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Innovation of Scientific Based Applied Physics Teaching Materials for Nautical Technology Study Program

Inovasi Bahan Ajar Fisika Terapan Berbasis Scientific untuk Program Studi Teknologi Nautika

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Nelfi Erlinda[1*], Melda Yanti[1], Slamet Riyadi[1], Lelfita Lelfita[2]
[1] Politeknik Pelayaran Sumatera Barat, Padang, Indonesia
[2] STKIP YDB Lubuk Alung
[*]E-mail: nelfierlinda02@gmail.com

Abstract

This study aims to develop Applied Physics teaching materials based on a scientific approach to enhance students' creativity in the Nautical Technology Study Program at the Politeknik Pelayaran Sumatera Barat. Creativity, which includes critical thinking, flexibility, and originality, is an essential competence in science education to address the challenges of the workforce. This study employs the Research and Development (R&D) method with the ADDIE development model, encompassing the stages of Analysis, Design, Development, Implementation, and Evaluation. The results indicate that students previously lacked relevant printed teaching materials, and the learning process relied on digital resources like presentations, which were deemed less scientific. The developed teaching materials cover Statics, Motion Dynamics, Fluids, and Temperature, presented systematically and applicatively. Experts have confirmed that these teaching materials have high feasibility, with an average score of ≥3.26, although some revisions are needed to enhance the context and relevance of the content. Student responses to these teaching materials demonstrate high effectiveness in helping them understand Applied Physics concepts, with average scores for material and language aspects reaching ≥3.09, respectively. Moreover, the scientific activities in the teaching materials successfully encouraged students to think creatively and generate new ideas. In conclusion, the scientific-based Applied Physics teaching materials developed effectively enhance student creativity and are relevant to education and industry needs. This study significantly contributes to innovation in science teaching methods in higher education.

Keywords: *Applied physics teaching materials, higher education, ADDIE development model.*

Abstrak

Penelitian ini bertujuan mengembangkan bahan ajar Fisika Terapan berbasis pendekatan saintifik untuk meningkatkan kreativitas mahasiswa Program Studi Teknologi Nautika di Politeknik Pelayaran Sumatera Barat. Kreativitas, yang mencakup kemampuan berpikir kritis, fleksibilitas, dan orisinalitas, merupakan kompetensi penting dalam pembelajaran sains untuk menghadapi tantangan dunia kerja. Penelitian ini menggunakan metode Research and Development (R&D) dengan model pengembangan ADDIE, meliputi tahap Analysis, Design, Development, Implementation, dan Evaluation. Hasil penelitian menunjukkan bahwa mahasiswa sebelumnya tidak memiliki bahan ajar cetak yang relevan, dan proses pembelajaran bergantung pada bahan digital seperti presentasi yang dianggap kurang saintifik. Bahan ajar yang dikembangkan mencakup topik seperti Statika, Dinamika Gerak, Fluida, dan Suhu, yang disajikan secara sistematis dan aplikatif. Validasi oleh ahli menunjukkan bahwa bahan ajar ini memiliki kelayakan tinggi dengan skor rata-rata ≥3,26, meskipun beberapa revisi diperlukan untuk meningkatkan konteks dan relevansi materi. Respon mahasiswa terhadap bahan ajar ini menunjukkan efektivitas yang tinggi dalam membantu memahami konsep Fisika Terapan, dengan skor rata-rata aspek materi dan bahasa masing-masing mencapai ≥3,09. Selain itu, aktivitas saintifik dalam bahan ajar berhasil mendorong mahasiswa untuk berpikir kreatif dan menghasilkan ide-ide baru. Kesimpulannya, bahan ajar Fisika Terapan berbasis saintifik yang dikembangkan efektif untuk meningkatkan kreativitas mahasiswa serta relevan dengan kebutuhan pembelajaran dan industri. Penelitian ini memberikan kontribusi signifikan terhadap inovasi dalam metode pembelajaran sains di perguruan tinggi.

Kata Kunci: Bahan ajar fisika terapan, pendidikan tinggi, model pengembangan ADDIE.

