Volume 4 Issue 2, December 2024

ISSN 2798-1762 (Print)
ISSN 2798-1754 (Online)

Impulse

Journal of Research and Innovation in Physics Education

Published by
Pendidikan Fisika
UIN Sunan Kalijaga Yogyakarta

Impulse: Journal of Research and Innovation in Physics Education

Volume 4 Issue 2, December 2024

EDITORIAL TEAM

Published by:
Department of Physics Education
Faculty of Tarbiyah and Education
State Islamic University Sunan Kalijaga Yogyakarta

ISSN 2798-1762 (Print)
ISSN 2798-1754 (Online)

CONTENTS

DOI: 10.14421/impulse.2023.42-01

IMPULSE: Journal of Research and Innovation in Physics Education
Volume 4, Issue 2, 62 – 78

© ISSN (p): 2798–1762; ISSN (e): 2798-1754
http://ejournal.uin-suka.ac.id/tarbiyah/impulse

Development of a Minimum Competency Assessment Instrument (AKM) for Students' Scientific Literacy on Hooke's Law and Elasticity

Cindy Aida Sari[1*], Fitriyawany[2], Arusman[3]

[1] Physics Education Study Program, UIN Ar-Raniry, Banda Aceh
*Corresponding author: cindyaidasari2@gmail.com

ABSTRACT

The low literacy rate and lack of question discussion in schools were the driving forces behind this research. Those problems caused students to have difficulty in understanding the material on Hooke's Law and elasticity. The researchers developed the Minimum Competency Assessment (AKM) literacy instrument as a learning resource to address this issue. The study aims to find out: (1) how the AKM instrument for students' scientific literacy was made and (2) how excellent it works, how challenging the questions are, how valid it is, and how reliable it is for students' scientific literacy on Hooke's Law and Elasticity at the senior high school level. This R&D method reseach used the Tessmer model. The research instruments consisted of question grid sheets and question validation sheets. This study produced two question packages (A and B), each consisting of twelve questions. The researchers examined the AKM instrument for scientific literacy on 24 students from MAN 1 Model Banda Aceh. The feasibility results show that the AKM instrument has met the very feasible category. The validation results from material experts yielded a percentage of 92.44%, while language experts reported a percentage of 85.83%. The trial results show the discriminating ability of AKM Instrument packages A and B in the excellent and outstanding categories. Package A displays reliability results of 0.791, while package B of 0.805. The AKM instrument for scientific literacy based on Hooke's Law and elasticity can be used as a supporting learning resource in or outside of learning activities.

ARTICLE HISTORY
Received: May 21, 2024

Accepted: October 9, 2024

KEYWORDS:

Minimum Competency Assesment Instrumen (AKM), Science Literacy, Hooke's Law and Elasticity.

INTISARI

Penelitian ini dilatarbelakangi oleh rendahnya tingkat literasi dan sedikitnya pembahasan soal di sekolah. Hal ini mengakibatkan siswa mengalami kesulitan dalam memahami materi Hukum Hooke dan elastisitas. Untuk mengatasi hal ini maka dilakukan pengembangan instrumen Asesmen Kompetensi Minimum (AKM) literasi sebagai sumber belajar. Penelitian ini ertujuan untuk: (1) mengetahui proses pengembangan instrumen AKM literasi sains siswa, dan (2) mengetahui daya beda, tingkat kesukaran soal, validitas dan reliabilitas dari instrumen AKM literasi sains pada materi Hukum Hooke dan Elastisitas tingkat SMA/MA. Penelitian ini menggunakan metode (R&D) dengan model Tessmer. Instrumen penelitian yang digunakan terdiri dari lembar kisi-kisi soal dan lembar validasi soal. Validator pada penelitian ini terdiri dari tiga ahli materi dan dua

KATA KUNCI:

Asesmen Kompetensi Minimum (AKM), Literasi Sains, Hukum Hooke dan Elastisitas

* Corresponding author:
Cindy Aida Sari, Physics Education Study Program, UIN Ar-Raniry, Banda Aceh
✉ cindyaidasari2@gmail.com

ahli bahasa. Penelitian ini menghasilkan dua paket soal (A dan B) Instrumen AKM yang masing-masing terdiri dari dua belas soal. Instrumen AKM literasi sains diujicobakan pada 24 siswa MAN 1 Model Banda Aceh. Hasil kelayakan menunjukkan bahwa instrumen AKM sudah memenuhi kategori sangat layak. Berdasarkan hasil validasi dari ahli meteri dengan persentase sebesar 92,44% dan ahli bahasa sebesar 85,83%. Hasil uji coba menunjukkan daya beda pada Instrumen AKM paket A dan B pada kriteria baik dan sangat baik. Hasil reliabilitas pada paket A sebesar 0.791 dan paket B sebesar 0.805 dan dinyatakan reliabel. Instrumen AKM literasi sains pada materi Hukum Hooke dan Elastisitas dapat digunakan sebagai sumber belajar pendukung dalam atau luar kegiatan pembelajaran.

A. Introduction

Learning is a process of interaction that occurs between educators and students, also involving teaching materials, methods, and media used in the teaching and learning process. In the 21st century learning era, students must possess skills, knowledge, and abilities in the fields of technology, media, and information. The learning process in this era is characterized by innovation and an emphasis on empowering students. These changes appear in various aspects, including curriculum, learning models, and teaching methods [1].

21st-century learning demands that students be able to be creative and innovative, think critically, solve problems, collaborate, and communicate. This curriculum has high expectations for the educational process by preparing students as human resources who have 21st-century skills. One of the requirements for developing 21st-century skills is literacy. The Ministry of Education and Culture has determined that Indonesian people need to master 6 basic literacies, namely (1) language literacy, (2) numeracy literacy, (3) scientific literacy, (4) digital literacy, and (5) financial literacy culture and citizenship [2].

Literacy is a language skill that involves several aspects, including speaking, reading, writing, evaluating, and understanding. There are three main indicators of literacy: finding, understanding, and evaluating and reflecting on the information obtained.trained. Scientific literacy, on the other hand, includes the scientific knowledge needed to identify a problem. Scientific literacy encompasses the capacity to make decisions based on facts gathered from observations. Apart from that, scientific literacy also includes the ability to communicate scientific knowledge both orally and in writing. Scientific literacy does not only focus on knowledge but also on the application of that knowledge in solving problems and participating in systems related to science [3]. This ability can This ability can be seen in the results of

measurements in the PISA study conducted by the OECD (Organization for Economic Cooperation and Development) every three years.

The shift from the National Examination to the National Assessment is an attempt to enhance the overall quality of education.ucation. The National Examination is considered less than optimal as a tool for evaluating the quality of education nationally [4]. The National Assessment consists of three parts, namely the Minimum Competency Assessment (AKM), the Character Survey, and the Learning Environment Survey. AKM measures students' reading literacy and numeracy skills. Apart from that, iIn addition, its design aims to stimulate innovative learning that prioritizes reasoning over rote memorization.The 2013 curriculum outlines the objectives of integrated science learning. We carry out AKM in an effort to improve the low quality of Indonesian education.

The Organization for Cooperation and Development (OECD) did research that showed Indonesia's low scientific literacy (74th place out of 78 countries), with an average score of 389 on the PISA (Program for International Student Assessment) and an average score of 489 for the OECD as a whole. Meanwhile, Indonesia's scientific literacy ability was achieved in 2018; it was ranked in the bottom 10 of 79 countries following the evaluation results conducted by the OECD through the PISA study [4].

The low results of the Progress in International Reading Literacy Study (PIRLS), Program for International Student Assessment (PISA), and Indonesian National Assessment Program (INAP) surveys are due to reading habits that are less popular with some students in Indonesia. Reading is an important part of education, especially in the teaching and learning process in the classroom. Reading activities can provide students with a wealth of knowledge and additional information. Reading activities can provide students with a lot of knowledge and additional information to support successful learning and teaching.

Regarding the required teaching materials and material difficulties, it was found that students needed a book of questions, and they experienced difficulties with Hooke's Law and Elasticity material. This is one of the Class XI high school physics materials for the odd semester. Students face challenges because they rarely discuss the questions, which makes it difficult for them to answer the provided questions during the exam.

Several studies on AKM instruments development and scientific literacy were discovered. First, the study by Nuzulia and Gafur [5] with the title "Development of a Minimum Competency Assessment-Based Practice Book to Improve Student Literacy and Numerization Abilities at SDN Janti 02 Sidoarjo." The research shows that the minimum competency assessment (AKM)-based exercise book is excellent

for students to use because it meets the valid criteria: experts in the material got 90.6%, experts in the design got 89.3%, and experts in the learning got 94.6%. The results of the trial to assess the attractiveness of the minimum competency assessment-based exercise book developed for students were 91.8%. Student learning outcomes increased, as seen by the pre-test results of 70.8 and post-test scores of 90.4 [6].

Researchers conducted the second study. The pre-test results of 70.8 and the post-test scores of 90.4 [6] indicate an increase in student learning outcomes. Assessing Understanding of Scientific Phenomena Regarding Energy." The results of this research indicate that scientific literacy-based test instruments are suitable for measuring students' scientific literacy abilities [7]. Mardhiyyah, Ani, and Suharto [8] conducted the third research, "Development of a Science Literacy Assessment Instrument on the Energy Theme." The research shows that the two sets of validity results for the multiple-choice test are correct. The reliability value was 0.865 for limited testing and 0.887 for extensive testing. This value shows that the instrument is reliable. The profile of students' scientific literacy abilities is in the low category [9].

What sets this research apart from previous research is the difference in the school levels studied, and the development of AKM instruments on scientific literacy. Previous research only focused on one of these areas, either on instrument development or on scientific literacy.

The development of the Minimum Competency Assessment (AKM) instrument for scientific literacy in schools has four main reasons. The first reason is that testing and learning have been changed so that they focus on more than just the content of the material. They also include scientific literacy, which includes things like being able to use science in everyday life, understanding context, thinking critically about problems, and a number of scientific process skills. This matter facilitates to create more holistic and relevant to students' developmental needs. The second reason is that the PISA and TIMSS (Trends in International Mathematics and Science Study) results at the secondary school level provide an important indication that students' scientific literacy abilities at the previous level also need to consider. Student competency in elementary school is the basis for student competency at a higher level. Therefore, there needs to be an AKM instrument that can assess scientific literacy based on the initial level of education. The third reason stems from the low level of scientific literacy among students, as evidenced by several prior studies. Therefore, developing the AKM scientific literacy instrument is important as an effort to increase students' understanding and ability to understand scientific concepts. The fourth reason is the lack of a collection of AKM questions that can help them understand the learning

material. The development of the AKM scientific literacy instrument can provide students with access to a collection of questions that support a comprehensive understanding of scientific concepts.

Students must practice answering AKM questions in order to improve their exam preparation. Every student undoubtedly possesses unique potential that sets them apart from their peers. The researhcers can later find out the form of these differences from the results of the exercises carried out by students.

Based on the background of the problem that has been explained, it is important for researchers to conduct research with a title "Development of a Minimum Competency Assessment Instrument for Students' Scientific Literacy on Hooke's Law and Elasticity Material at High School/MA Level.".

B. Method

This R&D method research applied a scientific method for conducting research, designing, producing, and validating already-produced products [10]. Research and Development refers to the systematic process of creating new products or enhancing existing ones.

This development research uses the Tessmer model (1993), consisting of several stages, including preliminary, self-evaluation, expert reviews, one-to-one, small group, and field tests [11]. The reason why researchers use the Tessmer development model in this research is because these stages are suitable for use in developing products in the form of questions. This is because in developing valid and reliable questions, assessment from experts is very necessary so that the questions developed are better.

In addition, the questions had be field-examined, including readability tests to determine if students understood them and limited tests on several students to determine their validity and practicality. Therefore, the Tessmer model was more suitable for developing questions because the stages in the Tessmer model correspond to the stages of question development.

C. Result and Discussion

Preliminary Stage

This stage began with seeking information on the Ministry of Education and Culture's policies. Researchers found a change from the National Examination to the National Assessment. The National Assessment comprised three components: the Minimum Competency Assessment (AKM), an environmental survey, and a character

survey. The next stage was determining the school, namely MAN 1 Banda Aceh (Islamic Senior High School Banda Aceh 1), with the research subjects being material class XI students.

A necessity analysis was given to class XI students at MAN 1 Banda Aceh with several questions related to the material and things the students needed. The results of the needs analysis by researchers found that students had difficulty understanding the material on Hooke's Law and elasticity due to a lack of reading and discussing the questions. Students also express that they need several sets of AKM questions on Hooke's Law and Elasticity.

Formative Evaluation Stage

The discussion focused on linking the data and analysis results to answer research problems or purposes of the study, and to broader theoretical context. The discussion is written attached to the data discussed and not to be separated from the results.

The table is written in the middle or at the end of each text description of the results research. The table title is written from the left-center; all words begin with uppercase letters, except conjunctions. Suppose more than one row is typed in a single-spaced. The table consists of top and bottom horizontal rules and the one separating the column heads from the rest of the table. For example, it can be seen in Table 1 below.

The formative evaluation stage is the second stage, consisting of self-evaluation, expert reviews, one-to-one, and small groups.

a. Self-Evaluation

At this stage, the AKM question grid, AKM questions, and validation sheet underwent an evaluation. Before creating AKM questions, researchers carried out curriculum analysis, material analysis, student analysis, and planning. The book that served as a guide in making AKM questions is a class XI student package book. Researchers also read and searched for several articles related to AKM, serving as a guide for researchers. The AKM question grid has several parts, namely the scientific literacy domain, scientific literacy indicators, learning indicators, questions, and answer keys. The researchers used two domains of scientific literacy: scientific knowledge and scientific competence. There were 4 scientific literacy indicators such as understanding scientific phenomena, explaining scientific phenomena, identifying problems scientifically, and interpreting data. There were 12 learning indicators for each question package, each of which has 3 parts that refer to indicators for each scientific literacy.

At this stage, the researchers produced draft 1, validated it, and refined it based on the validator's suggestions. The final result of the draft was a scientific literacy AKM question that met the AKM and scientific literacy criteria. The AKM science literacy questions were designed to consist of two packages, namely package A and package B. Each question package consisted of 12 multiple-choice questions. The researchers divided and sorted the designed questions based on scientific literacy indicators and learning indicators. Scientific literacy indicators are understanding scientific phenomena, explaining scientific phenomena scientifically, identifying problems scientifically, and interpreting scientific data and evidence. Additionally, the researchers designed the questions to incorporate stories, news, and practical applications from everyday life. The designed questions focus on measuring reasoning, understanding, and application abilities.

b. Expert Reviews

The expert review stage is carried out by providing a draft of the created questions to the validator to get input, suggestions, and whether or not the questions are suitable for testing to students. This research relies on the validation of both material and language experts. Two lecturers and one teacher from the school under test served as the material expert validators. Meanwhile, the language expert validators were two lecturers. The assessment items in column P-1 refer to both the assessment of the first question and the subsequent one.

The following are the results of the material expert validator's assessment of the scientific literacy AKM questions that will be developed.

Table 1. Data from validation results by material experts

Aspects	Average	Eligibility Percentage	Eligibility Criteria
Material	4.6	92	Very worthy
Question	4.73	92.00	Very worthy
Languange	4.67	93.33	Very worthy
Total	4.67	92.44	Very worthy

Based on the validation results by material experts listed in Table 1 against the question validation criteria, the overall assessment by material experts is that the AKM science literacy questions meet the criteria of being very worthy with a mean score of 4.67 and a percentage of 92.44%. When viewed from all aspects of the assessment, the material feasibility aspect has a mean score of 4.6 and a percentage of 92% with the criteria of very worthy. The question aspect has a mean score of 4.73

and a mean of 92%, meeting the criteria of being very worthy. The language aspect has an average score of 4.67 and a percentage of 93.33% with the criteria of very worthy.

The experts' validation of the results serves as the foundation for conducting field tests, calculating discriminating ability tests, determining the difficulty level of questions, and ensuring validity and reliability. The following are the results of the language expert validator's assessment of the scientific literacy AKM developed.

Table 2. Data from validation results by language experts

Aspects	Average	Eligibility Percentage	Eligibility Criteria
Material	5	100	Very worthy
Question	3.88	77.50	Very worthy
Construction	4.00	80.00	Very worthy
Total	4.29	85.83	Very worthy

To sum up, linguist experts gave the AKM science literacy questions an overall score of 4.29 out of 5 stars, which means they meet the very worthy criteria. This is shown in Table 2, which shows the validation results by linguist experts compared to the question validation criteria. If you look at all aspects of the assessment, the feasibility aspect of the questions has an average score of 5 and a percentage of 100% with very worthy criteria. The language aspect has an average score of 3.88 and a percentage of 77.50%, which meets worthy criteria. The construction aspect has an average score of 4 and a percentage of 80.00% with worthy criteria. Therefore, the study can continue to the next step by conducting field tests on students to calculate the discriminating ability tests, level of difficulty of questions, validity, and reliability. The researcher revised the draft questions based on the validator's suggestions and assessments before testing them on students.

c. One-to-one

This stage was carried out to test draft 2 on 6 randomly selected students. Students were divided into 2 parts, 3 students worked on draft 2 in package A and 3 other students worked on draft 2 in package B with a time of 90 minutes. The trial was carried out at MAN 1 Model Banda Aceh on December 14, 2023. This stage was carried out to test students' readability of the questions. As long as students work on the questions, it can be seen that the students are able to understand and solve the questions given. The questions presented are in the form of stories, pictures and graphs. However, there were several students who answered incorrectly in the graph section. Therefore, the researcher enlarged the graph presented in the questions for

the next job test. Researchers provided several initials to name respondents who took part in the one-to-one stage. As presented in the following table.

