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Development of REACT-Based Module Integrating Qurani in Temperature and Heat Materials in High School

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ABSTRACT

This study is motivated by the limited availability of physics learning resources, which are mostly textbooks, the lack of integration of Islamic values, and the implementation of a teacher-centered education system, resulting in reduced active student participation in the learning process. The aim of this research is to determine the feasibility and practicality of developing a REACT-based module with Quranic integration on temperature and heat material in SMA/MA. This research uses a type of R&D research with a 4D model which has several stages, namely the definition stage, design stage, development stage and disseminate stage. The instruments used in this research were material expert validation sheets, media expert validation sheets, as well as interpretation expert validation sheets and questionnaires. The research results obtained from material expert validation were 94%, media expert validation was 98%, and interpretation expert validation was 93%, resulting in an overall feasibility percentage of 95% with very feasible criteria, as well as practical results obtained from student responses. amounting to 88% with very practical criteria. It can be concluded that the REACT-based module with Quranic integration in temperature and heat material in SMA/MA is very feasible and very practical to use in the learning process.

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KATA KUNCI:
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ABSTRAK

Penelitian ini dilatarbelakangi oleh sumber bahan ajar fisika yang sangat terbatas dan hanya berupa buku paket, guru tidak memiliki bahan ajar yang mengandung nilai-nilai keislaman dan sistem pendidikannya menganut Teacher Center, yang peserta didik kurang aktif berperan dalam proses pembelajaran. Tujuan penelitian ini adalah untuk mengetahui kelayakan dan kepraktisan dari pengembangan modul berbasis REACT berintegrasi Qurani pada materi suhu dan kalor di SMA/MA. Penelitian ini menggunakan jenis penelitian R&D dengan model 4D yang memiliki beberapa tahapan yaitu tahap pendefinisian (Define), tahap perancangan (Design), tahap pengembangan (Development), dan tahap penyebaran (Disseminate). Instrumen yang digunakan dalam penelitian ini berupa lembar validasi ahli materi, lembar validasi ahli media, serta lembar validasi ahli tafsir dan angket. Hasil penelitian yang diperoleh dari validasi ahli materi sebesar 94%, validasi ahli media sebesar 98%, serta validasi ahli tafsir sebesar 93%, sehingga diperoleh hasil persentase keseluruhan

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kelayakan sebesar 95% dengan kriteria sangat layak, serta hasil kepraktisan yang diperoleh dari respon peserta didik sebesar 88% dengan kriteria sangat praktis. Dapat disimpulkan bahwa modul berbasis REACT berintegrasi Qurani pada materi suhu dan kalor di SMA/MA sangat layak dan sangat praktis digunakan dalam proses pembelajaran.

A. Introduction

Life continues to be dynamic with the times, all aspects of life are changing, especially the implementation of education. The education system is expected to continuously adapt to become more modern, relevant, and capable of addressing global challenges. Education is very important, as time goes by the quality of education will become more and more complex[1]. The purpose of education is inseparable from efforts to produce problem solving so that there are always new innovations in the learning model. The development of new innovations in learning materials is urgently needed in order to increase a child's interest in learning[2]. However, the reality in the field indicates a considerable gap. The limited availability of teaching materials has become one of the contributing factors to the decline in the quality of education in Indonesia, especially with more and more educational problems, it is necessary to improve the quality, one of which is in the development of teaching materials[3].

The limitation of teaching materials in learning has caused the decline of education in Indonesia, especially with more and more educational problems, it is necessary to improve the quality, one of which is in the development of teaching materials[4]. Learning materials are divided into four types, namely as follows (1) Teaching materials in the form of prints, for example*: handouts*, textbooks, modules, student worksheets, brochures, *leaflets,* photos, and models or markets. (2) Teaching materials in the form of listening (audio) for example: cassettes, radios, black plates or *audio compact discs.* (3) Teaching materials for visual (audiovisual) for example: for example, *video compact discs* and films. (4) Teaching materials are interactive, i.e. teaching materials that are combined from two or more media (audio, text, images, animations, and videos)[5].

The teaching materials used in this study are in the form of modules. A module is defined as a tool or means of containing learning information in which there are materials, methods, and others that are designed in a structured and attractive manner in order to achieve the expected learning objectives[6]. The module is one of the learning tools designed based on the running curriculum is expected to achieve the SK (Competency Standards) set[7]. The use of modules has many advantages so that it is suitable as a varied learning material rather than just using package books. The advantages of this module include: a) the pictures in the module explain the material, b) the colors in the module are interesting, bright so that they can increase students' interest in reading, c) they are able to overcome space and time for students and teachers, d) they develop interaction skills so as to improve learning skills, e) the role of teachers is not only as a teacher but also as a guide, f) students will be healthier in competence, g) can attract students' attention in learning, so that interactive learning emerges that makes children more confident[8].

Based on observations at MAS Darul Ihsan, it can be seen that the source of physics teaching materials is very limited and only in the form of package books, teachers do not have teaching materials that contain Islamic values and the education system adheres to *the Teacher Center,* where students do not play an active role in the learning process. Islamic religious learning only discusses religion, so students consider that there is no connection between religion and physics subjects, even though the two are very related. An example of the relationship between religion and physics is found in Q.S Al-Quraish : 2 which tells about the trade of the Quraish tribes in winter to Yemen and summer to Syria. Winter and summer are the magnitude of the temperature.

The relationship between physics and religion is very suitable to be integrated, so that the physics learning system also not only pursues the cognitive aspect, but also the learning of noble character[9]. The integration of Islamic-based physics in the learning process can raise students' awareness of good character and personality values in accordance with Islamic values[10] The integration of Islamic-based physics in the learning process can raise students' awareness of good character and personality values in accordance with Islamic values[8]

Another problem in observation is that the teaching materials in learning are only package books, so that students get bored quickly in learning. The learning system using package books results in a lack of interaction between students and teachers in the teaching and learning process. Therefore, a learning model is needed that is in accordance with this problem.

The learning model used in this study is *the REACT model,* which will provide opportunities for students to play a more active role in the classroom. *REACT* is defined as part of a contextual learning strategy consisting of five stages, namely *relating* (connecting), *experiencing*, *applying*, *cooperating*, and *transferring* (sharing or transferring). *REACT* will provide opportunities for students to learn to "experience" not just memorize, apply concepts, and practice students' thinking skills optimally.

The advancement of information technology offers opportunities to overcome the limitations of physics learning through the development of module based on React. Learning through a contextual approach enables students to construct their scientific understanding independently by connecting it with events and phenomena that occur in everyday life [15]. The integration of Qur'anic values within this module is considered strategic, as it not only enriches the cognitive dimension but also fosters students' spiritual awareness, leading to a religiously grounded rational understanding of knowledge. The topic of temperature and heat is particularly relevant, as it directly relates to everyday phenomena that align with Qur'anic verses. Thus, a React-based module that integrates Qur'anic perspectives has the potential to provide science learning that is innovative, contextual, and religiously oriented in accordance with the demands of contemporary education. Based on these problems, the purpose of this study is to determine the feasibility of developing a REACT-based module integrating Quranic on Temperature and Heat materials in SMA/MA, andto find out the practicality of developing a REACT-based module integrating Quranic on Temperature and Heat materials in SMA/MA.

B. Method

This research is a Research and Development (R&D) research. This research aims to test and develop a product in the form of a REACT-based module integrating Qurani which will be the final result of this research. The module was developed using Canva software to support content creation, interactive design, and the integration of various learning features, which serve as the final product of this research. Product development cannot be separated from product validation to produce a higher quality final product. The validation was carried out by six experts, consisting of two material experts, two media experts, and two Qur'anic exegesis experts. Validation refers to the research process where validators collect input and suggestions to assess the suitability of the resulting product[11]. This research uses a 4D model consisting of 4 (four) elements according to its abbreviation, namely, the stages of define, design, development, and disseminate.

This development research is specifically limited to the validation stage of feasibility, while the trial phase was not carried out within the scope of this study. This limitation was determined based on considerations of time constraints, availability of resources, and the research focus, which was directed at assessing the product's feasibility prior to conducting trials in subsequent stages. Therefore, the results of this study are expected to provide an initial overview of the quality of the developed product based on expert evaluation, which can later serve as a foundation for further research at the trial and classroom implementation stages.

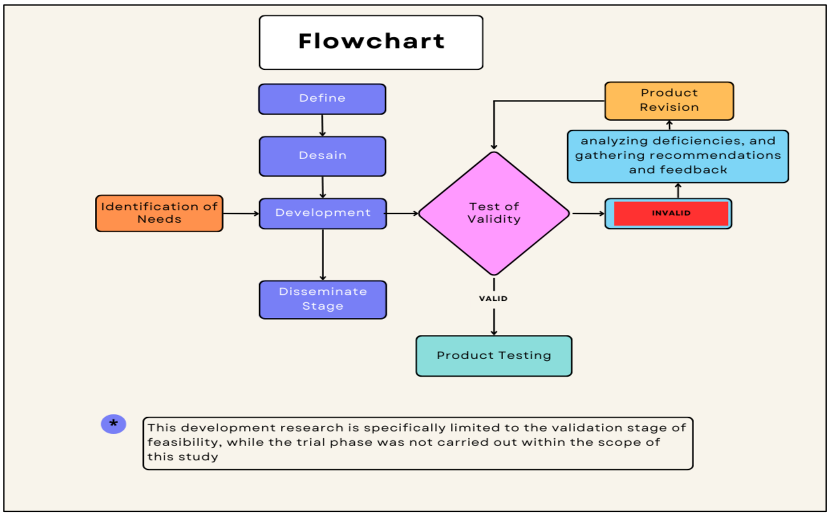

Figure 1. Module Development Flowchart

The research stages start from :

1. The Define *stage is part* of the beginning of the 4D step that determines and defines the learning requirements, namely making initial observations about school conditions. Of course, in determining learning needs, things that need to be considered include learning needs with the applicable curriculum, the condition of the school, how students develop, and even what developments are applied in the school.
2. Design Stage
   The design stage is the stage of designing learning tools. At the design stage, the selection of format, media for delivering learning materials and the process of making products will be the main basis for this stage. This research will focus on initial design planning in the form of learning modules with predetermined materials. Interesting media with material content that can be easily understood by students, so that students are interested in using this learning module. The initial product for the learning module will be adjusted to the suggestions and input of the supervisor to be developed.
3. Development Stage
   This development stage serves to produce products in the form of learning modules after going through revisions based on comments, suggestions and assessments through validators. The following steps describe this stage of development, which are as follows: a) Validation of experts or practitioners; b) Revision I, revision I is carried out after the completion of the validation process; and c) Developmental Testing.
4. Disseminate Stage

The dissemination stage (*Disseminate)* is the final process in the development stage. At this stage, it is carried out to disseminate the product to the public after it is declared that the product developed is feasible and can be used. However, in this study, the dissemination stage was not carried out by the researcher because of the constraints of relatively large production costs.

Instruments are defined as facilities or tools used in research, so that they can make it easier for researchers to process data and produce better results. The instruments used in this study are as follows:

1. Validation Sheet
   a. Material Expert Validation Sheet
      The instrument in the form of a material expert validation sheet will be assessed by validators who are competent in their field. The feedback and suggestions provided will be revised and utilized as valuable input for researchers in order to produce a better product that is feasible to be used as one of the teaching materials.
   b. Media Expert Validation Sheet
      The instrument in the form of a media expert validation sheet will be tested by validators who are experts in the media field.
   c. Interpretation Expert Validation Sheet
      The instrument in the form of an interpretation expert validation sheet will be tested by validators who are experts in the field of interpretation.
2. Questionnaire
   An instrument in the form of a questionnaire will be given to students, which contains questions. The goal is to get results related to practicality with the opinions of students in the *REACT-based* module integrating Qurani on temperature and heat materials.

Data collection techniques are very important according to the main purpose of obtaining data, data collection is the main part[11]. Data is obtained from validation sheets and questionnaires. Validation sheets by material experts, media expert validation, and interpretation expert validation will be inputs and suggestions so that researchers know the feasibility of the modules that have been developed. Meanwhile, a questionnaire was given to students containing questions to get results related to practicality with students' opinions in a *REACT-based* module integrating Qurani on temperature and heat materials.

This Quranically integrated *REACT-based* module uses quantitative data by referring to four criteria[12]. Below are the questionnaire criteria:

Table 1. Table of criteria for the questionnaire

Score	Information
1	Very Disagree (SKS)
2	Disagree (KS)
3	Agree (S)
4	Strongly Agree (SS)

Meanwhile, the criteria from the validation sheet use the following criteria[13].

Table 2. Validation sheet criteria table

Score	Information
1	Bad
2	Not Good
3	Good
4	Excellent

Furthermore, the data obtained with data collection instruments are analyzed using percentage analysis techniques according to a predetermined formula. To calculate the average score of each aspect of the equation is as follows:

$$\overline{x}=\frac{\sum x}{N}=\textit{Average Score by Experts}=\frac{\textit{Total Score}}{\textit{Number of Questions}} \quad (1)$$

To calculate the percentage as follows

$$\textit{Persentage Of Feasibility}=\frac{\textit{Average across all aspects}}{\textit{Maximum evaluation score}}\times 100\% \quad (2)$$

It is possible to match the assessment with the results of its eligibility as shown in Table 3 below[13]

Table 3. Eligibility Criteria

No	Value	Decision
1	76<x<100	Highly Worthy
2	51<x<75	Proper
3	26<x<50	Less Worthy
4	0<x<25	Not Eligible

C. Result and Discussion

This research and development aims to determine the feasibility and practicality of *the REACT-based* learning module integrating Quranic on temperature and heat materials in SMA/MA. This research and development uses a 4D model that goes through 4 stages as follows:

Define Stage

This define stage contains about activities related to learning at the place of research carried out, namely at MAS Darul Ihsan. The activities carried out by the researcher in this definition stage are divided into several stages of activities which will be discussed in more detail below.

1. Front-end Analysis

This initial analysis was carried out by the researcher with the aim of finding problems during the teaching and learning process. To obtain information about problems that occur during the teaching and learning process, researchers conduct observation activities in schools. Based on the results of observations made by the researcher, the problems obtained during the observation are as follows:

a. Students have difficulty solving problems related to temperature and heat materials.
b. The teaching materials used by teachers are in the form of worksheets and physics handbooks that are still not associated with the Quran.
c. The learning media used are in the form of whiteboards and markers.
d. Learning is based on the explanation of the teacher and students only record the material written by the teacher on the blackboard.

2. Learner Analysis

The analysis of students aims to find out the characteristics of students during the learning process. Based on the observations that have been made on students in class XI SMA/MA, it was found that the characters of some students gave passive responses and seemed not interested in physics lessons during learning. In addition to the characteristics of students, the researcher also observed the level of understanding and knowledge of students in solving physics problems related to temperature and heat materials.

a. Task Analysis

In this task analysis, the researcher details the tasks according to the content of the material based on basic competencies. The details of the content of the material are intended to achieve competency achievement indicators as competency achievement indicators are formulated. In addition, this can make it easier for researchers to summarize learning indicators and objectives.

b. Concept Analysis

In the concept analysis stage, the researcher has formulated material concepts that will be presented in the designed module. The material concepts presented are temperature and heat materials. The materials are adjusted to the material that is important for students to learn so that it is in accordance with the KD and the indicators set.

c. Specifying Instructional Objectives

At this stage, learning objectives can be formulated based on Core Competencies (KI) and Basic Competencies (KD), as well as indicators that are expected to be achieved in learning. The learning objectives are listed in the module teaching materials and lesson plans.

Design Stage

This design stage is used to design products that are suitable and in accordance with the problems that occur during the teaching and learning process. At this stage, the researcher designs the product to be developed. This design stage is divided into several stages, namely:

1. Media Selection

In the media selection phase, the researcher developed media in the form of *a REACT-based* module integrating Qurani. This module contains temperature and heat material associated with the Quran. The presentation of the material and questions that will be included by the researcher still refers to the basic competencies, indicators and learning objectives for students in class XI SMA/MA so that it is very suitable for use in the teaching and learning process.

2. Format Selection

The format used in *the REACT-based* module product integrates Qurani on temperature and heat materials is designed in such a way that it looks attractive. This module is created using Corel Draw starting from the foreword to the author's profile. However, the front and back covers are made using the Canva application which is a design application. The choice of color format is white combined with bright light green.

3. Initial Design

At this stage, the initial design of the module begins to be designed. The initial design of this module is made based on the results of the analysis in the definition phase and adjusted to the selected format.

Development Stage

This development stage consists of the validation of material experts, media experts, and interpretation experts. Some of the grids contained in the validation questionnaire sheet include:

1. Material expert validation sheet: Eligibility, serving components, and linguistic Components
2. Media expert validation sheet: Module size, module cover design, module design
3. Interpretation expert validation sheet: Fill, islamic values, language.

Disseminate Stage

The dissemination stage is the stage where the REACT-based module with Quranic integration on temperature and heat material that has been developed and revised is disseminated to the target research site. The researcher did not carry out this stage because the researcher was constrained by the large costs required. The results of the development stage which have been validated by material experts, media experts and interpretation experts are as follows.

1. Feasibility of REACT-based Module with Quranic Integration on Temperature and Heat Material

The feasibility or quality of the module product is determined from the results of the feasibility test which is carried out by validating the product that has been developed with two material experts, two media experts and two interpretation experts. This product validation aims to obtain a feasibility assessment and advice from professional experts in their field. The module developed has good quality and is declared worthy of being a module to support education after revisions have been made in accordance with the suggestions of material expert validators, media experts and interpretation experts.

Alpha testing is a validation process carried out by material experts, media experts and interpretation experts to assess the quality and suitability of the learning modules that have been developed. The results of the validation sheet will be used as a reference for revising modules, materials and interpretations.

a. Fasibility of a REACT-Based Module with Quranic Integration on Temperature and Heat Material by Material Experts.

The material experts provide an assessment based on the statement items attached to the material expert validation sheet by ticking the appropriate rows and columns, as well as providing suggestions and criticism as a reference for revising the material being developed. The results of the assessment by material experts on REACT-based module products integrating Qurani on temperature and heat material for each aspect can be seen in the graph in Figure 4.

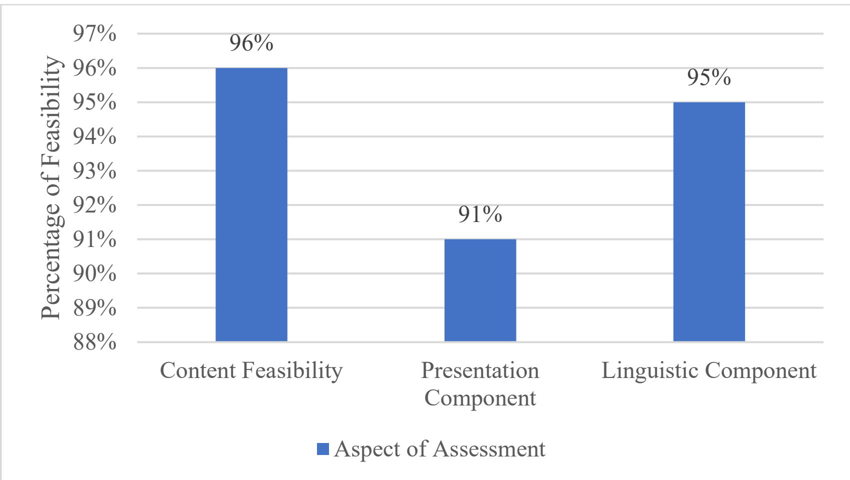

Figure 4. Material Expert Validation Chart

Based on data analysis of material expert validation results in figure 4 which is viewed from three aspects of assessment, namely content feasibility, getting an average of 3.83 with a percentage of 96% which is included in the very feasible criteria. In the presentation component aspect, the average was 3.63 with a percentage of 91%, which is included in the very appropriate criteria. In the linguistic component aspect, the average was 3.80 with a percentage of 95% which is included in the very appropriate criteria. The REACT-based module with Quranic integration on temperature and heat material overall received an average total score of 3.75 with a percentage of 94% which is included in the very feasible criteria.

b. Feasibility of a REACT-Based Module with Quranic Integration on Temperature and Heat Material by Media Experts

The assessment by media experts aims to determine the suitability of the module in terms of module size, module cover design, and module design. Media experts consist of two lecturers, namely: (1) SR is a lecturer in Electrical Engineering Education, Faculty of Tarbiyah and Teacher Training, Ar-Raniry State Islamic University Banda Aceh, and (2) KA is a lecturer in Information Technology, Faculty of Science and Technology, Ar-Raniry State Islamic University Banda Aceh. The results of the assessment by media experts on REACT-based module products with Quranic integration on temperature and heat for each aspect can be seen in the graph in Figure 5.

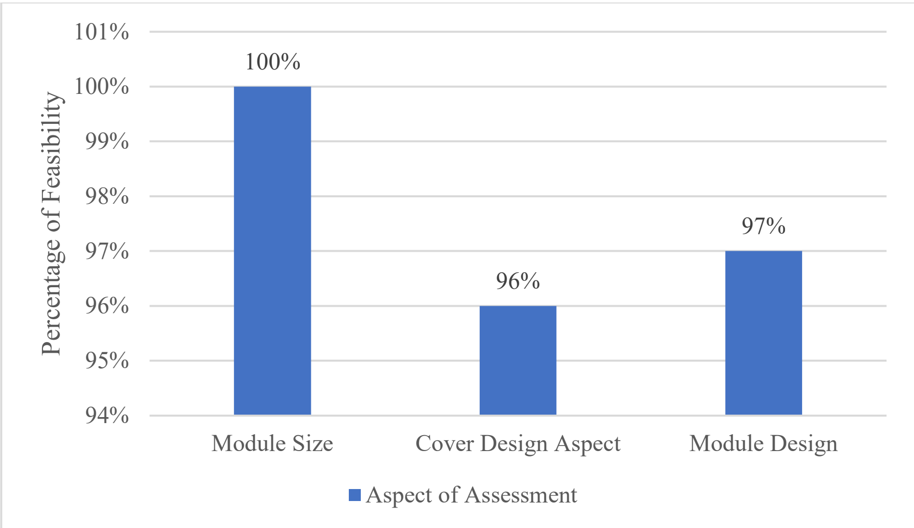

Figure 5. Media Expert Validation Chart

Based on data analysis of media expert validation results in figure 5 which is viewed from three aspects of assessment, namely module size, getting an average of 4 with a percentage of 100% which is included in the very feasible criteria. In the cover design aspect, the module received an average of 3.86 with a percentage of 96% which is included in the very feasible criteria. In the module design aspect, the average was 3.89 with a percentage of 97% which is included in the very feasible criteria. The REACT-based module with Quranic integration on temperature and heat material overall received an average total score of 3.92 with a percentage of 98% which is included in the very feasible criteria.

c. Feasibility of a REACT-Based Module with Quranic Integration on Temperature and Heat Material by Tafsir Experts

The assessment by interpretive experts aims to determine the suitability of the module in terms of content, Islamic values and language. The exegesis experts consist of two lecturers, namely: (1) RD is a lecturer in Physics Education, Faculty of Tarbiyah and Teacher Training, Ar-Raniry State Islamic University Banda Aceh, and (2) FQ who is a lecturer in Al-Qur'an and Tafsir Science, Ushuluddin Faculty, Ar-Raniry State Islamic University Banda Aceh. The results of the assessment by exegetical experts on the REACT-based module with Quranic integration on temperature and heat material for each aspect can be seen in the graph in Figure 6.