1. Introduction

Science is inherently a creative process where ideas evolve through the imagination of human thought (Aleinikov, 2020). As Einstein and Infeld noted, concepts in physics often emerge from imaginative leaps, such as Einstein's photon theory of light (Galili, 2024; Yerra & Bhamidipati, 2022). This highlights the importance of creativity in scientific advancements.

In higher education, fostering creativity is a crucial aspect of the teaching and learning process (Bonfield et al., 2020; Guo et al., 2020; Kustandi et al., 2020). Universities play a vital role in equipping students with knowledge while developing their critical and creative thinking to tackle real-world problems. To achieve this, integrating scientific and open-ended learning approaches is essential for nurturing creativity and innovation.

The gap in this research lies in addressing the lack of creative engagement in science education, particularly in physics courses at the higher education level. While creativity is recognized as a critical component involving the generation of novel ideas, experimentation, and original outcomes (Chan & Hu, 2023; Prakash et al., 2023), current science courses, especially physics, are often criticized for relying heavily on rote memorization. This traditional approach limits students' ability to understand real-world applications and the industrial relevance of physics concepts (Prasetya et al., 2024; R. D. Putra et al., 2024; R. E. Putra et al., 2024).

Although previous studies emphasize the importance of fostering creativity in science learning to enhance students' innovative and critical thinking (Syahril et al., 2022), there remains a lack of practical educational tools designed to develop scientific creativity within physics education. This gap highlights the need for instructional materials that not only teach physics concepts but also inspire creativity and demonstrate their applications in real-world contexts. To address this issue, this study proposes the development of applied physics textbooks based on a scientific approach, tailored to the needs of students at the Politeknik Pelayaran Sumatera Barat, to foster creativity and improve understanding of physics applications in maritime operations.

This study aims to develop a scientific-based Applied Physics textbook to enhance students' creativity in the Nautical Technology Study Program. By adopting a practical approach and aligning the material with student needs, the textbook is designed to deepen understanding of physics concepts while fostering creative and critical problem-solving skills. Furthermore, this research seeks to contribute to improving science learning methods in higher education, particularly in addressing challenges related to enhancing students' scientific creativity.

2. Literature Review

Research conducted by (Ritonga et al., 2018) developed a contextual-based applied science module for 11th-grade students specializing in nautical fishing vessel technology. The module was designed using the ADDIE model and tailored to students' needs during the learning process, both in class and during industrial work practice (prakerin). The validation results indicated that the module had excellent quality in terms of content (86.95%) and media design (87.36%). Teacher and student responses showed high levels of interest, making the module effective as a self-directed learning resource to help students better understand the material outside of face-to-face learning.

Another study by (Pineida & Dominguez, 2023) explored the use of specialized software and digital media in physics laboratory courses as a substitute for traditional laboratory settings. The course utilized PhET simulations and other digital tools to collect data virtually, providing greater flexibility in the experimental process. The findings revealed that this approach enhanced student engagement, created a dynamic learning experience, and supported the implementation of active

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learning. Although some challenges arose during its implementation, educational technology proved to be an effective solution to address the limitations of traditional laboratory facilities.

Based on previous research, the development of innovative teaching materials that integrate contextual and technological approaches can improve the quality of learning, particularly in specialized fields. In the context of this study, the innovation of scientific-based applied physics teaching materials for the nautical technology study program aims to deliver relevant, interactive, and industry-oriented learning. The integration of contextual approaches and technology is expected to help students understand the material more effectively and prepare them to face challenges in the workforce.

3. Research Methods

3.1. Research Type

Research and Development (R&D) is a systematic process used to develop and validate new products, processes, or techniques. In the context of educational research, R&D aims to produce innovative teaching materials, methods, or tools that can enhance the learning experience (Paiva et al., 2020; Waskito, Wulansari, et al., 2024). The primary goal of R&D in education is to bridge the gap between theory and practice by designing and validating effective, practical, and contextually relevant educational products.

