IJIS Edu : Indonesian J. Integr. Sci. Education, 8 (1) 2026

Volume 8 Issue 1 , Januari 2026
P-ISSN: 2655-2388, E-ISSN: 2655-2450

Enhancing Prospective Teachers' Skills in Designing Physics Learning: Developing Electronic Learning Materials with Interactive Reading, Scaffolding and Modeling (IRTaMS) Strategies

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Abstract: This study explores the development and implementation of electronic learning materials with interactive reading, scaffolding, and modelling (IRTaMS) strategies to improve the knowledge and skills of prospective physics teachers in designing learning that refers to the 4C skills-oriented Problem-Based Learning (PBL) model. This study uses the ADDIE development model which includes the stages of analysis, design, development, implementation, and evaluation. The research subjects involved 24 prospective teachers of the Physics Education Program at a university in West Kalimantan with a pre-experimental one-group pre-test–posttest design. The research instruments included expert validation sheets, attitude scales, knowledge tests, and skill assessment rubrics. Data analysis includes; analysis of the validity of learning products using Aiken's V coefficient from expert judges' scores, percentage analysis to determine the level of readability, Wilcoxon Test to measure the significance of the difference between pre-test and post-test (including pre-task and post-task), and analysis of the average N-Gain (<g>) to determine the extent of the increase in knowledge and skills of prospective teachers. The results of expert validation and user responses indicate that electronic learning materials with IRTaMS strategies have a high level of validity and readability. The results of the study also showed a significant increase in the knowledge and skills of prospective teachers in designing PBL-based physics learning oriented to 4C skills, as reflected in the N-Gain value in the medium to high category. Skills improvement includes the formulation of learning objectives, criteria for achieving learning objectives, teaching materials, assessment planning, media use, and learning stages. The research findings indicate that the integration of IRTaMS strategies in digital technology-based electronic learning materials has strong potential in strengthening the pedagogical competence of prospective physics teachers, although comparative exploration with a control group is still needed in further research. This study contributes to the development of digital learning innovations through practical and contextual approaches to support 21st-century physics learning.

Keywords: electronic learning materials, modelling, scaffolding, interactive reading, problem-based learning

How to cite this article :

Nurhayati, N., Wahyudi, W., Suhandi, A., Muslim, M., Kaniawati, I., & Saputri, D. (2026). Enhancing Prospective Teachers' Skills in Designing Physics Learning: Developing Electronic Learning Materials with Interactive Reading, Scaffolding and Modeling (IRTaMS) Strategies. *IJIS Edu : Indonesian Journal of Integrated Science Education, 8*(1). doi:http://dx.doi.org/10.29300/ijisedu.v8i1.8379

1. Introduction

In the 21st century, teachers are required to develop student competencies that align with the needs of modern education, particularly in improving critical thinking, collaboration, creativity, and communication skills known as the 4Cs (Partnership for 21st Century Skills, 2009). One of the learning approaches widely used to achieve these skills is problem-based learning (PBL), which emphasizes the active involvement of students in authentic problem solving and strengthening cognitive and metacognitive skills (Hmelo-Silver & Barrows, 2006; Savery, 2015) . However, the success of PBL implementation depends heavily on teacher competence in designing PBL-based learning, facilitating student-centered learning, and using appropriate assessment strategies (Simons & Ertmer, 2005; Tamim & Grant, 2013) .

Although the implementation of PBL is increasingly emphasized in teacher education programs, research shows that prospective teachers often experience difficulties in designing effective PBL-based lesson plans (Nurhayati et al., 2023). This is due to a lack of teaching experience and limited pedagogical training provided to them (Goodnough & Hung, 2008; Petek & Bedir, 2018). Many prospective teachers experience difficulties in developing appropriate learning stages, implementing scaffolding strategies, and integrating formative assessments that align with PBL principles (Brush & Saye, 2002; Simons & Ertmer, 2005). Therefore, a systematically designed training program is needed to improve prospective teachers' competency in designing PBL-based learning.

One promising approach to addressing this challenge is the development of electronic learning materials that integrate interactive reading, scaffolding, and modeling in learning. Interactive reading will make it easier for prospective teachers to understand the content being studied through reading texts presented in learning materials and other references that can be referred to in the learning materials. Scaffolding provides gradual support that decreases as prospective teachers' understanding increases, so they can develop their learning design skills independently (van de Pol et al., 2010; Wood et al., 1976). Meanwhile, modeling offers concrete examples related to the development of lesson plans and good instructional practices, helping prospective teachers internalize effective teaching strategies (Bandura, 1999; Collins et al., 1991). By adopting these strategies in independent learning materials, prospective teachers are expected to gain a deeper understanding of the principles of PBL-based learning design and be able to apply them optimally in the classroom.

Furthermore, electronically packaged learning materials can make it easier for prospective teachers to access materials anywhere and anytime. Furthermore, electronic learning materials provide broader access to a variety of educational resources, including interactive multimedia, which can improve comprehension and retention of information. A study by Gupta (2017) emphasized that e-learning allows students to learn at their own pace, review material as needed, and progress through courses in a way that suits their learning style. Furthermore, research by Abed (2017) shows that e-learning facilitates access to teachers and improves communication between students and schools through various digital communication tools. Thus, e-learning not only increases accessibility and flexibility in learning but also enriches the learning experience through interactivity and personalization.

Based on this background, this study aims to develop and evaluate electronic learning materials designed to improve the competence of prospective teachers in designing learning referring to the 4C skill-oriented PBL model based on interactive reading, scaffolding and modeling strategies. Specifically, this study focuses on: (1) Analyzing the feasibility and readability of electronic learning materials based on interactive reading , scaffolding and modeling to improve the knowledge and skills of prospective teachers in designing learning referring to the 4C skill-oriented PBL model; and (2) Analyzing the increase in knowledge and skills of prospective teachers in designing learning referring to the 4C skill-oriented PBL model after implementing electronic learning materials based on interactive reading , scaffolding and modeling.

By exploring these aspects, this research is expected to contribute to efforts to improve teacher education curricula, as well as provide empirical evidence on how electronic learning materials with interactive reading, scaffolding, and modeling strategies can support the development of instructional competencies in PBL-based learning designs oriented towards the 4C skills. The results of this study can also serve as a reference for curriculum designers, pre-service teacher educators, and policymakers in developing more effective teacher training programs to prepare educators who are able to face the challenges of 21st-century education.