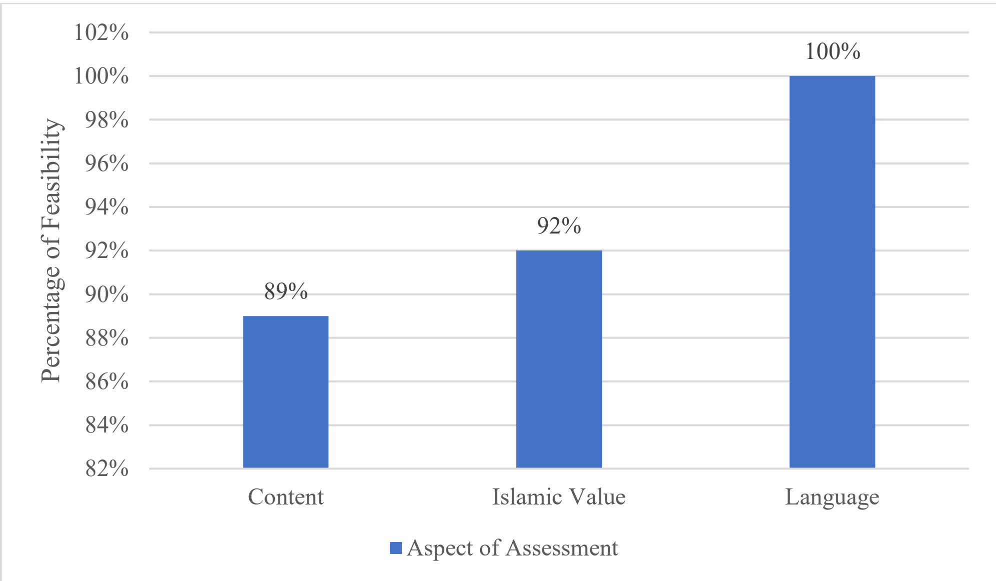

Figure 6. Expert Interpretation Validation Chart

Based on analysis of data from the validation results of interpreting experts in Figure 6 which is viewed from three aspects of assessment, namely content, the average is 3.55 with a percentage of 89% which is included in the very appropriate criteria. In the aspect of Islamic values, the average was 3.67 with a percentage of 92%, which is included in the very appropriate criteria. In the language aspect, it gets an average of 4 with a percentage of 100% which is included in the very appropriate criteria. The REACT-based module with Quranic integration on temperature and heat material overall received an average total score of 3.74 with a percentage of 93% which is included in the very feasible criteria.

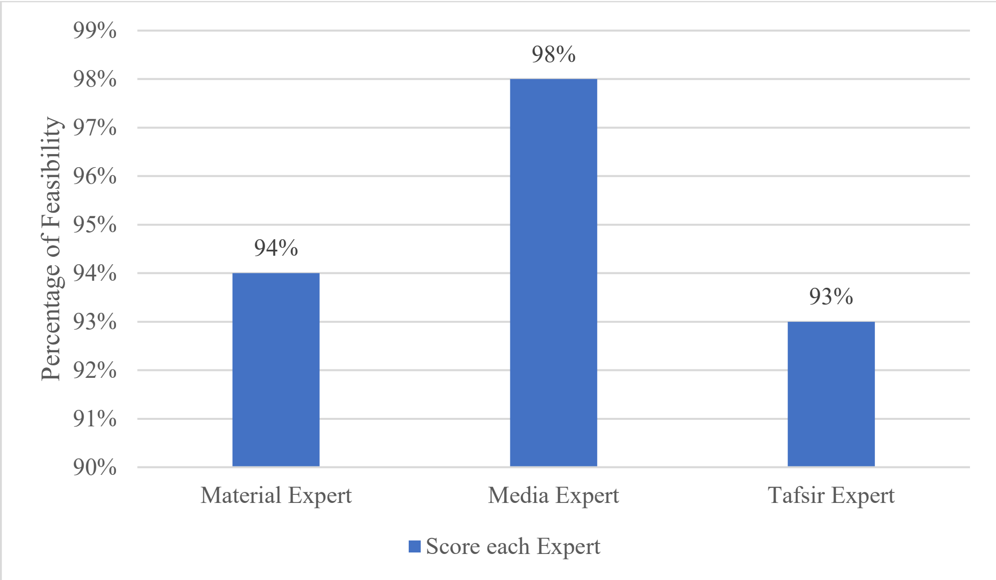

Figure 7. Total Validation Score

Figure 7. above shows that the validation results of material experts have a percentage of 94% with very feasible criteria, the validation results of media experts have a percentage of 98% with very feasible criteria, and the validation results of interpretation experts have a percentage of 93%. The total obtained from material expert validation, media expert validation, and interpretation expert validation is 95% with very feasible criteria. The REACT-based module with Quranic integration on temperature and heat material developed by researchers shows that it is very suitable to be used as a module in the learning process.

Based on Validation Percentage Data, it is known that the REACT-based module with Quranic integration in the temperature and heat material that has been developed has an average overall percentage of 95% with very feasible criteria. Based on the validation sheet from the learning experts, suggestions for improvement and input were obtained to produce a better module so that it is suitable for use in the learning process (Figure 8 & 9).

Figure 8. Module Cover Display and Conceptual Map

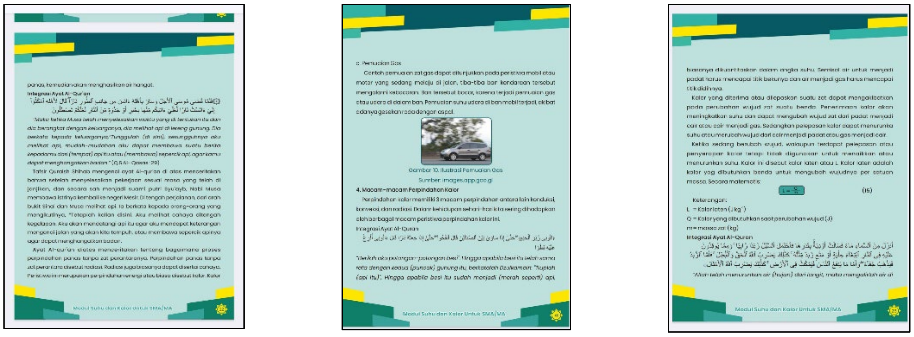

Figure 9. The visual design of a REACT-based module incorporating Quranic perspectives

2. Practicality of REACT-Based Modules Integrating Quranic Materials on Temperature and Heat

The practicality of the REACT-based module integrating Qurani on temperature and heat material was carried out in beta testing. Beta test or beta testing is full testing of the final product by end users (student response) [14]. The students' responses aim to find out the practicality of the REACT-based module with Quranic integration that has been developed in understanding temperature and heat material.

The students' practical results for the REACT-based module product with Quranic integration on temperature and heat material showed a percentage score of 88% with very practical criteria. This shows that the existence of a REACT-based module with Quranic integration in temperature and heat material will help students in the learning process.

The results of the research on the REACT-based module with Quranic integration on temperature and heat material in SMA/MA are in line with Chandra, et al's research [15] with the results of the practicality assessment on the REACT-based module with Quranic integration on temperature and heat material for class VII MTsN Talawi students which was stated to be very practical by the students' responses with the percentage of 91.76% is included in the very practical criteria.

D. Conclusion

Based on the results of research and discussions from the development of REACT-based modules with Quranic integration on temperature and heat material in SMA/MA, it can be concluded that:

The feasibility of the REACT-based module with Quranic integration on temperature and heat material is categorized into very feasible criteria in terms of validation results by material experts with a feasibility percentage of 94%, validation results by media experts with a feasibility percentage of 98% and validation results by interpretation experts with an eligibility percentage of 93%. The overall percentage results obtained from the validation of material experts, media experts and interpretation experts were 95%, so it was declared very suitable for use.

References

[1] P. S. Pernantah, M. Rizka, C. Handrianto, and E. Syaputra, "Inovasi Bahan Ajar Pendidikan IPS Berbasis Digital Flipbook Terintegrasi Local Wisdom dalam Menunjang Perkuliahan Jarak Jauh," *JPIPS*, vol. 8, no. 2, pp. 136–145, June 2022, doi: 10.18860/jpips.v8i2.14886.

[2] N. Fajriani, Baharuddin, and Latuconsina, "Pengembangan Media Pembelajaran Berbasis Website pada Materi Peluang Kelas XII SMA 4 Sinjay," in *Prosiding Seminar Nasional Fakultas Tarbiyah dan Keguruan UIN Alauddin Makassar*, Makassar: Fakultas Tarbiyah dan Keguruan UIN Alauddin Makassar, 2022, pp. 274–284.

[3] F. N. Asma, F. Fitriyawany, and C. R. Mustika, "Development of Project Based Learning Modules On Materials Static Fluids for Class of XI Senior High School," *AJSE*, vol. 4, no. 2, pp. 28–36, Oct. 2022, doi: 10.24815/ajse.v4i2.28342.

[4] Kosasih, *Pengembangan Bahan Ajar*. Jakarta: Bumi Aksara, 2021.

[5] A. A. Agustina, "Upaya Meningkatkan Kemampuan Guru Menerapkan Penggunaan Bahan Ajar di SMA Negeri 3 Ogan Komeriang Ulu," *Jurnal Educative: Journal of Educational Studies*, vol. 3, no. 1, pp. 16–29, 2018, doi: 10.30983/educative.v3i1.563.

[6] J. Untoro, *Buku Pintar Fisika SMP*. Jakarta: Wahyu Media, 2007.

[7] U. Maulida, "Pengembangan Modul Ajar Berbasis Kurikulum Merdeka," *Tarbawi : Jurnal Pemikiran dan Pendidikan Islam*, vol. 5, no. 2, pp. 130–138, Aug. 2022, doi: 10.51476/tarbawi.v5i2.392.

[8] Y. Susilawati and M. Muhfahroyin, "Analisis Pentingnya Pengembangan Modul Biologi Berbasis Potensi Lokal dengan Mengintegrasikan Nilai-Nilai Keislaman," *Biolova*, vol. 2, no. 2, pp. 103–107, Aug. 2021, doi: 10.24127/biolova.v2i2.1150.

[9] Trianto, *Model Pembelajaran Terpadu: Konsep, Strategi, dan Implementasinya dalam Kurikulum Tingkat Satuan Pendidikan (KTSP)*. Jakarta: Bumi Aksara, 2024.

[10] Fitriyawany, “Analisis Kemampuan Guru Fisika Alumni UIN Ar-Raniry dalam Merencanakan Pembelajaran Fisika Berbasis Islami di Kabupaten Pidie, Aceh,” in *Ar-Raniry International Conference on Islamic Studies*, Banda Aceh: UIN Ar-Raniry Banda Aceh, 2016. doi: 10.22373/aricis.v1i0.944.
[11] M. Aldin, “Pengembangan Modul Berbantuan Media Poster Berbasis Mind Mapping pada Materi Usaha dan Energi di SMA/MA,” UIN Ar-Raniry Banda Aceh, Banda Aceh, 2022M/1443H.
[12] L. Angela and R. Aprianto, “Pengembangan Modul Biologi Berbasis Contextual Teaching and Learning (CTL) pada Materi Keanekaragaman Hayati Kelas X Madrasah Aliyah,” *Jurnal Edukasi Matematika dan Sains*, vol. 6, no. 2, pp. 93–102, 2021, doi: 10.25273/jems.v6i2.5373.
[13] D. Prastiani, “Pengembangan Bahan Ajar Berbasis Literasi Sains pada Materi Momentum dan Impuls di SMA Negeri 3 Banda Aceh,” UIN Ar-Raniry Banda Aceh, Banda Aceh, 2023.
[14] R. N. Anisa, Solfarina, and I. E. Wijayanti, “Pengembangan Modul Pembelajaran Berbasis REACT pada Materi Senyawa Hidrokarbon untuk Menstimulus Keterampilan 4C,” *Jurnal Inovasi Pendidikan Kimia*, vol. 19, no. 1, pp. 1–17, 2025, doi: 10.15294/fx19nj72.
[15] A. N. Chandra, V. Haris, and D. Yulita, “Pengembangan Modul Fisika Berbasis REACH Berintegrasi Al-Quran Materi Suhu dan Kalor,” *JOSTECH*, vol. 1, no. 2, pp. 166–174, Sept. 2021, doi: 10.15548/jostech.v1i2.3097.

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The Analysis of Electric Circuit Studio-based Virtual Laboratory for Dynamic Electrical Material

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ABSTRACT

This study aimed to analyze the use of a virtual laboratory based on an electric circuit (EC) studio on dynamic electrical materials and to help physics education students and to determine the effect of using an EC studio-based virtual laboratory on dynamic electrical materials. This study uses qualitative descriptive research with a survey method through the provision of questionnaires filled out by 15 second-semester students of the physics education study program, at Cenderawasih University. Quantitative data was collected using a questionnaire with an approach to science process skills on dynamic electrical materials with the help of the EC studio application, while qualitative data was in the form of responses given by students about virtual laboratory media on dynamic electrical materials. There are three indicators that serve as a reference in analyzing the EC studio-based virtual laboratory on dynamic electricity: learning motivation, the stimulus for higher-order thinking skills, and understanding of concepts and problem-solving. Based on the results of the questionnaire, it was found that students' responses were very good to the EC studio-based virtual laboratory media because students could repeat themselves if they did not understand. The use of this media makes it easier for students to understand dynamic electricity.

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INTISARI

Penelitian ini dilakukan bertujuan untuk menganalisis penggunaan virtual laboratory berbasis electric circuit (EC) studio pada materi listrik dinamis dan membantu mahasiswa pendidikan fisika dan untuk mengetahui pengaruh pemanfaatan penggunaan virtual laboratory berbasis EC studio pada materi listrik dinamis. Penelitian ini menggunakan jenis penelitian deskriptif kualitatif dengan metode survey melalui pemberian angket yang diisi oleh 15 orang mahasiswa semester II program studi pendidikan fisika, Universitas Cenderawasih. Data kuantitatif dikumpulkan menggunakan angket dengan pendekatan keterampilan proses sains pada materi listrik dinamis dengan bantuan aplikasi EC studio sedangkan data kualitatif berupa tanggapan yang diberikan mahasiswa tentang media virtual laboratory pada materi listrik dinamis. Terdapat tiga indikator yang menjadi acuan dalam menganalisis virtual laboratory berbasis EC studio pada materi listrik dinamis: motivasi belajar, stimulus terhadap kemampuan berpikir tingkat tinggi, dan pemahaman konsep

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dan pemecahan masalah. Berdasarkan hasil angket, ditemukan bahwa respons mahasiswa sangat baik terhadap media virtual laboratory berbasis EC studio karena mahasiswa dapat mengulang sendiri jika belum paham. Penggunaan media ini membuat mahasiswa lebih mudah dalam memahami materi listrik dinamis

A. Introduction

The global issues surrounding the Corona Disease-19 Virus (COVID-19) have significantly altered the educational process, impacting areas such as learning methods [1], budgeting [2], objectives [3], and assessment. [4]. This inherently implies the need for online learning. Online learning is a form of education conducted without face-to-face interaction through platforms with internet connectivity and available personal devices [5]. The government has adopted online learning as an alternative policy to facilitate the continuation of the learning process. [6] and [7] explain that online learning has emerged as a viable alternative policy that supports the continuation of the learning process. However, the teacher has not prepared any learning activities to counterbalance the online learning tasks [8].

The development of virtual laboratory technology, or Lab-Vir, allows for interaction and visualization of phenomena experienced by students during experiments in real laboratories [9]. Lab-Vir helps to get people excited about and better their experience with Android-based practicals. It has three features: 1) virtual laboratories with all the tools and materials you need to do simulations or experiments in real labs [10]; 2) capable to use anywhere [11]; and 3) free internet (offline) [12]. Virtual laboratory-based learning is one of the flagship products resulting from advancements in information technology and laboratories [13]. Students conduct experiments in the laboratory based on the theories they have learned in class[14]. These experiments serve to enhance students' understanding of the studied material by supporting their learning [15]. However, due to budget constraints in providing laboratory equipment and the high operational costs of laboratories, virtual laboratory-based learning can serve as an alternative to eliminate the limitations of laboratory devices [16]. In the context of educational technology development, studying a studio-based virtual laboratory for dynamic electrical materials is important because it combines the interactivity of studio-based learning with the accessibility of digital simulations. Dynamic electrical phenomena—such as current and voltage variations over time—are often difficult for students to visualize and understand through static instruction or conventional laboratories. By integrating a studio-based approach, this research emphasizes active experimentation, collaboration, and iterative design, allowing students to explore real-time changes in electrical circuits through simulation. This approach not only supports conceptual understanding of dynamic electrical matter but also contributes to the innovation of technology-enhanced learning environments in engineering education.

In the learning activities, educators should assist students in developing their understanding by providing guidance and organization for learning, motivation to learn, explanations of concepts that are not easily learned independently by students, activities that can help pupils recognize (become aware of) and correct misconceptions, and opportunities to guide problem-solving [17]. Visualizing physical phenomena and their related concepts through animations at the microscopic level and simulations related to everyday examples can enhance students' knowledge visually and stimulate more students to achieve a high level of understanding of physics concepts [18]. Students are more motivated to learn physics concepts when accompanied by visualizations of abstract concepts [19]. Virtual labs can also serve as an effective educational tool because they can create active learning, thereby motivating students to learn. Rustaman, et al. [20] and Saputra et al. [21] explain that virtual labs can serve as an effective educational tool by fostering active learning, which in turn motivates students to learn. Motivation is important because it can enhance interest in learning and make it easier for students to start engaging in new learning activities. In addition, motivation can help students push themselves in order to achieve what they aspire to Sarwono & Lyau [22]. The internet operates the most ideal virtual lab, enabling participants to conduct experiments from any location and at any time [16]. However, learners can also run it in an intranet environment or on a standalone computer. A virtual lab converts physical buildings and lab equipment into computers and virtual lab software[14]. From the presented information, it is evident that virtual labs serve as a viable alternative to help humans improve productivity and well-being, solve problems, estimate various solution options, and implement solutions. Dynamic electricity is one of the physics topics taught via virtual labs.

Dynamic electricity is a fundamental subject that students need to understand, and currently, physics is one of the subjects that is considered difficult for learners to grasp [23]. Appropriate media is necessary in physics learning to enhance students' understanding of concepts through visualization-level explanations [24]. Developing learning models that can visually explain physics phenomena is necessary to achieve this [25]. The virtual lab developed and used in this research utilizes the features of the electric circuit (EC) studio program. Several studies, that found the EC studio program effective as a virtual lab medium for physics learning, informed the choice of this medium [26], [27]. According to Shan et al. [24], a meta-analysis of 46 studies in engineering education shows that virtual laboratories have a significant effect on learning outcomes with Hedges' $g = 0.686$ (CI 0.414–0.959), especially in motivating and increasing student engagement. Wahyudin et al. [28] found that although virtual laboratories offer better accessibility and flexibility, there are still challenges such as limited interactivity and content that does not fully simulate the physical laboratory experience. In the field of electrical engineering in particular, Wahyudin et al [28] showed that the use of virtual labs during the pandemic provided a practical alternative when physical laboratories were limited — but they also highlighted the need for strong pedagogical design to ensure effective learning.

The research questions in this study are: 1) Is the use of the EC studio-based virtual laboratory on dynamic electricity acceptable and helpful for physics education students? 2) What is the students' reaction to using the EC studio-based virtual laboratory on dynamic electricity? The goal of this study is to determine whether the use of dynamic electricity in the EC studio-based virtual laboratory is acceptable and beneficial to physics education students. This research aims to understand the impact of utilizing the EC studio-based virtual laboratory on dynamic electricity in a way that is acceptable and beneficial for physics education students. For students in the physics education program, this research can help assess the effectiveness of using the EC studio-based virtual laboratory on dynamic electricity and how it can support their learning. This study contributes to a deeper understanding of dynamic electrical matter by demonstrating how a studio-based virtual laboratory can effectively simulate and visualize time-dependent electrical phenomena. The developed system enhances students' conceptual comprehension of current, voltage, and resistance variations in dynamic circuits. Furthermore, it provides a pedagogical framework for integrating simulation-based learning into electrical engineering education.

B. Method

This research employs a qualitative descriptive research type using a survey method through a questionnaire filled out by 15 second-semester students from the Physics Education program at Cenderawasih University. This research was conducted at the Faculty of Teacher Training and Education at Cenderawasih University, specifically in the Physics Education program. The research date is Monday, April 11, 2022. The respondents participating in this study focus on second-semester students who have already taken or are currently taking Basic Physics I and II courses. The research instruments used is student response questionnaires. The questionnaire is filled out by placing a check mark (√) in the assessment column that corresponds to the respondent's opinion with the answer options: very poor, poor, good, and very good. There are ten positive statements in the questionnaire given to the students. The answer choice score category uses a positive statement score category [29]. In this study, the researchers used a Likert scale, so the students' answers were then analyzed for their scores.

To begin using the Electrical Circuit Studio, students first select the desired components from the component library and drag them onto the workspace to build a circuit schematic. Each component can be connected using virtual wires to form complete circuit configurations. After constructing the circuit, students can set parameters such as voltage amplitude, resistance, frequency, or time constants to define circuit behavior. Once the circuit design is completed, the "Simulation" feature allows students to observe the dynamic response of the circuit in real time. The software displays graphical outputs of voltage, current, and power as functions of time, helping students visualize transient and steady-state phenomena. The “Analysis” module enables users to calculate important electrical parameters automatically and compare them with theoretical predictions from class lectures. The Electrical Circuit Studio also integrates features for collaborative and reflective learning. Instructors can assign design-based projects where students propose circuit solutions, simulate them, and present their results within the same platform. This approach follows the principles of studio-based learning, emphasizing iterative design, peer feedback, and experimentation. Through this process, students not only learn how to assemble and analyze electrical circuits but also develop higher-order thinking skills such as problem-solving, design reasoning, and conceptual understanding of dynamic electrical phenomena.

C. Result and Discussion

The researchers looked at how the electric circuit (EC) studio-based virtual laboratory was used on dynamic electricity material and how it helped physics education students. We also wanted to see what effect using the EC studio-based virtual laboratory had on the dynamic electricity material. The survey results from the students were very different. The analysis of the students' responses is presented below.

Motivation

Item 1 is the first statement. Respondents said, "Learning using virtual laboratory media with the help of the EC Studio application can increase my motivation to learn." Table 1 displays the respondents' answers to item 1.

Table 1. The Respondent Statement for Item 1

No	Responses	n	%
1	Extremely poor	0	0
2	Under Average	0	0
3	Excellent	4	26.6
4	Extremely excellent	11	73.3

The data indicates that the majority of respondents rated their experience as extremely excellent when asked whether using virtual laboratory media with the help of the EC Studio application can provide motivation in learning. 11 respondents (73.3%) rated their experience as Extremely Excellent, while 4 respondents (26.6%) rated it as Excellent.

Reasoning and Thinking Skills

Item 2 is the second statement. Respondents said, "My reasoning skills and thinking abilities have developed more during learning using virtual laboratory media with the EC Studio application." Table 2 displays the respondents' answers to item 2.