The R&D process typically involves several key stages that emphasize product development and continuous improvement. These stages include needs analysis, design, prototype development, testing, and evaluation. The process is iterative, meaning that after each stage, the product is reviewed, tested, and refined to ensure it meets the needs of the target audience.

In this study, the R&D approach is applied to develop an Applied Physics textbook for Nautical Technology students. The study adopts the ADDIE model, an instructional design framework widely used in educational R&D (Branch, 2009). The ADDIE model consists of five phases. By following the ADDIE model, this study ensures that the developed textbook is not only relevant to the needs of the students but also serves as a valuable educational tool that promotes creative and critical thinking in Applied Physics. The phases of the ADDIE model are presented in Figure 1.

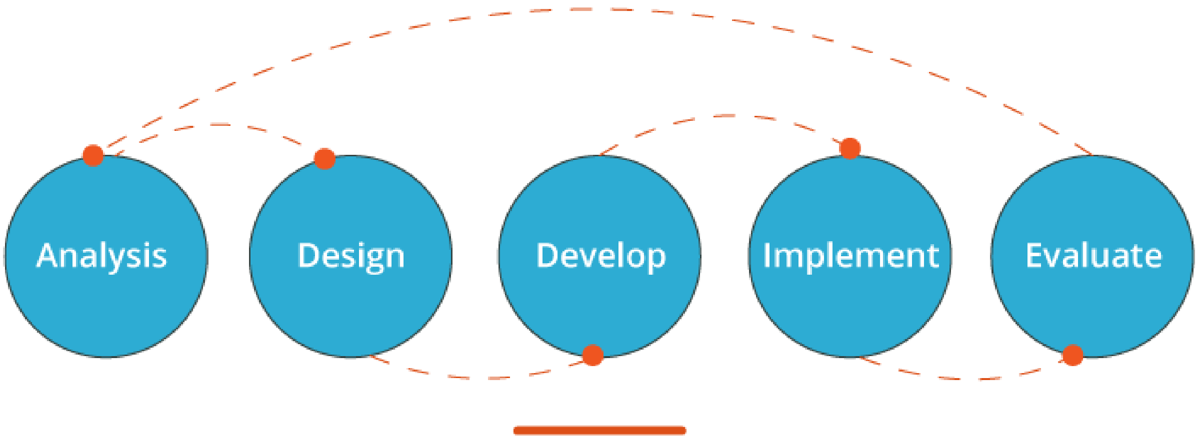

Figure.1. ADDIE Model

3.2. Research Procedure

The research procedure adopts the ADDIE model, which consists of five stages: Analysis, Design, Development, Implementation, and Evaluation. This model was chosen for its simplicity, ease of implementation, and its ability to maintain the critical principles of R&D (Murniati et al., 2022). In the first stage, Analysis, problems related to the availability and feasibility of Applied Physics teaching materials are identified. The Design stage focuses on defining objectives, formats, materials, activities, and selecting library sources (Fortuna, Rahmansyaf, et al., 2023; Fortuna, Waskito, et al., 2023). During the Development stage, a draft of the teaching materials is created, followed by validation by material experts. The Implementation stage involves testing the teaching materials in the learning environment and collecting student response data. Finally, the Evaluation stage consists of assessing the materials and making improvements based on student feedback and material expert validation.

3.3. Research Subject

In this study, a stratified random sampling technique was used for sampling. This approach was chosen to ensure that students from all three classes (Nautical Technology 3A, 3B, and 3C) were represented proportionally based on the number of students in each class: 16 students from 3A, 14 students from 3B, and 24 students from 3C. Stratified random sampling allows for the inclusion of diverse perspectives from each class, which ensures a more comprehensive analysis of the data regarding the effectiveness of the teaching materials developed. This technique also enhances the representativeness of the sample, ensuring that the research findings reflect the views of students from different class groups. Additionally, two expert validators with significant experience in Physics Education (30-40 years) were selected purposively to assess the feasibility and validity of the teaching materials (Syahril et al., 2021).

3.4. Data Collection

The use of three types of instruments—interviews, validation of teaching materials, and questionnaires—was chosen in this study for several key reasons, ensuring a comprehensive approach to data collection and analysis.