2. Method

This study uses the Development Research (DR) method. Development Research is a research method that focuses on the development and validation of educational products through a systematic, theory-based and empirical process, not only creating the product but also developing the process in stages (Richey & Klein, 2014). The development model used is the ADDIE development model, which includes the stages of *analyze, design, develop, implementation*, and *evaluate* (Branch, 2009; Cahyadi, 2019). The product implementation in this study employed a one-group pretest–posttest design.

This research was conducted at a university in West Kalimantan. The sample was selected based on certain criteria relevant to the research topic (Etikan, 2016). Participants were 24 prospective physics teacher students currently taking a physics lesson planning course. Research data were measured using validation sheets, attitude scales regarding the readability of learning materials, knowledge tests, and skills assessment rubrics. Table 1 summarizes the research instruments used to test the feasibility of learning materials, readability of learning materials, knowledge and skills of prospective teachers in designing physics learning referring to the 4C skills-oriented PBL model. The instruments used met the validity criteria based on expert judgment and empirical testing (Nurhayati et al., 2025).

Table 1. Data Collection Instruments

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Instrument	Data	Measurement	Data source
Validation sheet	Results of validation of the suitability of learning materials	Non-test / dichotomous scale	Validators
Readability attitude scale	Readability of learning materials	Test (Post-test)	Prospective teacher
Knowledge Test	Prospective teacher content knowledge related to 4C skills and PBL models	Test (Pre-test and Post-test)	Prospective teacher
Assessment Rubric for skills	Prospective teacher skills in designing PBL-based lesson plans oriented to 4C skills	Task (Pre-task and Post-task) task)	Prospective teacher

The first stage is the analyze, to find solutions to the problem through a gap analysis between demands and conditions in the field and an analysis of existing literature (Wahyudi et al., 2023). The research stages are presented in Figure 1.

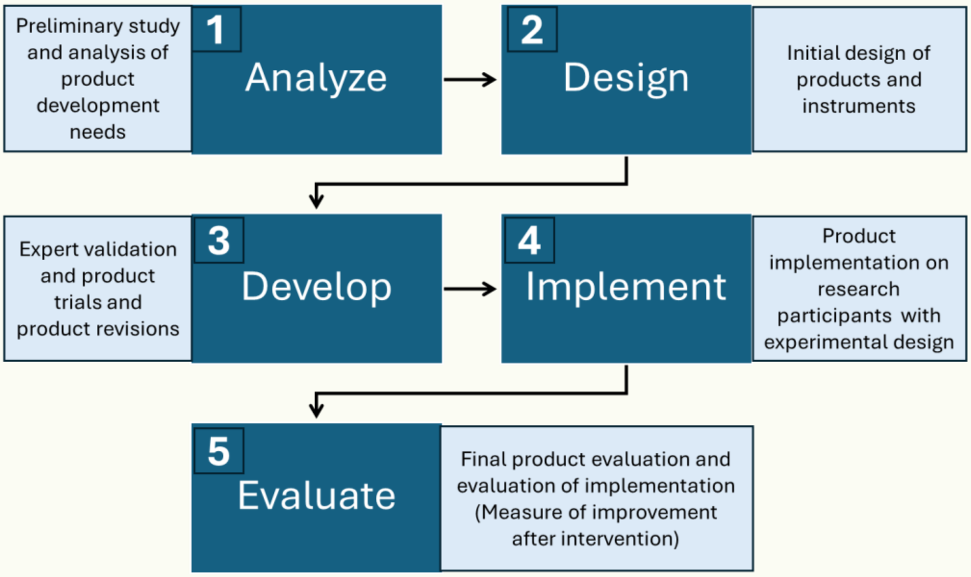

Figure 1. ADDIE Development Model Steps in Current Research

The second stage is the design. The design stage involves designing electronic learning materials using the IRTaMS strategy to facilitate prospective teachers in improving their knowledge and skills in designing learning based on the 4C skills-oriented PBL model. After completing the design of the electronic learning materials, the research proceeded to the develop stage. At the develop stage, seven activities are carried out: (1) development of electronic learning materials consisting of; (1) independent learning materials (in Indonesian: Bahan Belajar Mandiri/BBM) and workshop learning materials (in Indonesian: Bahan Belajar Workshop/BBW); (2) preparation of validation sheets; (3) preparation of learning design knowledge tests; (4) preparation of skills assessment rubrics; (5) preparation of readability response attitude scales; and (6) conducting validation tests. Expert validation scores were analyzed using Aiken's V coefficient with a minimum validity limit (>0.71) (Torres-Malca et al., 2022).

The fourth stage is the implement, which was carried out by testing the electronic learning materials on 24 prospective physics teacher students. After use, students filled out a scale of attitudes regarding the readability of the electronic learning materials. Student responses were scored using percentages for each statement submitted. After obtaining the percentage of student responses, criteria were then determined to interpret the attitude scale scores towards the readability of the developed electronic learning materials, namely 76–100% including the strongly agree (SA) category, 51–75% agree (A) category, 26–50% disagree (DA) category, and 0–25% strongly disagree (SDA) category (Matsun et al., 2025; Wong et al., 2022).

The fifth stage is the evaluate. At this stage, IRTaMS electronic learning materials are used in learning activities. Next, an evaluation is carried out to determine the effect of its use on improving the knowledge and skills of prospective teachers in designing PBL-based physics learning oriented to 4C skills. Differences in pretest , posttest and pre -task, posttask results using the Wilcoxon test because there are data that are not normally distributed while improvements are analyzed using N-Gain with categories $g > 0.7$ (high), $0.3 \leq g \leq 0.7$ (moderate), and $g < 0.3$ (low) (Hake, 2002; Nissen et al., 2018; Wright, 2020).

3. Result and Discussion

Analyze Stage

At the analysis stage, a needs analysis is conducted through document review, tests, questionnaires, and observations. The documents reviewed include the Semester Implementation Plan, teaching materials, references, and assignments for the physics teaching planning course.