Table 3. One-to-one respondents in MAN 1 Model

Responden	Information
CO1A	One-to-one subject 1 on package A
CO2A	One-to-one subject 2 on package A
CO3A	One-to-one subject 3 on package A
CO1B	One-to-one subject 1 on package B
CO2B	One-to-one subject 2 on package B
CO3B	One-to-one subject 3 on package B

d. Small Group

The draft 2 questions in package A and package B were not revised, because at the one-to-one stage students were able to understand and answer the questions. The next stage was that the draft 2 questions in packages A and B were examined on 24 students. Students were divided into 2 parts, namely 12 people working on package A and 12 others working on package B. Trials at this stage were carried out at MAN 1 Model Banda Aceh on December 15, 2023. Students working at this stage were different from students at this stage previously. Students work on the questions given for 90 minutes. Next, the researcher calculated the discriminating ability, level of difficulty of the questions, validity and reliability based on the scores obtained from the students.

Validity Test

Validity testing is carried out to see the validity of the questions. If rcount > rtable then the question is declared valid. Meanwhile, if rcount <rtable then the question is declared invalid and questions with a negative value are rejected. The following is data obtained from package A questions.

Table 4. Validity Test of Package A

Question Number	r_{count}	r_{table}	Criteria
1	0.814	0.576	Valid
2	0.577	0.576	Valid
3	0.288	0.576	Invalid
4	-0.208	0.576	Rejected
5	0.623	0.576	Valid
6	0.579	0.576	Valid
7	-0.499	0.576	Rejected
8	0.549	0.576	Invalid
9	0.115	0.576	Invalid
10	0.672	0.576	Valid
11	0.577	0.576	Valid
12	0.131	0.576	Invalid

Table 4 shows 6 valid questions, (number 1, 2, 5, 6, 10. and 11), and 4 invalid questions, (number 3, 8, 9, and 12) in the package A. The pakcage also has 2 questions with negative values, (number 4 and 7). The sixth 6 valid questions were used for reliability testing at the next stage. Table 5 shows the validity test in package B, consisting of 12 questions.

Table 5. Validity Test of Package B

Question Number	r_{count}	r_{table}	Criteria
1	0.792	0.576	Valid
2	0.00	0.576	Invalid
3	0.654	0.576	Valid
4	-0.223	0.576	Rejected
5	0.580	0.576	Valid
6	0.580	0.576	Valid
7	0.661	0.576	Valid
8	0.093	0.576	Invalid
9	-0.045	0.576	Rejected
10	-0.313	0.576	Rejected
11	0.661	0.576	Valid
12	0.661	0.576	Valid

Table 5 shows 7 valid questions, (number 1, 3, 5, 6, 7, and 11) and 2 invalid questions, (number 2 and 8) in the package B. The package also has 3 questions that have negative values, (number 4, 9, and 10) The sixth valid questions are used for reliability testing at the next stage.

Reliability Test

Reliability testing was carried out after examining the questions based on the validity testing stages. There are 6 questions in package A and 7 questions in package B considered valid. If the Croanbach's alpha value is > 0.60 then the items are reliable and vice versa. Package A questions have a Croanbach's alpha of 0.791 so the questions are reliable. Package B questions have a Croanbach's alpha of 0.805 so the questions are reliable.

Discriminating Ability Test

Reliability testing is carried out after the questions have gone through the validity testing stages. There are 6 questions in package A and 7 questions in package B which are considered valid. If the Croanbach's alpha value is > 0.60 then it is declared reliable and vice versa. Package A questions have a Croanbach's alpha of 0.791 so the questions are declared reliable. Package B questions have a Croanbach's alpha of 0.805 so the questions are declared reliable.

In the discriminating ability test, the researchers found the different strengths and different criteria in package A questions. For more details, see the Table 6.

Table 6. Discriminating Ability Test of Package A

Question Number	Discriminating Ability	Criteria
1	0.814	Very excellent
2	0.577	Excellent
3	0.288	Enough
4	-0.208	Excluded
5	0.623	Excellent
6	0.579	Excellent
7	-0.499	Excluded
8	0.549	Excellent
9	0.115	Underaverage
10	0.672	Excellent
11	0.577	Excellent
12	0.131	Underaverage

The data above revealed that question number 1 received a very high rating. Questions at numbers 2, 5, 6, 8, 10, and 11 were criticized as excellent; questions at number 3 were criticized as adequate; questions at numbers 9 and 12 were criticized as underaverage; and questions at numbers 4 and 7 were excluded because they were negative. Questions that have excellent and excellent criteria can be used without

revision. Meanwhile, questions with sufficient criteria can be used with revision. For questions that were underaverage and had negative value, the researcher excluded the questions. The researcher concluded that questions numbered 1, 2, 5, 6, 8, 10, and 11 could be used without revision.

The document outlines the discriminating ability and criteria for package B questions. For more details, see Table 7.

Table 7. Discriminating Ability Test of Package A

Question Number	Discriminating Ability	Criteria
1	0.792	Very excellent
2	0.00	Underaverage
3	0.654	Excellent
4	-0.223	Excluded
5	0.580	Excellent
6	0.580	Excellent
7	0.661	Excellent
8	0.093	Underaverage
9	-0.045	Excluded
10	-0.313	Excluded
11	0.661	Excellent
12	0.661	Excellent

The table shows that question number 1 is rated very excellent. Questions at numbers 3, 5, 6, 7, 11 and 12 were classified as excellent, questions at numbers 2 and 8 were classified as underaverage and questions at numbers 4, 9 and 10 were excluded because they had negative values. Questions that have very excellent and excellent criteria can be used without revision. Meanwhile, questions with sufficient criteria can be used with revision. For questions that were underaverage and had negative value, the researcher excluded the questions. The researcher concluded that questions with numbers 1, 3, 5, 6, 7, 11 and 12 could be used without revision.

Test the Difficulty Level of the Questions

The researchers carried out a test of the level of difficulty of the questions on 24 questions consisting of packages A and B. The researchers found that several questions were categorized as easy, medium and difficult. For more details about package A, see the Table 8.

Table 8. Difficulty Level Test Questions in Package A

Question Number	Discriminating Ability	Criteria
1	0.75	Easy
2	0.58	Medium
3	0.08	Hard
4	0.42	Medium
5	0.42	Medium
6	0.33	Medium
7	0.25	Hard
8	0.17	Hard
9	0.58	Medium
10	0.83	Easy
11	0.58	Medium
12	0.25	Hard

The table shows 4 questions with difficult criteria, consisting of questions number 3, 7, 8 and 12. 7 questions with medium criteria consisting of questions number 2, 4, 5, 6, 9 and 11. The easy questions consist of questions number 1 and 10. The table 9 shows the package B.

Table 9. Difficulty Level Test Questions in Package B

Question Number	Discriminating Ability	Criteria
1	0.50	Medium
2	0.50	Medium
3	0.33	Medium
4	0.42	Medium
5	0.42	Medium
6	0.42	Medium
7	0.25	Hard
8	0.33	Medium
9	0.42	Medium
10	0.42	Easy
11	0.25	Hard
12	0.25	Hard

Table 9 shows questions with difficult criteria consisting of questions number 7, 11 and 12. 8 questions have medium criteria consisting of questions number 1, 2, 3, 4, 5, 6, 8 and 9. 1 question is easy, consisting of question number 10.

Discussion

There were several steps or phases that went into making an AKM (minimum competency assessment) tool that was based on scientific literacy and met the AKM characteristics and scientific literacy indicators. The model used in this research refers to the Tessmer model. Therefore, the development stages follow the steps contained in Tessmer's model. These stages include preliminary, self-evaluation, expert reviews, and one-to-one and small group stages.

The Tessmer model initiated the preliminary stage. This stage began with seeking information on the Ministry of Education and Culture's policies, determining the school, namely MAN 1 Model Banda Aceh, and determining validators (language and material experts). At this stage, the researcher also carried out a needs analysis by class XI students at MAN 1 Model Banda Aceh. The results of the needs analysis carried out by researchers were that students had difficulty understanding the material on Hooke's Law and elasticity due to a lack of reading and discussing the questions. Students also expressed a need for multiple sets of AKM questions on Hooke's Law and Elasticity.

Some students at MAN 1 Model Banda Aceh are used to discussing HOTS-level questions, but few are used to questions that use scientific literacy because students had to read a lot, both from the stories and articles presented. This also makes students' literacy levels very low. The AKM questions developed by researchers were relevant questions with the characteristics and indicators of scientific literacy. The developed questions could measure the ability to analyze, interpret, and explain. The medium of science education aims to equip students for a successful life in the 21st century. One of the skills needed in the 21st century is scientific literacy [12].

The next stage is the self-evaluation stage, namely the design stage. At this stage, the researcher designs the AKM question grid, AKM questions, and AKM validation sheet. Before creating AKM questions, researchers carried out curriculum analysis, material analysis, student analysis, and planning. The book that serves as a guide in making AKM questions is a class XI student package book. The AKM question grid has several parts, namely the scientific literacy domain, scientific literacy indicators, learning indicators, questions, and answer keys. The questions developed by the researcher are 12 questions with 2 packages, namely package A and package B. At this stage, draft 1 would be produced and given to the supervisor to get suggestions and input so that the draft questions developed are of excellent quality.

The expert review stage was carried out by providing a draft of the created questions to the validator to get input, suggestions, and whether or not the questions were suitable for testing to students. This research relies on the validation of both

material and language experts. Before testing with students, researchers carried out revisions according to suggestions and input from each validator. This research was conducted at MAN 1 Model Banda Aceh by conducting 2 field trials with different people [13].

The researchers divided the field trial stages into two parts: one-to-one and small groups.

a. One-to-one

The researchers conducted this stage to test Draft 2 on six randomly selected students. Students were divided into 2 parts; 3 students worked on draft 2 in package A, and 3 other students worked on draft 2 in package B with a time of 90 minutes. This stage was carried out to test students' readability of the questions. As long as students worked on the questions, the students could understand and solve the questions given. The questions were in the form of stories, pictures, and graphs. However, in the section on reading graphs and analyzing questions from the presented story, several students provided incorrect answers [14].

This matter happened due to students' disinterest in reading and unfamiliarity with HOTS homework. Research supports this. Today's science education strives to prepare students with the necessary skills to thrive in the 21st century. Scientific literacy is one of the skills that this preparation primarily focuses on [15].

Fitri's research supports this by showing that students frequently make common mistakes when solving story problems or contextual questions. This is caused by students' perceptions that contextual questions are considered quite difficult. Many students were not careful in determining the solution approach, and they also often experienced conceptual errors because they had difficulty understanding the problem properly [8].

b. Small group

After the one-to-one stage is complete, the next stage is continued, namely the small group stage. At this stage, the questions in packages A and B were examined on 24 students. Students were divided into 2 parts, namely 12 people working on package A and 12 others working on package B. Students working at this stage were different from students at the previous stage. Next, researchers calculated the discriminating ability, level of difficulty of the questions, validity and reliability based on the scores obtained from students [16].

The discriminating ability results obtained from the questions developed were very excellent, excellent, fair, underaverage and excluded. In package A questions, questions numbered 1, 2, 5, 6, 8, 10 and 11 can be used without revision. Meanwhile, in package B, questions with numbers 1, 3, 5, 6, 7, 11 and 12 can be used without

revision. This is because the questions fall into the criteria of very excellent and excellent. The difficulty level of the questions in package A is obtained by questions with difficult criteria consisting of questions number 3, 7, 8 and 12, medium criteria consisting of questions number 2, 4, 5, 6, 9 and 11 and easy criteria consisting of question number 1 and 10. In package B, there are difficult criteria consisting of questions number 7, 11 and 12, medium criteria consisting of questions number 1, 2, 3, 4, 5, 6, 8 and 9, and easy criteria consisting of questions number 10 [17] .

Validity in package A questions, there are 6 valid questions, namely numbers 1, 2, 5, 6, 10 and 11, and there are 4 invalid questions, namely 3, 8, 9 and 12. In package B there are 7 valid questions, namely in numbers 1, 3, 5, 6, 7, 11 and there are 2 invalid questions, namely 2 and 8. The valid questions will be examined for reliability, in the questions package A has a Croanbach's alpha of 0.791 and package B has a Croanbach's alpha of 0.805 so the question is declared reliable [18].

After completing the one-to-one stage, the process proceeded to the small group stage. At this stage, the questions in packages A and B were examined on 24 students. Students were divided into 2 parts, namely 12 people working on package A and 12 others working on package B. Students working at this stage were different from students at the previous stage. Next, researchers calculated the discriminating ability, level of difficulty of the questions, validity and reliability based on the scores obtained from students [16].

The discriminating ability results obtained from the questions were very excellent, excellent, fair, underaverage and excluded. In package A questions, questions numbered 1, 2, 5, 6, 8, 10 and 11 were applicable without revision. In package B, questions with numbers 1, 3, 5, 6, 7, 11 and 12 were applicable without revision because the questions fell into the criteria of very excellent and excellent. The difficulty level of the questions in package A was obtained by questions with difficult criteria consisting of questions number 3, 7, 8 and 12, medium criteria consisting of questions number 2, 4, 5, 6, 9 and 11 and easy criteria consisting of question number 1 and 10. In package B, there are difficult criteria consisting of questions number 7, 11 and 12, medium criteria consisting of questions number 1, 2, 3, 4, 5, 6, 8 and 9, and easy criteria consisting of questions number 10 [17].

Validity in package A questions: there are 6 valid questions such as numbers 1, 2, 5, 6, 10, and 11, and 4 invalid questions, namely 3, 8, 9, and 12. In package B, there are seven valid questions, namely numbers 1, 3, 5, 6, 7, and 11, and two invalid questions, namely 2 and 8. The valid questions would be examined for reliability; in the questions package, A has a Cronbach's alpha of 0.791, and package B has a Cronbach's alpha of 0.805, so the question is declared reliable [18].

D. Conclusion

Based on the results of research conducted at MAN 1 Model Banda Aceh regarding the development of the Minimum Competency Assessment (AKM) instrument for students' scientific literacy on Hooke's Law and elasticity at the senior high school level, the researcher concluded that the development of the instrument involved several stages using the Tessmer model. The initial stage involves a preliminary evaluation to collect information and determine the school as the research subject, namely MAN 1 Model Banda Aceh. Then, it continues with the formulative evaluation stage which is divided into self-evaluation, expert reviews, one-to-one, and small group. The results of these stages show that the developed scientific literacy AKM instrument has gone through a thorough evaluation process, with validator results stating that the instrument is very feasible.

Furthermore, the development of this instrument also involved four tests, namely the discriminating ability test, question difficulty level test, validity test and reliability test. Through the use of SPSS software, the test results show several important things. First, the discriminating ability test concluded that most of the questions had excellent to very excellent criteria, but some questions needed revision. Second, the question difficulty level test classifies questions into difficult, medium and easy, giving an idea of the level of difficulty of the material being examined. Third, the validity test identifies valid and invalid questions, the basis for measuring. Finally, the reliability test shows that the developed instrument can be relied upon in measuring students' minimum scientific literacy competency, with adequate Cronbach's alpha values for the two question packages examined. Thus, the results of this research provide a significant contribution to the development of scientific literacy evaluation instruments at the senior high school level.

References

[1] A. Fatmawati, "Pengembangan Perangkat Pembelajaran Konsep Pencemaran Lingkungan Menggunakan Model Pembelajaran Berdasarkan Masalah untuk SMA Kelas X," *EduSains*, vol. 4, no. 2, pp. 94–03, 2016.

[2] Cari, *Panduan Pembelajaran Fisika Untuk SMA & MA*. Jakarta: Pusat Perbukuan Departemen Pendidikan Nasional, 2009.

[3] D. C. Rohim, "Konsep Asesmen Kompetensi Minimum untuk Meningkatkan Kemampuan Literasi Numerasi Siswa Sekolah Dasar," *Jurnal VARIDIKA*, vol. 33, no. 1, 2021, doi: 10.23917/varidika.v33i1.14993.

[4] D. Mardapi, *Pola Induk Sistem Pengujian Hasil KBM Berbasis Kemampuan Dasar SMU: Pedoman Umum*. Jakarta: Departemen Pendidikan Nasional, 2002.