Table 2. The Respondent Statement for Item 2

No	Responses	n	%
1	Extremely poor	1	6.7
2	Under Average	0	0
3	Excellent	4	26.6
4	Extremely excellent	10	66.7

The data shows that the majority of respondents rated the reasoning and thinking skills of students as Extremely excellent when learning with the use of virtual laboratory media aided by the EC Studio application. This is evidenced by 10 respondents (66.7%) stating Extremely excellent, and 4 respondents (26.6%) stating Excellent regarding reasoning in this component.

Learning Outcomes

Item 3 is the third statement. Respondents answered the question "The use of virtual laboratory media using the EC studio application can improve my learning outcomes." The responses to item 3 are shown in Table 3.

Table 3. The Respondent Statement for Item 3

No	Responses	n	%
1	Extremely poor	0	0
2	Under Average	0	0
3	Excellent	4	26.6
4	Extremely excellent	11	73.3

The data shows that the majority of respondents rated the use of virtual laboratory media through the EC Studio application as extremely excellent in enhancing students' learning outcomes in understanding and solving problems related to dynamic electricity. 11 respondents (73.3%) rated it as Extremely Excellent, while 4 respondents (26.6%) rated it as Excellent.

Thinking Skills

Item 4 is the fourth statement. The researchers asked the respondents to explain how "the virtual laboratory media using the EC Studio application enhances my thinking skills." Table 4 displays the respondents' answers.

Table 4. The Respondent Statement for Item 4

No	Responses	n	%
1	Extremely poor	0	0
2	Under Average	0	0
3	Excellent	3	20
4	Extremely excellent	12	80

The data shows that most respondents answered "Extremely excellent" to the question of whether the virtual laboratory media using the EC Studio application enhances students' thinking skills regarding dynamic electricity material. This is shown when 12 respondents (80%) stated Extremely Excellent, and 3 respondents (20%) stated Excellent.

Participating in Learning

Item 5 is the fifth statement. The content of the statement is "Learning by using virtual laboratory media decreases my interest in participating in learning." The respondents' answers to item 5 are shown in Table 5.

Table 5. The Respondent Statement for Item 5

No	Responses	n	%
1	Extremely poor	0	0
2	Under Average	2	13.3
3	Excellent	4	26.7
4	Extremely excellent	9	60

The data shows that the majority of respondents rated it as extremely excellent regarding the question that learning through the use of virtual laboratory media decreases students' interest in participating in learning. This is shown where 9 respondents (60%) stated Extremely Excellent, and 4 respondents (26.7%) stated Excellent. Meanwhile, students feel that the virtual laboratory media provides its own motivation without having to participate in the teaching and learning process related to dynamic electricity, although 2 respondents (13.3%) stated Under Average in the use of the virtual laboratory media.

Images And Simulations Using The EC Studio Application

Item 6 contains the sixth statement. The content of the statement is "images and simulations using the EC studio application are very interesting." The respondents' answers to item 6 are shown in Table 6.

Table 6. The Respondent Statement for Item 6

No	Responses	n	%
1	Extremely poor	0	0
2	Under Average	0	0
3	Excellent	1	6.7
4	Extremely excellent	14	93.3

Data shows that the majority of respondents rated the question about images and simulations using the EC Studio application as extremely excellent, indicating that it is very engaging and helps students understand dynamic electrical components more quickly. Additionally, the application provides formulas along with simulation examples that can assist students in more easily creating the circuits they wish to build. This is shown when 14 respondents (93.3%) stated Extremely Excellent, and 1 respondent (6.7%) stated Excellent.

Learning Experience

Item 7 contains the seventh statement. The content of the statement is "Learning using virtual laboratory media with the EC studio application is very interesting, and I can repeat it myself if I do not understand." The respondents' answers to item 7 are shown in Table 7.

Table 7. The Respondent Statement for Item 7

No	Responses	n	%
1	Extremely poor	0	0
2	Under Average	1	6.7
3	Excellent	3	20
4	Extremely excellent	11	73.3

Data shows that respondents rated their learning experience using the virtual laboratory media with the EC Studio application as extremely excellent, which is very interesting. Students can review on their own if they do not understand. This is indicated by 11 respondents (73.3%) stating Extremely Excellent, and 3 respondents (20%) stating Excellent because the EC studio application is very practical. If students do not understand, there is a guidance feature like simulations that can assist them (Simanullang, 2021). Nevertheless, there is 1 (6.7%) respondent who stated Under Average.

Effectiveness of Using EC Studio Application

Item 8 contains the statement of the seventh item. The content of that statement is "The virtual laboratory media is more effective when using the EC studio application." The respondents' answers to item 8 are shown in Table 8.

Table 8. The Respondent Statement for Item 8

No	Responses	n	%
1	Extremely poor	0	0
2	Under Average	1	6.7
3	Excellent	5	33.3
4	Extremely excellent	9	60

The data shows that respondents rated the virtual laboratory media question as extremely excellent when using the EC Studio application. Students can repeat on their own if they do not understand. This is evidenced by 9 respondents (60%) stating it is Extremely excellent, and 5 respondents (33.3%) stating Excellent because the EC studio application is very practical. If students do not understand, there is an option for repetition and easy access to help them (Hasanah, 2021; Simanullang, 2021). Nevertheless, there is 1 (6.7%) respondent who stated Under Average.

Self Learning

Item 9 contains the seventh statement. The content of the statement is "The virtual laboratory media using the EC studio application allows me to work independently in learning, especially in studying dynamic electricity material." The respondents' answers to item 9 are shown in Table 9.

Table 9. The Respondent Statement for Item 9

No	Responses	n	%
1	Extremely poor	0	0
2	Under Average	0	0
3	Excellent	3	20
4	Extremely excellent	12	80

Data shows that a significant number of respondents rated the virtual laboratory media using the EC Studio application as Extremely Excellent in enabling students to work independently in their studies, particularly in learning dynamic electricity material. This is evidenced by 12 respondents (80%) stating Extremely Excellent, while 3 respondents (20%) rated it as Excellent.

Conceptual Understanding

Item 10 contains the seventh statement. The content of the statement is "The use of virtual laboratory media using the EC studio application makes it easier for me to understand dynamic electricity material." The respondents' answers to item 10 are shown in Table 10.

Table 10. The Respondent Statement for Item 10

No	Responses	n	%
1	Extremely poor	0	0
2	Under Average	0	0
3	Excellent	4	26.7
4	Extremely excellent	11	73.3

Data shows that a significant number of respondents rated the use of the virtual laboratory media through the EC Studio application as extremely excellent, indicating that it makes it easier for students to understand dynamic electricity material. This is shown when 11 respondents (73.3%) stated Extremely Excellent, and 4 respondents (26.7%) stated Excellent.

This research advances education in dynamic electrical learning by providing a studio-based virtual laboratory that allows students to construct, simulate, and analyze time-varying circuits interactively. By visualizing voltage, current, and power in real time and promoting active, collaborative experimentation, the platform enhances conceptual understanding and problem-solving skills. These findings demonstrate how virtual laboratories can effectively complement traditional hands-on instruction, offering a scalable solution for technology-enhanced engineering education.

The use of the Electrical Circuit Studio offers several advantages in enhancing students' understanding of dynamic electrical phenomena. Its interactive and visual features allow learners to observe current and voltage variations in real time, supporting conceptual comprehension that is often difficult to achieve in traditional laboratories. The platform also provides a cost-effective, flexible, and safe learning environment, enabling students to conduct experiments anytime and anywhere without the need for physical components. Furthermore, the integration of studio-based learning principles fosters collaboration, creativity, and iterative design practices. However, despite these benefits, the virtual nature of the Electrical Circuit Studio also presents limitations. It cannot fully replicate the tactile experiences and troubleshooting challenges of real laboratory work, which are essential for developing practical engineering skills. Additionally, dependence on device performance and the absence of physical feedback may reduce students' engagement with real-world experimentation. Therefore, while the Electrical Circuit Studio is an effective tool for conceptual and interactive learning, it should be complemented by hands-on laboratory activities to provide a balanced and comprehensive learning experience.

The application of the Electrical Circuit Studio in learning may encounter several challenges that require careful consideration. Technological limitations, such as inadequate hardware, unstable software, or limited internet access, can hinder effective use and create unequal learning experiences among students. In addition, varying levels of digital literacy among learners and instructors may affect the efficiency of virtual laboratory implementation. The absence of real tactile interaction also limits the development of practical skills such as circuit wiring and troubleshooting, which are essential in engineering education. Furthermore, adapting teaching strategies and assessments to suit a virtual studio-based environment can be demanding for educators. Maintaining students' motivation and engagement in a non-physical learning setting also remains a persistent challenge. These obstacles suggest that successful integration of the Electrical Circuit Studio should involve balanced pedagogical planning and, where possible, a combination of virtual and hands-on laboratory experiences.

D. Conclusion

The results for the first indicator, the correlation between the EC Studio application and student motivation, are as follows: Extremely excellent (68.3%), Excellent (26.6%), Under Average (3.33%), and Extremely poor (1.66%). Based on these results, students' responses are Extremely excellent regarding the use of the virtual laboratory media with the EC Studio application, which can enhance student motivation in learning, especially in dynamic electricity material. The results also improve students' reasoning abilities, their developing thinking skills, and their learning outcomes. The use of media now has a significant connection to the decreasing interest in participating in learning. The second indicator is the application that stimulates higher-order thinking skills. The results obtained are Extremely Excellent (77.7%), Excellent (20%), Under Average (2.22%), and Extremely Poor (5.5%). Thus, students' responses are Extremely Excellent towards the virtual laboratory media using the EC studio application. This media can enhance thinking skills because the images and simulations in the EC Studio application components are very engaging and effective. The third indicator is conceptual understanding and problem-solving, with results of Extremely Excellent (75.5%), Excellent (28.8%), Under Average (2.22%), and Extremely Poor (0%). Based on these results, students' responses are Extremely Excellent towards the virtual laboratory media using the EC Studio application because it is very engaging. Students can also repeat if they do not understand, as this media allows them to work independently. The use of the virtual laboratory media with the EC Studio application makes it easier for students to grasp the material on dynamic electricity.

Future research is recommended to explore the integration of the Electrical Circuit Studio with physical laboratory activities to create a blended or hybrid learning environment. Such studies could examine how combining virtual and real experiments enhances students' conceptual understanding and practical skills simultaneously. Further investigations may also focus on assessing long-term learning outcomes, student engagement, and cognitive development when using studio-based virtual laboratories in electrical engineering education. In addition, future work could expand the application of the Electrical Circuit Studio to other domains of dynamic systems, such as electronics, control systems, or renewable energy, to evaluate its adaptability across different learning contexts. Finally, more advanced studies involving artificial intelligence, real-time data logging, or augmented reality integration could be conducted to improve interactivity, feedback precision, and the overall realism of virtual laboratory experiences.

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References

[1] S. Downes and A. Ralston, "Australian College of Physical Scientists and Engineers in Medicine Asia-Pacific Special Interest Group: The first ten years," *20 Juni 2021*, vol. 1.

[2] J.-W. Gong, H.-C. Liu, X.-Y. You, and L. Yin, "An integrated multi-criteria decision making approach with linguistic hesitant fuzzy sets for E-learning website evaluation and selection," *Appl. Soft Comput.*, vol. 102, p. 107118, Apr. 2021, doi: 10.1016/j.asoc.2021.107118.

[3] Y. Fitriyani, I. Fauzi, and M. Z. Sari, "Motivasi Belajar Mahasiswa Pada Pembelajaran Daring Selama Pandemik Covid-19," *J. Kependidikan J. Has. Penelit. Dan Kaji. Kepustakaan Bid. Pendidik. Pengajaran Dan Pembelajaran*, vol. 6, no. 2, p. 165, July 2020, doi: 10.33394/jk.v6i2.2654.

[4] S. Andari, W. Windasari, A. Setiawan, and A. Rifqi, "Student Exchange Program of Merdeka Belajar-Kampus Merdeka (MBKM) in Covid-19 Pandemic," *JPP J. Pendidik. Dan Pembelajaran*, vol. 28, no. 1, pp. 30–37, Apr. 2021, doi: 10.17977/um047v27i12021p030.

[5] C. A. VanLeeuwen, G. Veletsianos, O. Belikov, and N. Johnson, "Institutional Perspectives on Faculty Development for Digital Education in Canada," *Can. J. Learn. Technol.*, vol. 46, no. 2, Dec. 2020, doi: 10.21432/cjlt27944.

[6] L. C. Shan *et al.*, "Interactive Communication With the Public: Qualitative Exploration of the Use of Social Media by Food and Health Organizations," *J. Nutr. Educ. Behav.*, vol. 47, no. 1, pp. 104–108, Jan. 2015, doi: 10.1016/j.jneb.2014.09.004.

[7] M. Moallem, W. Hung, and N. Dabbagh, Eds., "Front Matter," in *The Wiley Handbook of Problem-Based Learning*, 1st ed., Wiley, 2019. doi: 10.1002/9781119173243.fmatter.

[8] H. Jusuf, N. Ibrahim, and A. Suparman, "Development of Virtual Learning Environment Using Canvas To Facilitate Online Learning at a covid-19 era.".

[9] J. Wang, D. Guo, and M. Jou, "A study on the effects of model-based inquiry pedagogy on students' inquiry skills in a virtual physics lab," vol. 49.

[10] F. Han and F. Kang, "Exploitation and Research on 3D Digital Modeling of Track Structure Based on VBA," in *Proceedings of the 2016 International Conference on Architectural Engineering and Civil Engineering*, Shanghai, China: Atlantis Press, 2017. doi: 10.2991/aece-16.2017.93.

[11] R. I. Adam, A. Rizal, and S. Susilawati, "Pelatihan Penggunaan Laboratorium Virtual Untuk Meningkatkan Kualitas Pemahaman Konsep Fisika di SMA Negeri 6 Karawang," *J. Penelit. Dan Pengabdi. Kpd. Masy. UNSIQ*, vol. 8, no. 1, pp. 95–98, Jan. 2021, doi: 10.32699/ppkm.v8i1.1008.

[12] R. A. Kurniawan, M. R. Rifa'i, and D. M. Fajar, "Analisis Kemenarikan Media Pembelajaran Phet Berbasis Virtual Lab pada Materi Listrik Statis Selama Perkuliahan Daring Ditinjau dari Perspektif Mahasiswa," *VEKTOR J. Pendidik. IPA*, vol. 1, no. 1, pp. 19–28, June 2020, doi: 10.35719/vektor.v1i1.6.
[13] T. Wiedmann, "An Input-Output Virtual Laboratory in practice – Survey of the uptake, usage and application of the first operational IELab".
[14] I. K. Semarayasa, "Pengaruh Metode Pembelajaran dan Tingkat Motor Educability (ME) Terhadap Keterampilan Dasar Smash Kedeng Dalam Permainan Sepak Takraw di SMPN 4 Kubutambahan," *J. Pendidik. Indones.*, vol. 2, no. 2, pp. 128–137, Apr. 2013, doi: 10.23887/jpi-undiksha.v2i1.1409.
[15] I. S. Budiarti, A. Suparmi, S. Sarwanto, and H. Harjana, "Effectiveness of Generation, Evaluation, and Modification-Cooperative Learning (Gem-Cl) Model Selaras Bakar Batu Cultural Practice in Papua," *J. Pendidik. IPA Indones.*, vol. 9, no. 1, pp. 32–41, Mar. 2020, doi: 10.15294/jpii.v9i1.22362.
[16] Y. Daineko, V. Dmitriyev, and M. Ipalakova, "Using virtual laboratories in teaching natural sciences: An example of physics courses in university," *Comput. Appl. Eng. Educ.*, vol. 25, no. 1, pp. 39–47, Jan. 2017, doi: 10.1002/cae.21777.
[17] R. D. Kurniati, D. Andra, and I. W. Distrik, "The Role of Social Media in Learning Physics: Teacher and Student Perceptions," *J. Pembelajaran Fis.*, vol. 8, no. 2, pp. 159–166, June 2019, doi: 10.23960/jpf.v8.n2.202004.
[18] R. T. Osguthorpe and C. R. Graham, "Blended Learning Environments: Definitions and Directions," *Q. Rev. Distance Educ.*, vol. 4, no. 3.
[19] Rahmawati, N. Y. Rustaman, I. Hamidah, and D. Rusdiana, "The Use of Classroom Assessment to Explore Problem Solving Skills Based on Pre-Service Teachers' Cognitive Style Dimension in Basic Physics Course," *J. Phys. Conf. Ser.*, vol. 812, p. 012047, Feb. 2017, doi: 10.1088/1742-6596/812/1/012047.
[20] F. A. Pacala, "PhET's Photoelectric Effect Simulation: Experiments and Analysis for Classroom Practice," *Asian J. Sci. Educ.*, vol. 5, no. 1, pp. 70–82, Apr. 2023, doi: 10.24815/ajse.v5i1.31373.
[21] F. Fitriyawany, F. Julita, and C. R. Mustika, "Development of e-Module based on Simulation PhET Fluid Material Dynamic in Senior High School," *Asian J. Sci. Educ.*, vol. 5, no. 2, pp. 39–47, Oct. 2023, doi: 10.24815/ajse.v5i2.32420.
[22] I. M. Nur, R. Medriati, and E. Risdianto, "Development of Interactive Game-Based Learning Media Assisted by Classpoint to Enhance Student Learning Motivation," *Asian J. Sci. Educ.*, vol. 6, no. 1, pp. 57–69, Apr. 2024, doi: 10.24815/ajse.v6i1.36129.
[23] H. Saputra, T. M. R. Al Auwal, and D. Mustika, "Pembelajaran Inkuiri Berbasis Virtual Laboratory Untuk Meningkatkan Kemampuan Literasi Sains Mahasiswa Calon Guru Pendidikan Fisika Universitas Samudra," *J. IPA Pembelajaran IPA*, vol. 1, no. 2, pp. 143–148, Dec. 2017, doi: 10.24815/jipi.v1i2.9688.
[24] W. D. Aryani, E. Suhendi, I. Suyana, A. Samsudin, and I. Kaniawati, "Effectiveness of implementation interactive conceptual instruction (ICI) with computer simulation to overcome students' misconceptions about newton's law of gravitation," *J. Phys. Conf. Ser.*, vol. 1280, no. 5, p. 052011, Nov. 2019, doi: 10.1088/1742-6596/1280/5/052011.
[25] N. I. Wulandari, A. Wijayanti, and W. Budhi, "Efektivitas Model Pembelajaran Problem Based Learning Terhadap Hasil Belajar IPA Ditinjau dari Kemampuan

Berkomunikasi Siswa," *J. Pijar Mipa*, vol. 13, no. 1, pp. 51–55, Mar. 2018, doi: 10.29303/jpm.v13i1.538.
[26] N. Hasanah, "Pengembangan Modul Pratikum Virtual Dengan Pendekatan Keterampilan Proses Sains Berbantuan Aplikasi Electric Circuit Studio (ECStudio) Pada Materi Listrik Dinamis," Universitas Negeri Medan, Medan, 2021.
[27] A. F. Simanullang, *Pemanfaatan Aplikasi Electric Circuit Studio Pada Matakuliah Elektronika*. Padang: Universitas Negeri Padang, 2021.
[28] M. N. A. Wahyudi, C. W. Budiyanto, I. Widiastuti, P. Hatta, and Mohd. S. B. Bakar, "Understanding Virtual Laboratories in Engineering Education: A Systematic Literature Review," *Int. J. Pedagogy Teach. Educ.*, vol. 7, no. 2, p. 102, July 2024, doi: 10.20961/ijpte.v7i2.85271.
[29] Sugiyono, *Statistika untuk Penelitian*. Bandung: Alfabeta, 2013.

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The Three-Tier Test Approach to Measuring Misconceptions in High School Physics: Focus on Work and Energy

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ABSTRACT

This study aims to identify misconceptions experienced 10th grade students on the subject of Work and Energy using a three-tier test. The type of research used is quantitative descriptive. The data collection instrument was a three-tier test consisting of 10 questions, which had been tested and found to have a validity of 0.96 and reliability (Cronbach's Alpha) of 0.81, making it suitable for measuring students' conceptual understanding. There were 34 students in this study, with purposive sampling used as the sampling technique. The data were obtained through Google Forms and analyzed statistically to identify the level of students' misconceptions. The results showed that the highest misconception occurred in the subconcept of work (79.41%), followed by kinetic energy and potential energy (55.88%), and the law of conservation of energy (41.18%). These findings are expected to provide insight for educators and curriculum developers in designing more effective learning strategies, thereby helping students overcome misconceptions and improve their understanding of physics concepts. Thus, it can be concluded that most students still have misconceptions about the concepts of Work and Energy, requiring learning strategies that emphasize strengthening conceptual understanding.

INTISARI

Penelitian ini bertujuan untuk mengidentifikasi miskonsepsi yang dialami oleh siswa kelas X pada materi Usaha dan Energi menggunakan three-tier test. Jenis penelitian yang digunakan adalah deskriptif kuantitatif. Instrumen pengumpulan data berupa three-tier test yang terdiri atas 10 butir soal, yang telah diuji dan dinyatakan memiliki validitas sebesar 0,96 dan reliabilitas (Cronbach's Alpha) sebesar 0,81, sehingga layak digunakan untuk mengukur pemahaman konseptual siswa. Responden dalam penelitian ini berjumlah 34 siswa, dengan teknik pengambilan sampel menggunakan purposive sampling. Data diperoleh melalui Google Form dan dianalisis secara statistik untuk mengidentifikasi tingkat miskonsepsi siswa. Hasil penelitian menunjukkan bahwa miskonsepsi tertinggi terjadi pada subkonsep usaha (79,41%), diikuti oleh energi kinetik dan energi potensial (55,88%), serta hukum kekekalan energi (41,18%). Temuan ini diharapkan dapat memberikan wawasan bagi pendidik dan pengembang kurikulum dalam merancang strategi pembelajaran yang lebih efektif, sehingga dapat membantu siswa mengatasi miskonsepsi dan meningkatkan pemahaman terhadap konsep-konsep fisika. Dengan demikian, dapat disimpulkan bahwa sebagian besar siswa masih mengalami miskonsepsi pada konsep Usaha dan

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Energi, sehingga diperlukan strategi pembelajaran yang menekankan pada penguatan pemahaman konseptual.

A. Introduction

Rapid advances in knowledge and technology have made various human activities in daily life easier. Physics, as one of the branches of Natural Sciences, plays a fundamental role in the development of Science and Technology [1]. Therefore, it is important for students to have a good understanding of physics concepts in order to keep up with the dynamics of technological development. However, physics is known as a subject that requires a high level of abstraction and mastery of mathematics as a tool, so many students find it difficult to learn. This often leads to students struggling with physics if their initial abilities are insufficient [2]. In line with the importance of physics in life and technological development, a strong conceptual understanding is necessary for students to master and apply physics concepts correctly.

Conceptual understanding is the main foundation in physics learning. Misconceptions or understandings that are not in line with generally accepted scientific concepts can hinder the learning process of students. These misconceptions often originate from incomplete initial understandings and then become firmly embedded in the cognitive structure of students, thereby hindering the learning of advanced concepts [3]. Pratiwi and Permadi [4] state that misconceptions often arise because students are unable to connect abstract concepts with the real-world contexts they experience in their daily lives, thus forming incorrect alternative ideas.

