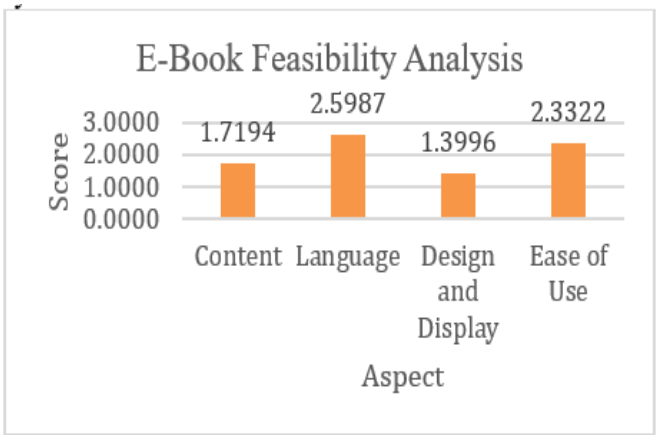


Figure 8. E-book feasibility test results

Criteria for eligibility for assessment are aspects of appearance, language and material suitability with validators, lecturers, media experts and material experts. The learning media is prepared based on the selected learning model with categories in the content aspect, namely feasible for E-Worksheet and E-Book and very feasible category for E-Module. This indicates that the selection of learning models on each media is very good for improving the research dependent variable. The content of learning media consists of product description, learning objectives, instructions for use, implementation of the learning process, sample questions, participant activities in the form of experiments, and practice questions. It contains a discovery learning syntax that is integrated with the bakpia concept and involves the use of AI in learning. Learners can independently explore the material, conduct simple experiments, design tools, and do practice questions.

The selection of bakpia is also considered appropriate or feasible to be implemented into Temperature and Heat material. This is because in the

process of making bakpia there is an application of the concepts of Temperature and Heat which can help students find the meaningfulness of Physics in everyday life. In line with research conducted by Wati et al. (2021) which states that the temperature and heat e-modules with local wisdom content are valid and feasible to use in learning.

Perplexity AI is considered valid and feasible to be used in E-Worksheet in Guided Inquiry learning model to confirm the analysis of students' answers. In the E-Module with Contextual teaching and Learning model, Perplexity AI is also considered valid and feasible to use in Physics learning which helps in finding the basic theory before the Learner Activity is carried out. The use of Chat GPT in Physics learning is selected on the E-Book with Think Pair Share Cooperative model.

Conclusion

AI-based E-Worksheet integrated with bakpia concept with Guided Inquiry model is feasible in content, language, design and display, also ease of use aspects in Physics learning to improve critical thinking ability and physics identity of high school class XI students. AI-based E-Modul integrated with bakpia concept with Contextual Teaching and Learning model is feasible to be used in Physics learning to improve science literacy skills and physics identity of high school students. AI-based e-book integrated with bakpia concept with Think Pair Share Cooperative model is feasible to use in Physics learning to improve problem solving and physics identity of high school students. This is based on the assessment of validators and student responses indicating a very feasible category for E-Worksheet and E-Book and a feasible category for E-Module. It is expected that the application of this media will be carried out more widely so that students experience improvements based on the results of data obtained from the use of instruments. Interactive learning media such as E-Modules, E-LKPD, and E-Books developed in this study can be used more interactively, accompanied by supporting visuals, and in accordance with student characteristics and developments so that students are interested, capable, and consider themselves as part of physics learning or have a physics identity. The results of the improvement can be seen through a questionnaire containing questions according to the physics identity indicators. Improvement in critical thinking skills, scientific literacy, and problem solving will be measured by pretest, observation of student performance during learning with learning media, and posttest.

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Conceptualization B. S.; methodology E. N. F.; validation R.P.; formal analysis N. F. M.; investigation P.; resources P.; data curation Y. M., and F. S. W; writing-original draft preparation E. N. F., N. F. M., and H. N.; writing-review and editing A. P. C. P.; visualization H. N. All authors have read and agreed to the published version of the manuscript.

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