

Development of a Physics Learning Module Based on the Scientific Creativity Project Model Integrated with Artificial Intelligence to Support the Sustainable Development in Education

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Abstract. To support the goals of sustainable development in education (SDGs), it is inseparable from the 21st-century learning framework. 21st-century learning has provided a framework known as 4C, one of which is critical thinking skills (CTS) and creativity. The critical thinking and creativity skills of high school students are still relatively low so they need to be improved. The purpose of this study is to create a suitable learning module (valid, practical, and effective) to support sustainable education. The method used in this study is the development method of Klein and Richey with a one-group pretest-posttest design type, the sample in this study was 180 high school students from various districts in Madura. The research instruments were validation sheets, implementation sheets, and pretest-posttest sheets. The results of this study indicate that the physics learning module integrated with artificial intelligence is proven valid with a validity level reaching 95% in the very valid category. Practically where the implementation of the learning module with this module reaches 95% is well implemented. The effectiveness of the module, with the N-gain analysis results, reached a score of 0.77, categorized as high. This result is reinforced by the results of the effect size test with a score of 0.57, which has a very positive effect on achieving learning objectives. Therefore, this module is suitable for improving CTS and scientific creativity so that it can achieve the SDGs.

Keywords: Modules, development, artificial intelligence, SDGs

Introduction

Education plays a crucial role in achieving the sustainable development goals (SDGs) (Alfathy et al., 2024) particularly SDG 4, which focuses on quality education (Astuty et al., 2024). Learning aligned with the SDGs aims to create an inclusive, innovative, and sustainability-oriented learning environment (Suprpto & Hidaayatullaah, 2023). The advantage of learning with an SDGs approach is its ability to instill sustainable values in students, such as 21st-century skills, including critical thinking, scientific creativity, and innovation (Rahayu et al., 2021). The SDGs offer hope for the education system, particularly in Indonesia. This hope is instilling character values and developing higher-order thinking skills, thus creating a generation aware of global issues and future

challenges (El-Kholei, 2023; Yi, 2023). Furthermore, SDG-based learning methods, strategies, and models also have the potential to narrow educational disparities by ensuring that every individual receives equal and quality learning opportunities (Mitarlis et al., 2023).

To achieve this, innovation in learning, particularly in physics learning in high schools, is necessary. Technological advancements are key to developing learning innovations. Among the rapidly developing technologies currently available are the internet of things (IoT), digital learning, and artificial intelligence (AI) (Heeg & Avraamidou, 2023). Each of these technologies has its own limitations and advantages in application. One advantage of AI technology is its ability to process information with various keywords very quickly. This advantage can be utilized by teachers to explore students' thinking skills at a higher level. The use of AI technology in the learning process has a positive impact (Filiz et al., 2025). AI can help students discover information, knowledge, and technology, and its application in everyday life (Jiao et al., 2024). With the various advantages of the technology mentioned above, it is hoped that it will contribute to the learning process, thereby indirectly improving the quality of education, particularly in Indonesia, on a sustainable basis. The presence of AI technology in the learning process will offer new opportunities for engaging students in every investigative activity, fostering critical and creative thinking (Shofiyah et al., 2024).

In reality, Indonesia's education ranking is still relatively low, this is based on the results of research conducted by PISA in 2015, Indonesia was ranked 64th out of 72 OECD participating countries where Indonesian students' abilities in science were at levels 1 and 2 of the 6 existing levels (creativity) in the field of scientific literacy (OECD, 2015). In 2018 and was ranked 69th out of 79 countries with a science score of 396 out of a maximum score of 850 (OECD, 2018). In 2022, the science literacy score of 383 decreased by 13 points from 2018 (OECD, 2023). One of the causes of Indonesia's low education ranking compared to other countries is the learning process which is still conventional (Sumo & Soeharto, 2025). This is evidenced by research conducted by researchers in 2023/2024, which found that learning was still ineffective because students felt bored with lecture-style material and tended to play with their phones during the learning process (Sumo et al., 2024; Wahyuni et al., 2025). Several researchers have attempted to address the low quality of learning by improving students' critical thinking skills (CTS) and scientific creativity, including developing physics learning modules based on the scientific creativity project model integrated with AI as teaching materials in the physics learning process.