The results of the curriculum study on the learning plan of the physics teaching planning course used show that the Learning Outcomes of Graduates of the study program charged to the course outcomes have been outlined in the Learning Outcomes of the physics teaching planning course. The formulation of course outcomes has covered aspects of attitudes, knowledge, general skills, and specific skills, namely students are able to master and compile instructional designs that include physics learning strategies, physics learning planning, and physics learning assessments oriented to the development of science and technology used in learning at school by applying logical, critical, systematic, and innovative thinking in the context of the development or implementation of science and technology that pays attention to and applies humanities values that are appropriate to their field of expertise, in order to be able to develop scientific thinking and attitudes.

The results of a field study through observations of Physics Teaching Planning lectures in one of the physics education programs at a university in West Kalimantan showed that the implementation of lectures was still dominated by lecturers. The learning methods used were discussion and lecture methods. Prospective teachers were asked to create teaching modules and assessment instruments, but the prospective teachers had not been invited to design learning according to the

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material, student characteristics, and the development of 21st-century skills. In addition, the learning also did not train prospective teachers to design authentic problem-based learning. Learning reflection was also not implemented both when designing, implementing and assessing physics learning. The results of research conducted by Astuti et al. (2019) showed that the teaching performance of prospective teachers in training critical thinking, creativity, communication and collaboration skills was still relatively low.

The results of the learning documents created by prospective physics teachers who have taken the Microteaching course show that the learning plans prepared by prospective teachers are still general and lack clear details. Although the PBL model has been included in the learning plan, the details of the learning stages do not reflect the main characteristics of each PBL step. In addition, the assessment results indicate that prospective teachers' understanding of 21st-century characteristics, 4C skills, 4C skills-based learning planning, and the implementation of the PBL model is still relatively low.

Physics teachers also face difficulties in designing 4C skills-oriented learning. Yoon & Woo (2010) revealed that teachers showed interest in PBL but felt burdened and found it difficult to implement it in the classroom. Research conducted by Tyas (2017) found that teachers had difficulty determining appropriate problems that could stimulate a good discussion atmosphere and stimulate students' intellectual development. Designing effective problems is a critical and challenging task (Angeli, 2002). Several experts have provided guidelines for developing PBL problems that focus on aspects of the problem: authentic, real-life, complex, unstructured, open-ended , encouraging teamwork, stimulating reasoning, improving problem-solving skills, promoting independent learning, and building on previous experiences (Dolmans et al., 1997; Duch, 2001; Torp & Sage, 1998). However, these guidelines still do not help teachers in designing PBL problems because there is no systematic conceptual framework or design process available in the literature (Goodnough & Hung, 2008) .

Therefore, it is necessary to develop electronic learning materials with interactive reading, scaffolding, and modeling strategies to facilitate prospective teachers in developing knowledge and skills in designing learning referring to the 4C skill-oriented problem-based learning model. Scaffolding consists of detailed steps in completing tasks and modeling consists of examples of the use of the scaffolding. The results of studies that have implemented scaffolding and modeling have proven that scaffolding and modeling are effective in training prospective teachers' competencies. The results of Wu et al (2019) study concluded that scaffolding can foster prospective teachers' knowledge and skills, especially design thinking competencies from different perspectives in designing interdisciplinary STEM learning. The presentation of illustrative examples (modeling) can facilitate the learning process because, according to Bandura's theory, prospective teachers will find it easier to complete or create something through imitation of examples (models) presented by lecturers (Alshobramy, 2019; Latham & Saari, 1979; Samsudin et al., 2017).

Design Stage

Design stage involves creating a plan for the specified product. The products designed consist of independent learning materials (BBM) and workshop learning materials (BBW). At this stage, the characteristics of the learning materials are determined, namely: 1) Learning materials are packaged in electronic format, written in PDF format and displayed using a flipbook application, the material in BBM is presented interactively with sections that require a response from the reader, while the material presented in BBW is in the form of scaffolding and modeling to guide prospective teachers in completing assignments, learning materials are equipped with various visual media such as images, photos, animations, simulations, and videos (phenomena and learning, supporting reference sources are available that can be accessed via barcode or link, the structure of the learning materials consists of: (1) Cover containing the title, (2) foreword, (3) table of contents, (4) instructions for using learning materials containing CP, Sub CP, learning indicators, learning materials and learning guides, (5) introduction presented in video form, (6) introduction to the material, (7) presentation of the material, (8) summary, (9) formative tests presented in the form of links and barcodes, (10) assignments presented in the form of links and barcodes, and (11) bibliography.

Develop Stage

Develop stage involves transforming the design into a product in the form of teaching materials. Independent learning materials are developed based on the characteristics established during the design phase. To ensure that BBM can be used independently by prospective teachers, BBM is packaged with interactive material presentations, complemented by various visual media such as images, simulations, and videos, as well as supporting references that prospective teachers can access using links or barcodes. At the beginning of BBM, an introductory video is presented to provide insight and motivation for prospective teachers in studying the material in BBM. Furthermore, BBM also presents assignments that prospective teachers must complete actively and responsibly.

The successfully developed BBM consists of three main materials: Material 1 on 21st-century skills and 4C skills; Material 2 on physics learning planning oriented towards 4C skills; and Material 3 on innovative learning models oriented towards 4C skills. The materials presented in the BBM are tailored to the desired outcome, namely improving the knowledge of prospective teachers.

Workshop learning materials (BBW) are learning materials developed within the PPF lecture program to improve prospective teachers' skills in designing physics learning based on the 4C skills-oriented PBL model. The successfully developed BBW consists of three main materials. Material 1 is about constructing HOTS assessment instruments and 4C skills; material 2 is about designing learning objectives, compiling learning objective flows and designing learning objective achievement criteria; and material 3 is about designing problem formulations, designing teaching modules, and compiling LKPD.

After the learning materials were developed, their feasibility was tested by five physics education experts to ensure their suitability before being piloted. Expert

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validation results for the BBM and BBW showed that the developed learning materials met the validity criteria (Table 2).