Good conceptual understanding is very important in physics learning so that students can relate concepts to phenomena that occur in their surroundings. Yuliati et al. [5] explain that the application of authentic problem-based learning can improve critical thinking skills and help students understand physics concepts in depth, thereby reducing the emergence of misconceptions. Meanwhile, Maliada et al. [6] emphasize that misconceptions are beliefs that are deeply ingrained and form a stable cognitive structure in students' minds, even though they contradict correct scientific concepts. Understanding physics concepts is very important for explaining various physical phenomena in everyday life and in more complex scientific contexts. Personal experiences or daily activities can also influence students' thinking and form conceptual patterns that are not always in line with scientific principles [7]. One example that is often found is students' misconceptions about work and energy, which is the focus of this study.

One of the topics in physics that most often causes misconceptions is Work and Energy. This is due to the complex concepts involved, such as the relationship between force, displacement, kinetic energy, potential energy, and the law of conservation of mechanical energy [8] [9]. These concepts require not only theoretical understanding, but also the ability to apply them in real-life contexts, which often poses a challenge for students. Utami and Rohmi [10] found that more than 70% of students had misconceptions about the concept of the law of conservation of mechanical energy, and about 57% of students had misconceptions about the concept of work. These findings emphasize the importance of a diagnostic approach to identify and address student misconceptions early on.

Based on previous research findings and to obtain an initial picture of the condition of students at the school where the research was conducted, the researcher conducted an interview with one of the physics teachers. From the interview results, it was found that students had difficulty understanding the material on work and energy, especially the concept of potential energy. The teacher also admitted that he was not aware of the misconceptions that often occur in physics learning, including on this topic. In addition, the teacher had never conducted diagnostic tests to find out whether students truly understood the concepts or had misconceptions. If there were students who scored below the Minimum Passing Grade in physics exams, the teacher would only provide additional guidance by asking students to repeat the exam questions without identifying the causes of their conceptual difficulties.

One approach that can be used to effectively identify misconceptions is to use diagnostic tests [11]. Three-level diagnostic tests are better than two-level models because they provide more in-depth information [12]. This test consists of three parts: (1) answers to conceptual questions, (2) the reasoning behind those answers, and (3) the level of confidence students have in their answers [12]. This test allows educators to distinguish between stable misconceptions, ignorance, and lucky guesses. Pratama & Istiyono [13] showed that this test is able to identify students' misconceptions with higher accuracy and provide valid and reliable diagnostic information. In addition, the study also revealed that misunderstandings are not limited to one topic, but spread to various concepts in physics. The three-tiered test can comprehensively map students' understanding categories, ranging from fully understanding the concept to not understanding it at all. This tool can be used by teachers to design more targeted learning interventions [14].

The use of a three-tier test in this study was chosen because it is simpler and more efficient than a four-tier test, yet still capable of providing in-depth conceptual information relevant to the research objectives [15]. Several previous studies have also shown that although the four-tier test is capable of providing an additional classification in the form of confidence in reason, the instrument has a high level of technical complexity, making it less efficient to apply in a school learning context [16]. Thus, the use of a three-tier test is considered more appropriate and proportional to effectively identify students' misconceptions while maintaining practicality in its implementation [17]. Based on this background, this study was conducted with the aim of identifying misconceptions experienced by 10th grade students on the topic of Work and Energy using a three-tier test.

B. Method

This study uses a quantitative descriptive approach. The purpose of this study is to identify misconceptions experienced by students regarding the concepts of work and energy. The research subjects consisted of 34 tenth-grade students, including 14 male students and 20 female students. Previously, students had studied work and energy material, but had never taken a three-tier test. The instrument used to measure misconceptions consisted of 10 three-tier test questions related to work and energy material. The three-tier test instrument used in this study was developed by the researcher and distributed online via Google Form to improve the efficiency of the data collection process and adapt to the characteristics of 21st-century learning. This is in line with the view of Jalinus et al. [18], who stated that the integration of digital technology in the learning and assessment process can increase student engagement and the effectiveness of measuring conceptual understanding.

The questions in this three-level test were designed in three levels. The first level contained students' responses or answer choices to measure their understanding of the concepts, the second level contained the students' reasons for choosing the answers in the first level, and the third level showed the students' level of confidence in their chosen answers. This instrument obtained a validity score of 0.96 and a Cronbach's Alpha reliability coefficient of 0.81, indicating that the instrument is valid and reliable for diagnosing students' misconceptions on the subject of work and energy.

The data analysis process was carried out by the researcher through several stages, as follows: (1) Analyzing students' answers between confidence responses, multiple-choice answers, and reasons aligned with categories related to the level of understanding in the diagnostic test; (2) Classifying students' answers into categories of understanding, not understanding, and misconceptions; and (3) Summarizing the data obtained with profiles and percentages of misconceptions

Table 1. Categories in the Three-tier test

Category	Tier 1	Tier 2	Tier 3
Understand	True	True	Convinced
Not Understand	True	True	Not Convinced
	False	False	Not Convinced
	True	False	Not Convinced
	False	True	Not Convinced
Misconception	False	True	Convinced
	True	False	Convinced
	False	False	Convinced

Source: Sopian, H. [19]

C. Result and Discussion

Based on the results of the three-tier test, it can be seen that the percentage of students with the highest level of understanding was found in question number 2 of the subconcept work, which was 52.94%, while the percentage of students with the highest misconception was found in question number 1 of this subconcept, which was 79.41%. In the energy subconcept, the highest percentage of students with the highest level of understanding was found in question number 6, at 35.29%, while the highest percentage of misconceptions was found in question number 8 of this subconcept, at 55.88%. Additionally, in the subconcept of the law of conservation of energy, the highest number of misconceptions was found in question number 9, at 41.18%. This data can be seen in Table 3.

Table 3. Test Results with Three-tier test

Subconcept	Question No.	Student Answer Category (%)		
		Understand	Not Understand	Misconception
Work	1	5.88	14.71	79.41
	2	52.94	20.59	26.47
	3	41.18	11.76	47.06
	4	35.29	20.59	44.12
	Average	33.82	16.91	49.27
Kinetic Energy and Potential Energy	5	32.35	20.59	47.06
	6	35.29	20.59	44.12
	7	29.41	20.59	50.00
	8	14.71	29.41	55.88
	Average	27.94	22.79	49.27
Law of Conservation of Energy	9	32.35	26.47	41.18
	10	32.35	32.35	35.29
	Average	32.35	29.41	38.24

The indicators in this study aim to measure students' understanding of subconcepts in the subject of Work and Energy. Students are asked to interpret images of negative work, classify examples of work, and summarize the concept of work. In addition, students are expected to be able to calculate power, explain the factors that affect kinetic energy, and provide examples of its application in everyday life. Understanding of potential energy, the relationship between kinetic and potential energy, and the law of conservation of energy is also measured, including conclusions regarding the law of conservation of mechanical energy.

Subconcept Work

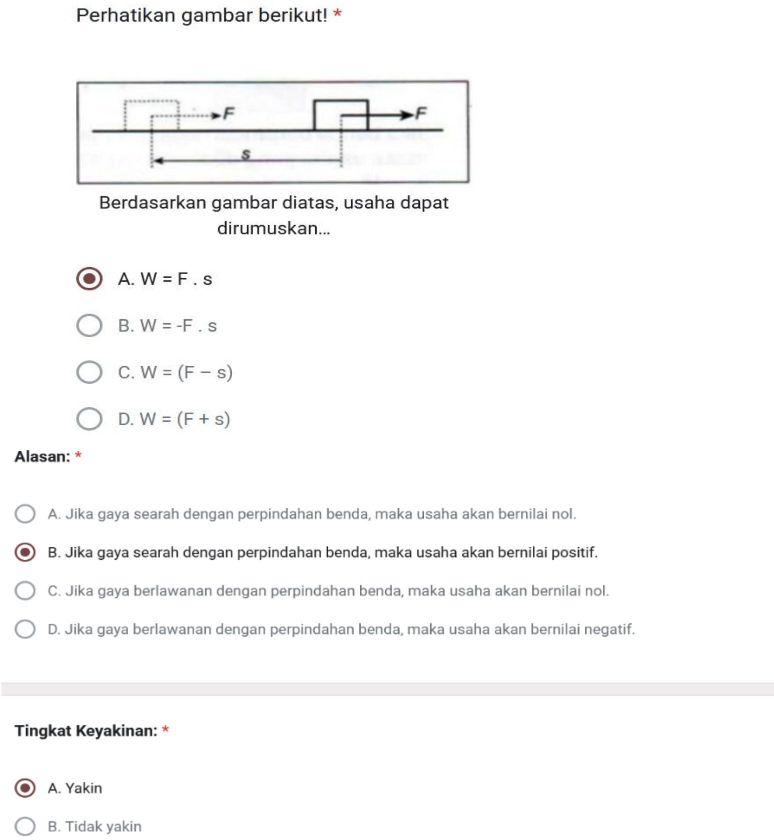
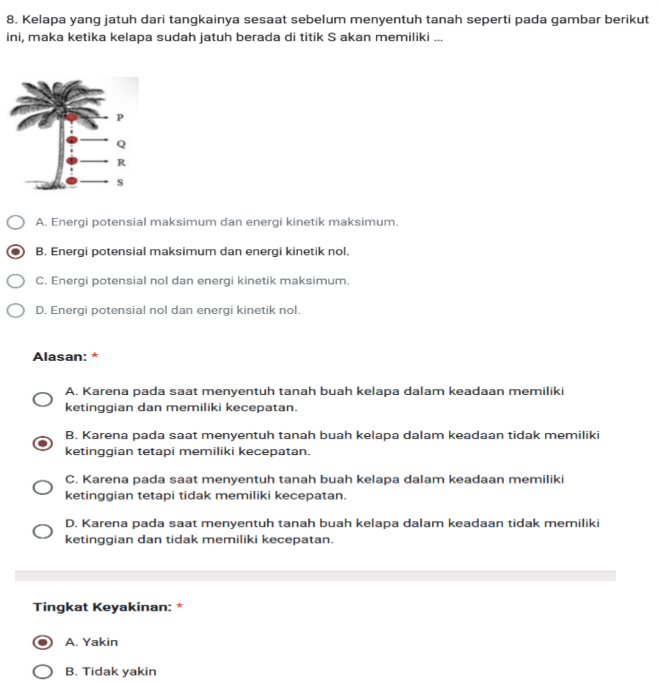


Figure 1. Student's Asnwer & Argument in Subconcept of Work

Based on the results of the study, it was found that 79.41% of students had the highest misconception on question number 1 in the subconcept of work with the question indicator interpreting an image of negative work. Many students chose option A (W = F.s) because they understood that "if the force is in the same direction as the displacement of the object, then the work will be positive." This is likely due to students' lack of understanding of the visual meaning of the image, particularly the direction of the force vector and displacement, leading to errors in interpreting the concept of negative work. However, the more accurate understanding is that "if the force is opposite to the direction of the object's displacement, then the work will be negative." Therefore, the correct answer is B (W = -F. s). This is supported by the research of Maison et al.[8], which found that the highest misconceptions also occur in the concepts of work and potential energy, with one of the students' errors being in interpreting the direction of the force relative to the displacement. Another study by Utami & Rohmi [10] also showed that 57% of students experienced similar misconceptions due to inaccuracies in understanding the relationship between the direction of the force and the displacement.

Subconcepts of Kinetic Energy and Potential Energy


8. Kelapa yang jatuh dari tangkainya sesaat sebelum menyentuh tanah seperti pada gambar berikut ini, maka ketika kelapa sudah jatuh berada di titik S akan memiliki ...

P
Q
R
S

- A. Energi potensial maksimum dan energi kinetik maksimum.
- B. Energi potensial maksimum dan energi kinetik nol.
- C. Energi potensial nol dan energi kinetik maksimum.
- D. Energi potensial nol dan energi kinetik nol.

Alasan: *

- A. Karena pada saat menyentuh tanah buah kelapa dalam keadaan memiliki ketinggian dan memiliki kecepatan.
- B. Karena pada saat menyentuh tanah buah kelapa dalam keadaan tidak memiliki ketinggian tetapi memiliki kecepatan.
- C. Karena pada saat menyentuh tanah buah kelapa dalam keadaan memiliki ketinggian tetapi tidak memiliki kecepatan.
- D. Karena pada saat menyentuh tanah buah kelapa dalam keadaan tidak memiliki ketinggian dan tidak memiliki kecepatan.

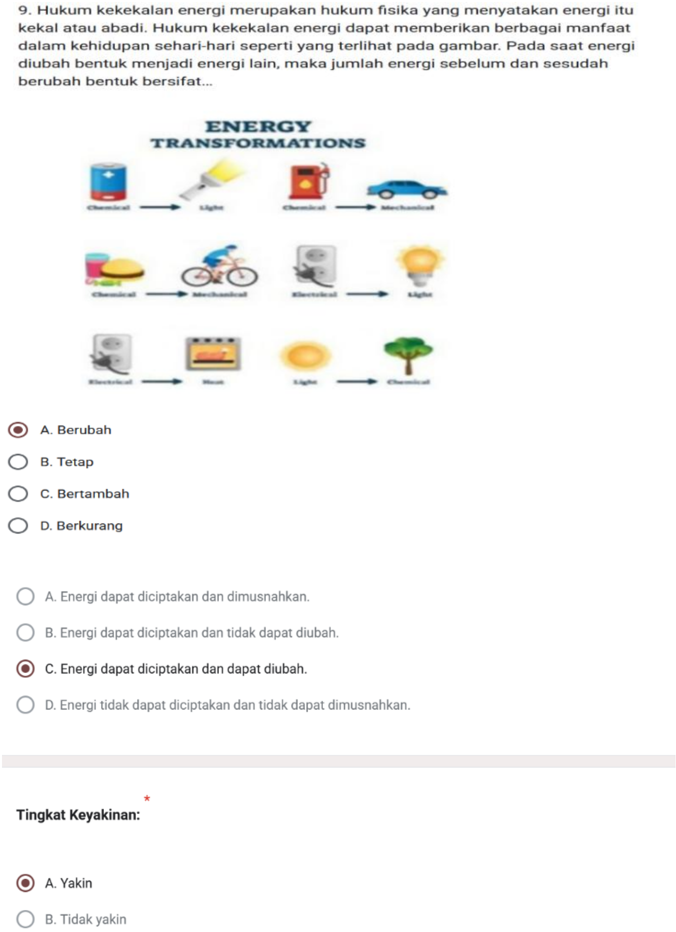
Tingkat Keyakinan: *

- A. Yakin
- B. Tidak yakin

Figure 2. Student’s Answer & Argument in Subconcepts of Kinetic Energy and Potential Energy

In the subconcepts of kinetic energy and potential energy, the results showed that 55.88% of students had misconceptions on question number 8, with the question indicator analyzing the relationship between potential energy and kinetic energy. Most students chose option B (maximum potential energy and zero kinetic energy). Students assume that when a coconut hits the ground, it has no height but has velocity. This is likely because students did not fully understand the conversion of energy from potential energy to kinetic energy, nor were they able to accurately relate physical events to theoretical concepts. This understanding needs to be corrected, as when the coconut hits the ground, it no longer has height or velocity. The correct answer choice is C, which states that “potential energy is zero and kinetic energy is maximum.” Utami & Rohmi [10] note that misconceptions are also common in the concepts of potential, kinetic, and mechanical energy, with a pre-learning misconception rate of 43%.

Subconcept of the Law of Conservation of Energy


9. Hukum kekekalan energi merupakan hukum fisika yang menyatakan energi itu kekal atau abadi. Hukum kekekalan energi dapat memberikan berbagai manfaat dalam kehidupan sehari-hari seperti yang terlihat pada gambar. Pada saat energi diubah bentuk menjadi energi lain, maka jumlah energi sebelum dan sesudah berubah bentuk bersifat...

- (•) A. Berubah
- ( ) B. Tetap
- ( ) C. Bertambah
- ( ) D. Berkurang

- ( ) A. Energi dapat diciptakan dan dimusnahkan.
- ( ) B. Energi dapat diciptakan dan tidak dapat diubah.
- (•) C. Energi dapat diciptakan dan dapat diubah.
- ( ) D. Energi tidak dapat diciptakan dan tidak dapat dimusnahkan.

Tingkat Keyakinan: *

- (•) A. Yakin
- ( ) B. Tidak yakin

Figure 3. Student's Answer & Arguments in Subconcept of the Law of Conservation of Energy

In the subconcept of the law of conservation of energy, the results of the study show that 41.18% of students had misconceptions on question number 9, which asked them to interpret the law of conservation of energy in the form of a picture, with many students choosing option A (Changed). Students incorrectly assumed that energy can be created and changed. This is likely because students interpret energy sources such as batteries or food as creating new energy, which is then converted into light energy in flashlights or kinetic energy in the body. For example, in the picture of food, students think that food creates mechanical energy when a person is active, rather than understanding that the chemical energy in food is only converted into kinetic energy. This understanding indicates that students have not grasped the fundamental principle of the Law of Conservation of Energy, which states that energy cannot be created or destroyed but only transformed. The correct answer choice is B (Remains the Same). Maison et al. [8] also revealed that misconceptions commonly occur in understanding the relationship between mechanical energy, potential energy, and kinetic energy. Students emphasized that these errors often arise due to a lack of reinforcement in connecting various forms of energy. Additionally, the three-tier instrument developed by Pratama & Istiyono [20] can identify misconceptions more accurately because it can distinguish between ignorance and misconceptions. This instrument also confirms that misconceptions remain high on the topic of energy and need to be addressed with more in-depth conceptual evaluation.

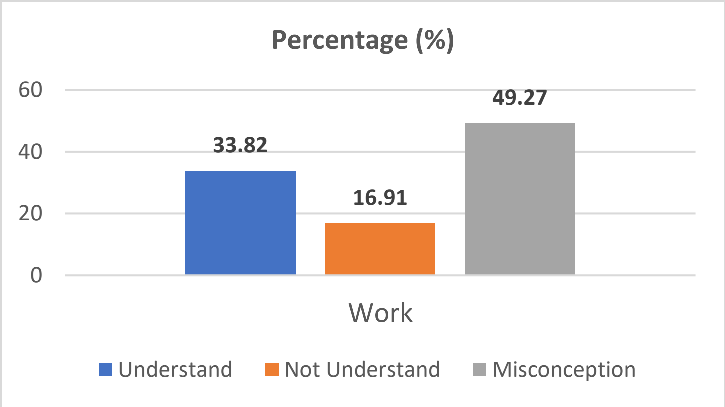


Figure 4. Percentage of Student Categories in the Subconcept Work

Figure 4 shows the percentage distribution of students' understanding of the subconcept of work based on the results of the three-tier diagnostic test. The data shows that an average of 49.27% of students have misconceptions, 16.91% do not understand the concept, and only 33.82% of students truly understand the concept of work. The high percentage of misconceptions indicates that more than half of the students have an incorrect understanding of the basic concept of work. One of the most common misconceptions is the assumption that work depends solely on the force applied, without considering the distance traveled. Students often think that the greater the force applied, the greater the work done, whereas work is also influenced by the distance traveled by the object.

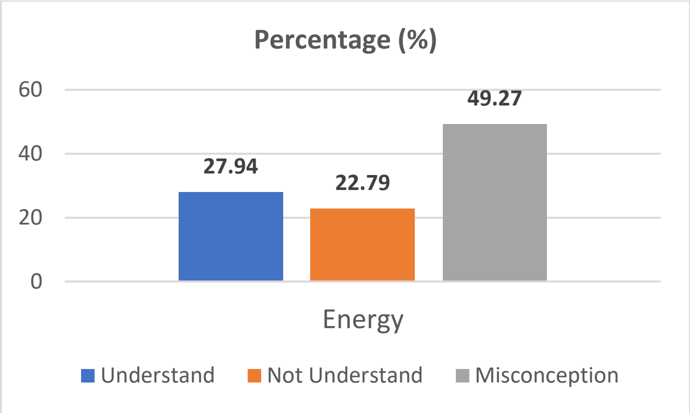


Figure 5. Percentage of Student Categories in the Subconcepts of Kinetic Energy and Potential Energy

Figure 5 shows the percentage distribution of students' understanding of the subconcepts of Kinetic Energy and Potential Energy based on the results of the three-tier diagnostic test. The data shows that an average of 49.27% of students have misconceptions, 22.79% do not understand the concept, and only 27.94% of students truly understand the concepts of kinetic energy and potential energy. The high percentage of misconceptions indicates that students struggle to understand the various forms of energy and how energy can transform from one form to another. One common misconception is the belief that energy exists only in specific forms, such as kinetic energy or potential energy, without realizing that energy can change forms and that all forms of energy are interconnected. This misconception can hinder students' understanding of more complex physics concepts, such as the laws of thermodynamics and the application of energy in everyday life.

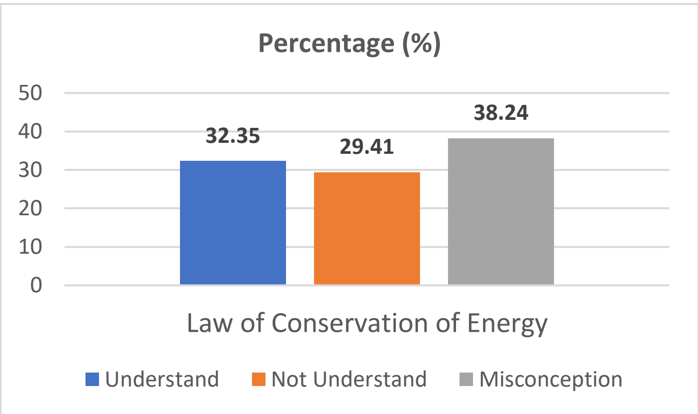


Figure 6. Percentage of Student Categories in the Subconcept of the Law of Conservation of Energy

Figure 6 shows the percentage distribution of students' understanding of the subconcept of the Law of Conservation of Energy based on the results of the three-level diagnostic test. Based on these results, it was found that an average of 38.24% of students had misconceptions, 29.41% did not understand the concept, and only 32.35% of students truly understood this concept. The analysis was conducted using quantitative descriptive methods with the application of descriptive statistics. The test results were analyzed to obtain the mean, the percentage of each understanding category, and the frequency distribution for each question item.

The average total score of the students showed that the level of conceptual understanding was still relatively low, with a standard deviation of 0.15, indicating a fairly high variation in understanding among students. This analysis provides a more comprehensive quantitative picture of the patterns of students' misconceptions about the concept of the Law of Conservation of Energy.

Although the level of misconception is lower than other subconcepts, this percentage still shows that more than one-third of students have a misconception about the basic principle that energy cannot be created or destroyed, but can only be converted from one form to another. One common misconception is the belief that energy can "disappear" in a process, when in fact energy only transfers or changes form. Thus, these results emphasize the importance of applying a more contextual and phenomenon-based learning approach so that students can understand the principle of conservation of energy more deeply.

D. Conclusion

The results of the study indicate that the level of misconceptions among 10th grade students regarding work and energy is still relatively high. The highest level of misconceptions was found in the subconcept of work at 79.41%, followed by kinetic energy and potential energy at 55.88%, and the law of conservation of energy at 41.18%. These findings indicate the need for improvements in teaching methods and the use of more interactive learning media to help students overcome these misconceptions. Regular evaluation and repetition of the material are necessary to ensure better understanding among students. Recommendations that can be made include the use of active learning methods, providing constructive feedback, and increasing the availability of learning resources that students can access outside of school hours. These steps are expected to enhance students' understanding of physics and reduce the level of misconceptions, thereby better preparing them to tackle more complex physics concepts in the future.