A learning module is a teaching material containing descriptions of material, practice questions, and scientific exploration through scientific investigation activities. Modules, which can be hard copies or electronic copies, are a key component as a learning resource for finding relevant information related to scientific investigations. The existence of learning modules is not merely a complement to the learning process; the learning model, as the main support for the module content, is a distinctive feature of the module in achieving learning objectives. There are many modules that have been developed by previous researchers, including the science learning module developed by Wahyuni et al. (2025) in this module it is presented how the role of the module in contributing as a teaching material that can improve high-level thinking skills. Research conducted by Barelli et al., (2025) science learning modules are integrated with AI, in this study states that the role of the module as a science teaching material has an impact on the level of student activity after integration with AI. Different research results were conducted by Barelli et al. (2025), The researcher developed a physics learning module to improve physics knowledge about Einstein's theory of energy, after using the learning module that has been developed, student knowledge has increased, this can be seen from the posttest which is 31% higher than the initial test. Handayani et al. (2023) has developed a module that is integrated with students' metacognitive abilities based on a virtual laboratory, the results state that the module has a positive impact on students' abilities after experimenting with the virtual laboratory.

The aforementioned studies demonstrate that learning modules have a positive impact on various student science learning activities, such as modules integrated with AI, modules developed based on knowledge content, and modules integrated with virtual laboratories. However, none of these studies have specifically integrated learning modules with AI to enhance 21st-century skills, such as critical thinking and scientific creativity. AI's role extends beyond simply guiding learning; it is expected to serve as a bridge to stimulate and assist students in mastering 21st-century skills, namely critical thinking and scientific creativity (Dahlkemper et al., 2023). Therefore, AI should be part of ongoing research in education. Comprehensive physics learning modules that accommodate 21st-century skills are a core component of the physics learning process, exploring students' thinking abilities (Dahalan, 2020).

The novelty of this research is the integration of learning modules developed based on the scientific creativity project model with AI to simultaneously enhance students' critical thinking and scientific creativity. To achieve this, this study uses two approaches: knowledge exploration using an AI-based website. Second, the results of this knowledge exploration are implemented in a project, transforming scientific knowledge into a product, either an idea or a tangible object. The goal of this study is to create a viable module (valid, practical, and effective) to enhance students' CTS and scientific creativity, supporting the SDGs in sustainable education.

Methods

Based on the background of the problem and the research objectives outlined in the introduction, this study uses the development research method from Richey & Klein, (2005). This method is used because the process produces a new creative product through systematic and planned steps, with each step being evaluated (Sugiyono, 2018). This research was conducted in public senior high schools in four districts in Madura with a sample of 180 grade XI science students. The research flow is shown in Figure 1.

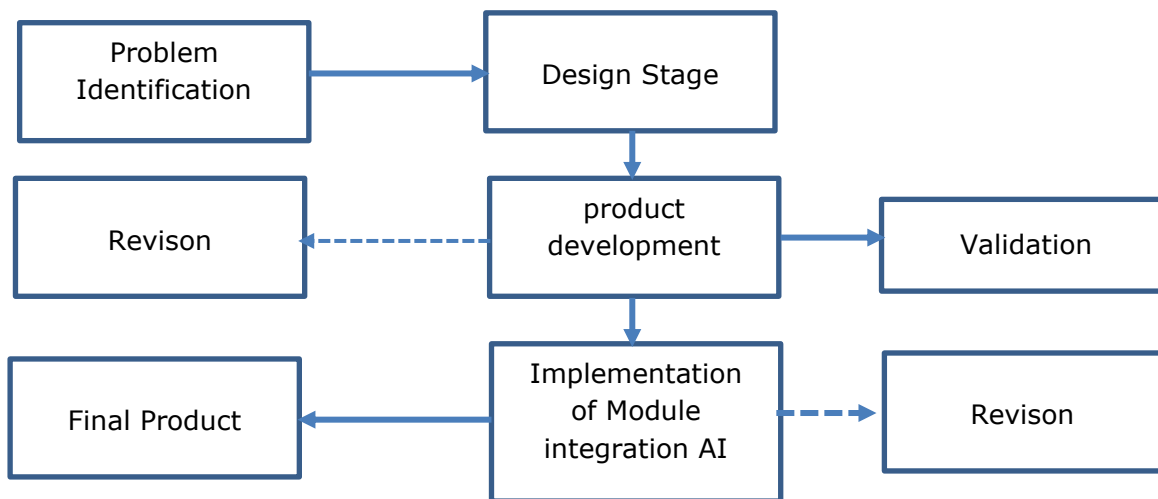


Figure 1. Flowchart of research and development (Richey & Klein, 2005)