[5] N. Nuzulia and A. Gafur, "Pengembangan Buku Latihan Berbasis Asesmen Kompetensi Minimum (AKM) untuk Meningkatkan Kemampuan Literasi dan Numerasi Siswa di SDN Janti 02 Sidoarjo," *Madrosatuna: Journal of Islamic Elementary School*, vol. 6, no. 1, pp. 1–14, May 2022, doi: 10.21070/madrosatuna.v6i1.1564.
[6] A. Sundari, "Pengaruh Pemberian Integrated Reading and Writing Task Berbasis Problem Based Learning terhadap Literasi Sains Siswa pada Konsep Keanekaragaman Hayati," UIN Syarif Hidayatullah, Jakarta, 2016.
[7] E. Y. Wijaya, D. A. Sudjimat, and A. Nyoto, "Transformasi Pendidikan Abad 21 sebagai Tuntutan Pengembangan Sumber Daya Manusia di Era Digital," in *Prosiding Seminar Nasional Pendidikan Matematika 2016*, Malang: Universitas Kanjuruhan Malang, 2016, pp. 263–278.
[8] L. A. Mardhiyyah, A. Rusilowati, and S. Linuwih, "Pengembangan Instrumen Asesmen Literasi Sains Tema Energi," *Journal of Primary Education*, vol. 5, no. 2, 2016, doi: 10.15294/jpe.v5i2.12905.
[9] F. N. N. Kholishoh, I. Pramudya, and I. Kurniawati, "Analisis Kesalahan dalam Menyelesaikan Soal Cerita dengan Fong's Schematic Model For Error Analysis pada Materi Volume Prisma dan Limas ditinjau dari Gender Siswa Kelas VIII E SMP Negeri 1 Kartasura Tahun Ajaran 2015/2016," *Jurnal Pendidikan Matematika dan Matematika)*, vol. 1, no. 1, pp. 16–35, 2017.
[10] I. Ghozali, *Aplikasi Analisis Multivariate*. Semarang: Universitas Diponegoro, 2006.
[11] I. Kurniasih, *Kupas Tuntas Asesmen Nasional*. Jakarta: Kata Pena, 2021.
[12] Kartina, Misriani, and Y. Fitriani, "Peningkatan Kemampuan Asesmen Kompetensi Minimum (AKM) Literasi Siswa melalui Pendekatan Saintifik SMP Negeri 2 Payaraman," *Wahana Didaktika*, vol. 20, no. 1, pp. 128–139, 2022, doi: 10.31851/wahanadidaktika.v20i1.7333Keywords:
[13] K. R. dan T. Kementerian Pendidikan, *Materi Pendukung Literasi Budaya dan Kewarganegaraan*. Jakarta: Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi, 2021.
[14] K. Haryanto, "Analisis Butir Soal Pilihan Ganda Ulangan Akhir Semester Genap Tahun Pelajaran 2014/2015 Mata Pelajaran IPA Kelas III SD di Kecamatan Depok," Universitas Sanata Dharma, Yogyakarta, 2016.
[15] X. Liu, "Beyond Science Literacy: Science and the Public," *International Journal of Environmental and Science Education*, vol. 4, no. 3, 2009.
[16] Sugiyono, *Metode Penelitian dan Pengembangan*. Bandung: Alfabeta, 2015.
[17] S. N. Pratiwi, C. Cari, and N. S. Aminah, "Pembelajaran IPA Abad 21 dengan Literasi Sains Siswa," *Jurnal Materi dan Pembelajaran Fisika*, vol. 9, pp. 34–42, 2019.
[18] Sujarweni, *Metode Penelitian Lengkap Praktis dan Mudah Dipahami*. Yogyakarta: Pustaka Budi, 2014.

DOI: 10.14421/impulse.2023.42-02

IMPULSE: Journal of Research and Innovation in Physics Education
Volume 4, Issue 2, 79 – 95

© ISSN (p): 2798–1762; ISSN (e): 2798-1754
http://ejournal.uin-suka.ac.id/tarbiyah/impulse

The Three-Tier Diagnostic Test Instrument Development to Identify the Students' Misconceptions about Motion Kinematic Material

Bagus Pratama[1*], Edi Istiyono[2]

[1] Department of Physics Education, Universitas Negeri Yogyakarta, Indonesia
*Corresponding author: bagusprt08@gmail.com

ABSTRACT

This research aims to: (1) determine the construction of the three-tier diagnostic test instrument to identify misconceptions. (2) Find out the quality of the three-tier diagnostic test instrument to identify misconceptions. (3) Know the profile of high school students' misconceptions. (4) Find out the level of practicality of the diagnostic test to identify misconceptions. This instrument development research adapted a method from the Oriondo and Antonio model. The researchers conducted this research at four high schools in Bantul Regency, using 343 students. Content validity was analyzed using Aiken's V formula. The applied data analysis technique is the polytomous item response theory approach according to the PCM. The test characteristics tested include item suitability, reliability, item difficulty level, item characteristic curve, information function, and SEM. Our research shows that (1) the physics research tool we made is made up of 15 questions that have valid and reliable test items. (2) Based on the criteria for the limit of the mean INFIT MNSQ, test items all fit the PCM model. The difficulty level of the test items is in the range between -0.561 and +0.330, which means the test items are in the good category. The total information function of the test is relatively high for abilities between -1.4 and +1.5. (3) The students' misconception profile obtained the highest misconceptions in the rectilinear motion sub-material in the medium category, and (4) The practicality of the instrument based on participants' responses stated that the instrument developed was included in the practical category.

INTISARI

Penelitian ini bertujuan untuk: (1) Mengetahui konstruksi instrumen three tier diagnostic test untuk mengidentifikasi miskonsepsi (2) Mengetahui kualitas instrumen three tier diagnostic test untuk mengidentifikasi miskonsepsi (3) Mengetahui profil miskonsepsi peserta didik SMA (4) Mengetahui tingkat kepraktisan instrumen untuk mengidentifikasi miskonsepsi. Jenis penelitian ini merupakan penelitian pengembangan instrumen menggunakan metode yang diadaptasi dari model Oriondo dan Antonio. Penelitian ini dilakukan di 4 SMA yang ada di Kabupaten Bantul dengan 343 peserta didik. Validitas isi dianalisis dengan formula V Aiken. Teknik analisis data yang digunakan yaitu pendekatan teori respo butir politomus menurut PCM. Karakteristik tes yang diuji antara lain kecocokan butir, reliabilitas, tingkat kesukaran butir, kurva karakteristik butir,

ARTICLE HISTORY
Received: June 11, 2024
Accepted: October 9, 2024

KEYWORDS:
Assessment instruments, Misconceptions, Three-tier diagnostic tests

KATA KUNCI:
Instrumen penilaian, Miskonsepsi, Three-tier diagnostic test

* Corresponding author:
Bagus Pratama, Universitas Negeri Yogyakarta, Indonesia
✉ bagusprt08@gmail.com

fungsi informasi dan SEM. Hasil penelitian menunjukkan bahwa: (1) Konstruksi intrumen penelitian fisika yang dikembangkan terdiri dari 15 butir soal memiliki butir tes yang valid dan reliabel, (2) Berdasarkan kriteria batas mean INFIT MNSQ, butir tes semuanya fit dengan model PCM. Tingkat kesukaran butir-butir tes berada pada rentang antara -0,561 sampai +0,330 yang berarti butir tes dalam kategori baik. Fungsi informasi total tes relatif tinggi untuk kemampuan antara -1,4 sampai +1,5, (3) Profil miskonsepsi peserta didik diperoleh miskonsepsi tertinggi pada submateri gerak lurus dengan kategori sedang, dan (4) Kepraktisan instrumen berdasarkan respon peserta didik menyatakan bahwa instrumen yang dikembangkan ini masuk dalam kategori praktis.

A. Introduction

Physics is a branch of science that studies how matter and energy function and interact. However, Grusche (2019) explains that physics is a field that utilizes mathematical models of scientific activity to help us understand everyday physical phenomena [1]. Understanding these concepts is essential for explaining daily physical phenomena and more complex scientific fields. Personal experiences or daily life can also foster students' thinking [2]. To design learning experiences that support the development of critical thinking and deeper conceptual understanding, educators must understand how ideas correlate with students' thinking.

Students' understanding of certain ideas can vary, and some may differ from experts' comprehension. One of the physics topics requiring conceptual understanding is the kinematics of motion. This concept is critical in physics education because it addresses how objects move without considering the reasons behind their motion. Understanding kinematics is fundamental for studying more complex physics disciplines. Indeed, middle schools have introduced this topic. However, many students still rely on misconceptions, making it difficult for them to grasp linear, projectile, and circular motion. Misconceptions are defined as situations where students have understandings that differ from expert knowledge [3]. The term describes inaccurate or incorrect understandings of concepts or information in a particular field or topic [4]. Often, students make errors in their understanding because the concepts they observe in daily life differ from those taught in the classroom [5], [6].

One of the biggest challenges encountered by high school students in learning physics is a lack of knowledge and difficulty understanding concepts. This issue can stem from incorrect understanding of physics material taught by their teachers or the influence of an inappropriate learning environment [7]. Students may fail to comprehend concepts taught at school if their learning environment is inadequate. Teacher errors, flawed ideas, and poor understanding can all contribute to students' misconceptions. Because they trust the knowledge their teachers impart, students

often find it challenging to correct misconceptions caused by teacher errors [8]. Thus, teachers also play a role in students' misconceptions.

Having tools to identify misconceptions is essential. To uncover and address conceptual errors, concept maps, classroom discussions, practical experiments with Q&A sessions, multiple-choice tests, and written essays are applicable [9]. Addressing students' misconceptions promptly is crucial. One way to do this is by creating assessment tools to evaluate students' understanding of concepts, such as diagnostic tests [10]. Literature research shows that diagnostic tests are an effective method for identifying misconceptions.

A diagnostic test is a systematically and purposefully designed evaluation tool to identify students' strengths and weaknesses in a specific knowledge domain or skill. In education, diagnostic tests aim to assess students' strengths and weaknesses during the learning process ([11]. These tests facilitate educators gather information about students' skills or conditions. Diagnostic tests assist teachers in designing lessons tailored to students' unique needs, such as aligning subject matter with their level of understanding, adapting teaching methods to their learning styles, and providing additional support when needed. Diagnostic tests identify problems or difficulties [12]. These identified issues are then addressed through planned interventions. Therefore, diagnostic tests are essential in decision-making processes regarding individualized learning.

Examples of diagnostic tests include one-tier, two-tier, three-tier, and four-tier diagnostic tests. Two-tier diagnostic tests use a tiered approach to identify students' weaknesses and errors in understanding concepts. However, these tests remain limited and cannot distinguish misconceptions between students who score 1 and 2[13]. Moreover, two-tier diagnostic tests tend to limit the understanding of misconceptions to superficial levels. Without thoroughly grasping the tested concepts, participants might answer correctly based on the options provided. Two-tier tests are often insufficient for identifying complex patterns of misconceptions [14]. For example, participants may frequently give incorrect answers, but these tests lack the flexibility to detect such patterns.

One type of diagnostic test used to identify students' conceptual errors is the three-tier diagnostic test, which evolved from the two-tier diagnostic test. It comprises three levels of questions [9]. The first tier involves standard multiple-choice questions, the second tier presents reasoning options for the first-tier questions, and the third tier assesses students' confidence in their answers. The three-tier diagnostic test provides more accurate results for distinguishing misconceptions from a lack of knowledge [15]. This test enhances conceptual understanding by identifying the depth of misconceptions at each level.

Paper-based tests are traditional assessment methods involving printed test materials distributed to students, who then write their answers directly on the provided sheets. However, paper-based tests require significant effort and time for examiners

to collect and manually review materials. Security and confidentiality can also be an issue due to risks of loss or physical damage to the papers [16].

Research on misconceptions shows that high school students may experience them. Therefore, we should conduct studies aimed at identifying misconceptions in kinematics. The title of this research is "Development of a Three-Tier Diagnostic Test to Identify Misconceptions in Kinematics."

B. Method

This quantitative-descriptive research employs the research and development (R&D) method to develop and examine products for educational use [17]. The study used a modified version of the Oriondo and Antonio model, consisting of three stages: (1) design, (2) testing, and (3) test measurement.

The design process included defining the test objectives, identifying the competencies to be assessed, selecting the subject matter, creating a test matrix, drafting blueprints, writing questions, developing scoring guidelines, validating instruments, and revising as needed. At this point, the test goals had to be set, and find out what high school students did not understand about the skills listed in the Kurikulum Merdeka (Independent Curriculum): Learning Outcomes (Capaian Pembelajaran/CP), Learning Progression (Alur Capaian Pembelajaran/ACP), and Learning Objectives Flow (Alur Tujuan Pembelajaran/ATP).

Kinematics of motion serves as the chosen physics topic for this research. The scoring guidelines had to be adapted to the applied question model. Istiyono (2022) explains the scoring guidelines for a three-tier multiple-choice test are as follows [13]:

Table 1. The Three Tier Multiple Choice Scoring

Answer	Reasons	Confidence Levels	Categories	Scores
Correct	Correct	Confident	Understanding the concept	7
Correct	Incorrect	Confident	Misconception	6
Incorrect	Correct	Confident	Misconception	5
Incorrect	Incorrect	Confident	Misconception	4
Correct	Correct	Not confident	Lucky guess	3
Correct	Incorrect	Not confident	Not understanding the concept	2
Incorrect	Correct	Not confident	Not understanding the concept	1
Incorrect	Incorrect	Not confident	Not understanding the concept	0

The trial phase involved determining the subjects, conducting the trial, and analyzing the results. The trial subjects were 11th-grade students from SMA Negeri 3 Bantul. The researchers conducted instrument testing to evaluate the characteristics

of the test items. The next step was to look at the trial data to find out about the test instruments' features, such as the standard error of measurement (SEM), the level of item difficulty, and their characteristic curves.

The test measurement stage identified misconceptions. The researchers conducted measurements on high school students in Bantul Regency. The students selected for this study are 11th-grade students in Bantul Regency who have previously studied the kinematics of motion.

C. Result and Discussion

The Test Instrument Design

The purpose of the three-tier diagnostic test is to identify high school students' misconceptions more accurately and comprehensively. This research tool attempted to find out how excellent the 11th graders understand the Kurikulum Merdeka's Learning Outcomes (CP), Learning Progression (ACP), and Learning Objectives Flow (ATP).

The test material included physics topics covered in the Kurikulum Merdeka for the odd semester of 11th grade. The researchers developed the test instrument matrix using the competencies and cognitive elements determined in the previous steps. Once the test instrument matrix was complete, the next step involved creating a blueprint.

The test consisted of fifteen multiple-choice questions, structured in three tiers. The first tier contains questions with five answer choices, the second tier required students to provide reasons for their answers, and the third tier assessed students' confidence in their choices.

The subsequent step was instrument validation, carried out by providing validation sheets to expert validators (lecturers from the Physics Education Department at UNY) and practitioner validators (high school physics teachers). Table 2 presents the validity scores of the test items.

Table 2. The Question Item Validity Scores

Question Numbers	V-Value	Criteria
1	1.00	Valid
2	1.00	Valid
3	0.92	Valid
4	0.85	Valid
5	0.96	Valid
6	0.96	Valid
7	0.96	Valid
8	0.96	Valid
9	0.96	Valid
10	0.96	Valid
11	0.92	Valid
12	1.00	Valid
13	0.92	Valid
14	0.92	Valid
15	1.00	Valid

The Trial Test Result Data

The analysis on R-studio program obtained the output values such as assessment of the instrument reliability, observed on the figure.

```
> # Reliabilitas Butir Politomus
> coeff_alpha <- function(responses) {
+   # Get number of items (N) and individuals
+   n_items <- ncol(responses)
+   n_persons <- nrow(responses)
+   # Get individual total scores
+   x <- rowSums(responses)
+   # Get observed-score variance of whole test (X)
+   var_x <- var(x) * (n_persons - 1) / n_persons
+   # Get observed-score variance of each item (Y_j)
+   var_y <- numeric(n_items)
+   for (j in 1:n_items) {
+     var_y[j] <- var(responses[, j]) * (n_persons - 1) / n_persons
+   }
+   # Apply the alpha formula
+   alpha <- (n_items / (n_items - 1)) * (1 - sum(var_y) / var_x)
+
+   alpha
+ }
> coeff_alpha(data_sman_3_bantul_coba)
[1] 0.8613063
>
```

Figure 1. Reliability Output

The figure indicates that the reliability of the developed instrument is 0.8613063. Efendi & Widodo (2019) explain the reliability value falls within the range of 0.81–0.90, which indicates a satisfactory level of instrument reliability [18].

The item-fit test using Infit Mean Square (MNSQ) is a critical tool in the development and validation of high-quality test instruments. The table presents the analysis results using RStudio software.

Table 3. Infit MNSQ

Item	INFIT MNSQ	Criteria
1	1.134	Fit with model
2	1.035	Fit with model
3	1.173	Fit with model
4	0.828	Fit with model
5	1.067	Fit with model
6	1.047	Fit with model
7	1.024	Fit with model
8	1.153	Fit with model
9	0.933	Fit with model
10	1.255	Fit with model
11	1.134	Fit with model
12	1.023	Fit with model
13	0.910	Fit with model
14	0.828	Fit with model
15	0.843	Fit with model

Table 3 shows the INFIT MNSQ scores are within the 0.828 – 1.255, indicating the fit-criterion of the items toward the model. This figure shows each item fit.

```
**************************************************

Summary outfit and infit statistic
     fit     M    SD
1 Outfit 1.067 0.196
2  Infit 1.026 0.134

**************************************************

Outfit and infit statistic
      item fitgroup Outfit Outfit_t Outfit_p Infit Infit_t Infit_p
1   item 1        1  1.196    1.216    0.224 1.134   1.106   0.269
2   item 2        2  1.212    1.017    0.309 1.035   0.296   0.767
3   item 3        3  1.227    1.734    0.083 1.173   1.361   0.174
4   item 4        4  0.801   -1.531    0.126 0.828  -1.453   0.146
5   item 5        5  1.243    1.324    0.186 1.067   0.538   0.591
6   item 6        6  0.990   -0.025    0.980 1.047   0.428   0.669
7   item 7        7  0.978   -0.084    0.933 1.026   0.243   0.808
8   item 8        8  1.224    1.570    0.117 1.153   1.308   0.191
9   item 9        9  0.872   -0.746    0.456 0.933  -0.577   0.564
10 item 10       10  1.303    2.117    0.034 1.255   2.066   0.039
11 item 11       11  1.196    1.216    0.224 1.134   1.106   0.269
12 item 12       12  1.263    1.743    0.081 1.023   0.226   0.821
13 item 13       13  0.944   -0.307    0.759 0.910  -0.658   0.511
14 item 14       14  0.801   -1.531    0.126 0.828  -1.453   0.146
15 item 15       15  0.755   -1.576    0.115 0.843  -1.308   0.191
>
```

Figure 2. Infit MNSQ

The difficulty levels of the items are based on the R-studio program as found in Figure 3.

```
Item Parameters -A*Xsi
      item   N     M xsi.item AXsi_.Cat1 AXsi_.Cat2 AXsi_.Cat3 AXsi_.Cat4
1   item 1 123 4.423   -0.284      1.477      1.501      0.529     -1.869
2   item 2 123 5.374   -0.561      0.952      0.059     -1.646     -1.855
3   item 3 123 3.024    0.055      0.403      1.413      2.215     -0.410
4   item 4 123 2.382    0.291     -0.036      0.287      3.002     -0.128
5   item 5 123 4.252   -0.058      2.170     -1.298     -0.425     -0.836
6   item 6 123 4.106   -0.231      0.655     -0.723     -1.370     -0.658
7   item 7 123 4.504   -0.299      1.777      0.472     -1.039     -0.584
8   item 8 123 3.138    0.136      0.976      0.044      0.199      0.012
9   item 9 123 2.350    0.330      0.552      1.143      3.288      0.340
10 item 10 123 3.423   -0.035      0.691      0.225     -0.371     -0.489
11 item 11 123 4.626   -0.371      1.526      0.429     -1.198     -2.054
12 item 12 123 3.675   -0.090      0.998      0.460      1.376     -1.076
13 item 13 123 4.081   -0.195      0.629      0.432      0.072     -0.682
14 item 14 123 3.577   -0.040      1.560      0.024      1.099     -0.850
15 item 15 123 3.724   -0.131      0.590      1.100      0.586     -0.597
   AXsi_.Cat5 AXsi_.Cat6 AXsi_.Cat7 B.Cat1.Dim1 B.Cat2.Dim1 B.Cat3.Dim1
```

Figure 3. The Question Item Difficulty Level Output

The figure shows the difficulty levels of the items are within the range of -0.561 and 0.330 based on the categorization of Qomariyah [19].