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References

[1] P. Subagiyadi, Y. B. Bhakti, and N. N. Mulyaningsih, "Pengaruh Metode Pembelajaran Inquiry Pictorial Riddle Terhadap Hasil Belajar Fisika Pada Sekolah Menengah Atas Negeri 85 Jakarta," *Navigation Physics: Journal of Physics Education,* vol. 2, no. 1, pp. 41–46, 2020. doi:10.30998/npjpe.v2i1.306

[2] S. Jatmika, J. Jumadi, P. Pujianto, and R. Rahmatullah, "Analisis Penyebab Kesalahan Pemahaman Siswa pada Materi Usaha dan Energi," *Indonesian Journal of Applied Science and Technology*, vol. 2, no. 3, pp. 97–105, 2021. https://journal.publication-center.com/index.php/ijast/article/view/1228

[3] B. Astuti, A. M. Fitrianingrum, and S. Sarwi, "Penerapan Instrumen Three-Tier Test untuk Mengidentifikasi Miskonsepsi Siswa SMA pada Materi Keseimbangan Benda Tagar," *Phenomenon: Jurnal Pendidikan MIPA,* vol. 7, no. 2, pp. 88-98, 2017. https://doi.org/10.21580/phen.2017.7.2.1118

[4] I. T. Pratiwi and D. Permadi, "The Development of the Two-Tier Diagnostic Test Instrument with Google Form to Measure Student Misconceptions on Energy and Energy Forms," *Impulse: Journal of Research and Innovation in Physics Education*, vol. 4, no. 1, pp. 22–30, 2024. doi: 10.14421/impulse.2024.41-03

[5] L. Yuliati, R. Fauziah, and A. Hidayat, "Student's Critical Thinking Skills in Authentic Problem based Learning," *in Journal of Physics: Conference Series,* Bandung: IOP Publishing, 2018, pp. 1–6. doi: 10.1088/1742-6596/1013/1/012025.

[6] N. Maliada, A. Kade, and M. Miftah, "Analisis Miskonsepsi Pada Mata Pelajaran Fisika Menggunakan Three-Tier Diagnostic Test," *JPFT (Jurnal Pendidikan Fisika Tadulako Online),* vol. 10, no. 1, pp. 84–89, 2022.

[7] A. Fadllan, W. Y. Prawira, Arsini, and Hartono, "Analysis of students' misconceptions on mechanics using three-tier diagnostic test and clinical interview," in Journal of Physics: Conference Series, 2019, vol. 1170, no. 1. doi:10.1088/1742–6596/1170/1/012027.

[8] M. Maison, N. Lestari, and A. Widaningtyas, "Identifikasi miskonsepsi siswa pada materi usaha dan energi," *Jurnal Penelitian Pendidikan IPA,* vol. 6, no. 1, pp. 32–39, 2020. doi: 10.29303/jppipa.v6i1.314

[9] P. Lestari and M. S. Hayat, "Analisis miskonsepsi siswa SMA pada materi usaha dan energi di kabupaten Kendal," *UPEJ Unnes Physics Education Journal,* vol. 10, no. 3, pp. 233–240, 2021.

[10] R. Y. Utami and P. Rohmi, "The Effectiveness of SETS Learning Model toward the Misconception Decrease of Tenth Graders on Work and Energy Materials," *Impulse: Journal of Research and Innovation in Physics Education*, vol. 3, no. 2, pp. 100–112, 2023. doi: 10.14421/impulse.2023.32-04

[11] D. S. Dasar, "Asesmen Diagnostik. Direktorat Sekolah Dasar, Direktorat Jenderal PAUD Dikdas Dan Dikmen, Kementrian Pendidikan Dan Kebudayaan, Riset Dan Teknologi," 2020.
[12] M. E. Suban and Z. Hidayatullah, "Identifikasi Miskonsepsi Menggunakan Three-Tier Diagnostic Test dan Representasi Gambar pada Konsep Gaya," *Hamzanwadi Journal of Science Education*, vol. 1, no. 2, pp. 1–9, 2024. doi:10.29408/hijase.v1i2.26917
[13] N. S. Pratama and E. Istiyono, "Studi pelaksanaan pembelajaran fisika berbasis higher order thinking (HOTS) pada kelas X di SMA Negeri Kota Yogyakarta," in *Seminar Nasional Fisika Dan Pendidikan Fisika Ke-4 2015*, Sebelas Maret University, 2015.
[14] D. Yuzianah and S. Fatimah, "Penggunaan Three Tier Test Untuk Mendiagnosa Miskonsepsi Siswa Dalam Menyelesaikan Masalah Eksponensial," *Jurnal Eduscience*, vol. 9, no. 1, pp. 19–27, 2022. doi:10.36987/jes.v9i1.2516
[15] R. Diani, S. Fadilah, and D. P. Sari, "Review and comparison of four-tier multiple choice and five-tier multiple choice diagnostic tests to identify mastery of physics concepts," *Jurnal Penelitian Pendidikan IPA*, vol. 8, no. 1, pp. 38–45, 2022. https://doi.org/10.29303/jppipa.v8i1.838
[16] S. Surmaini, I. Syafe'i, and R. Diani, "An analysis of students' physics misconceptions in online learning using the four-tier diagnostic test with certainty of response index (CRI)," *J. Phys. Conf. Ser.*, vol. 1796, no. 1, p. 012099, 2021. https://doi.org/10.1088/1742-6596/1796/1/012099
[17] N. Önder-Çelikkanlı and H. Ş. Kızılcık, "A review of studies about four-tier diagnostic tests in physics education," *J. Turkish Sci. Educ.*, vol. 19, no. 4, pp. 1291–1311, 2022. https://doi.org/10.36681/tused.2022.175
[18] N. Jalinus et al., "Developing Blended Learning Model in Vocational Education Based On 21st Century Integrated Learning and Industrial Revolution 4.0," *Turkish J. Comput. Math. Educ.*, vol. 12, no. 9, pp. 1276-1291, 2021.
[19] H. Sopian, "Deskripsi kemampuan berpikir logis dan pemahaman konsep sistem hormon pada siswa kelas XI SMA," *Edubiologica: Jurnal Penelitian Ilmu dan Pendidikan Biologi*, vol. 7, no. 2, pp. 85–88, 2019. doi:10.25134/edubiologica.v7i2.3023
[20] B. Pratama and E. Istiyono, "Development of a Three-Tier Diagnostic Test Instrument to Identify Students' Misconceptions on Motion Kinematics Material," *Impulse: Journal of Research and Innovation in Physics Education*, vol. 4, no. 2, pp. 79-95, 2024. doi: 10.14421/impulse.2023.42-02

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The Effect of the Science, Technology, Engineering, and Mathematics (STEM)-Based Problem-Based Learning (PBL) Model on Students' Creative Thinking Skills in the Topic of Heat in Grade XI at SMAN 1 Ngadiluwih

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ABSTRACT

Students are often trained to find a single correct answer rather than to develop various possible solutions to a problem. This study employed a quantitative approach with a Quasi-Experimental design, specifically the Posttest-Only Control Group Design. Data were collected through observation sheets, tests, and documentation. The data analysis techniques used consisted of Instrument Testing, Prerequisite Testing, and Hypothesis Testing. Based on the results of the study, it can be concluded that: 1) There is an effect of the Science, Technology, Engineering, and Mathematics (STEM)-based Problem-Based Learning (PBL) model on students' creative thinking skills, as indicated by the Mann-Whitney U test result with a significance value of 0.000 < 0.05. 2) The implementation of the STEM-based Problem-Based Learning (PBL) model effectively enhances students' creative thinking skills on the topic of heat. The results of learning in each aspect of creative thinking show that the application of this model can serve as an alternative solution to create active, meaningful, and challenging physics learning.

INTISARI

Siswa sering dilatih untuk menemukan satu jawaban yang benar dari pada mengembangkan berbagai kemungkinan solusi terhadap suatu masalah. Penelitian ini menggunakan pendekatan kuantitatif dengan desain Quasi Eksperimen jenis posttest Only Control Group Design. Pengumpulan data dilakukan melalui lembar observasi, tes, dan dokumentasi. Teknik analisis yang digunakan terdiri dari Uji Intrumen, Uji Prasyarat, dan Uji Hipotesis. Berdasarkan hasil penelitian, dapat disimpulkan bahwa: 1) Ada pengaruh model pembelajaran Problem-Based Learning (PBL) berbasis Science, Technology, Engineering, and Mathematics (STEM) terhadap kemampuan berpikir kreatif siswa, dengan hasil uji Mann Whitney U diperoleh nilai sig. 0,000 < 0,05. 2) Keterlaksanaan model Problem Based Learning (PBL) berbasis STEM terhadap kemampuan berpikir kreatif siswa pada materi kalor, dengan hasil pembelajaran pada setiap aspek kemampuan berpikir kreatif siswa penerapan model ini dapat

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menjadi solusi alternatif untuk menciptakan pembelajaran fisika yang aktif, bermakna, dan menantang.

A. Introduction

Creative thinking skills are one of the essential 21st-century competencies that students need to possess. These skills enable learners to generate diverse and original ideas and to solve problems from multiple perspectives. Unfortunately, physics learning in schools is still largely teacher-centered and outcome-oriented, which limits opportunities for fostering students' creativity [1].

Based on the results of observations and interviews with teachers at SMAN 1 Ngadiluwih, it was found that classroom learning often trains students to find a single correct answer rather than to develop multiple possible solutions to a problem. Students also lack the freedom to think broadly and creatively when responding to questions given by the teacher, particularly on the topic of heat. This condition has resulted in students' low creative thinking skills.

Problem-Based Learning (PBL) is a learning model designed to encourage students' active engagement in solving contextual problems. This aligns with the findings of Elizabeth & Sigahitong [2] in her study showed that the PBL model had a positive effect on students' creative thinking skills in learning static fluid material. The Science, Technology, Engineering, and Mathematics (STEM) approach is regarded as an effective strategy for promoting educational transformation in the 21st century [3]. This is in line with the findings of Aryani & Putri [4], whose research showed that the use of the Science, Technology, Engineering, and Mathematics (STEM)-based Problem-Based Learning (PBL) model had a significant effect on improving students' biology learning outcomes and their critical thinking skills in the topic of the immune system. This approach integrates various disciplines, allowing students to acquire knowledge and skills simultaneously. PBL helps students think critically, collaboratively, and creatively. When combined with the STEM approach, this model enables the integration of cross-disciplinary concepts to solve real-world problems [5].

The STEM-based PBL model has been proven effective in enhancing students' creative thinking skills [6]. There are various ways to integrate the STEM approach into the PBL model, one of which is through the use of teaching materials containing STEM contexts. These materials present problems related to real-world and interdisciplinary STEM contexts [7]. With this approach, students are not limited to solving physics problems alone but also draw upon knowledge from various STEM fields to find solutions [8]. Through this process, students gain new insights from multiple disciplines and are able to develop their thinking patterns in problem-solving [9]. This demonstrates that the implementation of a PBL model integrated with STEM in physics learning can enhance students' creative thinking skills [10].

The STEM approach is often used to encourage students to address various problems, including the development of creative thinking skills [11]. Based on this background, this study is entitled "The Effect of the Science, Technology, Engineering, and Mathematics (STEM)-Based Problem-Based Learning (PBL) Model on Students' Creative Thinking Skills in the Heat Topic for Grade XI at SMAN 1 Ngadiluwih, Kediri Regency" as a continuation of previous studies. This research aims to evaluate the effectiveness of the learning model in improving students' creative thinking skills.

B. Method

This study employed a quantitative approach using a quasi-experimental design with a post-test-only control group [12]. The research was conducted at SMAN 1 Ngadiluwih, Kediri Regency, during the even semester of the 2024/2025 academic year.

The population of this study consisted of all grade XI students, and the sample was determined using a purposive sampling technique. Class XI-2 was designated as the experimental class, where the STEM-based Problem-Based Learning (PBL) model was implemented, while Class XI-3 served as the control class, which was taught using conventional methods. Each class consisted of 35 and 36 students, respectively. The research was conducted by dividing the respondents into two groups: the experimental group and the control group. After the learning process, both groups were given post-test questions to determine the final condition and compare students' creative thinking skills between the experimental and control classes. The instrument used was a set of essay questions developed based on the indicators of creative thinking skills proposed by Munandar, namely: fluency, flexibility, originality, and elaboration [13].

The content validity was tested by expert lecturers and supervising teachers. The instrument was considered valid if it had a Pearson correlation value greater than 0.329. The reliability of the instrument was tested using the Cronbach's Alpha formula with the help of SPSS 30.0. Data analysis was conducted using the Kolmogorov-Smirnov test in SPSS 30.0 to examine the normality of the data. The decision criterion was that if the Sig value > 0.05, the data were considered normally distributed. Since the data were not normally distributed, the Mann-Whitney U test was used for hypothesis testing with the assistance of SPSS 30.0.

C. Result and Discussion

Before the instrument was used to collect data (distributed to respondents), the researcher first conducted an observation at the school to identify existing problems. Then, the researcher developed a set of instruments and conducted a series of instrument tests, beginning with expert validation.

The researcher sought assistance from a lecturer at UIN Sayyid Ali Rahmatullah Tulungagung to validate the instrument. Based on the results of the validation, the validator suggested that some questions should be removed, some should be added, and others should be revised in terms of wording and sentence structure. After the validator stated that the test instrument was feasible for trial, the questions were then tested on students who had already studied the topic of heat.

Table 1. Results of the Instrument Validity Test

Test	Pearson's r	t-statistic	r Table (N = 36)	Description
Item 1	0.435	2.816	0.329	Valid
Item 2	0.435	2.816	0.329	Valid
Item 3	0.737	6.358	0.329	Valid
Item 4	0.749	6.591	0.329	Valid
Item 5	0.656	5.067	0.329	Valid
Item 6	0.656	5.067	0.329	Valid
Item 7	0.345	2.143	0.329	Valid
Item 8	0.345	2.143	0.329	Valid

The table shows that the validity test results for the eight items indicate that all of them are valid. Each of the eight items has an $r_{calculated}$ value greater than the r_{table}. value. In addition, all items also have Pearson correlation coefficients greater than 0.329.

Table 2. Instrument Reliability Test Results

Correlation Coeficient	Criteria
0.00 ≤ r < 0.20	Very low
0.20 ≤ r < 0.40	Low
0.40 ≤ r < 0.60	Moderate
0.60 ≤ r < 0.80	High
0.80 ≤ r < 1.00	Very high

Based on the results of the instrument reliability test for students' creative thinking skills administered to 36 respondents from class XII-1, the findings are as follows:

Table 3. Results of the Instrument Reliability Test

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0.681	0.737	8

The table shows that the Cronbach's Alpha value is greater than 0.60, namely 0.681. Based on the reliability coefficient criteria, it can be concluded that all items of the creative thinking skills test instrument used by the researcher fall within the category of moderate reliability.

Table 4. Results of the Normality Test

		Group	
		Control	**Eksperimen**
Kolmogorov-Smirnov[a]	Statistic	0.220	0.218
	df	36	35
	Sig.	0.000	0.000
Shapiro-Wilk	Statistic	0.908	0.916
	df	36	35
	Sig.	0.006	0.011

Based on the normality test results shown in the table, it can be seen that the significance value of the experimental class is 0.000 < 0.05; therefore, the data in the experimental class are not normally distributed.

Table 5. Results of the Homogeneity Test

Levene Statistic	**df1**	**df2**	**Sig.**
1.443	1	69	0.234

Based on the homogeneity test results shown in the table, it can be seen that the significance value of the experimental class is 0.234 > 0.05; therefore, the data in the experimental class are homogeneous. However, because the data are not normally distributed, the hypothesis testing was carried out using the Mann‑Whitney U test. The Mann-Whitney U test is a non-parametric alternative to the independent samples t-test, used to examine the differences between two independent groups when the data are measured on an ordinal or interval scale but not normally distributed. Therefore, this test is appropriate for analyzing the differences in students' creative thinking skills between the experimental group and the control group after the implementation of the STEM-based Problem-Based Learning (PBL) model.

Table 6. Results of the Non-Parametric Mann–Whitney U Test

	Value
Mann-Whitney U	67.500
Wilcoxon W	**733.500**
Z	-6.534
Asymp. Sig. (2-tailed)	**0.000**

Based on the results of the Mann–Whitney U test analysis, a significance value of 0.000 was obtained, which is lower than 0.05. This indicates that there is a significant difference between the creative thinking skills of students in the experimental class and those in the control class.

Effect Size Cohen's d

The effectiveness test using Cohen's d is one of the methods used to evaluate the strength or effectiveness of a treatment in experimental research. Cohen's d provides a deeper interpretation of the significance test results, particularly in understanding the practical impact of the applied treatment [14]. The criteria for interpreting Cohen's d values are as follows:

d < 0.2 → the learning model has a low effect

d < 0.5 → the learning model has a moderate effect

d < 0.8 → the learning model has a high effect

Based on the analysis conducted, the following are the Cohen's d effect size results, which serve as indicators of the effectiveness level of the learning model.

	Control	**Experiment**
Mean	60.83	82.29
Standard deviation	11.180	8.166
Sample size (N)	36	35
Effect Size d_{Cohen} *resp.* g_{Hedges} *	2.187	
Common Language Effect Size *CLES***	0.939	

Based on the calculation using Cohen's d through the Psychometrica application, a value of 2.187 was obtained, indicating that the effectiveness of the STEM-based PBL model on the topic of heat falls into the high category according to Cohen's classification, which identifies the difference between the experimental group and the control group as highly significant. This value shows that the experimental class, with an average score of 82.29, performed significantly better than the control class, which had an average score of 60.83. The CLES value of 0.939 indicates a 93% probability that a student selected from the experimental class would score higher than a student from the control class.

Table 8. Descriptive Statistics of Students' Creative Thinking Skills Test

Statistic	Point	Class Eksperimen	Class Control
N	71	35	36
Minimum	35	60	35
Maximum	100	100	80
Mean	71.41	82.29	60.83
Standard deviation	14.545	8.166	11.180

Based on the table, the research results on creative thinking skills are as follows. The experimental class obtained a maximum score of 100 and a minimum score of 100, with an average test score of 82.29. The control class obtained a maximum score of 80 and a minimum score of 35, with an average score of 60.83. Across both classes, the maximum score was 100 and the minimum was 35, with an overall average test score of 71.41.

According to the assessment indicators of creative thinking skills [15]: Fluency: a score of 4 indicates that students correctly answered three or more questions on changes in heat; a score of 3 indicates correct answers for three questions; a score of 2 indicates correct answers for two questions; a score of 1 indicates one correct answer; and a score of 0 indicates no correct answer or an incorrect answer. Elaboration: a score of 4 indicates that students gave correct answers with four or more sentences detailing the response; a score of 3 indicates three sentences; a score of 2 indicates two sentences; a score of 1 indicates one sentence; and a score of 0 indicates no answer or an incorrect answer. Originality: a score of 4 represents responses given by 1%–4% of all students, a score of 3 represents 5%–9%, a score of 2 represents 10%–14%, and a score of 1 represents more than 19% of all students' answers. Flexibility: a score of 4 indicates that students provided four or more analytical factors; a score of 3 indicates three to four factors; a score of 2 indicates two to three factors; a score of 1 indicates one to two factors; and a score of 0 indicates no answer or an incorrect answer.

Based on the table of average scores for each aspect of creative thinking skills in the experimental class, originality and flexibility achieved the maximum average score of 4.00. Fluency had an average score of approximately 3.03, while elaboration had the lowest average score at around 1.71. The higher values of originality and flexibility indicate that originality reflects students' ability to generate unique and uncommon ideas, showing that they can think beyond usual patterns or conventional frameworks. Flexibility, on the other hand, demonstrates students' ability to produce a variety of ideas or solutions from different perspectives, signifying openness and adaptability in thinking. Thus, students with high originality and flexibility scores are typically able to solve problems in unconventional ways, not limited to a single approach. They are creative in expressing opinions or creating something new, open to new ideas, and capable of adapting to various situations.

The lower scores in the aspects of fluency and elaboration compared to originality and flexibility indicate that students possess creative thinking potential but have not yet fully optimized their ability to develop and communicate their ideas. A low fluency score suggests that students are not yet able to generate a large number of ideas within a certain period, even though the ideas they produce may be unique (original). This means that the quantity of ideas remains limited. Meanwhile, a low elaboration score implies that students are less detailed in developing their ideas, resulting in thoughts that are not deeply expanded or lack specificity in explanation and application. Such students are able to think creatively in unique and flexible ways but still need to be trained to: Generate a greater number of ideas (increase quantity), and Develop ideas in a more detailed and applicable manner. This may indicate that students have a high creative potential but are not yet accustomed to expressing it comprehensively. They require additional stimulation or practice in articulating and expanding their ideas, as they are still in the early stages of developing holistic creative thinking skills.

Based on the table of average scores for each aspect of creative thinking skills in the control class, originality obtained an average score of 2.11, flexibility obtained an average score of 3.47, fluency had an average of 2.89, and elaboration had the lowest average at approximately 1.56. These findings indicate that students show a strong tendency toward creative thinking in terms of flexibility, reflecting their ability to generate various ideas from different perspectives. However, the relatively lower level of originality suggests that the ideas produced are still less unique or do not fully demonstrate original thought. Meanwhile, fluency falls within the medium category, meaning that students are able to produce several ideas, though not yet in an optimal quantity. Elaboration, which obtained the lowest score, indicates that students have difficulty developing, detailing, and expanding their ideas in a more in-depth and structured manner. Overall, it can be concluded that students possess potential in creative thinking—particularly in the flexibility of ideas—but they still need further encouragement and training to improve their ability to generate more ideas (fluency), create more unique ideas (originality), and develop ideas into more complex and detailed forms (elaboration). The results also show that the experimental class demonstrated higher performance in creative thinking skills compared to the control class. This is evident from the average score of the experimental class (82.29), which was higher than that of the control class (60.83), with all students in the experimental class achieving a perfect score (100). Meanwhile, the control class showed greater variation, with scores ranging from 35 to 80. These results indicate that the treatment or intervention applied in the experimental class had a significant effect on improving students' creative thinking skills. This improvement is reflected not only in the higher average scores but also in the consistency of the experimental class, where all students achieved maximum results. The average creative thinking score of students in the experimental class was higher than that of the control class, with improvements observed across all aspects of creative thinking—fluency, flexibility, originality, and elaboration. This demonstrates that the STEM-based Problem-Based Learning (PBL) model is effective in enhancing creative thinking skills.

Based on the effectiveness calculation using Cohen's d through the Psychometrica application, the obtained value of d = 2.187 falls into the high category according to Cohen's classification, indicating that the STEM-based PBL model had a very large effect on improving students' creative thinking skills.

This result is further supported by the comparison of average scores between the two groups, where the experimental class achieved an average score of 82.29, while the control class obtained only 60.83. The considerable difference between these averages signifies a significant impact of the STEM-based PBL model on students' learning outcomes, particularly in the aspect of creative thinking in the topic of heat.