Figure 1 shows the stages of development research adapted from Richey and Klein. In the first stage of problem identification, the researcher focuses on a problem to be studied. In this case, the problem is low CTS and scientific creativity. This data was obtained from the results of previous research studies and initial research in the field when the researcher used the scientific creativity project integration AI model in the physics learning process. The results of the problem analysis indicate a need for learning tools that can facilitate the limitations of current learning tools such as the lack of teaching materials

that are not integrated with learning technologies such as AI. The second stage, designing learning tools including learning modules, student worksheets (LKPD), and tests. After the design was carried out, the researcher sought someone who was an expert in the field of learning technology, language experts, and learning pedagogy. These experts were asked to review the learning tools that had been prepared. After the review was carried out, the next stage was the development of learning modules.

In the third stage of module development, researchers integrated the AI into the learning module. This was done to facilitate real experiments to improve CTS and scientific creativity through the AI Website. After integrating the module with AI, the next step was to develop LKPD. Students were given access to a QR code that led to a Google Sites website containing AI. Students scanned the QR code to develop scientific creativity by reading and understanding the provided e-book. Afterward, students wrote down physics concepts and proved these concepts by conducting virtual experiments based on previously identified scientific phenomena. The developed device was then validated by three experts to determine its validity and reliability.

In the fourth stage, evaluation was carried out. The developed device was then tested on a limited basis with students. The results were then analyzed for shortcomings in the learning device, which consisted of a module. The practicality of the device was then evaluated. After assessing its practicality and effectiveness, the module was refined to become the final product, the fifth step in this development. It was then implemented in a large-scale trial or product testing. Valid, practical and effective products can be used to collect research data because their wettability has been tested in real time (Plomp & Nieveen, 2010)

The validity of the module and learning tools was determined by the assessment results of three validators who were experts in the fields of language, learning technology, and pedagogy. The learning tools that were validated were the physics teaching module, LKPD, and Test. The validation results were then analyzed using the formula from Aiken's v (Hasanah et al., 2023; Kamaliya et al., 2023). The validity of each item was calculated using formula 1. Meanwhile, to calculate the overall validity, formula 2 was used. Meanwhile, to calculate the reliability of all validity aspects, the formula from Cronbach's alpha (Mendes et al., 2021) was used as shown in Formula 3. After obtaining the validity score, it was then converted into a percentage.

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

$$V = \frac{\sum s}{mn(c-1)} \quad (2)$$

$$r_{ac} = \left(\frac{k}{K-1} \right) \left[1 - \frac{\sum \sigma_b^2}{\sigma_t^2} \right] \quad (3)$$

Information:

V : Item assessment index from experts
S : r-lo
r : Scores given by experts
lo : Lowest score from validator
n : number of validators
m : Item number
c : Number of categories selected by the validator
 r_{ac} : Alpha cronbach's reliability coefficient
k : item number
 $\sum \sigma_b^2$: Number of variants per item
 $\sum \sigma_t^2$: Number of variants

After calculating the validity and reliability scores of the learning devices, categorization is carried out based on the criteria as presented in Table 1.

Table 1. Validation result criteria

Number	Validity score (%)	Validity level
1	81-100	Very valid
2	61-80	Valid
3	41-60	Quite valid
4	21-40	Less valid
5	<21	Invalid

(Source: Arikunto, 2010)

To calculate the practicality of the AI integrated physics module using the implementation observation sheet, the observation results are then calculated using Arikunto's (2010) practicality equation, such as formula 4.

$$\text{Practicality Score} = \frac{\text{Score obtained}}{\text{maximal score}} \times 100\% \quad (4)$$

After calculating the module practicality score, categorization is carried out based on the criteria as presented in Table 2.

Table 2. Practicality result criteria

Number	Practicality scores (%)	Level of practicality
1	81-100	Very practical
2	61-80	Practically
3	41-60	Quite practical
4	21-40	Less practical
5	<21	Not practical

(Source: Arikunto, 2010)

To calculate data on increasing CTS and scientific creativity, the N-gain formula (Hake, 1998) is used as shown in formula 5.

$$N - \text{gain Score} = \frac{S_{\text{post}} - S_{\text{pre}}}{S_{\text{max}} - S_{\text{pre}}} \quad (5)$$

After calculating the N-gain score, it is categorized into criteria such as Table 3.