3.4.1. Interviews

The structured interview instrument was selected to gather qualitative data directly from educators and students regarding the availability and use of Applied Physics teaching materials at the Politeknik Pelayaran Sumatera Barat. Interviews allow researchers to obtain detailed, context-specific information that may not be captured by other methods. By asking about the frequency of use, adequacy of teaching materials, and the form in which they are provided (printed or digital), the interview provides insight into the real-world application of these materials and their alignment with students' learning needs. This interview consists of four questions:

Q1: Do students currently use Applied Physics teaching materials? If so, what forms and titles?
Q2: Do the teaching materials meet your needs as nautical technology students?
Q3: If applicable, how frequently? (e.g., often, rarely, very rarely).
Q4: Do lecturers provide adequate learning references? If yes, in printed or digital forms?

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3.4.2. Validation of Teaching Materials

The validation instrument was included to assess the quality and appropriateness of the teaching materials developed. This instrument evaluates four key aspects: content, presentation, language, and scientific approach, which are essential for ensuring that the materials are educationally sound and aligned with the needs of students. The use of expert validators helps provide an objective evaluation from those with deep expertise in the field, ensuring that the teaching materials meet the standards of quality, accuracy, and effectiveness.

3.4.3. Questionnaires

The questionnaire instrument was used to gather data on student responses to the developed teaching materials. This instrument collects quantitative data regarding the students' perceptions of the materials' effectiveness, their engagement with the content, and the extent to which the materials support their learning. The use of questionnaires allows for the collection of large-scale data that can be analyzed statistically to identify trends and patterns in student feedback.

Together, these three instruments offer a balanced approach to data collection, combining both qualitative and quantitative data to assess the feasibility, effectiveness, and student engagement with the teaching materials. This method provides a more holistic view of the research problem, ensuring that both the technical aspects of the materials and the users' experiences are thoroughly examined.

The validation instrument is used to evaluate the feasibility of teaching materials based on four main aspects: content, presentation, language, and scientific approach. Each aspect is translated into 14 indicators and 28 assessment items. This instrument also includes additional questions to obtain suggestions and input for improving teaching materials. The description of these aspects is illustrated in Table 1. These instruments are designed to provide comprehensive data related to the feasibility of teaching materials and student responses to the teaching materials developed.

Table.1. Validation Instrument Framework

Aspect and Indicator	Evaluation Criteria
I. Content Feasibility	
Material alignment with course outcomes	Completeness, breadth, and depth
Material accuracy	Accuracy of concepts, data, illustrations
Material relevance	Up-to-date examples and cases
II. Presentation Feasibility	
Systematic and logical organization	Consistency and logical flow
Supporting presentation techniques	Engagement and relevance
III. Language Feasibility	
Adherence to Indonesian language standards	Clarity and precision
Communicative and interactive language usage	Motivational and engaging
IV. Scientific Aspects	
Fluency, flexibility, originality, elaboration	Logical and innovative ideas

The questionnaire assesses students' responses to using scientific-based Applied Physics teaching materials. A Likert scale is used:

1 = Strongly Disagree
2 = Disagree
3 = Agree
4 = Strongly Agree

The questionnaire includes three aspects and 18 statements. Students are also encouraged to provide comments and suggestions for improvement.

Table.2. Questionnaire Framework

Aspect	Statements
Teaching Material Appearance	Attractive cover, precise visuals, and proportional design
Teaching Material Content	Logical sequence, clear concepts, and promotes critical thinking.
Language	Easy-to-understand terminology and symbols

3.5. Data Analysis Technique

This research uses several data analysis methods to ensure the teaching materials' validity, effectiveness, and acceptability. The following is an explanation of data analysis techniques based on the type of data used:

3.5.1. Data Analysis of Feasibility Validation of Teaching Materials

Data on the results of validation by experts on the feasibility of teaching materials were analyzed by calculating the average score using the formula:

$$\bar{x} = \frac{\sum x}{n}$$

Description:
$\bar{x}$ = Average Score
$\sum x$ = Total Score Obtained
n = Number of Assessment Items

The average score obtained is then converted into qualitative data based on the eligibility criteria as shown in Table 3.