Table 4. The Item Difficulty Level Criteria

Item	Difficulty Levels	Categories
1	-0.284	Moderate
2	-0.561	Moderate
3	0.055	Moderate
4	0.291	Moderate
5	-0.058	Moderate
6	-0.231	Moderate
7	-0.299	Moderate
8	0.136	Moderate
9	0.330	Moderate
10	-0.035	Moderate
11	-0.371	Moderate
12	-0.090	Moderate
13	-0.195	Moderate
14	-0.040	Moderate
15	-0.131	Moderate

Figure 4 shows the characteristic curve of the easiest items.

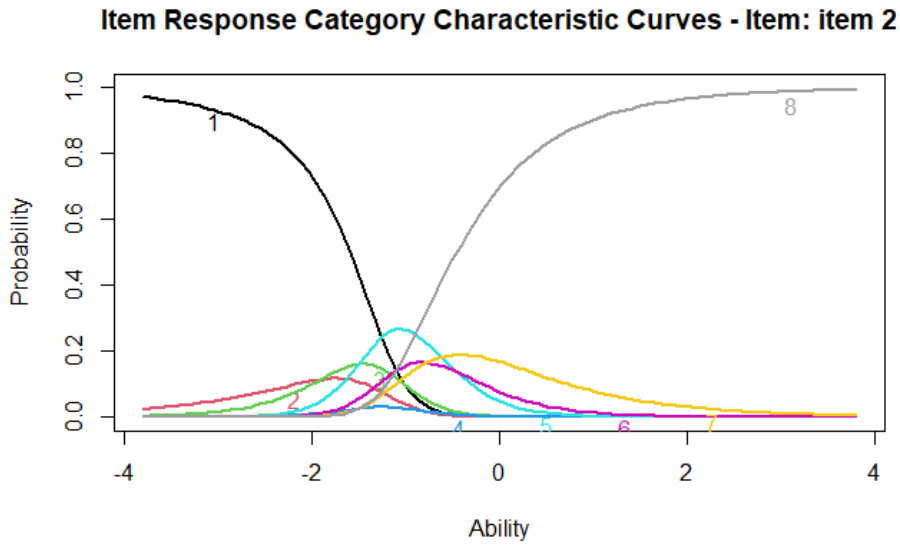

Figure 4. The Characteristic Curve of the Easiest Item Questions

Table 4 illustrates the types of tests that can differentiate the likelihood of responding correctly based on ability levels. The higher the students' ability score, the greater the likelihood of correctly answering higher-category questions. Conversely, the lower their ability score, the smaller the likelihood of correctly answering questions of higher value.

According to the ICC graph for Item 2, students with an ability level of -4 have a high probability of obtaining a score of 0 (Category 1). Students with an ability level of -1.8 are more likely to achieve a score of 1 (Category 2); those with an ability level of -1.5 are more likely to obtain a score of 2 (Category 3); students with an ability level of -1.2 are more likely to achieve a score of 3 (Category 4); and students with an ability level of -1 have a high likelihood of scoring 4 (Category 5). Similarly, students with an ability level of -0.8 have a high probability of obtaining a score of 5 (Category 6), while those with an ability level of -0.5 are likely to achieve a score of 6 (Category 7). Finally, students with an ability level of 4 have a high likelihood of obtaining a score of 7 (Category 8).

Figure 5 displays the information function and standard error of measurement (SEM) output from the RStudio program.

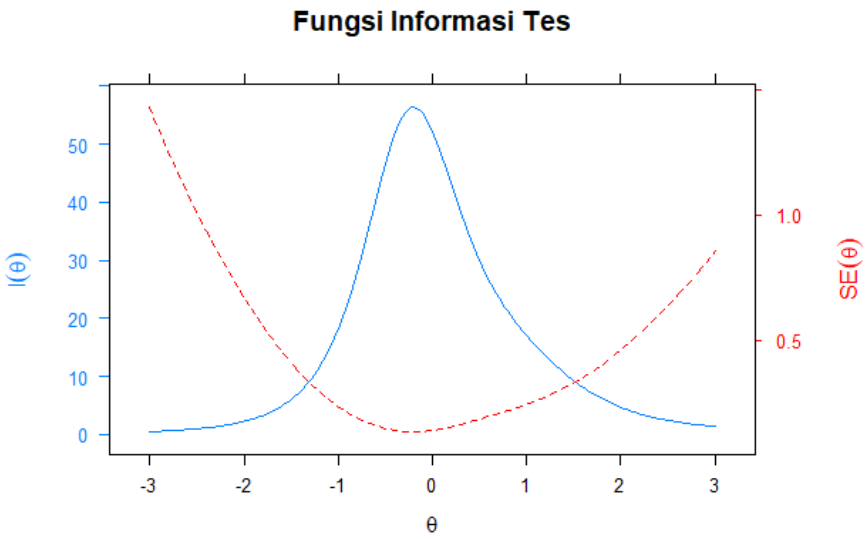

Figure 5. The Information Function and SEM

Based on the analysis results using the Partial Credit Model (PCM), the highest value on the information function curve was found to be 9, with an SEM value of 0.3. Additionally, the total information function curve shows that the first intersection between the information function curve and the SEM curve occurs at -1.4. This suggests that students with extremely low abilities can utilize the instrument.

The total information function curve also shows that the second point of intersection with the SEM curve is at 1.5. This means that the test questions are good for students and respondents with a range of abilities. This demonstrates that the test items can be effectively used for individuals across a wide spectrum of abilities.

The results indicate that this test instrument aligns well with the participants' abilities [20]. The reliability coefficient further confirms that the test instrument and its information function are highly reliable and stable

Measurement Results

The trial test found the developed instrument meet the requirement criteria such as validity, reliability, and fitness of each item toward the PCM. Figure 6 shows the physics misconception level percentage of students on each item.

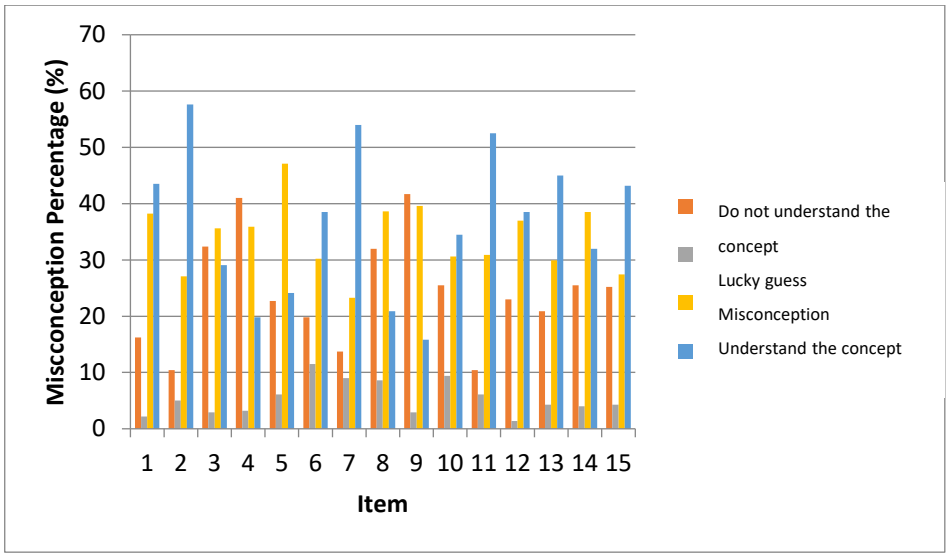

Figure 6. The Misconception Levels of Students on Each Item

Figure 7 shows the overall misconception level percentage.

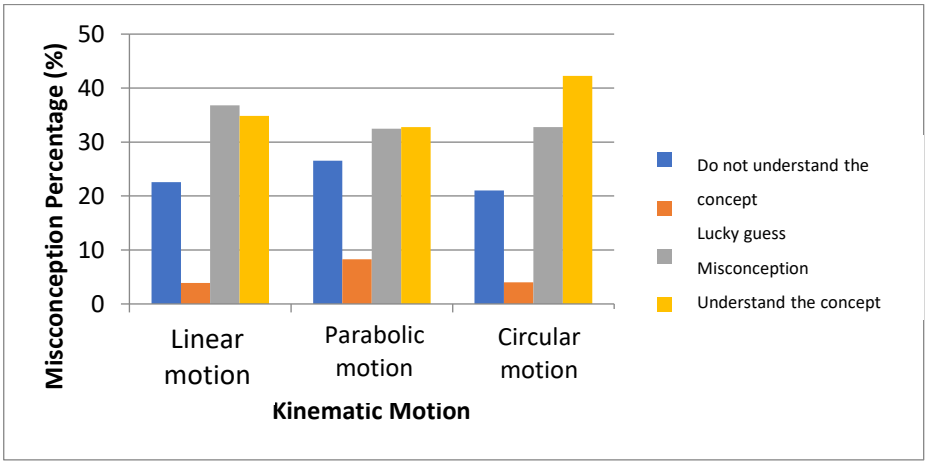

Figure 7. The Overal Misconception Percentage

Figure 7 presents the percentage of misconceptions among students in physics, specifically in the topic of motion kinematics. The results indicate that the highest percentage of misconceptions is found in the sub-topic of linear motion at 36.78%, followed by circular motion at 32.74% and parabolic motion at 32.46%.

Entino (2021) suggests that the data on the level of physics misconceptions among students from three schools in Bantul Regency were then put into levels of misconceptions [21]. Table 5 presents the identified levels of students' misconceptions.

Table 5. The Student Misconception Levels

Sub Materials	Misconception (%)			Overall (%)	Categories
	SMA N 1 Bantul	SMA N 1 Kasihan	SMA N 1 Sewon		
Linear motion	28,4	43,84	38,72	36,99	Moderate
Parabolic motion	23,6	41,46	33,68	32,91	Moderate
Circular motion	16,92	50,62	34	33,85	Moderate

The measurement results indicate that students experienced misconceptions at a moderate level. The grouping of misconceptions by Entino (2021) shows that students have moderate misconceptions about the subtopics of circular motion, parabolic motion, and linear motion [21].

A large-scale trial involving a total of 219 students was conducted across three schools: SMA Negeri 1 Kasihan, SMA Negeri 1 Sewon, and SMA Negeri 1 Bantul. This measurement phase aimed to determine students' levels of understanding during the product development process. Afterwards, the researchers analyzed and classified students' answers and reasoning into four categories of understanding: understanding the concept, misconception, lucky guess, and not understanding the concept.

To identify misconceptions in the topic of motion kinematics, the study employed a three-tier diagnostic test. The researchers chose this method because it offered higher quality and greater precision compared to previous research that used two-tier diagnostic tests.

The two-tier diagnostic test assessed students' understanding of kinematics concepts, whereas the three-tier diagnostic test also evaluated their confidence in the provided answers. This allowed for a more accurate identification of misconceptions, as students were required to explain their reasoning and indicate their confidence levels. Consequently, the three-tier diagnostic test provided more comprehensive and in-depth results regarding students' understanding of motion kinematics.

The misconceptions identified in each question item are: Firstly, 39% of students experienced misconceptions. When interpreting velocity-time graphs, students incorrectly believed that a horizontal line on the graph indicates constant acceleration. The correct concept is that a horizontal line signifies constant or unchanging velocity, meaning no acceleration occurs. Secondly, 28% of students experienced misconceptions regarding acceleration and deceleration in applying uniformly accelerated motion (GLBB). Students mistakenly believed that throwing a ball upward until it reaches its maximum height exemplifies accelerated and decelerated GLBB. However, the correct understanding is that accelerated and decelerated GLBB is observed when a ball is thrown vertically upward and allowed to fall back to the ground. Thirdly, 36% of students experienced misconceptions in calculating acceleration for GLBB. Students incorrectly assumed that the formula for calculating accelerated GLBB is $v_t^2 = v_o^2 - 2as$ leading to incorrect calculation. The correct concept should apply this formula $v_t^2 = v_o^2 + 2as$.

In the fourth question, 36% of students experienced misconceptions. When determining the solution for Aldi to arrive on time in City B, students incorrectly

believed that the required speed should remain constant. They assumed that if the speed remained constant, Aldi would not arrive in City B on time. The correct concept is that Aldi's car needs to accelerate.

In the fifth question, 46% of students experienced misconceptions. Students incorrectly classified the speeds of the three trucks. They believed that the truck's speed was inversely proportional to its acceleration, meaning that higher acceleration corresponded to lower speed. The correct concept is the relationship between speed and acceleration in linear motion.

In the sixth question, 31% of students experienced misconceptions. Students incorrectly understood the variables influencing the maximum horizontal position of an object. They believed that the angle of elevation and time variables affected the maximum horizontal position in parabolic motion. The correct idea is that the angle of elevation and the object's initial speed are the factors that affect its largest horizontal position in parabolic motion. The formula for the largest range in parabolic motion should be $X_{MAX} = \frac{v_o^2 sin2a}{g}$.

In the seventh question, 23% of students experienced misconceptions. They incorrectly interpreted the maximum range of parabolic motion, believing that speed is inversely proportional to the maximum range—meaning higher speed results in a shorter range. The correct concept is that speed is directly proportional to the maximum range.

In the eighth question, 39% of students experienced misconceptions. When applying parabolic motion to determine the farthest point an object reaches, students incorrectly assumed that the larger the angle of elevation, the greater the farthest point. The correct concept is that the farthest point occurs when the angle of elevation reaches 45°. When the angle exceeds 45°, the range begins to decrease again.

In the ninth question, 40% of students experienced misconceptions. Students misunderstood how to determine the position of a parabolic motion object on the x and y axes. They incorrectly assumed that the formula for the position of the object on the x-axis was $x = v_o sin\theta t - \frac{1}{2} g t^2$ and the position for two objects in y-axis was $y = v_o cos\theta t$. This misconception led to incorrect calculation. The correct concept for an object in x-axis is $x = v_o cos\theta t$ while for an object in y-axis is $y = v_o sin\theta t - \frac{1}{2} g t^2$.

In the tenth question, 32% of students experienced misconceptions. They misunderstood the relationship between speed and the angle of elevation with the maximum height in parabolic motion. They incorrectly believed that speed and the angle of elevation were inversely proportional to the maximum height, meaning that the greater the initial speed and the angle of elevation, the lower the height. However, the correct concept is - the initial speed and the angle of elevation are directly proportional to the maximum height—so the greater the speed and angle, the higher the parabola.

In the eleventh question, 32% of students experienced misconceptions. They failed to correctly categorize the linear speed in circular motion. Students incorrectly assumed that for concentric wheels, the linear speed is the same. The relationship between wheels A and C, in contact, was misunderstood. Students believed that since wheel C has a larger radius, $V_A < V_C$. However, the

correct concept is that for wheels in contact, their linear speeds are the same regardless of the radius difference. For the relationship between wheels A and B, concentric, with radius of A than B, the speed is $V_B < V_A$.

In the twelfth item, 39% of students experienced misconceptions. When calculating the period of circular motion, students encountered difficulties. According to their understanding, the period is the amount of time required to complete one rotation, leading to incorrect calculations. The correct concept of the period is the number of oscillations or rotations per unit of time.

A total of 31% of students incorrectly understood the thirteenth question. They incorrectly analyzed the differences in angular velocity, frequency, and time when a bicycle moved in a linear path without accelerating. They believed that when the bicycle moved linear without increasing its speed, its linear speed would increase. However, the correct concept is that when the bicycle moved on a flat surface without accelerating, its linear speed remains constant.

In the fourteenth question, 39% of students experienced misconceptions. When dealing with different speed, students misunderstood the analysis of frequency changes in circular motion. Most believed that frequency was inversely proportional to speed, meaning that the higher the frequency, the slower the speed. The correct concept is that frequency is directly proportional to speed, which means that the higher the frequency, the greater the speed.