Table 3. N-gain result criteria

Number	N-gain Score	N-gain criterion level
1	$g \geq 0.7$	High
2	$0.3 \geq g < 0.7$	Currently
3	$g < 0.3$	Low

(Source: Hake, 1998)

To determine the effectiveness of the integrated inquiry-based module AI can be seen from the completion of CTS indicators (Ennis, 1993), namely: providing simple explanations, building basic skills, making inferences, providing further explanations, organizing strategies and tactics. Then calculate the achievement score for the scientific creativity indicator (Hu & Adey, 2010), namely: identifying scientific phenomena, providing explanations for scientific phenomena, deepening scientific knowledge, solving problems, designing products, analyzing products, and evaluating scientific evidence.

The research data consisted of validity, practicality, and effectiveness data calculated using excel with the minimum criteria of validity, practicality, and effectiveness. Effectiveness data was calculated using SPSS 18 by looking for an increase in posttest

scores compared to pretest using the N-gain calculation and the completeness of CTS and scientific creativity indicators (Sudjana, 2004). After the N-gain calculation is done, then the pretest and posttest data are tested statistically, namely the Wilcoxon test and effect size. This is done to strengthen the effectiveness data of N-gain. The Wilcoxon test results follow the sig-2 tailed criteria smaller than 0.05, then there is a significant difference in the pretest and posttest scores, but if the sig-2 tailed value is smaller than 0.05, then there is no difference in the average pretest score compared to the posttest. Next, the effect size score is calculated to see the effectiveness of learning using a module integrated with AI. Before the Wilcoxon test is carried out, a normality test is first carried out with the criteria of Sig value $> \alpha = 0.05$, then the data is normal, but if the Sig value $< \alpha = 0.05$ the data is not normal, in addition to the normality test, the homogeneity test is first with the criteria if Sig $> \alpha = 0.05$, then the data is homogeneous, but if Sig $< \alpha = 0.05$ then the data is not homogeneous. If the data is not normal and not homogeneous, a non-parametric statistical test is carried out (Sudjana, 2004).

Results and Discussion

The results of the development research in the form of findings from the module developed with the title "physics learning module based on scientific creativity integrated with AI" to meet the eligibility criteria can be seen in the following stages:

Problem Identification

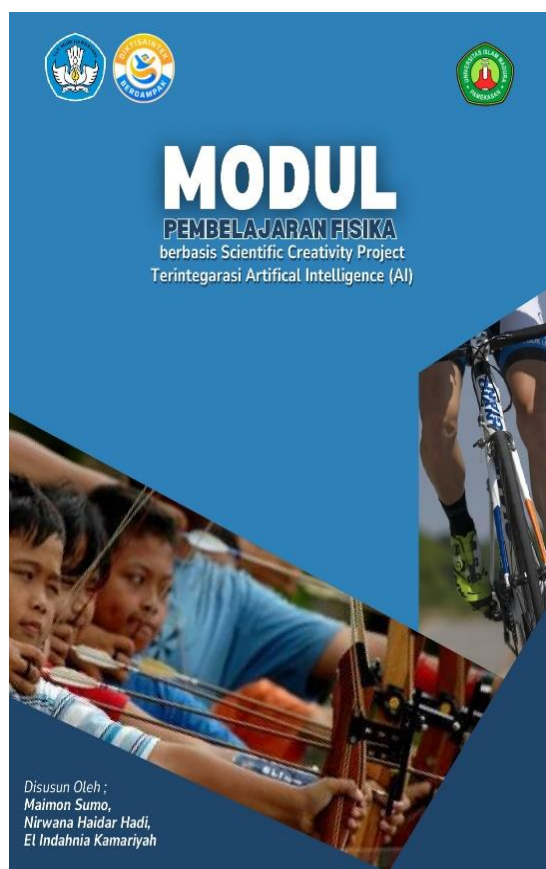
The results of the problem identification in this development research include findings from students and findings from teacher teaching activities. The first part of this study is a description of the analysis of field findings, which are empirical facts. The first finding stems from interviews and observations with students at SMAN 4 Pamekasan. The research findings indicate that students' physics scores are still relatively low, as evidenced by the results of daily exam reviews and teacher assignments, which are still below the school's minimum score of 75. This was followed by interviews between students and the researcher. Based on the interviews, students expressed that physics learning is difficult, and that they require memorizing numerous formulas, making it difficult to differentiate between them.