Table.3. Expert Validation Criteria

Average Score	Criteria	Description
$3.26 < \bar{x} \leq 4.0$	Highly Feasible to Use	No revision required
$2.51 < \bar{x} \leq 3.26$	Feasible to Use	Requires revision
$1.76 < \bar{x} \leq 2.51$	Less Feasible to Use	Requires revision
$1.00 < \bar{x} \leq 1.76$	Not Feasible to Use	Needs replacement

3.5.2. Data Analysis of Student Response Questionnaire Results

Student response questionnaire data were analyzed to determine the effectiveness of teaching materials. The average score of student responses was calculated using the same formula as the validation analysis, where the results of the average score calculation were converted into qualitative data based on the product effectiveness level criteria, as shown in Table 4.

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Table.4. Product Feasible Criteria

Average Score	Criteria
$3.26 < \bar{x} \leq 4.0$	Very Feasible
$2.51 < \bar{x} \leq 3.26$	Feasible
$1.76 < \bar{x} \leq 2.51$	Less Feasible
$1.00 < \bar{x} \leq 1.76$	Very Less Feasible

3.5.3.Data Analysis of Interview Results

The interview data were analyzed descriptively and qualitatively to provide more in-depth information related to the research findings. This Analysis aims to strengthen the data obtained through validation and questionnaires by further exploring the opinions and experiences of participants. This approach ensures that the research results are based on measurable quantitative Analysis and supported by qualitative data that enrich insights into the effectiveness and feasibility of teaching materials.

4. Results and Discussion

This section presents the results of the research conducted using a Research and Development (R&D) approach based on the ADDIE model. The goal of this study was to develop scientific-based Applied Physics teaching materials tailored to meet the needs of students in the Nautical Technology Study Program at the Politeknik Pelayaran Sumatera Barat. The study followed five strategic phases: Analysis, Design, Development, Implementation, and Evaluation, each aimed at producing teaching materials that enhance learning experiences. The findings provide insights into the current state of teaching materials, the design process, and the validation of the materials, along with their alignment with the students' needs and academic objectives.

The Design phase of this study focused on structuring the Applied Physics teaching materials, where specific objectives, content scope, format, organization, and learning activities were established. During this phase, the materials were carefully crafted to provide contextual, comprehensible content that supports the development of students' creative thinking skills, which are crucial for their future careers in the workforce. Seven main topics were selected: Measurement, Quantities, and Units; Statistics; Mass and Volume; Motion Dynamics; Work and Energy; Fluids; and Temperature and Heat. The structure of the materials included a Cover, Preface, Table of Contents, Chapters (which featured titles, content, scientific activities, and competency tests), and a Reference List. Following the Design phase, expert validators, including Dr. Laspida Harti, M.Pd., Lelfita, M.Pd., and Eka Susanti, S.Pd., M.Sc., reviewed and validated the materials to ensure their academic and practical feasibility. The outcomes of this Design and Development phase are visually represented in Figure 2.

Figure.2. Results of Design and Development of Applied Physics e-Books

Figure 2 the Applied Physics teaching materials designed aim to help students understand the basic concepts of physics through a scientific approach while honing critical and creative thinking skills that are relevant to the demands of the world of work, especially in the field of Nautical Technology. The scientific approach used in this teaching material integrates observation, analysis, and problem solving methods to encourage active and in-depth learning. In addition, this teaching material is designed contextually and interactively by focusing learning activities on the application of physics theory in real situations that are often encountered in maritime operations, such as ship stability, navigation, and shipping safety. Through various practice-based tasks and exercises, this teaching material ensures that students not only understand the theory, but are also able to apply it according to the needs of the workplace. With a problem-based approach, this teaching material is expected to create an interesting and relevant learning experience, while preparing students to face the challenges of the world of work in the maritime sector. To access

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this teaching material in full, please visit the following link: https://drive.google.com/file/d/1LZBET8TUH7yD422Bmy6kUpKJTLoA2V9U/view?usp=sharing.