In the fifteenth question, 29% of students experienced misconceptions. While analyzing the comparison of periods in circular motion, students misunderstood the relationship. They believed that time was inversely proportional to itself, implying that the longer the time required for one rotation, the shorter it becomes. In reality, time is directly proportional to itself, meaning that the longer the time for one rotation, the greater it is.

Subtopics on linear motion reached 37%, parabolic motion 33%, and circular motion 34%, indicating the overall percentage of conceptual errors or misconceptions among students. The results show that the test-takers exhibited a moderate level of misconceptions. The subtopics of linear motion, parabolic motion, and circular motion are considered to have a moderate level of misconceptions among students [21].

The researchers used the questionnaire results collected during the measurement phase to determine the students' reactions to the developed tool. The questionnaire consisted of ten questions addressing the readability of the instrument and its functionality. Students completed the questionnaire after finishing the three-tier diagnostic test. A total of 54 students participated in the survey, and the percentage responses for each question were as follows.

Table 6. The Students' Respons

Item	Respons	Percentage (%)
1	The applied sentences in the questions are readable	75
2	The Indonesian language of the items are excellent and correct.	78
3	The guidelines of the questions are readable.	71
4	The physics phenomena in the given items are understandable.	70
5	The given time is adequate	78
6	The sizes and positions of the figures are readable.	76
7	The graphics to present the items are understandable.	75
8	The products of the three-tier multiple choice test facilitate students to reflect about the physics conceptual understanding	78
9	The implementation of Microsoft Form is suitable for the Three-Tier Diagnostic Multiple Choice Test	73
10	The product motivates me to improve my conceptual understanding	76

The scores from the ten questionnaire items were then averaged, resulting in an overall percentage score of 75%. Nufus & Sakti (2021) explain this score falls within the range of 61% - 80% [22]. Thus, the three-tier diagnostic test instrument developed is practical for identifying physics misconceptions among high school students.

D. Conclusion

The research has led to several conclusions. The designed the physics assessment instrument to measure high school students' knowledge of motion kinematics. The instrument consists of a three-tier multiple-choice format. This physics assessment instrument is highly effective for evaluating high school students' conceptual understanding. The analysis results include validity, reliability, goodness of fit, difficulty level, characteristics, information function, and standard error measurement. The profile of misconceptions among 11th-grade physics students revealed a misconception rate of 37% in the kinematics subtopic, 33% in straight motion, and 33% in parabolic motion. Overall, the level of student misconceptions falls into the moderate category. The assessment tool is practical for identifying students' misconceptions. Student responses regarding the practicality of the instrument showed an mean score of 75%.

References

[1] S. Grusche, "Phenomenon-based learning and model-based teaching: Do they match?," in *Journal of Physics: Conference Series*, 2019, vol. 1287, no. 1. doi: 10.1088/1742-6596/1287/1/012066.

[2] 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.

[3] N. Mukhlisa, "Miskonsepsi Pada Peserta Didik," *SPEED J. J. Spec. Educ.*, vol. 4, no. 2, pp. 66–76, 2021, doi: 10.31537/speed.v4i2.403.
[4] R. Annisa, B. Astuti, and B. N. Mindyarto, "Tes Diagnostik Four Tier untuk identifikasi pemahaman dan miskonsepsi siswa pada materi gerak melingkar beraturan," *J. Pendidik. Fis. dan Keilmuan*, vol. 5, no. 1, 2019, doi: 10.25273/jpfk.v5i1.3546.
[5] S. Anggrayni and F. U. Ermawati, "The validity of Four-Tier's misconception diagnostic test for Work and Energy concepts," in *Journal of Physics: Conference Series*, 2019, vol. 1171, no. 1. doi: 10.1088/1742-6596/1171/1/012037.
[6] N. J. Fratiwi *et al.*, "Overcoming Senior High School Students' Misconceptions on Newton's Laws: A DSLM with Inquiry Learning based Computer Simulations," in *Journal of Physics: Conference Series*, 2019, vol. 1204, no. 1. doi: 10.1088/1742-6596/1204/1/012023.
[7] W. Wartono, M. N. Hudha, and J. R. Batlolona, "Guided inquiry and PSR in overcoming students' misconception on the context of temperature and heat," in *AIP Conference Proceedings*, 2018, vol. 2014. doi: 10.1063/1.5054433.
[8] A. Busyairi and M. Zuhdi, "Profil Miskonsepsi Mahasiswa Calon Guru Fisika Ditinjau Dari Berbagai Representasi Pada Materi Gerak Lurus Dan Gerak Parabola," *J. Pendidik. Fis. dan Teknol.*, vol. 6, no. 1, pp. 90–98, 2020, doi: 10.29303/jpft.v6i1.1683.
[9] A. M. Rampengan, K. G. Kumonong, and A. T. Rondonuwu, "Analisis Kesalahan Konsep Mahasiswa Calon Guru Fisika Pada Materi Kinematika Menggunakan Tes Diagnostik Three Tier," *Charm Sains J. Pendidik. Fis.*, vol. 2, no. 2, pp. 94–98, 2021, doi: 10.53682/charmsains.v2i2.113.
[10] H. Haerunnisa, P. Prasetyaningsih, and L. T. Biru, "Analisis Miskonsepsi Siswa SMP pada Konsep Getaran dan Gelombang," *PENDIPA J. Sci. Educ.*, vol. 6, no. 2, 2022, doi: 10.33369/pendipa.6.2.428-433.
[11] N. A. K. Asnawi, Tengku Muhammad Sahudra, Dini Ramadhani, Ary Kiswanto Kenedi, Muhammad Rizki Wardana, *Gaya Belajar Siswa Sekolah Dasar dan Tes Diagnostik*. Yogyakarta: Penerbit Deepubliser Digital, 2023.
[12] A. S. A. Wahyuni, A. Wartawijaya, and M. Hasyim, "Pelatihan Membuat Instrumen Tes Diagnostik Four Tier Test pada Guru SMAN 11 Makassar," *PENGABDI*, vol. 3, no. 2, 2022, doi: 10.26858/pengabdi.v3i2.40870.
[13] E. Istiyono, "Diagnostic Tests as an Important Pillar in Today's Physics Learning: Four-tier Diagnostic Test a Comprehensive Diagnostic Test Solution," in *Journal of Physics: Conference Series*, 2022, vol. 2392, no. 1. doi: 10.1088/1742-6596/2392/1/012001.
[14] M. A. Farrosi, W. Siswaningsih, N. Nahadi, and T. Rahmawati, "Profil Miskonsepsi Siswa SMA pada Materi Kesetimbangan Kimia Menggunakan Tes Diagnostik Pilihan Ganda Tiga Tingkat," *J. Ris. dan Prakt. Pendidik. Kim.*, vol. 10, no. 2, 2022, doi: 10.17509/jrppk.v10i2.52243.
[15] E. A. Soru, H. F. Rares, and J. Caroles, "Penggunaan Three-Tier Diagnostic Test Untuk Pemetaan Tingkat Penguasaan Elektrokimia Mahasiswa Kimia Semester II," *Oxyg. J. Chem. Educ.*, vol. 2, no. 1, 2020, doi: 10.37033/ojce.v2i1.132.

[16] R. Rachmawati and A. Kurniawati, "Pengembangan Instrumen Penilaian Tes Berbasis Mobile Online pada Prodi Pendidikan Matematika," *Prima J. Pendidik. Mat.*, vol. 4, no. 1, 2020, doi: 10.31000/prima.v4i1.1891.
[17] A. Maydiantoro, "Model-Model Penelitian Pengembangan (Research and Development)," *J. Metod. Penelit.*, no. 10, 2019.
[18] Y. Efendi and A. Widodo, "Uji Validitas Dan Reliabilitas Instrumen," *J. Kesehat. Olahraga*, vol. 7, no. 2, 2019.
[19] L. Qomariyah, "Analisis Tingkat Kesukaran dan Daya Pembeda Butir Soal TOAFL Universitas Hasyim Asy'ari Tebuireng Jombang," *Lisanan Arab. J. Pendidik. Bhs. Arab*, vol. 6, no. 1, 2022, doi: 10.32699/liar.v6i1.2549.
[20] A. Z. Zain, T. R. Ramalis, and M. Muslim, "Karakterisasi Instrumen Tes Keterampilan Bepikir Kreatif Berdasarkan Analisis Partial Credit Model," *J. Ilm. Pendidik. Fis.*, vol. 6, no. 1, 2022, doi: 10.20527/jipf.v6i1.4806.
[21] R. Entino, E. Hariyono, and N. A. Lestari, "Analisis Miskonsepsi Peserta Didik Sekolah Menengah Atas pada materi Fisika," *PENDIPA J. Sci. Educ.*, vol. 6, no. 1, 2021, doi: 10.33369/pendipa.6.1.177-182.
[22] V. F. Nufus and N. C. Sakti, "Pengembangan Lembar Kerja Peserta Didik Elektronik Berbasis Flipbook Pada Mata Pelajaran Ekonomi Kelas XI," *J. PTK dan Pendidik.*, vol. 7, no. 1, 2021, doi: 10.18592/ptk.v7i1.4633.

DOI: 10.14421/impulse.2024.42-03

IMPULSE: Journal of Research and Innovation in Physics Education
Volume 4, Issue 2, 96 – 106

© ISSN (p): 2798–1762; ISSN (e): 2798-1754
http://ejournal.uin-suka.ac.id/tarbiyah/impulse

Gravitational Acceleration: Its Determination from Gourami Jumping Motion Using Tracker Application

Arina Zaida Ilma[1*], Heru Kuswanto[2]

[1] Natural Science Education Department, Faculty Mathematics and Natural Sciences, Universitas Negeri Yogyakarta, Indonesia
[2] Physics Education Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Yogyakarta, Indonesia
*Corresponding author: arinazaida.2024@student.uny.ac.id

ABSTRACT

Jumping out of the water is one of the phenomena of aquatic animals. Analyzing the motions and routines of aquatic animals requires considerable time and is often subjective, making it susceptible to errors caused by observer fatigue. Investigating the motion of objects is a difficult thought, but with the development of technology it becomes easy, one of them is by using the Tracker. This research aims to analyze the Gourami jumping motion using the Tracker in independent experiment activities about animal motion. The materials and tools needed include Gourami fish, Android camera, and Tracker application. The measurement results are the data on time, position, and the graph of motion. Gourami jumping motion is a parabolic motion consisting of uniform linear motion on the x-axis, while uniformly accelerated linear motion on the y-axis. The value of the gravitational acceleration can be determined from the graph and its value is close to the gravitational acceleration constant. Utilizing video analysis of Gourami motion with the Tracker software can be applied in science education, particularly in physics experiments.

INTISARI

Abstrak : Melompat keluar dari air merupakan salah satu fenomena hewan akuatik. Menganalisis gerak dan rutinitas hewan akuatik membutuhkan proses yang memakan waktu dan cenderung subjektif, rentan terhadap kesalahan akibat kelelahan pengamat. Penyelidikan gerak suatu objek adalah suatu hal yang sulit, namun dengan berkembangnya teknologi menjadi mudah, salah satunya dengan menggunakan Tracker. Penelitian ini mempunyai tujuan guna menganalisis gerak melompat ikan gurami dengan Tracker pada kegiatan praktikum mandiri tentang gerak hewan. Bahan dan alat yang dibutuhkan antara lain ikan gurami, kamera android, dan aplikasi Tracker. Hasil pengukuran berupa data waktu, posisi, dan grafik gerak. Gerak melompat ikan gurami merupakan gerak parabola yang terdiri dari gerak lurus beraturan pada sumbu x, sedangkan gerak lurus beraturan dipercepat pada sumbu y. Nilai percepatan gravitasi dapat ditentukan dari grafik dan nilainya mendekati konstanta percepatan gravitasi. Pemanfaatan video analisis gerak ikan gurami menggunakan Tracker dapat diterapkan dalam pembelajaran IPA khususnya pada percobaan fisika.

ARTICLE HISTORY
Received: December 5, 2024
Accepted: March 14, 2025

KEYWORDS:
Gourami fish, Gravitational acceleration, Jumping motion, Tracker application

KATA KUNCI:
Aplikasi Tracker, Gerakan melompat, Ikan gurami, Percepatan gravitasi,

* Corresponding author:
Arina Zaida Ilma, Natural Science Education Department, Faculty of Mathematics and Natural Sciences, Universitas Negeri Yogyakarta, Indonesia
✉ arinazaida.2024@student.uny.ac.id ✆ +62 89671707601

A. Introduction

Science is a body of knowledge that involves ways of thinking, interactions with people, and the exploration of the universe along with various facts [1]. Science is a method of acquiring knowledge that serves as an approach to understanding natural phenomena. It emerges from our curiosity about ourselves, planets, living organisms, and the universe [2].

Throughout the universe, various animals from five different taxa jumping out of the water to evade their predators, breathing, catching watermelons, communicating, the mechanical motion of swimming fish have become topics of interest for many years [3]. This research emphasizes experimental activities in science learning related to animal motion. Franklin Fearing stated that experiments involving animals attracted the interest of almost all physiologists in the latter half of the 19th century. These experiments were conducted on fish, birds, and dogs [4].

One of the phenomena of various aquatic animals is jumping out of the water [5]. Several fish jump out to catch insects on and off low altitudes or escape from external stimuli [6]. Previous research explained an empirical study of the Silver Carp when swimming and jumping motion [7]. The results obtained are the influence of disturbing variables, intrinsic factor (size and morphology of fish), and extrinsic factor (temperature and water depth).

Several factors affect animal motion, including foraging behavior, human interference, and topography, all of which can be incorporated into mechanistic models [8]. Numerous studies assess hormonal or behavioral changes as direct responses to human disturbances but do not further explore their potential impacts on population size, demographic levels, or species resilience from a biological perspective [9], [10]. However, this phenomenon has not yet been studied based on physics experiment.

Analyzing the motions and routines of aquatic animals requires considerable time and is often subjective, making it susceptible to errors caused by observer fatigue [11]. In conducting an investigation of natural phenomena of motion is a difficult think, but with the development of technology, it can become easy. Currently, automated and semi-automated video-based tracking methods, such as D-Track [11], GroupTracker [12], idTracker [13], and Tracker [14], are used to reduce errors and biases in manual analysis

Tracker is an open-source software designed for video modeling and analysis. [15]. It allows to record videos on their mobile phones and analyze the video from the objects motion [16]. Tracker functions makes students easier to investigate speed, changes in position, the center of mass, and acceleration for time, and visualize the motion in a real-time [17], [18]. Tracker is related to real world models based on Newton's laws, for example in learning it is used to solve various physics problems

that are already known in everyday life including pendulum motion, parabola, free fall motion [19]. Tracking methods can analyze the various animals motion, namely fish [13], [20], [21], cats [22], primates [23], and mouse [24]. It also transforms video data into positional trajectories over time.

The use of tracker applications in learning can optimize the use of experimental devices, one of which is the use of trackers to determine the gravitational acceleration through free-fall motion [25], anomaly of Earth through solar eclipse [26], investigate the uniform motion of the straight line and determine the moon's gravity [27] and determining fluid viscosity coefficient [28]. The difference in this research is applying the Tracker application to the Gourami jumping motion.

Practice in science learning is expected to be a means for students to learn independently, around nature, and solve existing various challenges [29]. The nature of science is essential in informal science education. Scientists understand how science operates through experimentation and intuition. It makes sense to add science traits to the intended curriculum at producing faster and better [30].

The problem that arises from learning science is a phenomenon that can be seen directly, but there is also something that cannot be observed easily by students like difficulty reading graphs, analyzing problems and applying them in equations of motion [31]. This research aims to analyze the phenomena from Gourami jumping motion using the Tracker application in independent experiment activities in science learning.

B. Method

The materials and tools needed are Gourami fish, Android phone camera, and also Tracker application. The results from the measurement are graphs of the motion of the Gourami jumping, the value of the distance traveled with Tracker application and then compared with constant value.

The procedure of this research is as follows, namely:

1. The phenomenon of Gourami jumping motion in the environment was recorded using an Android camera.
2. Gourami motion is analyzed using the Tracker through importing recorded videos with the file menu, then importing videos, the videos to be analyzed are then selected by clicking open
3. If the video is available in the Tracker, the frame is set from beginning to end using the track menu, and the new option is clicked and then the calibration tools stick is selected.
4. After the y and x coordinates are obtained, then select the axes for analysis.
5. Then the Gourami mass point is determined for analysis using the track menu by selecting point mass and new.

6. Finally, the Gourami motion is analyzed by auto-track or manually placing frame points on the gourami jump out. The data was obtained in the form of motion vertically and horizontally in two dimensions (x, y). The components that are calculated on the Gourami jumping out of the water using the Tracker are the x(t), y(t), and t (s).

In this experiment, we use three Gourami fish (see Figure 1). Two black Gourami, one with a mass of 0.30 kg and a length of 0.25 m (BG-A), and another with a mass of 0.20 kg and a length of 0.17 m (BG-B), along with an albino Gourami weighing 0.25 kg and measuring 0.20 m (AG), were analyzed. Data from the Tracker were processed using Microsoft Excel to generate graphs of position versus time, altitude versus time, and the trajectory of parabolic motion. The next step is to determine the gravitational acceleration (g) of the Gourami jumping motion using the Tracker application and compare it with the gravitational acceleration constant of 9.8 m/s^2[32], [33], [34].