The researcher then conducted interviews with teachers. The interviews revealed that during the learning process, teachers use the same models, methods, and strategies at every meeting. Meanwhile, the learning resources used are still based on books provided in the library. This finding was reinforced by the researcher's observations of teachers teaching physics in class. Teacher observations tend to emphasize only the cognitive level of memorization and understanding, for example, requiring students to memorize physics concepts and formulas. This contrasts sharply with the concept of 21st-century learning, which emphasizes four core competencies: critical thinking and problem-solving, creativity and innovation, communication, and collaboration (Sumo & Soeharto, 2025). Furthermore, learning with 21st-century skills emphasizes the learning process to enhance metacognitive abilities through innovative learning processes (Andres & Rosalinda, 2023).

Based on these findings, researchers developed learning resources with more innovative models. This was done to address the limitations outlined above. The development of physics learning modules represents a concrete step toward changing the paradigm of the learning process, which has remained conventional and monotonous. The development of learning modules serves as an alternative solution to problems (Ion & Popescu, 2025). The developed learning modules are integrated with AI technology. Modules that are integrated with technology to make it easier for readers to understand and access the information they need (Barelli et al., 2025).

Design Stage

The second stage of this development research is the module design stage. In this stage, the learning module is designed based on the needs of the learning process, namely through identification. The characteristics of the developed learning module include the integration of physics learning with AI technology. The use of AI in learning facilitates filtering and confirming information found (Al Sagri & Sohail, 2024; Yannier et al., 2024). The characteristics of the developed physics learning module are to support the SDGs. SDGs in learning support improving the quality of learning outcomes through increased scientific creativity and critical thinking. One of the SDG goals is improving the quality of education, which can be achieved by improving the learning process (Pangsuma et al., 2024). The learning module, as a learning resource to achieve learning objectives and learning success, is one factor in improving the SDGs in education (Alfathy et al., 2024). In this module, students will learn about oscillations or simple harmonic motion based on the syntax flow of the scientific creativity project model integrated with AI. Students observe scientific phenomena as a scientific orientation. Based on scientific observations, students identify problems and then study physics material to connect them to the observed phenomena. Students can scan QR codes to learn more about the material and product design. This knowledge exploration activity provides a more meaningful learning experience (Orozco, 2024; Shofiyah et al., 2024). The design results of a physics learning module based on the scientific creativity project model and AI integration are shown in Figure 1.



a



b

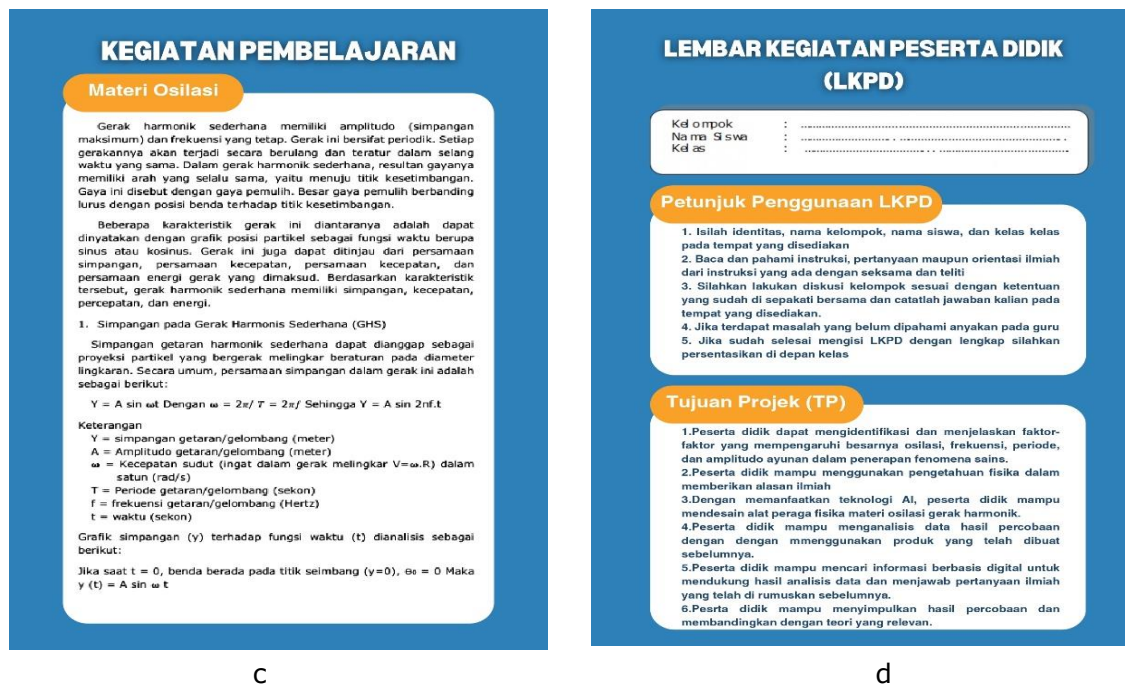


Figure 2. Design SCP AI module: (a) module cover, (b) module content of phenomena, (c) activities of learning, (d) LKPD