Table 2. Summary of Expert Validation Results on Learning Materials

Aspects of Validity	BBM		BBW	
	V Coef.	Category	V Coef.	Category
Content	0.93	Valid	0.90	Valid
Systematics	1.00	Valid	1.00	Valid
Graphically	1.00	Valid	0.98	Valid
Grammar and sentence structure	1.00	Valid	1.00	Valid
Overall	0.98	Valid	0.97	Valid

Table 2 shows that the overall assessment of the BBM and BBW by five experts had an average V-value above the minimum limit, namely >0.71. This indicates that the BBM and BBW were deemed valid and appropriate by the experts in terms of content, systematics, graphics, grammar, and sentence structure. The experts' conclusions indicate that the learning materials are suitable for use in research with revisions based on the suggestions provided. The suggestions for revision and improvement of the BBM and BBW based on expert assessments are presented in Table 3.

Table 3. Summary of Expert Team Comments and Suggestions in Validating Independent Learning Materials and Workshop Learning Materials

Assessment Aspects	Expert Team Comments and Suggestions	
	Independent Learning Materials	Workshop Learning Materials
Learning Material Content	Avoid using unusual abbreviations in sentences (e.g., KKO, etc.)	Consider some choices of essential concepts in the sentences that are constructed.
Systematics of Learning Materials	a. Include primary reference sources for some of the images in the study materials. b. Add reference sources in topics about assessment and Learning Plans. c. Use the latest higher education curriculum guides in compiling study materials.	a. Improve accuracy in writing video sources b. Use the latest higher education curriculum guides in compiling study materials.
Graphics Learning Materials	a. Provide at least 1 illustration for 2-3 pages of the manuscript, so that readers do not get bored. b. Use the correct numbering hierarchy in compiling learning materials (eg. A, 1, a, etc.). c. Add interactive videos to add variety to learning.	a. Pay attention to the appropriate variations in text (letter) size to emphasize certain parts of the text. b. Arrange the images more effectively so that they are clearly visible to the reader.

Assessment Aspects	Expert Team Comments and Suggestions	
	Independent Learning Materials	Workshop Learning Materials
	d. Consider text variations, especially in sections of text that contain a lot of content.	
Grammar and sentences	a. Check for direct and indirect quotes. It is best to avoid using indirect quotes. b. It is best to focus on questions that encourage critical thinking. It is best to avoid closed-ended questions, such as those that only require a "Yes" or "No" answer.	No comment

Based on expert suggestions and input on the learning materials, revisions were made, namely: using more appropriate terms or abbreviations in the text of the learning materials, adding image reference sources, adding reference sources to assessment topics and learning plans, replacing terms according to the latest 2024 higher education curriculum guidelines, providing appropriate image illustrations every two pages of the manuscript, making numbering consistent and sequential, adding interactive videos, and increasing variations in text/letter sizes and colors, adding virtual simulations, and replacing images with good resolution.

Implement Stage

At the implement stage, the learning materials were applied to prospective teachers. Prospective teachers were given a pretest and pretask before implementation, as well as a posttest, posttask, and an attitude scale to measure responses to the readability of the learning materials after implementation. The percentage of prospective teachers' responses to the readability of the BBM and BBW are presented in Table 4.

Table 4. Average Percentage of Prospective Teachers' Responses to the Readability of Learning Materials

Assessment Aspects	Indicator	Assessment Results (%)			
		BBM		BBW	
		%	Criteria	%	Criteria
Display aspect	1. Clarity of text	100.0	SA	100.0	SA
	2. Image clarity	100.0	SA	100.0	SA
	3. Attraction	100.0	SA	100.0	SA
	4. Image conformity	100.0	SA	100.0	SA
Aspects of material presentation	5. Content representation	100.0	SA	100.0	SA
	6. Conformity of content	100.0	SA	100.0	SA
	7. Clarity of sentences	100.0	SA	100.0	SA
	8. Conformity of technical terms	100.0	SA	100.0	SA

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Table 4 shows that all prospective teachers strongly agreed (SA) with all statements representing the eight indicators of readability of learning materials. This indicates that BBM and BBW have good readability and that the material presented is easy for prospective teachers to understand.

Evaluate Stage

Based on the results of the hypothesis test using the Wilcoxon test presented in Table 5, it is known that the significance value of 0.000 is smaller than the significance value (0.05) so that Ho is rejected and Ha is accepted. This means that there is a significant difference between the pre-test and post-test scores for the use of electronic learning materials on the knowledge of prospective teachers in designing learning referring to the 4C skills-oriented PBL model. The same thing is also seen in the significance value for the pre -task and posttask data which is smaller than the significance value (0.05). This means that there is a difference in the skills of prospective teachers in designing learning referring to the 4C skills-oriented PBL model.

Table 5. Results of Hypothesis Testing of Student Knowledge and Skills Data in Designing Learning

Data	Z	Asymp. Sig. (2-tailed)
Posttest- Pre - test (Knowledge)	-3.289 [b]	0,000
Posttast- Pre -tast (Skills)	-4.287 [b]	0,000

The N-gain test was conducted to determine the effectiveness of the learning materials. The results of the N-Gain knowledge test presented in Table 6 show that the knowledge of prospective teachers increased for all materials with a high N-Gain category, with the highest N-Gain value for the material on 21st-century characteristics and 4C skills (0.87). This indicates that the applied learning successfully increased the knowledge of prospective teachers in designing physics learning referring to the PBL model oriented to 4C skills.