(a) BG-A (b) BG-B (c) AG

Figure 1. Gourami fish in this experiment

C. Result and Discussion

The use of video analysis of Gourami jumping motion using Tracker application helps students when investigating the center of mass position, acceleration and velocity in a real-time [17] and determines the type of motion. Before analyzing the video, students initially recorded the motion of the Gourami that jumped out of the water. Students can open a digital video file and import it into Tracker. Students can calibrate the scale and set the appropriate coordinate axes. The results obtained after the Gourami jumping motion video were analyzed using Tracker for each fish as presented in Table 1.

Table 1. Data of Gourami Jumping Motion

Type of Gourami	t (s)	x (m)	y (m)
BG-A	0.00	0.02	0.00
	0.03	-0.06	0.03
	0.07	-0.15	0.04
	0.10	-0.22	0.05
	0.13	-0.31	0.04
	0.17	-0.40	0.02
	0.20	-0.48	-0.01
	0.23	-0.56	-0.05
	0.27	-0.64	-0.11
BG-B	0.00	0.01	0.00
	0.03	-0.06	0.03
	0.07	-0.15	0.05
	0.10	-0.25	0.07
	0.13	-0.35	0.08
	0.17	-0.46	0.06
	0.20	-0.54	0.05
	0.23	-0.65	0.01
	0.27	-0.73	-0.02
AG	0.00	0.27	0.19
	0.03	0.23	0.27
	0.07	0.19	0.32
	0.10	0.13	0.37
	0.13	0.07	0.41
	0.17	0.02	0.42
	0.20	-0.05	0.44
	0.23	-0.14	0.45
	0.27	-0.22	0.44

Based on the data (see Table 1), a graph can be created to show the relationship between time and position along the x-axis and y-axis (see Figure 2).

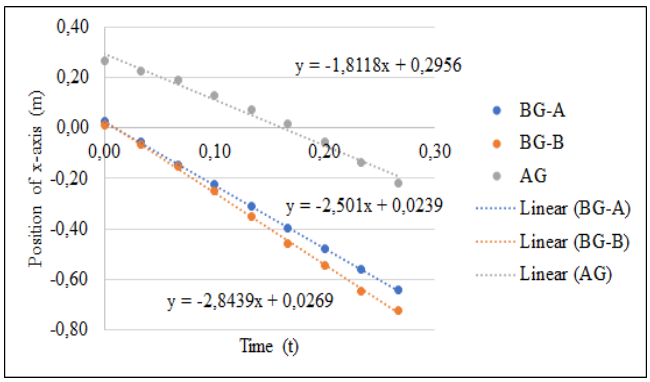

Figure 2. Graph of position versus time on the x-axis of BG A, BG-B and AG.

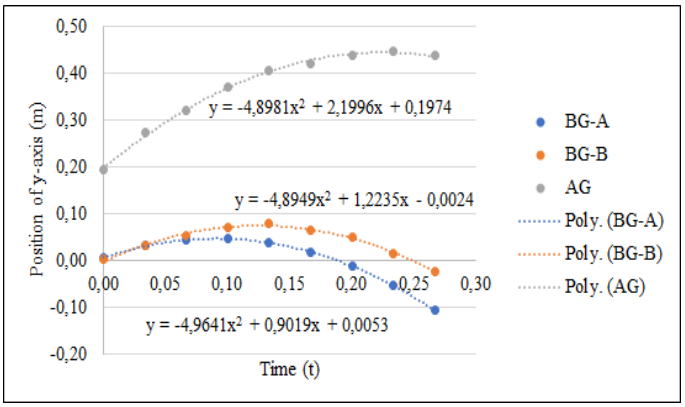

Figure 3. Graph of position versus time on the y-axis of BG A, BG-B and AG.

The graph gets a linear equation (see Figure 2). The equations generated from the data trackers sequentially from BG-A, BG-B and AG are:

$y_{(BG-A)} = -2.501x + 0.0239$ (1)

$y_{(BG-B)} = -2.8439x + 0.0269$ (2)

$y_{(AG)} = -1.8118x + 0.2956$ (3)

The initial velocity from BG-A on the x-axis component (v_{ox}) is 2.501 m/s. The initial velocity from BG-B on the x-axis component (v_{ox}) is 2.8439 m/s. The initial velocity from AG on the x-axis component (v_{ox}) is 1.8118 m/s. The negative sign indicates that the direction of the fish's speed is in the negative x direction.

The graph gets a parabolic equation (see Figure 3). The equations generated from the data trackers sequentially from BG-A, BG-B and AG are:

$y_{(BG-A)} = -4.9641x^2 + 0.9019 + 0.0053$ (4)

$y_{(BG-B)} = -4.8949x^2 + 1.2235x - 0.0024$ (5)

$y_{(AG)} = -4.8981x^2 + 2.1996x + 0.1974$ (6)

The initial velocity from BG-A on the y-axis component (v_{oy}) is 0.9019 m/s. The initial velocity from BG-B on the y-axis component (v_{oy}) is 1.2235 m/s. The initial velocity from AG on the x-axis component (v_{oy}) is 2.1996 m/s. The positive sign indicates that the direction of the fish's speed is in the positive y direction.

In the experiment of fish jumps out of the water using Tracker, it shows that the Gourami fish perform a parabolic motion. The Gourami fish are given a stimulus to jump out of the water when the water is in a small pond, then they are given humans disturbance who seem to be catching it so that the Gourami jumping motion is a parabolic trajectory.

Tracker as a pedagogical tool in learning and teaching effective projectile motion in science (physics) [15]. Parabolic motion is a specific type of two-dimensional

motion in which a particle moves within a vertical plane, utilizing an initial velocity while experiencing constant acceleration due to gravity acting downward [35]. Parabolic motion is basically a combination of uniform linear motion and uniformly accelerated linear motion [36].

In the motion of the fish above, the resulting graph shows a linear line on the y-axis so that it includes uniform linear motion, while on the y-axis a parabolic graph shows that the motion includes uniformly accelerated linear motion. The use of the Tracker software on the Atwood aircraft showed the characteristics of uniform linear motion and uniformly accelerated linear motion so that it was classified as suitable for use in science learning at school [37]. Both have their respective interpretations on the components of the x and y axes. In parabolic motion, vertical and horizontal motion are independent, thus no motion affects each other [35].

The equation that applies to each component is written as the following equation and to find the magnitude of the gravitational acceleration from the resulting graph (see Figure 3).

Equation on the x-axis component:

$$v_{ox} = v_0 \cos\theta \tag{7}$$

Equation on the y-axis component:

$$v_{oy} = v_0 \sin\theta \tag{8}$$

The gravitaty acceleration can be calculate from the experiments using the equation.

$$y = v_0 t - \frac{1}{2} g t^2 \tag{9}$$

The difference in the gravitational acceleration value of Gourami fish jumping out of the water using the tracker application is shown in Table 2.

Table 2. Gravitational Acceleration of Gourami Jumping Motion

Type of Gourami Fish	Gravitational Acceleration	Gravitational Acceleration Constant
BG-A	9.928 m/s^2	
BG B	9.789 m/s^2	9.8 m/s^2
AG	9.782 m/s^2	

From the results (see Table 2), the data using the tracker application is close to the gravitational acceleration constant (9.8 m/s^2), namely in BG-A the results of the gravitational acceleration are 9.928 m/s^2 with level of accuracy is 99,96% , in BG-B is is 9.789 m/s^2 with level of accuracy is 99.15% and error value is 0,0085 and at AG is 9.782 m/s^2 with level of accuracy is 99.75%.

The previous study also found the gravitational acceleration with the Tracker application [38]. An experiment to determine the acceleration due to gravity obtained a value of g = 9.63 ± 0.07 m/s^2 with a relative accuracy of RA% = 98.2% and a relative statistical uncertainty of 0.7%. Thus, the high level of accuracy of the Gourami fish jumping out of the water using the Tracker can make it easier for students in

experiment activities to determine the magnitude of the gravitational acceleration. Experimental activities in science learning can foster the independence of students' scientific work [39].

D. Conclusion

Tracker is an open-source application for modeling tools and video analysis to investigate speed, changes in position, center of mass, and the acceleration for time and also visualize the motion concepts in a real-time. By using a Tracker application, it can be make the position versus time graph to determined the gravitational acceleration. Gravitational acceleration resulting from the Gourami jumping motion is always showing a value about 9.782 – 9.928 m/s^2 which is analyzed from the parabolic graph of position y. Therefore, it can be concluded that video analysis of the Gourami's jumping motion using the Tracker can be utilized in physics experiments for science learning about animal motion. It helps students interpret the obtained data through graphs and data tables, making it easier to draw conclusions and accurately identify motion parameters.

References

[1] W. Widodo, D. A. P. Sari, T. Suyanto, M. Martini, and I. Inzanah, "Pengembangan keterampilan pemodelan matematis bagi calon guru IPA," *J. Inov. Pendidik. IPA*, vol. 6, no. 2, pp. 146–155, 2020, doi: 10.21831/jipi.v6i2.27042.

[2] N. A. Campbell, L. A. Urry, M. L. Cain, S. A. Wasserman, P. V. Minorsky, and J. B. Reece, *Biology A Global Approach*, Eleventh E. United States of America: Pearson Education, 2018.

[3] C. Eloy, "Optimal Strouhal number for swimming animals," *J. Fluids Struct.*, vol. 30, pp. 205–218, 2012, doi: 10.1016/j.jfluidstructs.2012.02.008.

[4] A. Klein, "The curious case of the decapitated frog: on experiment and philosophy," *Br. J. Hist. Philos.*, vol. 26, no. 5, pp. 890–917, 2018, doi: 10.1080/09608788.2017.1378866.

[5] B. Chang, J. Myeong, E. Virot, C. Clanet, H. Y. Kim, and S. Jung, "Jumping dynamics of aquatic animals," *J. R. Soc. Interface*, vol. 16, no. 152, 2019, doi: 10.1098/rsif.2019.0014.

[6] B. J. Vetter, A. F. Casper, and A. F. Mensinger, "Characterization and management implications of silver carp (Hypophthalmichthys molitrix) jumping behavior in response to motorized watercraft," *Manag. Biol. Invasions*, vol. 8, no. 1, pp. 113–124, 2017, doi: 10.3391/mbi.2017.8.1.11.

[7] G. R. Parsons, E. Stell, and J. J. Hoover, "Estimating burst swim speeds and jumping characteristics of silver carp (Hypophthalmichthys molitrix) using video analyses and principles of projectile physics," *Report*, no. October 2016, 2016.

[8] H. K. Preisler, A. A. Ager, and M. J. Wisdom, "Analyzing animal movement patterns using potential functions," *Ecosphere*, vol. 4, no. 3, pp. 1–13, 2013, doi: 10.1890/ES12-00286.1.

[9] Z. Tablado and L. Jenni, "Determinants of uncertainty in wildlife responses to human disturbance," *Biol. Rev.*, vol. 92, no. 1, pp. 216–233, 2017, doi: 10.1111/brv.12224.
[10] M. R. Baker, K. S. Gobush, and C. H. Vynne, "Review of factors influencing stress hormones in fish and wildlife," *J. Nat. Conserv.*, vol. 21, no. 5, pp. 309–318, 2013, doi: 10.1016/j.jnc.2013.03.003.
[11] P. Rachinas-Lopes, R. Ribeiro, M. E. Dos Santos, and R. M. Costa, "D-Track—A semi-automatic 3D video-tracking technique to analyse movements and routines of aquatic animals with application to captive dolphins," *PLoS One*, vol. 13, no. 8, pp. 1–12, 2018, doi: 10.1371/journal.pone.0201614.
[12] T. Fukunaga, S. Kubota, S. Oda, and W. Iwasaki, "GroupTracker: Video tracking system for multiple animals under severe occlusion," *Comput. Biol. Chem.*, vol. 57, pp. 39–45, 2015, doi: 10.1016/j.compbiolchem.2015.02.006.
[13] A. Pérez-Escudero, J. Vicente-Page, R. C. Hinz, S. Arganda, and G. G. De Polavieja, "IdTracker: Tracking individuals in a group by automatic identification of unmarked animals," *Nat. Methods*, vol. 11, no. 7, pp. 743–748, 2014, doi: 10.1038/nmeth.2994.
[14] A. Rossouw, M. Hacker, and M. J. De Vries, "Concepts and contexts in engineering and technology education: An international and interdisciplinary delphi study," *Int. J. Technol. Des. Educ.*, vol. 21, no. 4, pp. 409–424, 2011, doi: 10.1007/s10798-010-9129-1.
[15] L. K. Wee and T. K. Leong, "Video Analysis and Modeling Performance Task to Promote Becoming Like Scientists in Classrooms," *Am. J. Educ. Res.*, vol. 3, no. 2, pp. 197–207, 2015, doi: 10.12691/education-3-2-13.
[16] D. H. Nichols, *Physics for Technology*, Second Edi. Boca Raton: Taylor & Francis Group, 2019.
[17] P. Hockicko, "Forming of physical knowledge in engineering education with the aim to make physics more attractive," in *Physics Teaching in Engineering Education (PTEE)*, 2011, pp. 1–5.
[18] E. Yusuf, "Using tracker to engage students' learning and research in physics," *Pertanika J. Sci. Technol.*, vol. 24, no. 2, pp. 483–491, 2016.
[19] A. Anissofira, F. Dzar, and E. Latief, "Analisis Gerak Roller Coaster Menggunakan Tracker dengan Pendekatan Multi Modus Representasi Sebagai Sarana Siswa Memahami Konsep Kinematika," *Pros. SKF 2016*, pp. 26–32, 2016.
[20] O. Mirat, J. R. Sternberg, K. E. Severi, and C. Wyart, "ZebraZoom: An automated program for high-throughput behavioral analysis and categorization," *Front. Neural Circuits*, vol. 7, no. June, pp. 1–12, 2013, doi: 10.3389/fncir.2013.00107.
[21] A. Z. Ilma, H. Kuswanto, and A. Hujatulatif, "Jumping Motion of Gourami Fish Using Tracker Software as a Mechanical Energy Conservation Practicum," *J. Penelit. Pendidik. IPA*, vol. 8, no. 5, pp. 2154–2158, 2022, doi: 10.29303/jppipa.v8i5.2071.
[22] D. Ramadhanti, H. Kuswanto, H. Hestiana, and A. Azalia, "Penggunaan Analisis Video Gerak Kucing Melompat Berbantuan Aplikasi Tracker Sebagai Kegiatan Praktikum Mandiri Materi Gerak pada Peserta Didik SMP," *J.*

Pendidik. Sains Indones., vol. 9, no. 3, pp. 459–470, 2021, doi: 10.24815/jpsi.v9i3.20547.
[23] S. Ballesta, G. Reymond, M. Pozzobon, and J. R. Duhamel, "A real-time 3D video tracking system for monitoring primate groups," *J. Neurosci. Methods*, vol. 234, pp. 147–152, 2014, doi: 10.1016/j.jneumeth.2014.05.022.
[24] F. De Chaumont *et al.*, "Computerized video analysis of social interactions in mice," *Nat. Methods*, vol. 9, no. 4, pp. 410–417, 2012, doi: 10.1038/nmeth.1924.
[25] L. K. Kanga, R. B. Astro, Y. E. Ika, P. Education, and S. Program, "Analysis of Vertical Movements on Freedom and Bullet," vol. 4, no. 1, pp. 19–25, 2021.
[26] A. H. Setyadin *et al.*, "Optimalisasi Bandul Matematis Menggunakan Tracker dalam Penentuan Perubahan Percepatan Gravitasi Permukaan Bumi (G) Akibat Gerhana Matahari Sebagian (GMS) 9 Maret 2016," in *Seminar Nasional Fisika*, 2016, pp. 167–170. doi: 10.21009/0305020132.
[27] D. P. Sari, W. Widodo, and Madlazim, "Sciences Practicum in The Covid-19 Pandemic Era by Using a Video Tracker," *J. Inov. Pendidik. dan Sains*, vol. 2, no. 3, pp. 75–81, 2021.
[28] R. B. Islami, L. A. Didik, and B. Bahtiar, "Determine of the nira water viscosity by using video based laboratory falling ball method with tracker software," *Gravity J. Ilm. Penelit. dan Pembelajaran Fis.*, vol. 7, no. 2, pp. 8–20, 2021, doi: 10.30870/gravity.v7i2.10165.
[29] I. Diamond, *Science Education in school, TLRP Institute of Education*. London: University of London, 2011.
[30] W. F. McComas, *Nature of Science in Science Instruction*. Switzerland: Springer Nature Switzerland AG, 2020.
[31] F. Mufit, "The study of misconceptions on motion's concept and remediate using real experiment video analysis," *Asean Comp. Educ. Res. Netw. Conf.*, pp. 1–7, 2018.
[32] D. Halliday, R. Resnick, and J. Walker, *Fundamental of Physics*, 9th Editio. New Jersey: John Wiley & Sons Inc, 2011.
[33] R. . Serway and J. Jewett, *Physics for Scientists and Engineers with Modern Physics*, Ninth Edit. United Stated of America: Books/Cole, 2014.
[34] Giancoli and C. Douglas, *Physics Principles with Application*, Sixth Edit. New Jersey: Upper Saddle River, 2005.
[35] J. Halliday, D., Resnick, R., Walker, *Fundamentals of Physics*, 9th Editio. New Jersey: John Wiley & Sons, Inc, 2011.
[36] T. S. Tuhusula, B. Pattana, E. Randai, D. . Wateriri, and A. . Walukow, "Experiments Usingbased Virtual Lab Phet Simulation in Learning Physics on Parabolic Movement Materials," *J. Pendidik. fIS*, vol. 9, no. 2, pp. 128–135, 2020.
[37] M. G. Nugraha, K. H. Kirana, F. Nugraha, E. A. Nurinsani, and F. N. Sholihat, "Optimization of Rectilinear Motion Experiments using Tracker Application," *IOP Conf. Ser. Mater. Sci. Eng.*, vol. 288, no. 1, 2018, doi: 10.1088/1757-899X/288/1/012096.
[38] M. Anni, "Quantitative comparison between the smartphone based experiments for the gravity acceleration measurement at home," *Educ. Sci.*, vol. 11, no. 9, pp. 1–20, 2021, doi: 10.3390/educsci11090493.