Product Development

After the module is designed, the module is then developed. The development stage begins with the development of a website in the form of Google sites containing AI content to support learning activities and find the information needed. These Google sites consist of e-books on complex physics material, the PhET website for viewing experimental simulations, and an AI website about physics and its applications. Before entering this website, students first scan the barcode provided in the module as shown in Figure 3a. After scanning, students are directed to the website as shown in Figure 3b.

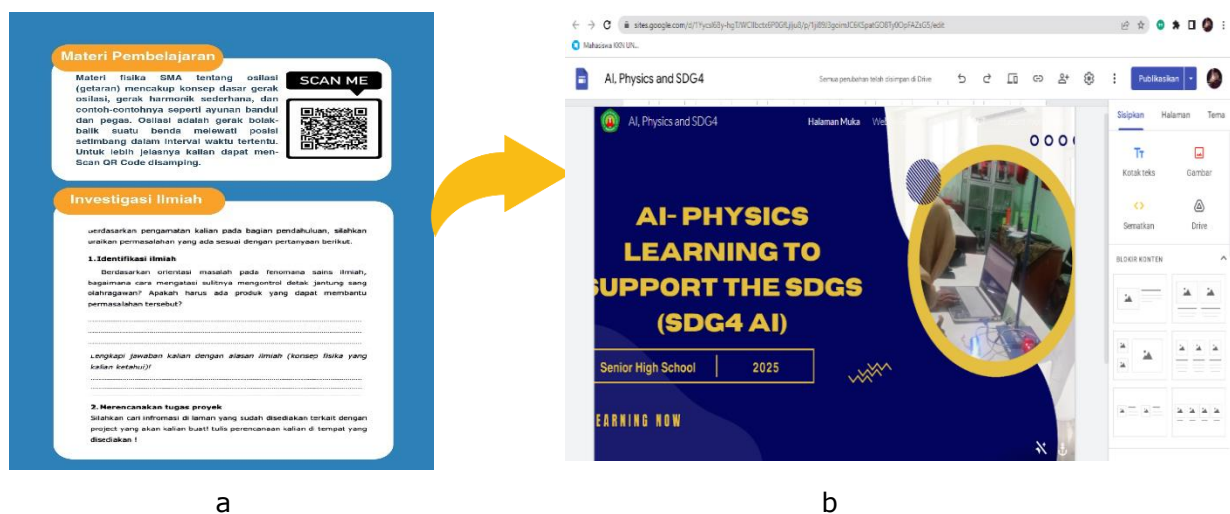
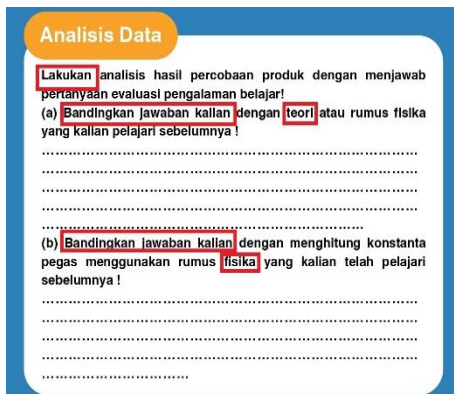


Figure 3. Results of AI integrated module development: (a) QR code, (b) AI integrated website

The developed module was then consulted for review by three reviewers from Madura Islamic University and Surabaya State University. These three reviewers also served as validators for the module and other supporting tools. The three reviewers included three experts in language, learning technology, and pedagogy. The module review results provided input and suggestions for improvements before validation. The reviewers' input is shown in Table 4.

Table 4. Suggestions and input from reviewers

Revision	Before	After
Problem-oriented based phenomena need to be accompanied by images.		
On the student activity sheet or LKPD, write down trigger questions when students observe the phenomenon.		
There are still sentences that are not standard and there are typos in the data analysis section.		

Based on Table 4, the module reviewers provided suggestions on several conceptual and technical components. Overall, the module received positive feedback and was considered worthy of further development. The reviewers' suggestions and input were used to improve the module and then validated. The module validation results are shown in Table 5.