Table 6. N-Gain Results of Pre-Service Teachers' Knowledge in Designing 4C-Oriented PBL Instruction

Material	<g>	Category
21st century characteristics and 4C skills	0.87	High
Physics Learning Planning Oriented to 4C Skills	0.79	High
Problem-based learning model oriented to 4C skills	0.74	High
Overall	0.81	High

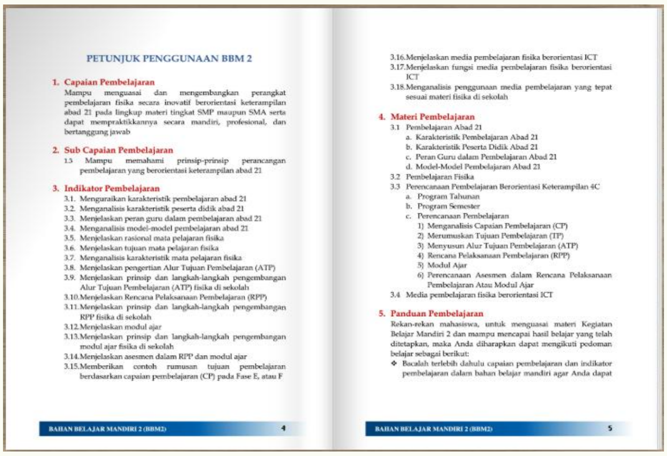
The results of the N-Gain skills test are presented in Table 7. Table 7 shows that prospective teachers experienced improvements in their skills in designing teaching modules in various aspects. High category improvements occurred in the aspects of formulating learning objectives with an average N-Gain of 0.96, formulating Learning Objective Achievement Criteria with an average N-Gain of 0.87, planning assessments with an average N-Gain of 0.78, and selecting learning tools and media with an average N-Gain of 0.72. This indicates that prospective teachers began to be able to formulate learning objectives and criteria for achieving 4C skills-oriented learning objectives, were able to plan assessments and select learning tools and media after the implementation of the lectures. Meanwhile, the aspects of compiling Learning Materials and learning steps experienced improvements in the moderate category.

Table 7. N-Gain Results of Pre-Service Teachers' Skills in Designing 4C-Oriented PBL Instruction

Design Skills in	<g>	Category
Learning objectives	0.96	High
Learning objective achievement criteria	0.87	High
Subject matter	0.55	Medium
Assessment plan	0.78	High
Learning tools & media	0.72	High
Learning steps	0.69	Medium
Overall	0.76	High

Discussion

The use of BBM with an interactive reading strategy in physics lesson planning lectures has been proven to improve the knowledge of prospective physics teachers in designing physics learning based on the 4C skills-oriented PBL model. All tested materials are in the high category. Independent learning materials are packaged interactively through questions that require responses from readers (prospective teachers). The presentation of materials in BBM is not only in the form of text (sentences) but also equipped with images, videos, and supporting references that can be accessed through links or barcodes. In addition, BBM uses a flipbook application that makes it easy for prospective teachers to use BBM and the appearance like a real book makes it attractive for prospective teachers to read BBM. At the beginning of BBM, instructions for using BBM are presented, consisting of learning outcomes, sub-learning outcomes, learning indicators, learning materials, and learning guides. A screenshot of the BBM instructions page is presented in Figure 2.



PETUNJUK PENGGUNAAN BBM 2

1. Capaian Pembelajaran
Mampu menguasai dan mengembangkan perangkat pembelajaran fisika secara inovatif berorientasi keterampilan abad 21 pada lingkup materi tingkat SMP maupun SMA serta dapat mempraktikkannya secara mandiri, profesional, dan bertanggung jawab

2. Sub Capaian Pembelajaran
1.3 Mampu memahami prinsip-prinsip perancangan pembelajaran yang berorientasi keterampilan abad 21

3. Indikator Pembelajaran
3.1. Menguraikan karakteristik pembelajaran abad 21
3.2. Menganalisis karakteristik peserta didik abad 21
3.3. Menjelaskan peran guru dalam pembelajaran abad 21
3.4. Menganalisis model-model pembelajaran abad 21
3.5. Menjelaskan rasional mata pelajaran fisika
3.6. Menjelaskan tujuan mata pelajaran fisika
3.7. Menganalisis karakteristik mata pelajaran fisika
3.8. Menjelaskan pengertian Alur Tujuan Pembelajaran (ATP)
3.9. Menjelaskan prinsip dan langkah-langkah pengembangan Alur Tujuan Pembelajaran (ATP) fisika di sekolah
3.10. Menjelaskan Rencana Pelaksanaan Pembelajaran (RPP)
3.11. Menjelaskan prinsip dan langkah-langkah pengembangan RPP fisika di sekolah
3.12. Menjelaskan modul ajar
3.13. Menjelaskan prinsip dan langkah-langkah pengembangan modul ajar fisika di sekolah
3.14. Menjelaskan asesmen dalam RPP dan modul ajar
3.15. Memberikan contoh rumusan tujuan pembelajaran berdasarkan capaian pembelajaran (CP) pada Fase E, atau F

BAHAN BELAJAR MANDIRI 2 (BBM2) 4

3.16. Menjelaskan media pembelajaran fisika berorientasi ICT
3.17. Menjelaskan fungsi media pembelajaran fisika berorientasi ICT
3.18. Menganalisis penggunaan media pembelajaran yang tepat sesuai materi fisika di sekolah

4. Materi Pembelajaran
3.1 Pembelajaran Abad 21
a. Karakteristik Pembelajaran Abad 21
b. Karakteristik Peserta Didik Abad 21
c. Peran Guru dalam Pembelajaran Abad 21
d. Model-Model Pembelajaran Abad 21
3.2 Pembelajaran Fisika
3.3 Perencanaan Pembelajaran Berorientasi Keterampilan 4C
a. Program Tahunan
b. Program Semester
c. Perencanaan Pembelajaran
1) Menganalisis Capaian Pembelajaran (CP)
2) Merumuskan Tujuan Pembelajaran (TP)
3) Menyusun Alur Tujuan Pembelajaran (ATP)
4) Rencana Pelaksanaan Pembelajaran (RPP)
5) Modul Ajar
6) Perencanaan Asesmen dalam Rencana Pelaksanaan Pembelajaran Atau Modul Ajar
3.4 Media pembelajaran fisika berorientasi ICT

5. Panduan Pembelajaran
Rekan-rekan mahasiswa, untuk menguasai materi Kegiatan Belajar Mandiri 2 dan mampu mencapai hasil belajar yang telah ditetapkan, maka Anda diharapkan dapat mengikuti pedoman belajar sebagai berikut:
❖ Bacalah terlebih dahulu capaian pembelajaran dan indikator pembelajaran dalam bahan belajar mandiri agar Anda dapat

BAHAN BELAJAR MANDIRI 2 (BBM2) 5

Figure 2. Screenshot of Instructions Page Usage in Independent Learning Materials (BBM)

Online ISSN 2655-2450 | Print ISSN 2655-2388

Instructions for using BBM serve to provide guidance to prospective teachers regarding the milestones to be achieved during the learning process, as well as provide clear direction on the learning flow and activities so that prospective teachers can organize their learning process to understand each topic in the learning materials. This aligns with the findings of Koňušíková & Kostelník (2009) in their research, which emphasized the importance of directed independent learning by students and the use of high-quality independent learning texts (Pradhan, 2021).