In the development phase, a draft of the teaching materials was prepared based on the established design and validated by subject matter experts. Validators such as Lelfita, M.Pd., and Eka Susanti, S.Pd., M.Sc., evaluated the feasibility of the teaching materials to ensure their effectiveness in student learning, as detailed in Table 5.

Table.5. The results of the feasibility validation of teaching materials

Aspect - Indicator	Assessment Item	Score		
		I	II	Average
I. Content Feasibility				
Relevance of Material to Course Learning Outcomes	Completeness of material	4	4	4
	Breadth and depth of material	3	3	3
Accuracy of Material	Accuracy of concepts and definitions	3	3	3
	Accuracy of facts and data	3	3	3
	Accuracy of images, diagrams, and illustrations	3	3	3
	Correctness and clarity of notations and symbols	3	3	3
	Relevance and credibility of references	4	3	3.5
Material Currency	Currency of facts and data	4	4	4
	Currency of examples and cases	4	4	4
	Average	**3.05**		
II. Presentation Feasibility				
Presentation Technique	Systematic consistency	4	3	3.5
	Logical sequence of concepts	4	3	3.5
Supporting Presentation	Appeal of chapter introduction	3	4	3.5
	Accuracy of examples and cases	3	3	3
	Effectiveness of competency tests	4	3	3.5
	Coherence of bibliography	4	3	3.5
Learning Presentation	Student engagement	4	3	3.5
Coherence and Logical Flow	Interrelation between subchapters and paragraphs	3	3	3
	Completeness of meaning in chapters/subchapters/paragraphs	3	3	3
	Average	**3.33**		
III. Language Feasibility				
Adherence to Indonesian Language Rules	Sentence structure accuracy	3	3	3
	Sentence effectiveness	3	3	3
	Standardized terminology	3	3	3
Communicative	Clarity of message or information	3	3	3
Dialogical and Interactive	Ability to motivate	4	3	3.5
	Encouragement for critical thinking	4	3	3.5
	Average	**3.16**		
IV. Scientific Feasibility				
Fluency	Smoothness of ideas, answers, or scientific questions	3	3	3
Flexibility	Adaptability of ideas, answers, or scientific questions	3	3	3

Originality	Novelty of ideas, answers, or scientific questions	4	4	4
Elaboration	Depth of scientific idea explanations	4	3	3.5
	Average			**3.33**
	Overall Average			**12.87/4 = 3.21**

The results of the feasibility validation of the teaching materials presented in Table 5 show a generally good assessment across various aspects. In terms of content feasibility, the teaching materials are considered relevant to the learning outcomes, particularly in terms of the completeness of the material, which received an average score of 4. However, some indicators such as the depth of the material and the accuracy of concepts and notations need improvement, with an average score of 3. The overall score for content feasibility is 3.05. Regarding presentation feasibility, the presentation technique is fairly systematic with an average score of 3.5, but the interrelation between subchapters and logical flow still needs enhancement, scoring an average of 3. This aspect received an overall average score of 3.33. In terms of language feasibility, the materials comply with Indonesian language rules well and are communicative, although there is room for improvement in motivating students and encouraging critical thinking, with an average score of 3.16. In scientific feasibility, originality scored the highest (4), but the fluency, flexibility, and elaboration of ideas require further development, with average scores ranging from 3 to 3.5. Overall, the teaching materials received an average score of 3.21 in the category of "Feasible to Use", indicating that they are feasible for use, with some areas that need improvement to enhance their effectiveness and quality.