Table 5. Validator assessment results

Number	Rated aspect	Validator assessment (%)			Average value (%)	Category
		1	2	3		
1	Relevance of module content to the topic	100	95	97	97	Very valid
2	Language Accuracy	90	89	92	90	Very valid
3	Suitability of AI applications with learning outcomes	100	90	98	96	Very valid
Average validator value		97	91	96	95	Sangat valid

Based on the results of the validation analysis from three experts in their respective fields. The physics learning module based on the scientific creativity project model integrated with AI to improve scientific creativity and critical thinking to support the SDGs goals received an average score from three experts of 95% in the very valid category. The results of the average score for each aspect received a score of 97% in the aspect of the relevance of the module content to the topic, the accuracy of the language received a score of 90%, the suitability of the AI application to the learning outcomes of 96% with the very valid category. These results indicate that the physics learning module is relevant and in line with the research objectives to be achieved, namely valid. These results are in line with the results of research conducted by Wahyuni et al., (2025) which stated that a valid learning module meets the aspects of content, constructs and components in accordance with the objectives. This learning module integrates innovative models with AI technology. Modules designed and integrated with AI technology make it easier to find information according to the desired algorithm (Barelli et al., 2025) The results of research conducted by Asih et al. (2022) stated that learning modules that fulfill all aspects of learning needs can be categorized as valid module characteristics.

Implementation of Module integration AI

After the module was declared valid, an implementation was carried out to see the practicality of the module. The results of the module's practicality were seen from the implementation of learning observed by three observers. The instrument used was an observation sheet for the implementation of learning activities during the learning process in the classroom. The learning used a physics learning module based on the scientific creativity project model integrated with AI. Observations of the implementation of learning focused on: (1) problem orientation based on scientific phenomena, (2) the process of deepening physics material activities with the help of AI, (3) scientific investigations based on AI technology, (4) Analysis of investigation results, (5) evaluation of learning experiences. The results of the analysis of the learning implementation observation sheet are shown in Table 6.

Table 6. Results of practicality assessment

Activities assessed	Meeting (%)				Average value (%)	Category
	1	2	3	4		
Problem orientation based on phenomena contained in the module	95	97	100	100	98	Very practical
The process of deepening physics material with the help of AI	90	96	98	100	96	Very practical
AI Technology-based scientific investigation	92	88	92	94	91	Very practical
Analysis of investigation results	92	90	90	93	91	Very practical
Evaluation of learning experiences	90	95	97	100	95	Very practical
Total	92	93	95	97	94	Very practical

Based on the results of the practicality analysis as shown in Table 6, the implementation of the learning process during the four meetings achieved an average score of 94%, which was carried out very practically. The learning activities assessed by observers were problem-based orientation based on phenomena contained in the module well, in this aspect reaching 98% implemented with the category of very practical. The teacher was able to prepare students by providing problem-based phenomena as an initial opening for learning. Meaningful learning activities can begin with a phenomenon that provides interest in subsequent learning (Engelschalt et al., 2023). The physics deepening process obtained a percentage of 96%, the teacher successfully guided students in using AI technology to find information related to the required material. Mastery of the initial material has a positive effect on the subsequent learning process (Hu, 2024). The process of student activities in project-based activities obtained a percentage score of 91%, then continued to analyze the results of the investigation and evaluate the learning experience which reached 91% and 95%, respectively. Students were able to carry out project activities with the teacher as a consultant for the completion of student assignments. Collaborative activities between students and teachers have a positive impact on the success of the learning process (Chang et al., 2022; Hartini, 2021; Reith & Nehring, 2024). Based on the results of the practicality data analysis, the physics learning module based on the scientific creativity project model integrated with AI can be said to meet the eligibility criteria.

To assess the effectiveness of the developed modules in enhancing CTS and scientific creativity to support the SDGs, an N-gain calculation was performed on the pretest and posttest score increases. The results of the N-gain calculation can be seen in Table 7.

Table 7. Results of N-gain calculations

Number of students	Average pre-test score	Post-test average score	N-gain	Category
180	455.5	87.61	0.77	High

Based on the pretest and posttest analysis results, calculated using the N-gain formula, the average N-gain score was 0.77, categorized as high. These results indicate that the physics learning module integrated with AI has proven effective in improving CTS and scientific creativity. Research conducted by Barelli et al. (2025) stated that modules integrated with AI technology are effective in achieving learning objectives. Another study conducted by Asih et al. (2022) explained that technology-based learning modules help students achieve learning objectives, one of the characteristics of which is practicality and

effectiveness. After calculating the N-gain, a Wilcoxon statistical test and effect size were conducted to determine significant differences in the pre-test and post-test results of 180 high school students. The results of the Wilcoxon test and effect size are shown in Table 8.