Additionally, the Common Language Effect Size (CLES) calculation produced a value of 0.939, meaning there is a 93% probability that a randomly selected student from the experimental class will have a higher score than a student from the control class. This further reinforces the evidence that the STEM-based PBL model is highly effective in enhancing students' creative thinking abilities.

In conclusion, the use of the STEM-based Problem-Based Learning (PBL) model has proven to be effective and highly impactful in improving students' creative thinking skills in the topic of heat. This model not only encourages students to actively solve real-world contextual problems but also integrates science, technology, engineering, and mathematics concepts in a unified manner, thereby fostering the development of higher-order thinking skills, including creative thinking.

D. Conclusion

There is a significant effect of applying the Problem-Based Learning (PBL) model based on Science, Technology, Engineering, and Mathematics (STEM) on students' creative thinking skills regarding the topic of heat. Based on the Mann–Whitney U test, the obtained Asymp. Sig value was 0.000. Since the value ≤ 0.05, H_0 was rejected and Ha was accepted. This indicates that students' creative thinking skills in the experimental class were higher than those in the control class. Therefore, the research hypothesis stating that "There is an effect of the STEM-based PBL model on students' creative thinking skills on heat material" is accepted.

The STEM-based Problem-Based Learning model was proven to be effective in improving students' creative thinking skills. The effectiveness test using Cohen's d obtained a value of 2.187, which falls into the high category, indicating that the model had a very strong influence on improving creative thinking skills. In addition, the Common Language Effect Size (CLES) analysis resulted in a value of 0.939, meaning that there is a 93% probability that a randomly selected student from the experimental class would have a higher score than a student from the control class.

Based on these findings, it is recommended that physics teachers adopt and adapt the STEM-based Problem-Based Learning model in their teaching practices, particularly for topics that require problem-solving and creative thinking skills, such as the concept of heat.

References

[1] N. A. Awalin and I. Ismono, "The Implementation of Problem Based Learning Model with STEM (Science, Technology, Engineering, Mathematics) Approach to Train Students' Science Process Skills of XI Graders on Chemical Equilibrium Topic," *INSECTA Integr. Sci. Educ. Teach. Act. J.*, vol. 2, no. 1, pp. 1–14, May 2021, doi: 10.21154/insecta.v1i2.2496.

[2] A. Elizabeth and M. M. Sigahitong, "Pengaruh Model Problem Based Learning Terhadap Kemampuan Berpikir Kreatif Peserta Didik SMA," *Prisma Sains J. Pengkaj. Ilmu dan Pembelajaran Mat. Dan IPA IKIP Mataram*, vol. 6, no. 2, pp. 66–76, 2018.

[3] H. C. Kurniawan, N. F. Amilia, G. Resbiantoro, and M. L. H. Abbas, "Pengaruh Model Pembelajaran Problem Based Learning (PBL) Berbantuan Mind Mapping Terhadap Kemampuan Berpikir Kritis Materi Getaran di MTsN 5 Tulungagung," *JEAS J. Educ. Appl. Sci.*, vol. 1, no. 1, pp. 20–23, Sept. 2023, doi: 10.30739/jeas.v1i1.2515.

[4] Aryani and J. Putri, "Pengaruh Model Pembelajaran Problem Based Learning Berbasis STEM Terhadap Hasil Belajar Biologi Dan Keterampilan Berpikir Kritis Siswa," Universitas Jember, 2023.

[5] Siswono, "Menilai Kreativitas Siswa dalam Matematika," in *Proseding Seminar Nasional Matematika dan Pendidikan Matematika*, Surabaya: Universitas Negeri Surabaya, 2005.

[6] K. S. Kallesta and M. Erfan, "Analisis Faktor Penyebab Kesulitan Belajar IPA Fisika pada Materi Bunyi," *Junal Pendidik. Fis.*, vol. 1, no. 1, pp. 1–13, 2017.

[7] M. N. Hidayat, A. D. Wulandari, and F. Ronilaya, "Design and analysis of multiple charge controller systems in hybrid power generation," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 1098, no. 4, p. 042056, Mar. 2021, doi: 10.1088/1757-899X/1098/4/042056.

[8] Lusiani *et al.*, *Fisika Terapan*. Yogyakarta: Zahir Publishing, 2021.

[9] I. W. Widana and K. L. Septiari, "Kemampuan Berpikir Kreatif dan Hasil Belajar Matematika Siswa Menggunakan Model Pembelajaran Project-Based Learning Berbasis Pendekatan STEM," *J. Elem.*, vol. 7, no. 1, pp. 209–220, Jan. 2021, doi: 10.29408/jel.v7i1.3031.

[10] M. F. Vistara, M. Asikin, A. S. Ardiansyah, and E. Pudjiastuti, "Problem Based Learning Berorientasi STEM Context Terhadap Kemampuan Berpikir Kreatif Matematika Siswa," in *Prosiding Seminar Nasional Matematika XV*, Semarang: Universitas Negeri Semarang, 2022.

[11] N. Sara, P. Murni, and S. Syamsurizal, "The Effect of the Problem-Based Learning Model Based on the Science, Technology, Engineering, and

Mathematics (STEM) Approach on Students' Creative Thinking Ability," *J. Inov. Pendidik. Dan Sains*, vol. 6, no. 2, pp. 339–344, July 2025, doi: 10.51673/jips.v6i2.2528.

[12] K. E. Lestari, *Penelitian Pendidikan Matematika*. Bandung: Refika Aditama, 2016.

[13] U. Munandar, *Mengembangkan Kreativitas Anak Berbakat*. Jakarta: Rineka Cipta, 2012.

[14] J. Cohen, *Statistical Power Analysis for the Behavioral Sciences*, 0 ed. Routledge, 2013. doi: 10.4324/9780203771587.

[15] H. T. Damayanti and S. Sumardi, "Mathematical Creative Thinking Ability of Junior High School Students in Solving Open-Ended Problem," *JRAMathEdu J. Res. Adv. Math. Educ.*, vol. 3, no. 1, p. 36, Jan. 2018, doi: 10.23917/jramathedu.v3i1.5869.

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Quality Analysis of the Final Examination Instrument and Its Implication for Student Learning Outcomes in the Fundamentals of Physics II

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ABSTRACT

The low student learning outcomes in the Fundamentals of Physics II raise concerns about the quality of the evaluation instrument used to measure the students' achievement. This study aims to analyze the quality of the Final Semester Examination (UAS) instrument and its relation with students' learning outcomes. The subjects of this study were 53 second-semester students from the Department of Physics, Universitas Negeri Malang. The evaluation instruments consisted of 30 multiple-choice questions. The items were analyzed using PSPP statistical software, which functions similarly to SPSS. The analysis involved validity testing using the Pearson Correlation Method, reliability testing using Cronbach's Alpha, the discrimination power and difficulty indices. The results showed that 50% of the items were valid, the instrument's reliability was moderate with a Cronbach's Alpha value of 0.60, and only 10% of the items had very good discrimination power, while most (63.4%) were categorized as low to negative. In terms of difficulty, 53.3% of the items were classified as difficult, 20% as moderate, and 26.7% as easy. These findings indicate that the low student learning outcomes are influenced not only by internal factors but also by the quality of the evaluation instrument. So, this study not only test the validity and reliability of the test items but also explores how the question construction can affect learning achievements. This study offers new insights for lecturers to design more accurate instruments that can truly reflect students' ability, especially in the Fundamentals of Physics II course.

INTISARI

Rendahnya capaian hasil belajar mahasiswa pada matakuliah Fisika Dasar II menimbulkan kekhawatiran terhadap kualitas intrumen evaluasi yang digunakan untuk menilai hasil belajar. Penelitian ini bertujuan menganalisis kualitas butir soal Ujian Akhir Semester (UAS) dan hubungannya dengan hasil belajar mahasiswa. Subjek dari penelitian ini adalah 53 orang mahasiswa semester kedua pada Departemen Fisika, Universitas Negeri Malang. Instrumen yang dievaluasi adalah soal UAS yang berjumlah 30 soal berbentuk pilihan ganda. Soal di analisis dengan perangkat lunak PSPP. PSPP merupakan perangkat

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lunak statistik yang memiliki fungsi mirip dengan SPSS. Soal dianalisis dengan Uji Validitas menggunakan Pearson Correlation Method, Uji Reliabilitas dengan Cronbach's Alpha, daya beda soal dan tingkat kesukarannya. Hasil analisis menunjukkan 50% soal valid, reliabilitas instrumen moderat dengan Cronbach's Alpha 0,60, serta hanya 10% soal memiliki daya beda sangat baik, sedangkan sebagian besar (63,4%) tergolong rendah hingga negatif. Dari sisi kesukaran, 53,3% soal sukar, 20% sedang, dan 26,7% mudah. Temuan ini mengindikasikan bahwa rendahnya hasil belajar mahasiswa tidak hanya dipengaruhi faktor internal, tetapi juga kualitas instrumen. Sehingga, penelitian ini tidak hanya menilai validitas dan reliabilitas soal, tetapi juga menelusuri bagaimana konstruksi soal dapat mempengaruhi capaian belajar. Penelitian ini juga memberikan sudut pandang baru bagi dosen untuk merancang instrumen yang dapat merefleksikan kemampuan mahasiswa, khususnya pada matakuliah Fisika Dasar II.

A. Introductions

Fundamentals of Physics is one of the course that must be completed by first semester students in the Department of Physics, Universitas Negeri Malang, both in education and non education program. This course is really important because it's being a foundation for all advanced physics subjects and shaping students' conceptual understanding. Students are expected to connect the basic theory with mathematical formulations and know how to applying it in real life phenomena[1],[2]. Especially for students in education programs, well understanding the basic concept in Fundamentals of Physics also prepares them to become a teacher who can explain physics phenomena to others effectively. Because of this, students' achievement in this course reflects how successful the learning process.

From the evaluation of learning outcomes of Physics Education students in Department of Physics, Universitas Negeri Malang, the results of the Final Semester Examination (UAS) in the Fundamentals of Physics II course were found relatively low. This condition raises questions about the problems in the learning process, such as the effectiveness of teaching methods, students' understanding, and also the instrument's quality that are used to evaluate students' learning outcomes [3],[4],[5]This case indicates a gap between the learning objectives stated in the Course Learning Outcomes (CPMK) and the results students actually achieve. Low examination results do not always mean that students lack of understanding. But, they also can reveal weaknesses of the test items. When test instuments are not properly validated, it may be leading to inaccurate interpretation of students' abilities.

The assessment process cannot be separated from the quality of the assessment instruments used [6],[7]. A good instruments, through written or oral tests, assignments and project based, should be able to measure cognitive, psychomotor and affective skills[3],[8]. In physics learning, test items play a role in identifying how well students in understanding the basic concepts and how to applying it in various problem contexts [9],[10],[11],[12]. Because of that, the quality of test items that used in evaluation need to be analyzed to ensure that the given accurately, objectively, and proportionally measure students' abilities[13],[14],[15],[16].

A good assessment instrument should have a balanced level of difficulty and non-ambiguous answer choices[17]. An effective instrument must be able to measure the achievement of the competencies stated in the Learning Outcomes. Problematic instruments, such as those that are too difficult or contain ambiguous wording, can cause evaluation outcomes that do not accurately reflect students' actual abilities. To determine the causes of low student learning outcomes, it is necessary to analyze the test items used in the Final Semester Examination (UAS). Items analysis helps to identify the quality of each question, whether it is good, less effective or poor, or which questions perform well and which need revision, so it can be used as the assesment instruments[18]. A test item is considered high quality if it has strong validity, good reliability, and meets other criteria outlined in the assessment guidelines [3],[15],[19].

Moreover, item's analysis can give information how each question distinguishes between students with high and low levels of understanding effectively. This process, helps lecturer to identify items that need to be revised, removed or replaced. Item's analysis also can identify the strengths and weaknesses of each question, give detailed information about test items, and identify the problem within the questions themselves[3],[20],[21].

An important aspect that being urgency in this study is the test items used in the Final Semester Examination has not passed validity and reliability testing before being distributed to students. So, the test instrument does not guarantee that it can measure students' abilities objectively. Based on that need, this study focuses on analyzing the multiple choice test items used in The Fundamental of Physics II Final Semester Examination to evaluate students' learning outcomes. The analysis of test items cover validity and reliability testing, discriminatory power and difficulty indices. This study expected to provide useful insight for improving the quality of assessment instrument. Also, it can serve as a reference for the lecturers to make assessment process is fair, objective and students' learning outcomes truly reflective.

B. Methods

General Background

This study uses descriptive quantitative methods to analyze the evaluation instrument in the Final Semester Examination (UAS) items in the Fundamentals of Physics II and its relation to students' learning outcomes. The focus of this study was to assess the validity and reliability of the test items, the discriminatory power dan the difficulty indices. This approach was chosen because the 4 aspects provides empirical evidence, ensuring that the evaluation instrument able to measure the learning outcomes consistently, objectively and proportionally.

Participants

The participants of this study were 53 second-semester students enrolled in the Fundamentals of Physics II course during the even semester of the 2024/2025 academic year, in the Department of Physics, Universitas Negeri Malang.

Instruments and Procedures

The instrument used in this study was Final Semester Examination sheet, containing 30 multiple-choice questions designed to assess the level of students' understanding of the fundamental concepts. Each question was scored : a score of 1 if the answer is correct and a score of 0 if the answer is incorrect. The students' responses were recorded on standard answer sheets.

Each question was constructed to measure one or more indicators in the Sub-Course Learning Outcome (Sub-CPMK). For Example :

Sample Question 1 (Sub CPMK 3.3 : Students showed mastery the Thermodynamics concepts and able to identify and analyze solutions for standard physical systems.)

A parfume bottle made from glass, consists of a main bottle and a vertical cube as shown in the Figure 1.

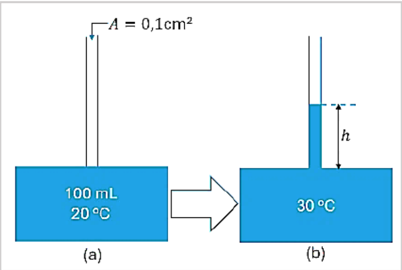

Figure 1. Liquid parfume fulfills the main bottle (a) and parfume rise into the tube by a height of *h* (b)

In room temperature (20 °C), 100 cm^3 liquid parfume poured into the bottle, it fulfills the main bottle (Figure 1.a). The vertical tube has cross-sectional area 0.1 cm^2. When the bottle heated to a temperature of 30 °C, parfume from the main bottle will rise into the tube by a height of h (Figure 1.b). Assume that the linear expansion coefficient of the glass is $0.3 \times 10^{-6}/°C$ and the volume expansion coefficient of the liquid parfume is $1.5 \times 10^{-4}/°C$. What is height h ?

a. 1.5 mm
b. 5 mm
c. 10 mm
d. 15 mm
e. 16.5 mm

Sample Question 2 (Sub CPMK 3.4 : Students showed mastery the Optics concepts and able to identify and analyze solutions for standard physical systems.)

Two symmetric biconcave lenses A and B, made from the same material but have different radius of curtivature and also have different thicknesses $t_B > t_A$ (see Figure 2 below)

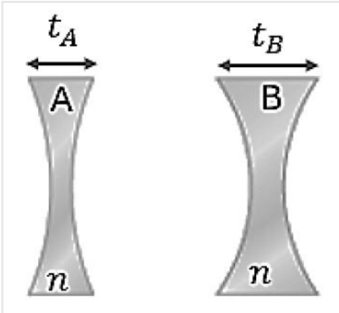

Figure 2. Two symmetric biconcave lenses A and B

The ratio of the radius of curtivature R and the focal lengths f of two lenses are…

a. $R_B > R_A$ and $f_B > f_A$

b. $R_B > R_A$ and $f_B < f_A$

c. $R_B < R_A$ and $f_B < f_A$

d. $R_B < R_A$ and $f_B = f_A$

e. $R_B < R_A$ and $f_B > f_A$

Data Analysis

The data were analyzed using PSPP, a statistical software package that functions similarly to SPSS. Using PSPP, validity testing (Pearson correlation), reliability testing (Cronbach's Alpha), discriminatory power, difficulty indices were computed for each question. The test item was analyzed in four stages :

1. Validity test basically means "measure what is intended to be measured"[22]. The validity testing uses the Bivariate Pearson (Product Moment) correlation at a 5% significance level to determine the accuracy of each test item. With 53 respondents, the r-table used as the threshold was 0.266. Items with score equal to or greater than the threshold were categorized as valid and it contributed to assessing students' learning outcomes. The validity value was computed using Bivariate Pearson formula, expressed as [13], [20], [23]:

$$r=\frac{n\sum xy-(\sum x)(\sum y)}{\sqrt{\left(n\sum x^2-(\sum x)^2\right)\left(n\sum y^2-(\sum y)^2\right)}} \quad (1)$$

2. Reliability tes refers to the consistency of a research study or measuring test[24]. Reliability testing uses the Cronbach's Alpha coefficient, with interpretation: 0.00 – 0.20 (very low), 0.20 – 0.40 (low), 0.40 – 0.60 (medium), 0.60 – 0.80 (high) , and 0.80 – 1.00 (very high)[3],[25] ,[26] ,[27]. The instrument considered as reliable if the Cronbach's Alpha value is greater than 0.60[28]. In this analysis,

the reliability value was computed using the Cronbach's Alpha formula, expressed as [23],[28],[29]:

$$r=\left(\frac{n}{n-1}\right)\left(\frac{S^2-\sum pq}{S^2}\right) \tag{2}$$

$$S^2=\frac{\sum x^2-\frac{(\sum x)^2}{n}}{n} \tag{3}$$

3. Discriminatory power analysis to evaluate the ability of each question to distinguish between high and low-achieving students, with criteria ranging from 0.70–1.00 (excellent) to negative values (poor)[3],[23]. The discriminatory power value was computed using formula below [13], [23]:

$$D=P_A-P_B=\frac{B_A}{J_A}-\frac{B_B}{J_B} \tag{4}$$

4. Item difficulty analysis or difficulty indices, which classifies test items according to their level of difficulty based on the proportion of students who answered each question correctly[23],[30]. According to standard interpretation criteria, items are categorized as difficult (0.00–0.30), moderate (0.31–0.70), or easy (0.71–1.00)[31]. The formula used to analyze the item difficulty is [13],[23]

$$P=\frac{B}{J_s} \tag{5}$$

C. Result and Discussion

Result

Validity Test

In analyzing the data using PSPP, the first stage was testing the validity of the Final Semester Examination (UAS) items. The results of the validity testing are presented below on Table 1.

Table 1. Validity Test Result

Items	Result	Criteria	Items	Result	Criteria	Items	Result	Criteria
1	0.309	V	11	0.014	IV	21	0.276	V
2	0.301	V	12	0.377	V	22	0.394	V
3	0.127	IV	13	0.015	IV	23	0.121	IV
4	0.289	IV	14	0.258	IV	24	0.499	V
5	0.059	IV	15	0.256	IV	25	0.049	IV
6	0.164	IV	16	0.526	V	26	0.208	IV
7	0.277	V	17	0.535	V	27	0.217	IV
8	0.403	IV	18	0.692	V	28	0.398	V
9	-	IV	19	0.445	V	29	0.511	V
10	-	IV	20	0.519	V	30	0.403	V

Note: V = Valid, IV = Invalid

Reliability Test

The second stage was conducting the reliability test. The reliability test used to measure the consistency of an assessment instrument. Based on the analysis using the PSPP program with the Cronbach's Alpha coefficient, the results presented below on Table 2.

Table 2. Reliability Test Result

Case Processing Summary			Reliability Statistics	
Cases	N	Percent	Cronbach's Alpha	N of Items
Valid	53	100.0 %	0.60	30
Excluded	N	.0%		
Total	54	100.0%		

Discriminatory Power

The third stage is measuring the discriminatory power of each question. In this study, the discriminatory power was measured using the *Corrected Item-Total Correlation* value in the PSPP program. This correlation value represents the strength of the relationship between each item's score and the students' total score. The result of discriminatory power each showed below on Table 3.

Table 3. Discriminatory Power Test Results

Item-Total Statistics			
Items Number -	Scale Mean if Item Deleted-	Scale Variance if Item Deleted-	Corrected Item-Total Correlation
1	11.57	10.29	0.19
2	11.72	10.51	0.23
3	11.66	10.81	0.02
4	11.62	10.39	0.18
5	11.64	10.97	-0.05
6	11.04	10.69	0.03
7	11.34	10.31	0.13
8	11.36	9.89	0.27
9	11.79	10.98	NaN
10	11.79	10.98	NaN
11	11.36	11.27	-0.16
12	11.53	10.06	0.25
13	11.74	11.01	-0.05
14	11.62	10.47	0.15
15	11.70	10.56	0.17
16	10.87	10.12	0.46
17	10.94	9.82	0.45
18	11.06	9.13	0.61
19	11.04	9.88	0.33

Item-Total Statistics			
Items Number -	Scale Mean if Item Deleted-	Scale Variance if Item Deleted-	Corrected Item-Total Correlation
20	10.94	9.86	0.43
21	11.36	10.31	0.13
22	11.08	9.99	0.27
23	11.49	11.56	-0.25
24	11.47	9.64	0.38
25	11.15	11.05	-0.10
26	11.34	10.54	0.06
27	11.70	10.64	0.13
28	11.66	10.19	0.31
29	10.89	10.06	0.44
30	11.53	9.98	0.28

Item Difficulty Result

The last stage in analyzing the test instrument is the level of item difficulty or difficulty indices. The difficulty indices calculated based on the average number of student who answered each question correctly or mean. The result of difficulty indices analysis is showed on Table 4 below.

Table 4. Difficulty Indices Test Result

Items Number -	N		Mean	Standard Deviation	Minimum	Maximum
	Valid	Missing				
1	53	0	0.23	0.42	0.00	1.00
2	53	0	0.08	0.27	0.00	1.00
3	53	0	0.13	0.34	0.00	1.00
4	53	0	0.17	0.38	0.00	1.00
5	53	0	0.15	0.36	0.00	1.00
6	53	0	0.75	0.43	0.00	1.00
7	53	0	0.45	0.50	0.00	1.00
8	53	0	0.43	0.50	0.00	1.00
9	53	0	0	0	0.00	1.00
10	53	0	0	0	0.00	1.00
11	53	0	0.43	0.50	0.00	1.00
12	53	0	0.26	0.45	0.00	1.00
13	53	0	0.06	0.23	0.00	1.00
14	53	0	0.17	0.38	0.00	1.00
15	53	0	0.09	0.30	0.00	1.00
16	53	0	0.92	0.27	0.00	1.00
17	53	0	0.85	0.36	0.00	1.00
18	53	0	0.74	0.45	0.00	1.00
19	53	0	0.75	0.43	0.00	1.00

Items Number -	N		Mean	Standard Deviation	Minimum	Maximum
	Valid	Missing				
20	53	0	0.85	0.36	0.00	1.00
21	53	0	0.43	0.50	0.00	1.00
22	53	0	0.72	0.45	0.00	1.00
23	53	0	0.30	0.46	0.00	1.00
24	53	0	0.32	0.47	0.00	1.00
25	53	0	0.64	0.48	0.00	1.00
26	53	0	0.45	0.50	0.00	1.00
27	53	0	0.09	0.30	0.00	1.00
28	53	0	0.13	0.34	0.00	1.00
29	53	0	0.91	0.30	0.00	1.00
30	53	0	0.26	0.45	0.00	1.00

Discussion

Validity Test

The validity test for the Final Semester Examination in the Fundamentals of Physics II course ensures that the test items can measured students' abilities accurately in accordance with the course learning outcomes. With a total of 53 respondents, the validity testing used the Pearson Product-Moment correlation between each item score and the total score, applying a 5% significance level. In this condition, 0,266 used as the r-table value.