Furthermore, BBM presents an introductory video as a stimulus for learning the material and demonstrating its usefulness in real life for prospective teachers. A screenshot of the introductory video page is presented in Figure 3. The purpose of presenting this video is to motivate prospective teachers to be interested in learning the material contained in BBM. This video also provides a clear illustration of the importance of mastering the material in the context of classroom learning.

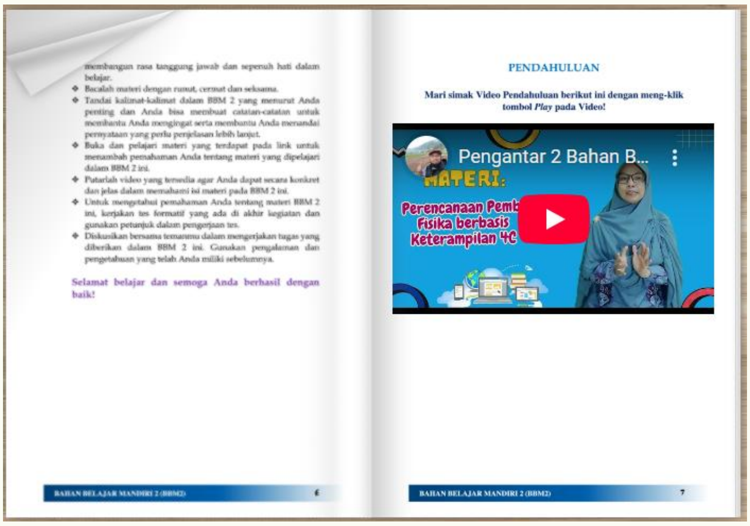


Figure 3. Screen Capture of Introduction Video Page in Independent Learning Materials (BBM)

The next step is the presentation of the material, which covers all the materials prospective teachers need before being assigned to design physics learning tools, based on the 4C skills-oriented PBL model. The material is presented interactively, beginning with questions to stimulate prospective teachers' thinking. A screenshot of the material presentation page in BBM is shown in Figure 4. The use of questions as a trigger aims to spark curiosity and increase prospective teachers' engagement in the learning process.

Several studies have shown that interactive learning is effective in improving students' comprehension and motivation. Kulo et al. (2019) found that interactive reading strategies have a positive impact on secondary school students' reading achievement. Research by Bahari et al. (2021) found that a computer-assisted interactive reading model, incorporating computer-assisted language learning tools

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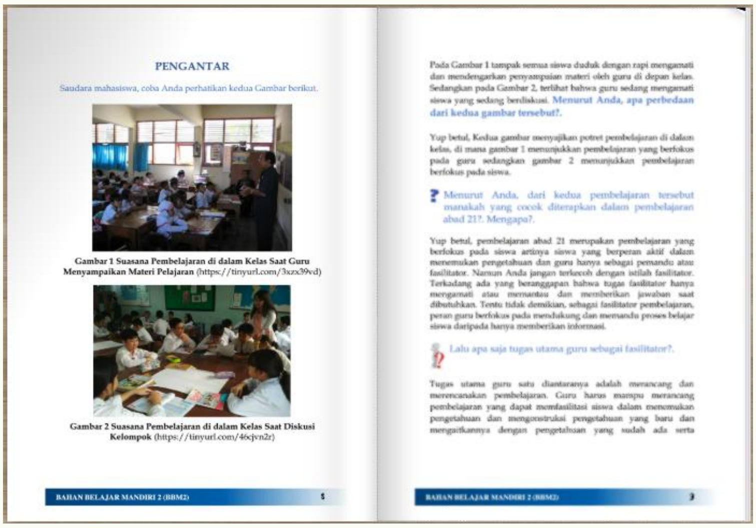
and resources, effectively improved students' reading comprehension in blended and distance learning contexts. Interactive reading models can improve students' reading and comprehension skills (Banditvilai, 2020; Fu, 2015).


PENGANTAR

Saudara mahasiswa, coba Anda perhatikan kedua Gambar berikut.

Gambar 1 Suasana Pembelajaran di dalam Kelas Saat Guru Menyampaikan Materi Pelajaran (https://tinyurl.com/3xzx39vd)

Gambar 2 Suasana Pembelajaran di dalam Kelas Saat Diskusi Kelompok (https://tinyurl.com/46cjvn2r)

BAHAN BELAJAR MANDIRI 2 (BBM2)

Pada Gambar 1 tampak semua siswa duduk dengan rapi mengamati dan mendengarkan penyampaian materi oleh guru di depan kelas. Sedangkan pada Gambar 2, terlihat bahwa guru sedang mengamati siswa yang sedang berdiskusi. **Menurut Anda, apa perbedaan dari kedua gambar tersebut?.**

Yup betul, Kedua gambar menyajikan potret pembelajaran di dalam kelas, di mana gambar 1 menunjukkan pembelajaran yang berfokus pada guru sedangkan gambar 2 menunjukkan pembelajaran berfokus pada siswa.

Menurut Anda, dari kedua pembelajaran tersebut manakah yang cocok diterapkan dalam pembelajaran abad 21?. Mengapa?.

Yup betul, pembelajaran abad 21 merupakan pembelajaran yang berfokus pada siswa artinya siswa yang berperan aktif dalam menemukan pengetahuan dan guru hanya sebagai pemandu atau fasilitator. Namun Anda jangan terkecoh dengan istilah fasilitator. Terkadang ada yang beranggapan bahwa tugas fasilitator hanya mengamati atau memantau dan memberikan jawaban saat dibutuhkan. Tentu tidak demikian, sebagai fasilitator pembelajaran, peran guru berfokus pada mendukung dan memandu proses belajar siswa daripada hanya memberikan informasi.