Table 8. Results of the Wilcoxon Signed Rank test

Data	Z Value	Asymp. Sig. (2-tailed)	Significance Level	Interpretation
Pretest-posttest	-6.271	0.000	0.05	The difference between pretest and posttest mean scores is statistically significant

Based on the Wilcoxon test results as shown in Table 5, the sig (2-tailed) value of 0.000 is smaller than the significance level of 0.05. This means there is a significant difference between the average pretest score and the average posttest score. A Z-value of 6.271 and $N = 180$ were used to calculate the effect size. After calculating the effect size, a score of 0.57 was obtained. This score indicates that the learning module based on the AI-integrated scientific creativity project model has met the requirements for effectiveness in improving CTS and scientific creativity to support the SDGs. Modules that have met the requirements for effectiveness in improving CTS can be characterized by the ability to solve problems with interpretation, analysis (C4), evaluation (C5), and creativity (C6) (Asih et al., 2022). The next step to determine the effectiveness of the module is to calculate the completeness of the CTS and scientific creativity indicators. The results of the N-gain calculation for each critical thinking and scientific creativity indicator are shown in Tables 9 and 10.

Table 9. N-gain for critical thinking indicator achievement

Critical thinking indicators	Test scores		N-gain	N-gain category
	Pretest	Posttest		
Provide a simple explanation	28	86	0.81	High
Building basic skills	42	87	0.77	High
Making inferences	35	82	0.72	High
Provide further explanation	25	86	0.81	High
Setting strategy and tactics	33	85	0.78	High

To see the completeness of scientific creativity indicators in the learning process using a module based on the scientific creativity model integrated with AI, see Table 10.

Table 10. N-gain for achievement of scientific creativity indicators

Indicators of scientific creativity	Test scores		N-gain	N-gain Category
	Pretest	Posttest		
Scientific phenomena	33	87	0.81	High
Scientific problem solving	40	88	0.80	High
Scientific knowledge	35	82	0.72	High
Ability design product	29	75	0.65	Moderate
Technical product	20	78	0.72	High

Table 6 shows that each indicator of CTS overall experienced an increase, with the results categorized as high. This is due to several factors, including the design of the learning module applied by physics teachers, which is not only easy to use but also stimulates higher-order thinking skills. It provides challenges for exploring knowledge and

solving problems. Research conducted by Uslan et al. (2024) found that using the developed module helped students learn the material contextually, enabling them to solve problems. Further studies have shown that physics learning modules tailored to innovative learning can improve CTS (Yulianti & Herpratiwi, 2024).

Another 21st-century skill targeted by this research is scientific creativity. The achievement of scientific creativity in learning using a module based on the AI-integrated scientific creativity project model can be seen in Table 7. Based on the results of the analysis of the scientific creativity indicator scores, students can explain scientific phenomena well, in addition, students have been able to solve my problems while deepening knowledge related to the problem, after deepening the material, students plan project assignments well, with instructions from the teacher, students design and plan project assignments as an implementation of solving the problems they previously identified. All of these indicator achievements are evidenced by the acquisition of N-gain scores that reach the high category. Prepared learning including the creation of valid modules is one step to achieve the learning objective of increasing scientific creativity (Pangsuma et al., 2024). The results of this study are in line with research conducted by (Mendoza, 2020; Park, 2021; Susongko et al., 2024) students will be encouraged to study knowledge in depth due to external factors, one of which is the use of good learning facilities and technological support. Research conducted by Luzyawati et al., (2025) states that teaching materials or learning media based on scientific creativity should be in line with the goals of high-level thinking skills.

Conclusion

Based on the research results, the developed physics learning module is categorized as feasible. Where the module's feasibility is reviewed from the validity aspect, the physics learning module is proven valid with a validity level in the very valid category. This module has also proven practical in improving students' CTS and scientific creativity with the implementation level reaching the very good implementation category. Meanwhile, reviewed from the effectiveness aspect, this learning module has proven effective with an average increase in students' N-gain in the high category. Another proof of effectiveness is the results of the Wilcoxon test which obtained results in the form of a difference in posttest scores higher than the pretest score and the module's effect size reaching a very positive category on improving students' critical thinking and scientific creativity. Thus, this learning module is in accordance with the SDGs goals in the field of education quality. Suggestions for educators to use physics learning modules that have been integrated with AI during the teaching and learning process.

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