[39] P. Parmin, E. N. Savitri, and Y. N. Ifriza, “Scientific work independence application for various education levels referring to Piaget’s theory to support the implementation of science integrated learning model,” *J. Penelit. dan Pembelajaran IPA*, vol. 8, no. 2, pp. 175–191, 2022, doi: 10.30870/jppi.v8i2.17442.

DOI: 10.14421/impulse.2023.42-04

IMPULSE: Journal of Research and Innovation in Physics Education
Volume 4, Issue 2, 107 – 117

© ISSN (p): 2798–1762; ISSN (e): 2798-1754
http://ejournal.uin-suka.ac.id/tarbiyah/impulse

Development of Simple Pyphox-based Regular Straight Motion Practicum Tools

Jeli[1*], Artha Nesa Chandra[1]

[1] Physics Education Study Program, UIN Mahmud Yunus Batusangkar, Indonesia
*Corresponding author: jeligaul06@gmail.com

ABSTRACT

This research aims to develop a practicum tool for Regular Straight Motion (RSM) based on the Phyphox application as an innovation in physics learning that is more interactive and accurate. The research method uses an experimental approach, where the Phyphox application is utilized to record time and distance data automatically, replacing manual methods that often face accuracy problems due to human error. The research successfully demonstrated that the use of the Phyphox application can increase measurement accuracy to 95% and reduce the human error rate by 30%. It also enables real-time data visualization, which not only facilitates the analysis of relationships between variables but also helps students better understand physics concepts. In addition, the app enriches students' learning experience by increasing their motivation and engagement, and supports the mastery of 21st century skills such as data analysis and use of technology. The development of Phyphox-based tools is expected to be a strategic step to modernize physics learning, prepare students to face global challenges, and make a real contribution in improving the quality of physics education in the digital era. This shows that technology has great potential in transforming education, especially in improving the effectiveness and efficiency of the teaching and learning process.

INTISARI

Penelitian ini bertujuan untuk mengembangkan perangkat praktikum Gerak Lurus Beraturan (GLB) berbasis aplikasi Phyphox sebagai inovasi pembelajaran fisika yang lebih interaktif dan akurat. Metode penelitian yang digunakan adalah pendekatan eksperimen, dimana aplikasi Phyphox dimanfaatkan untuk merekam data waktu dan jarak secara otomatis, menggantikan metode manual yang sering kali mengalami kendala akurasi akibat human error. Hasil penelitian menunjukkan bahwa penggunaan aplikasi Phyphox dapat meningkatkan akurasi pengukuran hingga 95% dan mengurangi human error hingga 30%. Aplikasi ini juga memungkinkan visualisasi data secara real-time, yang tidak hanya memudahkan analisis hubungan antar variabel tetapi juga membantu siswa lebih memahami konsep fisika. Selain itu, aplikasi ini memperkaya pengalaman belajar siswa dengan meningkatkan motivasi dan keterlibatan mereka, serta mendukung penguasaan keterampilan abad 21 seperti analisis data dan penggunaan teknologi. Pengembangan perangkat berbasis Phyphox diharapkan

ARTICLE HISTORY
Received: December 25, 2024
Accepted: March 14, 2025

KEYWORDS:
Fixed straight motion, Measurement accuracy, Phyphox application, Physics education, Technology in education

KATA KUNCI:
Aplikasi Phyphox, Gerakan lurus beraturan, Ketelitian pengukuran, Pendidikan fisika, Teknologi dalam pendidikan

* Corresponding author:
Jeli, Physics Education Study Program, UIN Mahmud Yunus, Indonesia
jeligaul06@gmail.com +62 82287565897

dapat menjadi langkah strategis untuk memodernisasi pembelajaran fisika, mempersiapkan siswa menghadapi tantangan global, dan memberikan kontribusi nyata dalam meningkatkan kualitas pendidikan fisika di era digital. Hal ini menunjukkan bahwa teknologi memiliki potensi besar dalam mengubah pendidikan, terutama dalam meningkatkan efektivitas dan efisiensi proses belajar mengajar.

A. Introduction

Physics as a basic science has an important role in understanding natural phenomena by providing an explanation of the principles that govern events in the universe [1]. Not only does it explain basic concepts such as motion and energy, physics also provides a theoretical basis that is used to predict and analyze the natural phenomena we observe. One example of a phenomenon that can be explained through the principles of physics is a solar eclipse [2].

A solar eclipse occurs when the Earth, Moon and Sun are in a straight line. In this situation, the Moon orbiting the Earth will block some or all of the Sun's light from reaching the Earth [3]. This phenomenon can be explained using the laws of motion of bodies governed by Newton's universal gravitation. The Moon's motion follows Kepler's second law of planetary motion and Newton's law of gravity, showing how regular circular and linear motion play a role in this natural phenomenon [4].

Historically, the concept of RSM has long attracted the attention of scientists. Galileo Galilei was one of the pioneers in understanding the motion of objects, where he conducted a simple experiment to observe the relationship between distance and time. This discovery paved the way for a better understanding of the laws of motion. In addition, Isaac Newton formulated the laws of motion that became the foundation of classical mechanics, including the principle of inertia that explains why an object in RSM maintains its speed if no external force is applied to it [5].

RSM is theoretically understood through Newton's laws, especially the principle of inertia. According to Tipler & Mosca [6] in “Physics for Scientists and Engineers”, RSM is a direct application of the principle of inertia which states that an object unaffected by external forces will move at a constant and unchanging speed. This phenomenon covers a wide range of real-life situations, such as a car moving straight at a constant speed. The basic formula is the main analytical tool for studying this motion.

The main characteristics of RSM are constant speed and straight trajectory. This means that the acceleration of an object in RSM is zero, which indicates that the total force acting on the object is also zero [7]. On a distance-time graph, this motion is represented by a straight line with a fixed slope, while in a velocity-time graph it is represented by a horizontal line [8].

Traditionally, RSM trajectories are performed using simple equipment such as pulleys, ropes, dumbbells and stopwatches. However, this manual method has limited accuracy. Human error in measuring time and distance often results in inconsistent results. With the advancement of technology, modern devices such as smartphone apps have been integrated to improve the accuracy and efficiency of RSM practicum [9].

Phyphox, which stands for "Physical Phone Experiments," is an innovative app that uses a smartphone's built-in sensors, such as accelerometers, gyroscopes, magnetometers, and microphones, to measure physical parameters in real time. Technically, Phyphox operates by taking data from these sensors to record changes in position, velocity, acceleration, or even the frequency of sounds produced by the movement of objects [10]. Unlike conventional tools that require separate instruments for each type of measurement, Phyphox combines them all in one tool [11]. Phyphox's ability to present data interactively and with high accuracy makes it a highly effective tool when compared to manual methods that are prone to human error. In addition, it allows data export to spreadsheet format, which facilitates in-depth analysis through software such as Excel or MATLAB. Phyphox's main advantage is its ability to present precise data and interactive graphs that illustrate relationships between variables [12].

The use of technology in physics teaching not only improves accuracy but also enriches students' learning experience [13]. The utilization of technology in physical teaching, especially on the concept of RSM, does have a great influence on the accuracy of measurements and the quality of students' learning experience. The application of technology provides opportunities for students to conduct experiments and observations more accurately and with more repetitions without being bound by the limitations of traditional tools [14].

A study O'Neil, et al [15] showed that utilizing digital sensors in RSM experiments increased the accuracy of velocity and acceleration measurements by 10% when compared to traditional methods. With tools that are able to process data automatically, human error in recording or measurement can be minimized [16].

Based on a report from the International Society for Technology in Education, 78% of teachers stated that the use of technology in teaching physics accelerates understanding of difficult concepts such as RSM [17]. In addition, 65% of students admit that they are more interested and active in learning physics when utilizing technology in experiments and simulations. This report reveals that technology not only improves learning outcomes but also encourages student motivation and participation in more complicated material [18].

With the available data and research, it can be concluded that technology plays a significant role in improving the accuracy of physics experiments as well as the learning experience of students. The utilization of technology not only makes physics

learning more efficient, but also more engaging and interactive, providing opportunities for students to better understand and master concepts such as RSM [19].

According to Ramadiani, et al. [20], integrating IoT (Internet of Things) technology into physics learning allows accurate measurements of up to 95% compared to manual methods. This shows that technology not only improves accuracy but also offers opportunities for further innovation in physics education. By using Phyphox-based practical tools, students can develop a deeper understanding of RSM while preparing them for future technological challenges [21].

According to Sya'bana, et al. [22] stated that integrating technology into learning allows students with limited resources to access complex experiences. Therefore, the development of Phyphox-based tools is a strategic step towards modernizing physics learning and preparing students to face the challenges of science and technology in the future.

The development of Phyphox-based practical tools is an innovative solution to address the challenges of physics learning in the digital era. By using available technology, students not only learn physics concepts but also develop 21st century skills, such as critical thinking, data analysis, and effective use of technology [23]. Therefore, this development has great potential to improve the quality of physics education in Indonesia and prepare students to face future global challenges.

B. Method

This research method uses an experimental approach with a practicum design to evaluate the effectiveness of the Phyphox application in improving understanding of the concept of Regular Straight Motion (RSM). The research was conducted in the physics laboratory of Mahmud Yunus State Islamic University Batungkar by involving students as respondents. The research was designed to support active learning through practicum.

This research began with preparation which included problem identification, namely how the Phyphox application can improve students' understanding of Regular Straight Motion (RSM). After that, the researcher conducted a literature study to understand RSM theory and how to use Phyphox application in physics learning. Next, the researcher designed the experimental method, including the necessary tools and materials, as well as the steps of conducting the experiment.

After planning, the researcher prepared the tools needed, such as wooden blocks, wooden boards, pulleys, ropes, weights, and toy cars as experimental objects. The Phyphox application was also installed on a smartphone to record data. In the experimental design stage, the researcher determines the mass variation of the load to be used to see its effect on the motion of the test object. The experimental apparatus was carefully assembled to make it stable and function properly.

When everything was ready, the researcher conducted the experiment by making sure the device was functioning and the app was ready to use. The experiment was

conducted by releasing the load to make the test object move, and data such as acceleration, time, and distance were recorded automatically by the application. Each experiment was repeated several times with variations in load mass to get more accurate data.

After data collection was completed, the researcher organized the results into tables to facilitate analysis. The data obtained was then analyzed to show the relationship between variables, such as acceleration against time and distance against time. The researcher also compared the data obtained with the RSM theory to evaluate the success of the experiment.

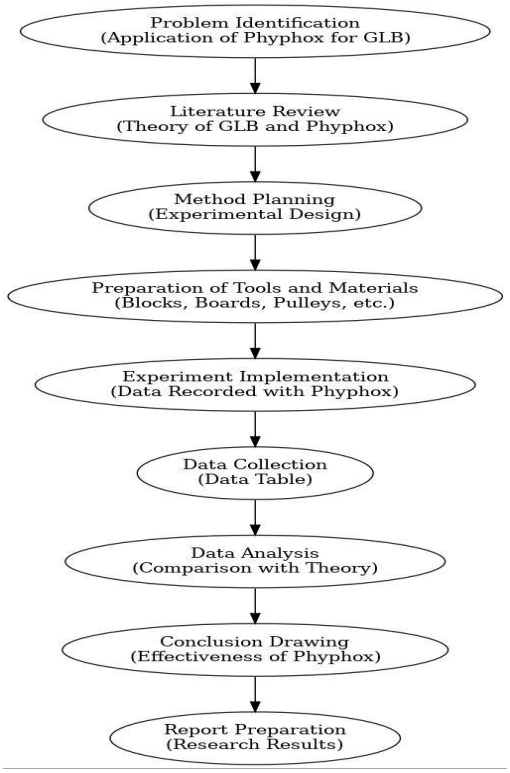

Figure 1. Flowchart of Research Stages

With this approach (Figure 1), the research aims to contribute to the innovation of physics learning that is more effective and interactive.

C. Result and Discussion

Result

The results show that the Phyphox application provides more accurate data than the manual method in RSM experiments. In the table of experiments conducted five times at different distances show a fairly stable speed, close to the characteristics of RSM. Below are the results of the experiment:

Table 1. RSM Experiment Results with Phyphox Application

Distance (m)	Time (s)	Speesd (m/s)
0.20	0.052	3.85
0.25	0.066	3.79
0.30	0.078	3.85
0.35	0.091	3.85
0.40	0.104	3.85

Measurement accuracy with Phyphox app improves consistency of results and reduces human error by 30% [24]. Phone's built-in sensor provides more precise timekeeping capabilities than a manual stopwatch [25].

Discussion

Regular Straight Motion (RSM) is the motion in which an object moves at a constant speed on a straight trajectory, as stated by Halliday & Resnick [26]. In the context of this practicum, observations were made of a toy car moving a certain distance in a measured time. From the data above, we can analyze the speed of the car, the suitability of the motion with RSM characteristics, and the factors that affect the observation results.

Based on experiments conducted using the Phyphox application, it is shown that this tool has a higher level of accuracy compared to manual measurement methods, especially in measuring travel time in regular straight motion experiments. One of the main advantages of using Phyphox is its ability to eliminate human error that often occurs in manual measurements, especially in terms of recording time.

In experiments using a manual stopwatch, errors often occur due to delays in human response to pressing the button or in recording the time correctly [27]. This error is especially noticeable when the object starts moving or when the object is nearing the end of the track. For example, when using a manual stopwatch, there is a time lag caused by inaccuracy in pressing the start or stop button, which certainly affects the accuracy of the measurement results. This is in accordance with the explanation of Harjono [28] which states that the human error factor in measuring time using a manual stopwatch often results in inaccuracies, due to delays in human reactions.

On the other hand, the Phyphox app utilizes sensors on smartphones that can detect time with more accuracy and precision. Phyphox uses the accelerometer and gyroscope integrated in mobile devices to measure movement in real-time, reducing reliance on human reactions in time recording. With the app's ability to record data automatically and simultaneously, the resulting data is more consistent and reliable. In this experiment, although the velocity of the object was not completely constant, the data obtained from Phyphox better reflected the pattern of regular straight motion in accordance with physical theory than the data from a manual stopwatch which is prone to measurement errors [29].

In this experiment, the Phyphox application showed advantages over the manual method in several aspects:

1. Travel Time Accuracy

Phyphox utilizes the built-in accelerometer and gyroscope sensors on smart phone devices to detect motion in real-time. The accuracy of this tool is in accordance with the statement of [30], which states that the integration of sensors on digital devices can provide a much higher time resolution than traditional methods. This proves that Phyphox is able to minimize human error, such as response delays when starting or stopping the stopwatch, which is often the main obstacle in manual methods

2. Data Consistency

Measurements with Phyphox are more consistent, as reported by Faradiba [27], which shows that sensor technology-based applications can produce data that is more precise and free from variations in operator subjectivity. In this experiment, although the speed of the toy car was not completely constant, the data obtained through Phyphox was closer to the RSM pattern than the data from the manual stopwatch.

3. Ease and Efficiency in Data Analysis

After the measurement is completed, Phyphox automatically calculates important parameters such as average speed, distance, and travel time. This is in line with the research of Kause, et al [31], which shows that Internet of Things (IoT) and sensor-based technologies can improve data processing efficiency, reduce the risk of manual calculation errors, and speed up analysis.

The use of Phyphox also brings advantages in terms of:

1. Higher Precision

The sensors on Phyphox have the ability to detect small changes in the motion of objects. For example, Phyphox can record time intervals down to milliseconds, which suits the needs of advanced physics experiments. This is supported by the findings of Mahardika, et al [32], which showed that sensor-based devices have a much better level of precision than conventional stopwatches.

2. Elimination of Systematic Error

In manual measurements, systematic errors often occur due to tool or operator limitations. With Phyphox, these errors are minimized because the entire measurement process is automated. This result is consistent with the study of Singh

et al. [33], which mentioned that sensor-based devices can eliminate operator bias in experiments.

Furthermore, the use of Phyphox provides another advantage, namely ease of data processing. After measurements are taken, the app automatically calculates the average speed, distance, and travel time, thus reducing manual calculation errors that often occur in traditional experimental data processing. This is in line with the findings of Boimau et al. [34], who showed that the use of IoT and sensor-based technologies in motion experiments can improve measurement accuracy and efficiency. In the context of this experiment, Phyphox simplified the measurement and data analysis process, thus accelerating students' understanding of the concept of regular straight motion.

Thus, it can be concluded that the Phyphox application provides significant advantages in terms of measurement accuracy compared to manual methods, especially in physics experiments involving time and distance measurements. The use of Phyphox not only increases the accuracy of the data obtained, but also makes it easier for students or researchers to conduct experiments in a more practical and efficient way. Therefore, the use of sensor-based applications such as Phyphox is highly recommended for experiments that require high-precision time measurements, such as regular straight motion experiments.