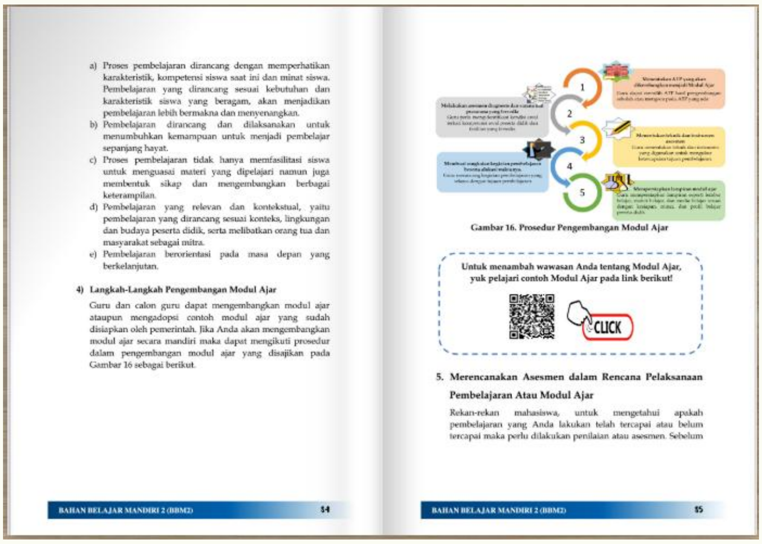
Lalu apa saja tugas utama guru sebagai fasilitator?.

Tugas utama guru satu diantaranya adalah merancang dan merencanakan pembelajaran. Guru harus mampu merancang pembelajaran yang dapat memfasilitasi siswa dalam menemukan pengetahuan dan mengonstruksi pengetahuan yang baru dan mengaitkannya dengan pengetahuan yang sudah ada serta

BAHAN BELAJAR MANDIRI 2 (BBM2)

Figure 4. Screenshot of the Material Presentation Page in Independent Learning Materials (BBM)

To enhance prospective teachers' knowledge of the material, supporting references are provided, accessible via links or barcodes. A screenshot of the page displaying the links and barcodes for additional references is shown in Figure 5. These references can be used by prospective teachers to assist in understanding the material, and they can determine for themselves which references to use to reinforce the material being studied.


a) Proses pembelajaran dirancang dengan memperhatikan karakteristik, kompetensi siswa saat ini dan minat siswa. Pembelajaran yang dirancang sesuai kebutuhan dan karakteristik siswa yang beragam, akan menjadikan pembelajaran lebih bermakna dan menyenangkan.
b) Pembelajaran dirancang dan dilaksanakan untuk menumbuhkan kemampuan untuk menjadi pembelajar sepanjang hayat.
c) Proses pembelajaran tidak hanya memfasilitasi siswa untuk menguasai materi yang dipelajari namun juga membentuk sikap dan mengembangkan berbagai keterampilan.
d) Pembelajaran yang relevan dan kontekstual, yaitu pembelajaran yang dirancang sesuai konteks, lingkungan dan budaya peserta didik, serta melibatkan orang tua dan masyarakat sebagai mitra.
e) Pembelajaran berorientasi pada masa depan yang berkelanjutan.

4) Langkah-Langkah Pengembangan Modul Ajar

Guru dan calon guru dapat mengembangkan modul ajar ataupun mengadopsi contoh modul ajar yang sudah disiapkan oleh pemerintah. Jika Anda akan mengembangkan modul ajar secara mandiri maka dapat mengikuti prosedur dalam pengembangan modul ajar yang disajikan pada Gambar 16 sebagai berikut.

BAHAN BELAJAR MANDIRI 2 (BBM2)

Gambar 16. Prosedur Pengembangan Modul Ajar

Untuk menambah wawasan Anda tentang Modul Ajar, yuk pelajari contoh Modul Ajar pada link berikut!

5. Merencanakan Asesmen dalam Rencana Pelaksanaan Pembelajaran Atau Modul Ajar

Rekan-rekan mahasiswa, untuk mengetahui apakah pembelajaran yang Anda lakukan telah tercapai atau belum tercapai maka perlu dilakukan penilaian atau asesmen. Sebelum

BAHAN BELAJAR MANDIRI 2 (BBM2)

Figure 5. Screen Capture of Reference Link and Barcode Presentation Page Addition in Independent Learning Materials (BBM)

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At the end of the BBM, prospective teachers are given assignments to complete in groups. A screenshot of the page displaying the link and barcode for the test and assignment is shown in Figure 6. Assignments can be accessed by prospective teachers using the link and barcode provided in BBM. Assignments are crucial for guiding and mentoring prospective teachers in learning the material contained in BBM. Assignments are a crucial element in independent learning. Assignments should be challenging and engaging for prospective teachers to complete (Hockings et al., 2018) . Discussion among peers during assignment completion also influences the effectiveness of independent learning. This aligns with Bandura's social learning theory, which states that individuals form ideas through observing others and interacting socially with others in their environment. Hockings et al. (2018) also found that peers are a powerful resource for developing independent learning. Furthermore, Rowe et al. (2021) stated that collaboration can be effective when carried out together with peers, i.e., people at the same level, to share information and support each other. This is also evident in this study, where prospective teachers grouped at the same level were quicker to reach joint decisions and more confident in communicating the results of their group work. Similar findings were also identified by Keenan (2014) , who found that peer-led learning survey results can increase student self-confidence. This type of learning, based on Vygotsky's (1978) social constructivist theory , places social interaction at the center of learning and understanding, and learning is essentially a social process, through collaboration between peers.