In addition to quantitative data, validation by the two material experts was also qualitative. The following presents the material experts' answers to several supporting questions:

a. What advantages does this Applied Physics teaching material have compared to other materials? If any, in which aspects?
    1) Expert I (Lelfita, M.Pd.):
    "Yes, several discussions are presented quite effectively and creatively. Including problem-solving tasks to train creative thinking skills has been done well."
    2) Expert II (Eka Susanti, S.Pd., M.Sc.):
    "Yes, this teaching material connects the context of Applied Physics learning with students in Nautical Technology. Furthermore, it is designed to enhance critical and creative thinking skills, and the material accommodates these objectives effectively."
b. What suggestions do you have for improving and developing this teaching material?
    1) Expert I (Lelfita, M.Pd.):
    "Such teaching materials are rare and interesting because they bridge the gap in explaining phenomena. To further improve, it is recommended that data and information be incorporated more closely aligned with the Nautical Technology field. Additionally, problems should be presented in novel contexts or situations similar to previously discussed cases to intensify creative thinking skills."
    2) Expert II (Eka Susanti, S.Pd., M.Sc.):
    "I suggest developing more practical contexts from the foundational level. Begin with the basic concepts of Applied Physics, then gradually build hierarchical connections to derive formulas applicable to ships."
c. Please provide your conclusion on the evaluation of this teaching material.
    1) Expert I (Lelfita, M.Pd.):
    "The teaching material is usable with revisions."

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2) Expert II (Eka Susanti, S.Pd., M.Sc.):
"The teaching material is usable with revisions."

In the implementation phase, the process of collecting data on student responses to the use of the developed Applied Physics teaching materials is presented in Table 6.

Table.6. Student Responses to the Use of the Teaching Materials

Aspect	Statement	Average Score
Appearance of Teaching Materials	The cover illustration is attractive	3.00
	Images, diagrams, and illustrations are varied	3.09
	Text variation is proportional and easy to read	3.09
	The combination of images, text, and colors is proportional	3.13
	The combination of images, text, and colors helps in understanding the material of the teaching material	3.35
Average		**3.13**
Material of the Teaching Materials	The material of the teaching materials is interesting	3.09
	The material of the teaching materials is explicit and complete	3.09
	The sequence and presentation of the material are logical and systematic	3.17
	The material of the teaching materials helps in understanding the concepts of Applied Physics	3.30
	The content coverage of the teaching materials is very complete	3.39
	The Scientific Activity section encourages the quick discovery of various answers	2.96
	The Scientific Activity section encourages the creation of various solutions to problems from different perspectives	3.83
	The Scientific Activity section encourages the creation of new ideas from perspectives not previously considered by others	3.22
	The Scientific Activity section encourages detailed Analysis of ideas	3.22
	The presentation of the teaching material encourages me to discuss and search for other information	3.35
Average		**3.26**
Language	The teaching material contains competency tests that can measure higher-level understanding	3.04
	Sentences are easy to understand	3.30
	Terms, notations, and symbols are clear and easy to understand	3.09
Average		**3.14**
Overall Average		**3.17**

The student responses to the use of the teaching materials, as shown in Table 6, reflect generally positive feedback across various aspects. In terms of the appearance of the materials, students rated it with an average score of 3.13, indicating that the cover illustration, image variety, text readability, and overall design were deemed appealing and helpful in understanding the material. The highest score in this section was given to the combination of images, text, and colors that aided comprehension, scoring 3.35.

Regarding the content of the materials, the average score was 3.26, showing that students found the material interesting, complete, and logically presented. The content's ability to help students understand Applied Physics concepts was highly rated (3.30). However, the "Scientific Activity" section received mixed feedback, with the highest score (3.83) for encouraging creative problem-solving, while the lowest score (2.96) indicated room for improvement in stimulating the quick discovery of answers.

In terms of language, students rated the teaching materials with an average score of 3.14, reflecting that the sentences were clear and understandable, and the terminology was appropriate. The overall average score across all aspects is 3.17, indicating that the teaching materials are well received, including in the “Feasible” category.

5. Discussion

Developing scientific-based teaching materials for the Applied Physics course tailored to Nautical Technology students at the Politeknik Pelayaran Sumatera Barat is essential for enhancing comprehension, engagement, and applicability in learning. Teaching materials serve as pivotal tools that guide educators and help students achieve defined competencies (Kilag et al., 2023; Rupia, 2022). However, current resources, such as Physics for Science and Engineering (Munfaridah et al., 2021) or Basic Physics (Oakey, 2020), predominantly emphasize mathematical approaches and fail to address the practical needs of Nautical Technology students, who require materials focused on applied physics in maritime contexts.