Based on the 30 test items analyzed on Table 1, 15 (50%) were declared valid: 1, 2, 7, 12, 16, 17, 18, 19, 20, 21, 22, 24, 28, 29, and 30. Meanwhile, the other 15 items (50%) were found to be invalid, including items numbers 3, 4, 5, 6, 8, 9, 10, 11, 13, 14, 15, 23, 25, 26, and 27. From these results, we can see that only half of the questions met the validity criteria, and the remaining items couldn't be used to measure students' learning outcomes accurately.

The valid test showed high validity can be found in item 17 which had a correlation coefficient of r = 0.535 and item 18 with r = 0.692. The item score with values about 0.50 indicate high validity. It's mean that these items can be used as assessment instrument in future and also can effectively distinguish between students who have understanding the course and those who have not. In the other side, items called invalid when they have very low or negative correlation value. For example, item 13 (r = 0.015) and item 11 (r = -0.014). These items are contributing little to measuring students' ability. The low validity of test items can be caused by several factors such as ambiguous answer choices, unclear question wording, and students' misconception about the materials.

A more extreme condition was observed in items 9 and 10, which could not be analyzed for validity because none of the students answered them correctly (all respondents scored 0). With no variation in the item score, it becomes statistically imposible to compute the correlation coefficient. It called as a dead item in Classical Test Theory. The questions in this type need to be revised immediately because they have no meaningful information about students' ability.

Overall, we can concluded that the invalid test items need to be reviewed to ensure that the assessment function as intended. The development of valid assessment instrument is important to ensure that evaluation results accurately reflect the abilities that being measured.

Reliability Test

Overall, the reliability analysis in Table 2 above, yield a value of 0.60. This value is below the ideal threshold of 0.70, which is generally used for a reliable instrument. However, it is still in the moderate or acceptable reliability category and can be used to assess learning outcomes[27] .Although the Cronbach's Alpha value is 0.60, the test's quality still needs improvement. A qualitative review of the items, refinement of question wording, and the selection of more effective distractors can help enhance the overall reliability and quality of the instrument. This is also because, even if we say an instrument may be reliable, it is not necessarily valid, because reliability must be combined with validity[4].

Discriminatory Power

Discriminatory power is one of the main indicator of test quality, as it shows an item's ability to distinguish between students with high and low levels of understanding. The higher the discriminatory power value, the more effective the item in identifying students who have truly mastered the material. In general, the interpretation of correlation values follows the guideline that ≥ 0.40 are considered as very good, 0.30–0.39 are good, 0.20–0.29 are moderate and 0.00–0.19 are poor. Negative values are regarded as very poor and unsuitable for use. The results of discriminatory power tes can we see on Table 3. Based on the analysis of 30 questions from the Fundamentals of Physics II Final Examination with a total of 53 respondents, only 3 items (10%) were categorized as very good, specifically items 20, 27, and 29. This indicates that only a small portion of the questions effectively distinguishes students with high mastery of the material. Meanwhile, 2 items (6.7%) were classified as good (items 28 and 30), and 4 items (13.3%) were classified as moderate.

However, a rather concerning finding is that the majority of the items (63.4%) fall into low to very low discriminatory power category. Fourteen items were identified as having low discriminatory power, while five showed negative correlation values. Items with low or negative discriminatory power undermine the test overall validity and may lead to misleading interpretations of the results. When an item produces a negative discrimination value, it's indicating that the items not functioning as intended. Items with negative discriminatory power values should be revised immediately, because they can undermine the test's overall reliability.

Item Difficulty Result

Based on the table 4, difficulty indices test results, most questions were categorized as difficult. 16 items (about 53.3%) had difficulty indices of < 0,30, including 1, 2, 3, 4, 5, 9, 10, 11, 12, 14, 15, 21, 26, 28, 29, and 30. This finding indicates that less than 30% of students were answered correctly and also these 16 items were found relatively challenging for students and may need to be revised in terms structure of wording, cognitive level and content alignment.

A total of 6 items (about 20%) were categorized as moderate, including 7, 8, 22, 23, 24 and 25. It's mean that they have difficulty indices ranging from 0,31 to 0.70. Every items in this category are classified as ideal items because the can distinguish proportionally between students with high and low understanding. Last, 8 items (about 26.7%) were categorized as easy, including 6, 16, 17, 18, 19, 20, 22, and 27. These items have difficulty indices about 0.70. The amount of easy items is still acceptable, if too many, it can reduce the test's overall discriminatory power.

The unbalanced composition of difficulty levels indicates that improvements to the question bank are necessary, especially for items with difficulty levels. Questions that are too difficult can cause frustration among students and reduce the validity of the evaluation results, while questions that are too easy may obscure students' true abilities. Therefore, a thorough evaluation and revision of items with excessively high or low difficulty indices is strongly recommended to improve the test instrument's quality for future exams.

Overall, this study shows that the low achievement in student learning outcomes is not only caused by students' internal factors, but is also related to the quality of the evaluation instruments used. To improve students' learning outcomes, actions incude enhancing teaching methods, providing relevant practice questions, and developing of evaluation instruments that are valid, reliable, have high discriminatory power, and have a balanced distribution of difficulty levels.

D. Conclusion

Based on the study's result, the evaluation instrument used in the Fundamental of Physics II Final Examination still needs improvement. Only half of the questions were found to be valid; the instrument's reliability was in the moderate range, and most of questions showed low discriminatory power and an unbalanced level of difficulty proportion. This condition indicates that the evaluation instrument does not fully effective in representing students' ability accurately. The low student's learning outcomes observed in this course does not fully reflect their actual abilities, but also influenced by the weaknesses of the evaluation instrument itself. When the test items too difficult or have ambiguous phrased, the test result cannot be used as an accurate representation of students' understanding of the material. The findings underline that the evaluation instrument need to be urgently improved. In the future, assessment instrument should focus on increasing the validity and realibity, balancing the difficulty level, and enhancing discriminatory power. Developing better instrument will help to produce more accurate and more informative evaluations, also improving the quality of students' learning outcomes.

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References

[1] Hamatun and M. R. Rifai, "Studi Pemahaman Konsep Energi dalam Penyelesaian Berbagai Persoalan Fisika Pada Perkuliahan Fisika Dasar," *Al-Ikmal: Jurnal Pendidikan*, vol. 2, no. 1, pp. 90–99, 2022.

[2] D. Riwanto, A. Azis, and K. Arafah, "Analisis Pemahaman Konsep Peserta Didik dalam Menyelesaikan Soal-Soal Fisika Kelas X MIA SMA Negeri 3 Soppeng," *JSPF*, vol. 15, no. 2, Nov. 2019, doi: 10.35580/jspf.v15i2.11033.

[3] H. D. Saputra, W. Purwanto, D. Setiawan, D. Fernandez, and R. Putra, "Hasil Belajar Mahasiswa: Analisis Butir Soal Tes," *Edukasi: Jurnal Pendidikan*, vol. 20, no. 1, pp. 15–27, 2022, doi: 10.31571/edukasi.v20i1.3432.

[4] A. Loka Son, "Instrumentasi Kemampuan Pemecahan Masalah Matematis: Analisis Reliabilitas, Validitas, Tingkat Kesukaran Dan Daya Beda Butir Soal," *Gema Wiralodra*, vol. 10, no. 1, pp. 41–52, 2019, doi: 10.31943/gemawiralodra.v10i1.8.

[5] A. Iskandar and M. Rizal, "Analisis kualitas soal di perguruan tinggi berbasis aplikasi TAP," *Jurnal Penelitian dan Evaluasi Pendidikan*, vol. 22, no. 1, pp. 12–23, June 2018, doi: 10.21831/pep.v22i1.15609.

[6] Y. Utami, "Uji Validitas dan Uji Reliabilitas Instrument Penilaian Kinerja Dosen," *SAINTEK*, vol. 4, no. 2, pp. 21–24, Feb. 2023, doi: 10.55338/saintek.v4i2.730.

[7] R. Ika Ningtiyas, M. Sahal, and Y. Gusmeri, "Validitas dan Reliabilitas Butir Soal Berbasis Kemampuan Berpikir Kritis Pada Materi Listrik Dinamis," *j.armada.pendidik.*, vol. 1, no. 1, pp. 26–30, Jan. 2023, doi: 10.60041/jap.v1i1.5.

[8] K. Bashooir and S. Supahar, "Validitas dan reliabilitas instrumen asesmen kinerja literasi sains pelajaran fisika berbasis STEM," *Jurnal Penelitian dan Evaluasi Pendidikan*, vol. 22, no. 2, pp. 219–230, Dec. 2018, doi: 10.21831/pep.v22i2.19590.

[9] C. H. Sulistiawan, "Kualitas Soal Ujian Sekolah Matematika Program IPA dan Kontribusinya Terhadap Hasil Ujian Nasional," *Jurnal Penelitian dan Evaluasi Pendidikan*, vol. 20, no. 1, pp. 1–10, June 2016, doi: 10.21831/pep.v20i1.7516.

[10] A. Anita, S. Tyowati, and Z. Zuldafrial, "Analisis Kualitas Butir Soal Fisika Kelas X Sekolah Menengah Atas," *J Educ*, vol. 16, no. 1, p. 35, June 2018, doi: 10.31571/edukasi.v16i1.780.

[11] Nasir, "Analisis Empirik Program Analisis Butir Soal Dalam Rangka Menghasilkan Soal Yang Baik dan Bermutu Sebagai Alat Evaluasi Pembelajaran Fisika," Pros. Semirata, 2015, pp. 336–347.
[12] Umacina, "Analisis butir soal sumatif semester ganjil mata pelajaran fisika," *J. Pendidik. Fis. Unima*, vol. 1, no. 2, pp. 33–38, 2020.
[13] F. R. Dianova and N. Anwar, "Analisis Butir Uji Validitas, Reliabilitas, Tingkat Kesukaran, dan Daya Pembeda Soal Sumatif Bahasa Arab SD Islam," *Jurnal Bahasa Daerah Indonesia*, vol. 1, no. 3, p. 13, 2024, doi: 10.47134/jbdi.v1i3.2863.
[14] M. Solichin, "Analisis Daya Beda Soal, Taraf Kesukaran, Validitas Butir Tes, Interpretasi Hasil Tes dan Validitas Ramalan dalam Evaluasi Pendidikan," *Dirāsāt J. Manaj. Pendidik. Islam*, vol. 2, no. 2, pp. 192–213, 2017.
[15] T. Novia, A. Wardani, C. Canda, N. Nurdi, and N. Nurmasyitah, "Analisis Validitas dan Reliabilitas Butir Soal UTS Fisika Kelas X SMA Swasta Muhammadiyah 4 Langsa," *GRAVITASI: Jurnal Pendidikan Fisika dan Sains*, vol. 3, no. 01, pp. 19–22, 2020, doi: 10.33059/gravitasi.jpfs.v3i01.2256.
[16] L. Purniasari, M. Masykuri, and S. R. D. Ariani, "Analisis Butir Soal Ujian Sekolah Mata Pelajaran Kimia SMA N 1 Kutowinangun Tahun Pelajaran 2019/2020 menggunakan Model Iteman dan Rasch," *J. Pendidik. Kim.*, vol. 10, no. 2, pp. 205–214, 2021.
[17] N. Abdullah, M. Jahja, and D. G. E. Setiawan, "Analisis Kualitas Butir Soal pada Mata Pelajaran Fisika di Jurusan Fisika Fakultas MIPA Universitas Negeri Gorontalo Tahun Ajaran 2021/2022," *JSPF*, vol. 18, no. 1, p. 44, Apr. 2022, doi: 10.35580/jspf.v18i1.32358.
[18] Fitrah, "Analisis Butir Soal Ulangan Akhir Semester Ganjil Mata Pelajaran Teori Kejuruan Akuntansi Analysis of the Final Examination Items of Teori Kejuruan Akuntansi At Fisrt Semester," pp. 1–11, 2016.
[19] "Kualitas Soal Bahasa Indonesia di SMP Muhammadiyah 1 Pontianak: Analisis Butir Soal," *J. Pendidik. Bhs. dan Sastra Indones.*, vol. 11, no. 2, pp. 112–119, 1022.
[20] I. Magdalena, A. Fitroh, D. K. Fadhilah, D. Habsah, and R. Y. Qodrawati, "Mengelolah Data Uji Validitas Ddn Reliabilitas Dalam PenelitianPendidikan : Instrumen Tes Dan Non Tes Peserta Didik Kelas IV SDN Pondok Kacang Barat 03," *Jurnal Pendidikan Sosial Dan Konseling*, vol. 01, no. 02, pp. 49–53, 2023.
[21] Y. F. Alista and R. A. Syahzanani, "Analisis Butir Soal Ulangan Harian Fisika dengan Pendekatan Teori Tes Klasik menggunakan Program Anates," pp. 1–11, 2023.
[22] H. Taherdoost, "Validity and Reliability of the Research Instrument; How to Test the Validation of a Questionnaire/Survey in a Research," *Jurnal Elektronik SSRN*, 2016, doi: 10.2139/ssrn.3205040.
[23] I. Magdalena, S. N. Fauziah, S. N. Faziah, and F. S. Nupus, "Analisis Validitas, Reliabilitas, Tingkat Kesulitan Dan Daya Beda Butir Soal Ujian Akhir Semester Tema 7 Kelas Iii Sdn Karet 1 Sepatan," *BINTANG : Jurnal Pendidikan dan Sains*, vol. 3, no. 2, pp. 198–214, 2021.
[24] I. Kennedy, "Sample Size Determination in Test-Retest and Cronbach Alpha Reliability Estimates," *British Journal of Contemporary Education*, vol. 2, no. 1, pp. 17–29, Feb. 2022, doi: 10.52589/BJCE-FY266HK9.

[25] S. Wahyuning, *Dasa-Dasar Statistik*. Semarang: Yayasan Prima Agus Teknik, 2021.

[26] R. Ananda and M. Fadhli, *Statistik pendidikan: teori dan praktik dalam pendidikan*. Medan: Widya Puspita, 2018. [Online]. Available: http://repository.uinsu.ac.id/id/eprint/3586

[27] H. Taherdoost, H. Business, S. Sdn, C. Group, and K. Lumpur, "Validity-and-Reliability-of-the-Research-Instrument-How-to-Test-the-Validation-of-a-Questionnaire-Survey-in-a-Research interesante revisar el concurrente.pdf," *International Journal of Academic Research in Management*, vol. 5, no. 3, pp. 28–36, 2016.

[28] F. Fatayah, I. F. Yuliana, and L. Mufidah, "Validity and Reliability Analysis in Supporting Mastery Learning STEM Model," *BP*, vol. 18, no. 1, pp. 49–60, Feb. 2022, doi: 10.36456/bp.vol18.no1.a5175.

[29] S. Ekolu O. and H. Quainoo, "Reliability of assessments in engineering education using Cronbach's alpha, KR and split-half methods," *Global Journal of Engineering Education*, vol. 21, no. 1, pp. 24–29, 2019.

[30] A. Friatma and A. A, "Analysis of validity , reliability , discrimination , difficulty and distraction effectiveness in learning assessment Analysis of validity , reliability , discrimination , difficulty and distraction effectiveness in learning assessment," *Journal of Physics: Conference Series*, vol. 1387, no. 012063, 2019, doi: 10.1088/1742-6596/1387/1/012063.

[31] A. Kausar, S. Daimi, and T. Borulkar, "Assessing an assessment tool: Analysis of multiple choice questions on difficulty level and discrimination power, from an assessment in physiology," *Natl J Physiol Pharm Pharmacol*, no. 0, p. 1, 2021, doi: 10.5455/njppp.2022.12.103872202129112021.

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English for Physics Laboratory Work: Needs Analysis of Undergraduate Learners

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ABSTRACT

The increasing use of English in laboratory manuals requires Physics Education students to possess adequate language skills in order to carry out practical activities effectively. However, many students still struggle to understand scientific terminology and interpret instructions written in English. Previous studies have also shown a gap between the linguistic demands of laboratory work and students' actual language proficiency, making needs analysis essential to conduct. This study aims to identify the English language needs of Physics Education students and the linguistic challenges they encounter during laboratory practice. A descriptive survey method was employed through a mixed-method approach involving fifty students at UIN Syarif Hidayatullah Jakarta. Data were collected using an ESP-based questionnaire and semi-structured interviews, then analyzed through descriptive statistics and thematic analysis. The findings indicate that reading is the most needed skill (M = 4.1; 78%), followed by listening (M = 3.9; 75%), speaking (M = 3.8; 72%), and writing (M = 3.7; 70%). Limited mastery of scientific vocabulary emerged as the main obstacle in understanding texts and instructions. Practically, this study contributes by highlighting ESP needs that are specific to the physics laboratory context, which differ from those addressed in general ESP instruction. These findings emphasize the importance of ESP teaching that focuses on technical vocabulary development, comprehension of procedural texts, and listening practices relevant to real laboratory situations.

INTISARI

Meningkatnya penggunaan bahasa Inggris dalam buku panduan laboratorium menuntut mahasiswa Pendidikan Fisika memiliki kemampuan bahasa yang memadai agar dapat melaksanakan kegiatan praktikum dengan baik. Namun, banyak mahasiswa masih mengalami kesulitan dalam memahami terminologi ilmiah dan menafsirkan instruksi berbahasa Inggris. Studi sebelumnya juga menunjukkan adanya kesenjangan antara tuntutan bahasa di laboratorium dan kemampuan bahasa mahasiswa, sehingga analisis kebutuhan menjadi penting dilakukan. Penelitian ini bertujuan untuk mengidentifikasi kebutuhan bahasa Inggris mahasiswa Pendidikan Fisika serta hambatan linguistik yang mereka hadapi selama praktikum. Metode survei deskriptif digunakan melalui

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pendekatan mixed-method dengan melibatkan lima puluh mahasiswa di UIN Syarif Hidayatullah Jakarta. Data diperoleh melalui kuesioner berbasis ESP dan wawancara semi-terstruktur, kemudian dianalisis menggunakan statistik deskriptif dan analisis tematik. Hasil penelitian menunjukkan bahwa keterampilan membaca menjadi kebutuhan tertinggi (M = 4.1; 78%), diikuti menyimak (M = 3.9; 75%), berbicara (M = 3.8; 72%), dan menulis (M = 3.7; 70%). Penguasaan kosakata ilmiah menjadi kendala utama dalam memahami teks dan instruksi. Secara praktis, penelitian ini memberikan kontribusi dengan menyoroti kebutuhan ESP yang bersifat khusus pada konteks laboratorium fisika, yang berbeda dari pengajaran ESP umum. Temuan ini menegaskan pentingnya pengajaran yang berfokus pada kosakata teknis, pemahaman prosedur, serta latihan menyimak yang relevan dengan situasi laboratorium nyata.

A. Introduction

English for Specific Purposes (ESP) has evolved into a broader and more adaptable field that emphasizes language instruction aligned with the academic, professional, and situational needs of learners. ESP focuses on the vocabulary, topics, and communicative tasks that students encounter in real contexts, supported by materials intentionally designed to meet their specific purposes [1]. This alignment strengthens the relevance of English instruction and enables students to communicate effectively across academic and professional environments [2].

In physics education, English proficiency is essential as it significantly affects students' learning outcomes [3]. This highlights the importance of language skills for understanding scientific concepts and engaging effectively with laboratory materials. As a result, both general English competence and subject-specific language skills are necessary to support the conceptual and practical aspects of physics learning [4].

Research on ESP in science-related fields identifies recurring challenges that students face in laboratory settings. The most frequently reported issue is limited mastery of scientific and technical vocabulary, which affects students' ability to read laboratory manuals, understand safety instructions, and interpret procedural texts written in English [5]. Many laboratory terms appear only in specialized materials and are rarely addressed in standard English courses, causing students to struggle when encountering them during experiments [6]. In addition to vocabulary gaps, previous studies have noted the scarcity of ESP materials specifically tailored to laboratory procedures, resulting in instructional content that does not fully address students' actual academic needs [7]. Needs analysis research by Sulistio [8], identified significant gaps between the language demands of physics laboratory contexts and the English instruction typically provided to students. This discrepancy highlights the necessity for more context-specific ESP materials.

These linguistic challenges extend to practical laboratory activities. Students often find it difficult to understand spoken instructions, laboratory announcements, and experiment videos, especially when these are delivered in English with unfamiliar accents [9]. During experimental activities, students also encounter difficulties in understanding technical expressions related to equipment operation, calibration procedures, units of measurement, and data interpretation, as scientific and technical information is predominantly presented in English and requires adequate mastery of technical English proficiency [10]. As a result, students frequently depend on peers for translation or clarification, a practice that increases the likelihood of misunderstandings or procedural errors [8].

The limitations in vocabulary and procedural comprehension also affect students' communicative competence when presenting experimental findings. Needs analysis studies have identified that students require targeted support in describing experimental observations, explaining results, and participating in scientific discussions in English [5]. Literature reviews in ESP, such as that conducted by Sintia et al. [6], consistently identify vocabulary limitations as a major barrier affecting students' fluency and clarity in scientific communication. These issues collectively demonstrate the need for ESP instruction that is contextualized to laboratory-specific language demands.

The theoretical basis of this study is grounded in the broader ESP framework, which scholars describe as encompassing English for academic, occupational, vocational, or general practical purposes depending on learners' goals [11]. Rahman [12] classifies ESP into two main divisions, English for Academic Purposes (EAP) and English for Occupational Purposes (EOP), each serving distinct communicative functions relevant to students and professionals in scientific fields. Within this classification, English for Science and Technology (EST) provides the most appropriate lens for understanding the linguistic needs of physics laboratory learners.

The present study employs the theoretical model of Dudley-Evans and St John, as discussed in Yan [13], to frame the investigation. This model consists of three interrelated components: (1) needs analysis, which identifies the specific linguistic and communicative requirements of laboratory tasks; (2) course design, which aligns ESP instruction with authentic laboratory procedures, materials, and communication genres; and (3) ESP practitioner roles, which emphasize the teacher's responsibility in integrating scientific content with language instruction so that learners acquire both conceptual understanding and laboratory-appropriate communication skills.

The physics laboratory serves as a central context in this study due to its established role in supporting students' conceptual understanding and inquiry processes through hands-on experimental activities. Laboratory environments provide opportunities for active experimentation, data collection, and analysis, which enhance students' comprehension of scientific concepts and support the development of scientific reasoning and self-efficacy in science learning [14]. Through hands-on activities, students develop inquiry skills, problem-solving strategies, and the ability to articulate scientific processes, all of which depend on clear communication and comprehension of relevant terminology [15]. Laboratory work also encourages interaction, peer learning, and the articulation of scientific conceptions, making language a critical component of successful engagement in experimental tasks [16].