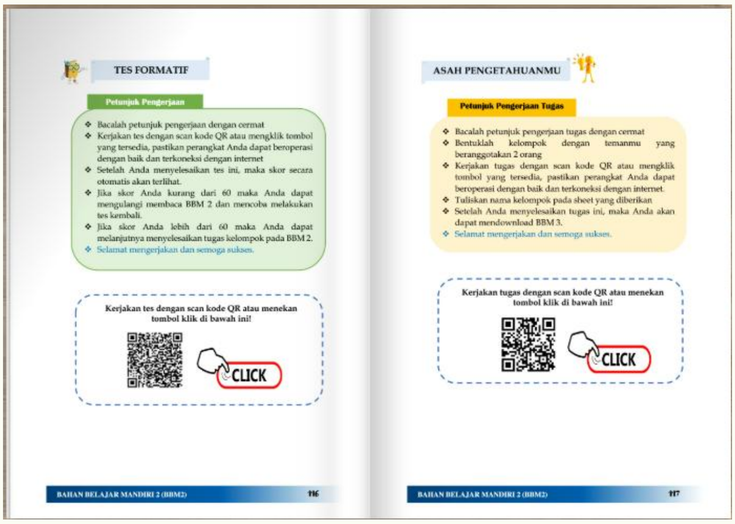

Figure 6. Screenshot of the Link and Barcode Presentation Page for Tests and Assignments in Independent Learning Materials (BBM)

Another important element in independent learning is assessment. Therefore, in this course, prospective teachers are assigned to complete a test after studying the material in the BBM. This assessment serves to identify prospective teachers' knowledge and understanding of the learning process. Furthermore, assessment can serve as a form of evaluation for prospective teachers to improve their learning process. Prospective teachers can identify material that needs reinforcement, allowing them to review the material presented and provide additional references. This is reinforced by Rahman (2015) who argued that assessment plays a crucial role in independent learning activities using independent learning materials.

In addition to enhancing prospective teachers' knowledge, the learning materials have also been shown to be effective in enhancing their skills in designing learning based on the 4C skills-oriented PBL model. The workshop learning materials present scaffolding and modeling that prospective teachers can follow to design physics learning based on the 4C skills-oriented PBL model. An example of scaffolding for formulating learning objectives is shown in Figure 7, while modeling for formulating learning objectives can be seen in Figure 8.

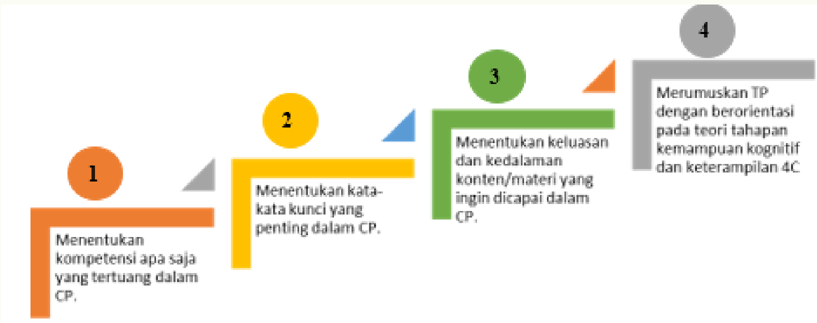

Figure 7. Scaffolding in Formulating Learning Objectives in Workshop Learning Materials (BBW)

CP 4 (Elemen Pemahaman IPA) Peserta didik mengelaborasikan pemahamannya mengenai posisi relatif bumi-bulan-matahari dalam sistem tata surya untuk menjelaskan fenomena alam dan perubahan iklim		
Konten/ Materi	**Kompetensi**	**Kedalaman Materi**
1. Sistem tata surya 2. Fenomena alam dan perubahan iklim	1. Menjelaskan fenomena alam terkait posisi relatif bumi-bulan-matahari dalam sistem tata surya 2. Menjelaskan perubahan iklim berdasarkan pemahaman tentang sistem tata surya	1. Sistem tata surya 1.1 Komponen penyusun tata surya 1.2 Gerak planet dan hukum Keppler 1.3 Gerak bumi dan gerak bulan 1.4 Rotasi dan revolusi bumi 2. Struktur lapisan bumi 2.1 Konsep lapisan bumi 2.2 Atmosfer 2.3 Litosfer 2.4 Hidrosfer 3. Fenomena Alam 3.1 Gempa bumi 3.2 Gunung berapi 3.3 Hidrosfer 4. Perubahan iklim dan dampak perubahan iklim
• Perhatikan untuk kompetensi apakah sudah menggunakan kata kerja operasional dan menggunakan teori perkembangan kognitif (lihat BBM 2). • Perhatikan hubungan tiap kedalaman materi. Jika antar kedalaman materi saling berhubungan atau berkaitan maka untuk perumusan TP dapat digabungkan atau dijadikan satu TP. • Perhatikan kompetensi pertama dan kedua. KKO menjelaskan merupakan tahapan perkembangan kognitif menurut Anderson dan Krathwohl pada level menganalisis. Anda dapat menggunakan KKO menjelaskan dan menganalisis untuk TP ini. **Rumusan Tujuan Pembelajaran CP 4:** 1. Menganalisis fenomena alam terkait posisi relatif bumi-bulan-matahari dalam sistem tata surya. 2. Menganalisis struktur lapisan bumi untuk menjelaskan fenomena alam yang terjadi dalam rangka mitigasi bencana. 3. Menjelaskan perubahan iklim dan dampaknya dalam sistem tata surya.		

Figure 8. Modeling in Formulating Learning Objectives in Workshop Learning Materials (BBW)

Prihastuti et al. (2020) stated that prospective teachers need to be given more concrete examples to understand the material and be able to practice it in their lessons. The use of interactive ICT-based learning materials also enriches the prospective teachers' experience in practicing their skills in designing physics lessons. Interactive ICT-based learning materials provide a more concrete picture because they not only present written explanations but also include videos, images, and

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barcodes that prospective teachers can easily access. Openly accessible learning materials make it easier for prospective teachers to read the material anywhere and anytime, and the presentation of the material in the teaching materials through various media makes prospective teachers interested in reading the material. This supports previous studies that learning materials delivered through various electronic media will improve student performance and learning effectiveness (Alenezi, 2020).

4. Conclusion

This study shows that electronic learning materials using the IRTaMS strategy can be declared valid for use by prospective physics teacher students. The validity of the electronic learning materials can be proven by the agreement of student responses as users regarding the readability aspect of the learning materials by 100% for all aspects. There is a significant difference between the results before and after the use of IRTaMS electronic learning materials, which indicates an increase in knowledge and skills of prospective teachers in designing physics lessons. This research provides benefits for lecturers as an alternative innovative media to strengthen pedagogical competence and 21st-century skills of prospective teachers. In the future, it is hoped that the development of innovative electronic learning materials can continue, not only as a source of independent learning, but also as a means of exploring various contextual issues relevant to local wisdom and physics learning.

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