The gap in existing teaching materials reveals the difficulty in aligning instructional content with students' practical needs. Students frequently struggle with abstract physics concepts due to reliance on mathematics-heavy textbooks that lack relevance to their vocational context (Agustyaningrum et al., 2020; Andriani et al., 2024). This misalignment can result in cognitive overload and diminished learning outcomes (Rahim et al., 2024). Furthermore, instructional approaches that disregard students' vocational focus can negatively impact their motivation and physiological state, ultimately hindering their achievement (Cattaneo et al., 2022; Choi et al., 2019; Indrawati & Kuncoro, 2021).

Research highlights that contextualized and relevant teaching materials can enhance student understanding and engagement. For instance, (Waskito, Fortuna, et al., 2024), demonstrate that teaching designs aligning with students' prior knowledge and real-world applications yield improved outcomes. Specifically, in Applied Physics, students better grasp principles when teaching materials integrate physics applications in contexts like navigation mechanics, ship stability, and maritime safety (Finkenberg & Trefzger, 2019).

This study employs the ADDIE model (Analysis, Design, Development, Implementation, and Evaluation) to systematically create materials incorporating practical scenarios and maritime-specific problems. Each stage ensures alignment with both theoretical concepts and vocational needs, facilitating a seamless connection between theory and practice. The integration of active learning strategies, such as problem-solving exercises, practical applications, and case studies, fosters critical thinking and prepares students for real-world maritime challenges. Active learning has proven effective in increasing retention and understanding of complex concepts (AlAli, 2024; Bugis et al., 2023). By embedding interactive elements, such as real-time feedback mechanisms and maritime case analyses, the teaching materials aim to enhance both student engagement and applicability in professional scenarios.

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The triangulation between this study and previous research reinforces the need to develop teaching materials tailored to the needs of Nautical Technology students. As discussed, teaching materials relevant to students' needs are essential to improve motivation and learning outcomes. The use of mathematics-oriented physics textbooks may not fully support the needs of students who focus on the practical application of physics in shipping (Mikhaylovsky et al., 2021). Integrating scientific-based teaching materials that emphasize the application of physics in real shipping scenarios is a more practical approach.

Validation by experts confirmed that the developed materials are "feasible to use with revision," addressing concerns about systematic presentation, relevance, and creative engagement. The materials successfully bridge the gap between theoretical knowledge and real-world application, as evidenced by their ability to attract student attention, present content systematically, and foster creativity through scientific activities tailored to maritime contexts.

This study emphasizes the importance of developing Applied Physics teaching materials aligned with the needs of Nautical Technology students to improve motivation, comprehension, and learning outcomes. By integrating practical applications and scientific approaches, the materials not only address existing gaps but also align with global standards for vocational education in maritime fields. Future research should focus on expanding these teaching materials with cutting-edge technologies, such as augmented reality, to further enhance student engagement and understanding.

6. Conclusion

This study successfully developed Applied Physics teaching materials based on a scientific approach aimed at enhancing students' creativity in the Nautical Technology Study Program at the Politeknik Pelayaran Sumatera Barat. The ADDIE model, encompassing Analysis, Design, Development, Implementation, and Evaluation phases, was employed during the development process. Expert validation indicated that the teaching materials meet the eligibility criteria, categorized as "feasible to use with revision." The materials effectively attract student attention, present content systematically, and foster creativity through scientific activities relevant to the professional maritime industry. Overall, the teaching materials can help students understand physics concepts practically, support critical thinking skills, and enhance creativity, making them suitable for broader implementation in higher education institutions.

In order to further improve the teaching materials, feedback from validators and students highlighted the need to strengthen the practical contextualization of learning activities to align more closely with the field of nautical technology. Additionally, incorporating innovative problem-solving exercises in the learning activities is recommended to further challenge and engage students. These enhancements could optimize the effectiveness of the teaching materials and better prepare students for real-world applications in their field.

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