Based on this background, the present study is designed to (1) identify the English language needs of students when conducting physics laboratory activities and (2) examine the linguistic and procedural difficulties they encounter when using English in laboratory settings. By addressing these aims, the study seeks to provide a more detailed understanding of learners' communication challenges and contribute to the development of ESP instruction that is more contextual, relevant, and responsive to the realities of physics laboratory practice.

B. Method

This study employed a descriptive survey design with a mixed-methods approach to comprehensively understand students' needs regarding English language use during physics laboratory activities. In such a design, quantitative data serve as the primary data, used to map general patterns of students' needs, while qualitative data support them by providing deeper explanations and contextual insights. This position concurs with Creswell & Clark [17], who detail that, in an explanatory or convergent mixed-method design, quantitative data provide an overview of the phenomenon, while qualitative data supplement and illustrate the results through more detailed contextual information.

Fifty students from the Physics Education Study Program at UIN Syarif Hidayatullah Jakarta participated in this study and were purposively selected based on their experience of attending laboratory practicum courses. Three students were chosen as interview participants for qualitative data collection, which is considered sufficient because small-scale qualitative studies typically reach data saturation with two to three participants, a condition in which the information becomes repetitive, and no new themes emerge.

The research instrument was a five-point Likert-scale questionnaire to measure the levels of need, difficulty, and frequency of use of four English language skills: Reading, listening, speaking, and writing. Each of these was operationally defined as the skills to understand procedural texts, diagrams, and tables; follow verbal instructions and understand videos of English experiments; explain experimental steps and discuss physics concepts in English; and write laboratory reports on the characteristics of tools and procedures using appropriate scientific terms. The questionnaire's reliability test, using Cronbach's Alpha, yielded 0.97, indicating very high internal consistency. Examples of the items of the questionnaire are as follows: "I can understand procedural instructions in the laboratory manual," "I am able to follow verbal explanations during practicum sessions," "I can explain experimental steps in English," and "I can write descriptions of tools and materials using scientific terminology."

Semi-structured interviews were conducted as part of the qualitative data collection to gain deeper insights into the reasons, experiences, and difficulties students face when using English during laboratory activities. The interviews were conducted online with the participants' consent, recorded, transcribed, and analyzed by using thematic analysis: coding, categorizing themes, and interpreting them. All procedures followed principles of ethical research, including informing participants of the purpose of the research study, their right to refuse or withdraw from the research interview at any time, and the guarantee that all data would be anonymous and used only for academic purposes.

Quantitative data were analyzed by descriptive statistics to retrieve mean scores and patterns of need for each language skill, while qualitative data were analyzed to enhance the interpretation of quantitative findings. Triangulation was conducted methodologically through the comparison of the two types of data to enhance the accuracy and comprehensiveness of research results.

C. Results and Discussion

This section presents the findings of the study in relation to its main objectives, namely to identify the English language needs of physics students during laboratory activities and to examine the linguistic difficulties they encounter in that context. The results are organized into quantitative data derived from the questionnaire and qualitative insights from the interviews. Together, these findings provide a comprehensive overview of how students engage with English in laboratory settings and the specific language skills required to support their learning.

Table 1. Reading Skills Needed for Physics Laboratory Activities

Most Critical Skill	Score Range	% Range	Level
Understanding procedural steps	4.2-4.4	78-82%	High
Interpreting diagrams	3.8-4.0	71-76%	Medium
Reading scientific articles	<3.8	<71%	Low

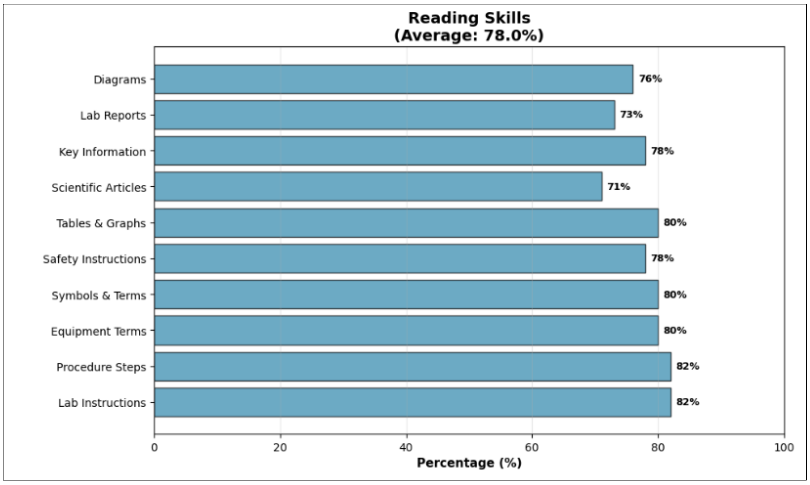

Figure 1. Reading Skills

Reading skills were identified as the most needed aspect. Most respondents stated that they often encounter laboratory manuals, experimental procedures, and scientific texts written in English. The ability to comprehend English texts is considered essential for students to conduct experiments accurately and correctly.

Table 2. Writing Skills Needed for Physics Laboratory Activities

Most Critical Skill	Score Range	% Range	Level
Writing conclusions	3.9-4.2	73-78%	High
Scientific vocabulary	3.6-3.7	67-71%	Medium
Error analysis	<3.6	<67%	Low

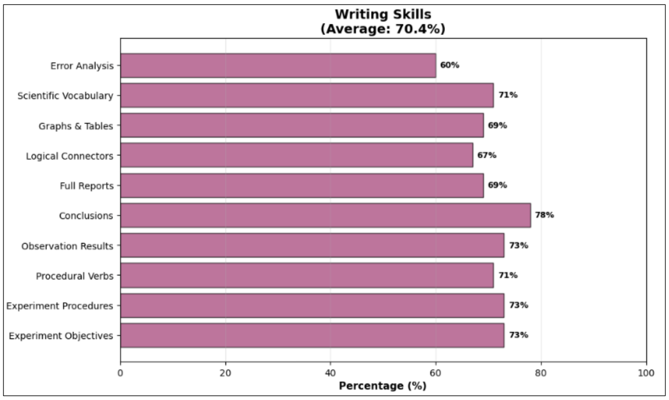

Figure 2. Writing Skills

Writing skills were also viewed as important, especially for composing laboratory reports. However, some respondents expressed difficulty in selecting appropriate scientific vocabulary and using correct grammar when writing.

Table 3. Speaking Skills Required in Physics Laboratory Activities

Most Critical Skill	Score Range	% Range	Level
Explaining experimental steps	3.8-4.3	73-80%	High
Presenting hypotheses	3.5-3.7	67-71%	Medium
-	<3.5	<67%	Low

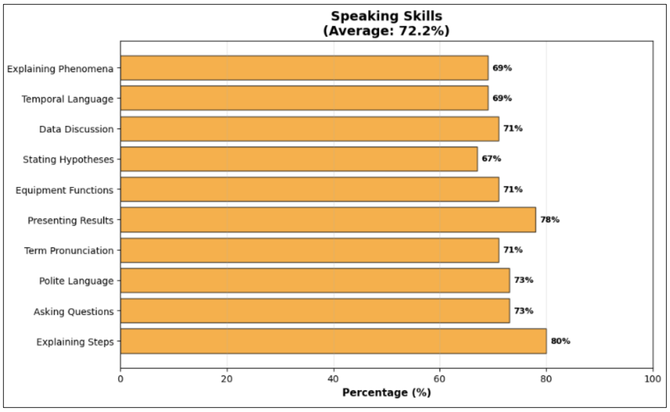

Figure 3. Speaking Skills

Students reported that they rarely use spoken English in the laboratory, except during presentations or group discussions. Nevertheless, some students mentioned that speaking skills could be useful for future academic presentations or international collaboration.

Table 4. Listening Skills Required in Physics Laboratory Activities

Most Critical Skill	Score Range	% Range	Level
Understanding lecturer's instructions	3.9-4.4	75-82%	High
Following instructor's directions	3.4-3.8	64-73%	Medium
-	<3.4	<64%	Low

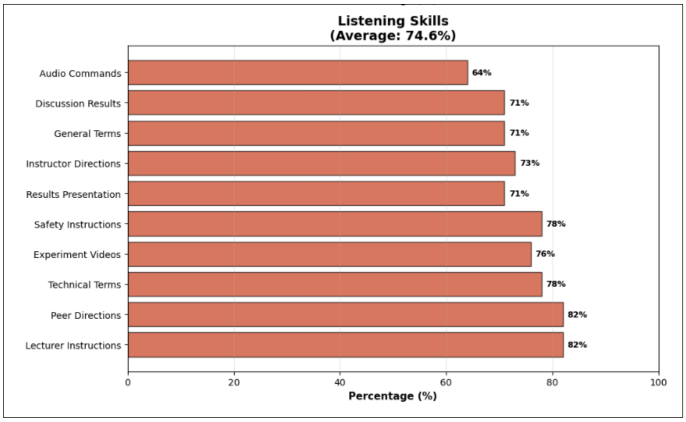

Figure 4. Listening Skills

Students stated that the ability to understand oral instructions from lecturers or laboratory assistants is important. Difficulties in comprehending spoken explanations often lead to confusion during the implementation of experiments.

Table 5. Summary of English Language Needs Across Four Language Skills

Most Critical Skill	Average Score	Need Level	Language Skill
Understanding Procedures	4.1	78%	Reading
Lecturer's Instructions	3.9	75%	Listening
Explaining Procedures	3.8	72%	Speaking
Writing Conclusions	3.7	70%	Writing

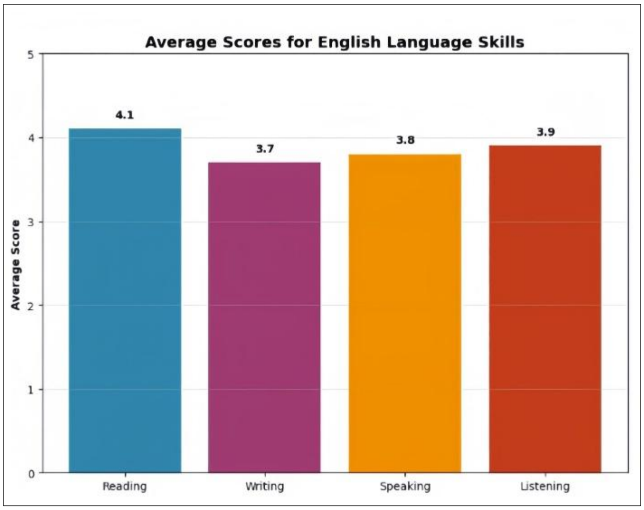

Figure 5. Average Score for English Language Skills

The analysis of the questionnaire administered to fifty Physics Education students showed that reading had the highest mean score (M = 4.1), followed by listening (M = 3.9), speaking (M = 3.8), and writing (M = 3.7). Reading emerged as the most essential skill because students rely heavily on written materials such as laboratory manuals, procedural texts, equipment descriptions, and safety guidelines. These materials form the foundation of every laboratory activity and must be understood before students can carry out any experimental procedures. Listening needs were also notably high, particularly because students must follow instructors' oral explanations and real-time safety instructions during laboratory work. In contrast, speaking and writing received lower ratings because these skills are required only at specific stages, such as presenting results or writing conclusions, and are less central to the immediate operation of laboratory activities.

These patterns align with the nature of physics laboratory practices, which place stronger demands on receptive skills. Unlike classroom-based ESP activities that frequently involve discussions, presentations, or writing assignments, laboratory environments require students to comprehend protocols, interpret diagrams, read procedural steps, and follow verbal guidance in real time. Each experiment begins with reading instructions and continues with listening to clarifications from lecturers or laboratory assistants, making the ability to understand written and oral input far more essential than the ability to produce extended scientific language. This highlights that laboratory contexts shape a distinctive ESP profile characterized by procedural literacy and immediate comprehension demands.

To refine the descriptive findings, score variability was examined through standard deviations. The standard deviations for the four skills were relatively low (SD ≈ 0.25–0.32), indicating that student responses were consistent and that the perceived needs were largely shared across the cohort. Reading and listening showed the least variability, reinforcing the strong consensus that these skills are most crucial in laboratory work. Meanwhile, speaking and writing showed slightly higher variability, reflecting differences in prior exposure, confidence levels, and familiarity with productive tasks.

Further analysis based on student characteristics revealed additional patterns. Students in later semesters reported slightly higher reading and listening needs than those in earlier semesters, likely due to increased engagement with more complex laboratory procedures. Students with lower GPAs or limited English course experience assigned lower scores to items involving technical vocabulary, indicating greater difficulty interpreting scientific terminology. Similarly, students who had not taken science-oriented English courses reported lower confidence in writing methodological sections of laboratory reports. These variations show that ESP needs in laboratory settings are not homogeneous but shaped by academic exposure, linguistic background, and the extent of laboratory experience.

Table 6. Summary of Interview Data on Students' Difficulties and Needs

Respondent	Skill	Difficulties and Needs
Respondent 1	Reading	Difficulties: "The vocabulary." Needs: "Getting used to using physics terms in English."
	Writing	Difficulties: "Having difficulty writing the description of tools or materials in English." Needs: "Getting used to using physics terms in English."
	Speaking	Difficulties: "Having difficulty explaining experimental steps in English." Needs: "Getting used to using physics terms in English during practice."
	Listening	Difficulties: "Never watched an English experiment video." Needs: "Getting used to listening to physics terms in English."
Respondent 2	Reading	Difficulties: "Understanding experimental procedures without visual aids." Needs: "Practice reading academic physics texts with visual supports (graphs and tables)."
	Writing	Difficulties: "Writing the method section of lab reports." Needs: "Guidance in writing scientific reports focusing on grammar and method structure."
	Speaking	Difficulties: "Not fluent in discussing physics concepts in English." Needs: "Practice in academic speaking and pronunciation of physics terminology."

Respondent	Skill	Difficulties and Needs
Respondent 3	Listening	Difficulties: "Understanding English experiment videos, especially with British accents." Needs: "Listening practice using lab-related videos with various accents to improve comprehension."
	Reading	Difficulties: "Hard to understand lab terms & physics vocabulary." Needs: "Practice reading & lab vocabulary."
	Writing	Difficulties: "Hard to write theory & explain graphs." Needs: "Guidance for lab reports & writing practice."
	Speaking	Difficulties: "Cannot explain procedures & concepts." Needs: "Speaking practice & simple presentations"
	Listening	Difficulties: "Hard to understand accents & lab instructions." Needs: "Exposure to lab videos & listening practice

The qualitative findings reinforce and contextualize the quantitative patterns obtained from the questionnaire. The survey results indicated that limited mastery of scientific vocabulary is the primary obstacle across reading, listening, speaking, and writing, a finding confirmed by Respondent 1, who emphasized that their most significant difficulty lies in understanding vocabulary across all skills. This consistency demonstrates that scientific terminology serves as a fundamental barrier to comprehension during laboratory activities.

Furthermore, the questionnaire showed that students struggle to understand procedural instructions and English-language experiment videos, a finding supported by Respondent 2, who explained that interpreting procedural texts without visual support is a significant challenge, particularly when listening to experiment videos delivered with unfamiliar accents. The alignment between the survey data and this statement confirms that listening demands are exceptionally high in laboratory contexts because students must process information in real time.

The questionnaire also revealed that productive skills, especially speaking and writing, received lower scores because students find it difficult to use technical terminology when constructing scientific explanations. This result aligns with the statement of Respondent 3, who reported difficulties in verbally explaining concepts and writing tool descriptions due to limited mastery of technical vocabulary. These findings indicate that the primary barrier to productive skills is not grammar but an insufficient command of scientific lexical items.

Overall, the interview evidence is consistent with the questionnaire data. This triangulation clarifies that vocabulary mastery is not merely a component of a single language skill but a foundational factor that simultaneously influences reading, listening, speaking, and writing. The lack of lexical resources leads students to struggle with decoding instructions, interpreting procedural texts, following oral explanations, and articulating scientific ideas accurately. This is the main reason receptive skills rank highest: students depend on their ability to understand written and spoken input before they can produce language effectively.

These findings align with the theory of English for Specific Purposes (ESP), which emphasizes the importance of needs analysis in designing language instruction relevant to the academic context [12]. In addition, these results support the studies of Sintia et al. [6] and Mourssi [9], which state that the lack of mastery of scientific vocabulary and the limited exposure to English in scientific practice are the main causes of students' low ESP proficiency. Thus, both the quantitative and qualitative results show a consistent direction, namely that students need more contextual ESP instruction, especially in strengthening scientific vocabulary, understanding procedural texts, and developing listening skills based on the physics laboratory context.

Beyond describing students' needs, the present study offers a significant contribution and novelty to ESP research. Unlike previous studies that generally examine program-level or classroom-based ESP requirements, this study demonstrates a clear novelty that laboratory-based ESP presents a distinct needs profile characterized by strong demands for procedural literacy, real-time oral comprehension, and discipline-specific vocabulary. It also specifically focuses on English language needs withing physics laboratory which remains as underexplored area in ESP. Additionally, the study reveals the integration of linguistic and procedural dimension that vocabulary limitations function as a cross-skill bottleneck affecting the four language skills simultaneously and directly influence students' accuracy in conducting experiment. This is a nuanced insight that has received limited attention in prior research. These findings highlight the urgency of developing ESP materials that are explicitly integrated with laboratory practices rather than relying solely on general academic English. Such an approach would better support students' safety, accuracy, and performance during experimental activities.

D. Conclusion

The present study shows that students' English language needs in physics laboratory contexts are closely shaped by the procedural and real-time nature of experimental work. These characteristics create a stronger demand for reading and listening skills compared to speaking and writing. The results also indicate that scientific vocabulary serves as a cross-skill challenge that simultaneously affects comprehension and language production. This research offers a fresh contribution to the field of ESP by illustrating that laboratory-based ESP possesses a unique needs profile, defined by procedural literacy, discipline-specific terminology, and real-time oral comprehension, which differs from the typical requirements found in classroom-based ESP. Such findings provide a more context-sensitive understanding of how language functions within authentic scientific practices.

Building on these findings, several practical recommendations can be made. ESP instruction should incorporate laboratory procedures directly into its learning materials, focusing on the mastery of scientific vocabulary, the interpretation of procedural texts, and listening exercises that replicate actual experimental conditions. Moreover, productive language activities, such as presenting experimental results or writing laboratory reports, should include explicit vocabulary support to help students overcome specific lexical difficulties. Curriculum developers are also encouraged to work collaboratively with laboratory instructors to ensure that language teaching aligns closely with the real workflows and communicative practices of laboratory environments.

While this study provides valuable insights, it also has several limitations. The research was conducted within a single institution, which may limit the generalizability of the results. Furthermore, the quantitative data were based on self-reported perceptions, which may not fully reflect students' actual language performance during laboratory tasks. Future studies should therefore employ performance-based assessments, compare findings across multiple institutions, and examine how ESP programs grounded in laboratory practices influence students' safety, accuracy, and communicative effectiveness during experiments.

In conclusion, this study underscores the importance of developing ESP instruction that is deeply integrated with laboratory activities, offering both practical implications and theoretical contributions to the broader field of English for Specific Purposes.

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References

[1] P. Ayu, W. Usadiati, and E. Karani, "An Approach of English Teaching for Automotive and Vehicle Engineering Students," *intensive*, vol. 4, no. 2, p. 1, Oct. 2021, doi: 10.31602/intensive.v4i2.5749.

[2] K. Hyland, "English for Specific Purposes: What Is It and Where Is It Taking Us?," *ESP Today*, vol. 10, no. 2, pp. 202–220, 2022, doi: 10.18485/esptoday.2022.10.2.1.

[3] H. S. Samosir, Nyeneng I. Dewa Putu, and W. Suana, “Pengaruh Kemampuan Bahasa Inggris Terhadap Hasil Belajar Fisika Menggunakan Model Inkuiri,” *Jurnal UNILA*, vol. 2, no. 6, pp. 66–75, 2015.
[4] P. Wulff, “Physics language and language use in physics—What do we know and how AI might enhance language-related research and instruction,” *Eur. J. Phys.*, vol. 45, no. 2, p. 023001, Mar. 2024, doi: 10.1088/1361-6404/ad0f9c.
[5] I. F. Rahman and A. P. Rukmana, “Physics Education Students’ Need Analysis Toward English Teaching Material,” *ETERNAL*, vol. 8, no. 02, Dec. 2022, doi: 10.24252/Eternal.V82.2022.A6.
[6] D. Sintia, I. Perdana, and E. Karani, “ESP in Practice: A Literature Review of Challenges Faced by Teachers and Learners,” *EJI*, vol. 9, no. 2, pp. 584–597, July 2025, doi: 10.61672/eji.v9i2.3003.
[7] Z. Qamariah and H. Yuliani, “Language and Science: The Importance of English Language Learning for Students of the Physics Education Study Program,” *Sintaksis*, vol. 2, no. 3, pp. 01–11, Apr. 2024, doi: 10.61132/sintaksis.v2i3.461.
[8] P. H. Sulistio, “Analisis Kebutuhan ESP (Bahasa Inggris untuk Tujuan Khusus) untuk Mahasiswa Fisika,” *Jurnal Ilmu Pendidikan*, vol. 1, no. 2, 2016.
[9] A. Mourssi, “English for Specific Purposes: Challenges and Teaching Strategies for Non-native Learners,” *International Journal of Linguistics, Literature and Translation*, vol. 4, no. 7, pp. 21–29, 2021.
[10] Abd. Syakur, H. M. Zainuddin, and M. A. Hasan, “Needs Analysis English For Specific Purposes (ESP) For Vocational Pharmacy Students,” *birle, budapest. internation. research. and. critic. in. linguistic. educatie*, vol. 3, no. 2, pp. 724–733, May 2020, doi: 10.33258/birle.v3i2.901.
[11] U. Umar and S. Basuki, “ESP: The Development and The Challenges,” *jell*, vol. 8, no. 02, pp. 187–196, Aug. 2023, doi: 10.37110/jell.v8i02.178.
[12] M. Rahman, “English for Specific Purposes (ESP): A Holistic Review,” *ujer*, vol. 3, no. 1, pp. 24–31, Jan. 2015, doi: 10.13189/ujer.2015.030104.
[13] H. Yan, “Trends in Empirical Research in English for Specific Purposes: A Systematic Review of SSCI-Indexed Journal Articles (2014–2023),” *SAGE Open*, vol. 15, no. 1, p. 21582440251328460, Jan. 2025, doi: 10.1177/21582440251328460.
[14] N. Kyriazis, G. Stylos, and K. Kotsis, “Impact of inquiry-based laboratory activities on understanding heat concepts and self-efficacy in pre-service teachers,” *JPR*, p. 1, Mar. 2025, doi: 10.33902/JPR.202530426.
[15] N. Papalazarou, I. Lefkos, and N. Fachantidis, “The Effect of Physical and Virtual Inquiry-Based Experiments on Students’ Attitudes and Learning,” *J Sci Educ Technol*, vol. 33, no. 3, pp. 349–364, June 2024, doi: 10.1007/s10956-023-10088-3.
[16] I. Fitriah and S. F. Zawanis, “The Effectiveness of Virtual Laboratory Media in Physics Education: A Meta-Analysis on Students Conceptual Understanding and Higher-Order Thinking Skills,” *Indonesian Science Education Journal*, vol. 5, no. 2, pp. 65–72, 2024.
[17] J. W. Creswell and V. L. Plano Clark, *Designing and conducting mixed methods research*, Third edition. Los Angeles: Sage, 2018.

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