D. Conclusion

The use of technology such as the Phyphox app in learning regular linear motion is proven to improve measurement accuracy and enrich students' learning experience. Using built-in sensors on smartphones, the app enables automated data recording, interactive graphical presentations and in-depth analysis not easily achieved by manual methods. Research shows that Phyphox can reduce the human error rate by 30% and increase measurement accuracy by 95% compared to conventional tools. In addition, the app facilitates concept understanding through real-time visualization, which has a positive impact on students' motivation and engagement in learning physics. Applying Phyphox-based tools in the RSM experience also reinforces 21st century skills, such as data analysis, critical thinking and use of technology. Although there are challenges, such as limited access to technology for some students, intensive training and teacher support can overcome these barriers.

Overall, the development of Phypox-based RSM practice tools is a strategic step towards modernizing physics education, helping students deepen their understanding of physics concepts and preparing them for the global challenges of the digital era. This research makes an important contribution to the modernization of physics learning in the digital era. The use of the Phyphox app not only improves the quality of education through more precise measurements but also prepares students with 21st century skills, such as data analysis and the use of technology. This supports

educational endeavors that are more interactive, engaging, and relevant to future global challenges.

Acknowledgements

The first thanks are of course to the Lord of the universe, Allah Swt. then to the Prophet Muhammad SAW. then thanks to Mrs. Artha Nesa Chandra, M.Pd as the supervisor and lecturer of the school Physics Labor course. Thank you also to my mother and younger siblings who have provided support and enthusiasm and sent their best prayers. Thank you to my father who has been the author's guide in behavior. Furthermore, thank you to Naufal Haris who always provides support and encouragement to the author, thank you for your love and affection all this time. And the most special thanks are for the author himself, thank you for being yourself

References

[1] A. R. Harefa, "Peran Ilmu Fisika Dalam Kehidupan Sehari-Hari," *J. War.* , no. April, pp. 1–10, 2019.

[2] T. K. Indratno, "Pengaruh Gerhana Matahari Terhadap Nilai Percepatan Gravitasi Bumi: Sarana Pembelajaran untuk Mendekatkan Fisika pada Kehidupan Sehari-hari," *J. Ris. dan Kaji. Pendidik. Fis.*, vol. 3, no. 1, p. 10, 2016, doi: 10.12928/jrkpf.v3i1.4539.

[3] Y. Yulianty and Luthfiandari, "Buku Panduan Gerhana Matahari Panduan Dasar Sains Gerhana dan Bagaimana Mengamati Gerhana Matahari," pp. 1–75, 2023.

[4] A. Muzakki, I. N. Ramadhanti, I. N. Alifiyan, and T. S. Ayu, "Kajian Model Pembelajaran Fisika SMA pada Topik Kinematika Gerak Lurus," *Mitra Pilar J. Pendidikan, Inovasi, dan Terap. Teknol.*, vol. 1, no. 2, pp. 85–98, 2022, doi: 10.58797/pilar.0102.04.

[5] F. Issue, W. Johnmoore, and L. L. J. Nat, "Book Note Galileo ' S Revenge : Junk Science," vol. 2844, 1992.

[6] T. Mosca, "Paul A. Tipler, Gene Mosca - Physics for Scientists and Engineers. A Strategic Approach." 2007.

[7] H. Setyawan, "Modul pembelajaran SMA Fisika," *Direktorat Pembin. SMA - Kementeri. Pendidik. dan Kebud.*, no. 465, pp. 56–59, 2019.

[8] M. M. Radjawane, A. Tinambunan, and S. Jono, *Kementerian pendidikan, kebudayaan, riset, dan teknologi 2022 sma/ma kelas xi*. 2022.

[9] M. Novita and N. Ainun, "Rancangan Alat Gerak Lurus Beraturan (GLB) Berbantuan Sensor Ultrasonik HCSR04 Pada Pembelajaran Fisika SMA," 2020.

[10] M. Islamiah, R. Rostati, and Neneng Triyunita, "Pengembangan Alat Praktikum Gerak Jatuh Bebas Menggunakan Phyphox Berbasis Smartphone untuk Siswa Kelas X," *J. Pendidik. Mipa*, vol. 13, no. 3, pp. 887–892, 2023, doi: 10.37630/jpm.v13i3.1203.

[11] W. A. S. Putri, L. Hakim, and R. Sulistyowati, "Pengembangan E-Lkpd Materi Efek Doppler Berbasis Inkuiri Terbimbing Berbantuan Aplikasi Phyphox Untuk Meningkatkan Pemahaman Konsep Fisika," *ORBITA J. Pendidik. dan Ilmu Fis.*, vol. 8, no. 1, p. 15, 2022, doi: 10.31764/orbita.v8i1.6828.

[12] Toyyib, “Pemanfaatan Smartphone Berbasis Aplikasi Phyphox Untuk Mengukur Keterampilan Proses Sains Siswa Pada Percobaan Fisika Sedehana,” *J. Guru Inov.*, pp. 103–114, 2022.
[13] I. K. Mahardika, M. H. Muzammil, D. F. Saragih, F. H. Putri, N. E. Putri, "Peranan Teknologi dalam Proses Pembelajaran Fisika SMA, " *J. Ilmiah Wahana Pendidikan*, vol. 9, no. 2, 245-252, 2023
[14] R. Simamora, “Penggunaan Teknologi sebagai Inovasi Media pada Pembelajaran Fisika di Era Persaingan Industri untuk Mendukung Kampus Mengajar,” *Pros. Webinar Nas. Pendidik. Dan Sains Kim.*, pp. 54–59, 2021.
[15] O’Neil et al., “ Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy. New York: Crown Publishers, 2016.
[16] S. H. Prasastono and M. H. Holili, “Media Pembelajaran Gerak Lurus Beraturan Dan Gerak Lurus Berubah Beraturan Dengan Adobe Flash,” *J. Manuhara Pus. Penelit. Ilmu Manaj. dan Bisnis*, vol. 1, no. 2, pp. 01–16, 2023, doi: 10.61132/manuhara.v1i2.212.
[17] E. A. Fitri, B. Karyadi, and H. Johan, “Analisis Kebutuhan: Pemanfaatan Teknologi sebagai Media Pembelajar Fisika bagi Peserta didik di Pulau Enggano,” *J. Pendidik. tambusai*, vol. 7, no. 1, pp. 1789–1794, 2023.
[18] N. L. Mardiana, “Optimalisasi Penerapan Model Pembelajaran Discovery Learning dalam Upaya Meningkatkan Hasil Belajar Mata Pelajaran Fisika Materi Gerak Melingkar,” *J. Educ. Action Res.*, vol. 5, no. 2, pp. 200–207, 2021, doi: 10.23887/jear.v5i2.33315.
[19] A. N. Fauziah and D. Sulisworo, “Pembelajaran Fisika dengan Memanfaatkan Teknologi Guna Meningkatkan Minat Belajar,” *J. Genes. Indones.*, vol. 1, no. 02, pp. 79–86, 2022, doi: 10.56741/jgi.v1i02.93.
[20] S. Ramadiani, N. Silvianti, R. P. Putra, and R. D. Agustina, “Uji Perbandingan Kegiatan Laboratorium berbasis IoT dengan Virtual Laboratory pada Materi Periode Bandul dengan HOTLAB,” *J. Penelit. Ilmu Pendidik.*, vol. 15, no. 1, pp. 11–21, 2022, doi: 10.21831/jpipfip.v15i1.41485.
[21] C. J. Kauwo, T. K. Londa, and A. Komansilan, “Efektivitas Eksperimen pada Pegas Menggunakan Aplikasi Charm Sains,” *J. Pendidik. Fis.*, vol. 3, no. 3, pp. 158–162, 2022.
[22] S. S. Zahra, I. H. Syahbana, M. O. Wiyadnyana, and F. Anggraini, “Analisis Ayunan Pendulum Menggunakan Aplikasi Phyphox Pada Materi Fisika Kelas X,” *Mitra Pilar J. Pendidikan, Inovasi, dan Terap. Teknol.*, vol. 1, no. 2, pp. 53–64, 2022, doi: 10.58797/pilar.0102.02.
[23] L. P. B. Yasmini, D. O. Rachmawati, "Pemanfaatan Smartphone Dan App Phyphox Untuk Percobaan Fisika Bagi Guru Kelas X di SMA Negeri 2 Singaraja." In *Proceeding Senadimas Undiksha* (pp. 571–578). 2021
[24] J. Pebralia, “Determining the Coefficient of Restitution Through the ‘Bouncing Ball’ Experiment using Phyphox,” *Int. J. Appl. Sci. Smart Technol.*, vol. 4, no. 1, pp. 35–46, 2022, doi: 10.24071/ijasst.v4i1.4548.
[25] A. Wijayanti, P. Marwoto, W. Wiyanto, S. Ridlo, and P. Parmin, “Contextual Science Learning using Smartphone Audio Sensor Application (Phyphox) on Restitution Coefficient Measurement,” *J. Penelit. dan Pembelajaran IPA*, vol. 8, no. 2, p. 256, 2022, doi: 10.30870/jppi.v8i2.13400.

[26] D. Halliday, R. Resnick, "*Physic Vol 1 Ed 5*," New York: John Wiley & Sons. 2002.
[27] S. Staacks, S. Hütz, H. Heinke, and C. Stampfer, "Advanced tools for smartphone-based experiments: Phyphox," *Phys. Educ.*, vol. 53, no. 4, pp. 1–8, 2018, doi: 10.1088/1361-6552/aac05e.
[28] Faradiba, "Metode Pengukuran Fisika," *Buku Mater. Pembelajaran Metod. Pengukuran Fis.*, pp. 1–195, 2020.
[29] Harjono, "Pemanfatan Sensor Android Sebagai Media Eksperimen Pada Materi Gerak Harmonis Sederhana," *J. Teknodik*, vol. 25, no. 2, p. 131, 2021, doi: 10.32550/teknodik.v25i2.666.
[30] A. Anildo, A. A. Anas, W. Romi, and J. Ahmad, "Perancangan Alat Praktikum Berbasis Internet Of Things, " *Jurnal Teknologi Terapan*, vol 5, no 3, hal 212-221, 2024.
[31] M. C. Kause, "Rancang Bangun Alat Peraga Fisika Berbasis Arduino (Studi Kasus Gerak Jatuh Bebas)," *Cyclotron*, vol. 2, no. 1, 2019, doi: 10.30651/cl.v2i1.2511.
[32] I. K. Mahardika, S. A. Rohma, E. D. Krisnawanto, M. N. Hamdi, "Analisis Efektifitas Media Pembelajaran Phypox Berbasis Android Pada Pembelajaran Fisika Sma Pada Materi Tumbukan,". *Wahana Dedik.*, vol. 5, no. 2, 2022.
[33] G. K. S. Singh, "Evaluating the Factors Influencing Child Development and Strategies used by Educators in Teaching Low-performance Children in an International Preschool," *Int. J. Educ. Psychol. Res.*, vol. 11, no. 1, pp. 20–29, 2022,
[34] I. Boimau, A. Y. Boimau, and W. Liu, "Eksperimen Gerak Jatuh Bebas Berbasis Smartphone Menggunakan Aplikasi Phyphox," *Semin. Nas. Ilmu Fis. dan Ter.*, vol. 10, no. 07, pp. 67–75, 2021.

DOI: 10.14421/impulse.2023.42-05

IMPULSE: Journal of Research and Innovation in Physics Education
Volume 4, Issue 2, 118 – 128

© ISSN (p): 2798–1762; ISSN (e): 2798-1754
http://ejournal.uin-suka.ac.id/tarbiyah/impulse

Motivation from People Closest to Local and Non-Local Students Against Determining Physics Identity in Analytical Mechanics Courses

Anindita Putri Canina Pitono[1*], **Motik Mutiara Ramadhani**[1], **Bayu Setiaji**[1]

[1] Department of Physics Education, Universitas Negeri Yogyakarta, Indonesia
*Corresponding author: aninditaputri.2022@student.uny.ac.id

ABSTRACT

This study aims to find out more about the influence of motivation from people closest to them on the formation of physics identity, especially for local students (living in D.I. Yogyakarta) and non-local (from outside D.I. Yogyakarta), on the results of analytical mechanics courses. This qualitative descriptive study uses a descriptive-analytical approach based on the results of interviews with 8 sample respondents representing local students (living in D.I. Yogyakarta) and non-local (coming from outside D.I. Yogyakarta) in the Physics Education Department, Yogyakarta State University. All respondents have been able to describe their physics identity, accompanied by strong motivation from people closest to them, including themselves, without any differences between local and non-local students regarding the final results of analytical mechanics. After knowing the results of this study, it is hoped that students can further develop their physics identity so that it has an impact on the final grades of the courses they take.

INTISARI

Penelitian ini bertujuan untuk mengetahui lebih jauh mengenai pengaruh motivasi dari orang-orang terdekat terhadap pembentukan identitas fisika, khususnya bagi mahasiswa lokal (tinggal di D.I. Yogyakarta) dan non-lokal (berasal dari luar D.I.Yogyakarta), terhadap hasil mata kuliah mekanika analitik. Penelitian deskriptif kualitatif ini menggunakan pendekatan deskriptif-analitik berdasarkan hasil wawancara terhadap 8 sampel responden yang mewakili mahasiswa lokal (tinggal di D.I. Yogyakarta) dan non-lokal (berasal dari luar D.I. Yogyakarta) di Jurusan Pendidikan Fisika Universitas Negeri Yogyakarta. Seluruh responden telah mampu mendeskripsikan identitas fisika yang mereka miliki, disertai dengan motivasi yang kuat dari orang-orang terdekat, termasuk diri mereka sendiri, tanpa adanya perbedaan antara mahasiswa lokal dan non-lokal terkait hasil akhir mekanika analitik. Setelah mengetahui hasil penelitian ini, diharapkan mahasiswa dapat lebih mengembangkan identitas fisika yang dimiliki sehingga berdampak pada nilai akhir mata kuliah yang diambil.

ARTICLE HISTORY
Received: March 9, 2024
Accepted: July 9, 2024

KEYWORDS:
Analytical Mechanics, Motivation, Non-local and Local, Physics Identity

KATA KUNCI:
Identitas Fisika, Mekanika Analitik, Motivasi, Non Lokal dan Lokal

* Corresponding author:
Anindita Putri Canina Pitono, Department of Physics Education, Universitas Negeri Yogyakarta, Indonesia
✉ aninditaputri.2022@student.uny.ac.id

A. Introduction

Physics is generally considered a prestigious subject, and comparatively, many students still need to have a physics identity during their studies. Physics identity is a process of self-identification as a physicist, which is essential for students studying physics to understand the diversity of issues in education [1]. The existence of a physics identity in a student can bring up the process of self-knowledge and increase motivation to achieve good learning outcomes in physics [2] The correlation of physics identity to the formation of physics attitudes and learning outcomes has also been explained by high learning outcomes of students with good physics attitudes [3]. Wang & Hazari [4] created a physics identity framework formed from interest, namely the desire to learn physics, self-perceived performance or ability to successfully carry out activities and understand physics, and recognition (beliefs recognized by others as a physics person). These three indicators can be developed according to research objectives, such as to find out the relational relationship to figures that impact life to generate motivation and encouragement to form a physics identity [5, 6]. The research reviewed can prove the effect of student physics identity.

Motivation is a person's way of maintaining activity directed at the goals made [7]. Adriani R. & Rasto [8] also explained that motivation in learning encourages a person to learn attitudes and behaviors to generate enthusiasm and significantly influence learning outcomes. In addition, motivation and learning outcomes have a positive relationship [9, 10, 11]. Motivation in a person can come from within (internal) or from outside the individual (external).

The internal influence of learning motivation is from belief and encouragement of one's abilities [12]. Influence internally appears on a person's self-awareness in dealing with a condition. The internal influence of motivation to learn physics is a person's power to master process-oriented physics concepts, products, and scientific attitudes by carrying out an exploratory process to find concepts, principles, theories, and natural laws and apply them in everyday life. Weak student motivation to study physics can be seen from the decreased result of student learning outcomes. The decrease in learning outcomes can be caused by the presence of influencing factors, namely the interest in learning physics, the condition of students in mastering and understanding physics concepts, and the limited ability to study physics.

The external influence of motivation to learn comes from the environment and other people [13]. Several parties who can provide external motivation usually come from the closest people, such as family, peers, and teachers. Several previous studies have mentioned the correlation between motivation from the closest people. Rosa [14] stated that social support from those closest to her could increase student motivation to study online during the COVID-19 pandemic, one of which came from parents [15].

Terok and Huwae [16] also revealed that optimizing the role of social support from peers and coaches in addition to parents can increase athlete achievement motivation, in line with Sunaida & Leonardi [17], who explained that peer social support could have a significant effect on achievement motivation.

Physics students' perceptions of physics influenced by those closest to them can differ depending on the individual. Especially for local and non-local students. Non-local students who come from specific areas move to certain areas to study. In comparison, local students are students who come from the city where the university is located. These differences are based on field facts, with whom they have been close and have the motivation to learn, as well as differences in circumstances that affect learning achievement and peer social support.

Most local students have more time with their parents and family at home. Students who live with their parents do not have anxiety, so they can go through college well. Meanwhile, non-local students spend more time with their peers [18]. Choirunisa & Marheni [19] found that the phenomenon of achievement motivation and social support for non-local students was higher than for local students. The intended local and non-local students are students who do not migrate and students who migrate.

Meanwhile, Sudarji and Juniarti [20] revealed that the grit (level of persistence) originating from the motivation of non-local students was higher than that of non-local students. Being a non-local student means not living with your parents. This makes the condition of students different from local students who live and can meet daily with their parents. Non-local students get little attention from parents because of the need for more intense meetings. Non-local students long for their parents, so they will seek friends to eliminate this longing. Non-local students will look for non-local friends before getting non-local friends. Positive peer groups will help adolescents understand that they are not alone in facing the challenges of fulfilling their duties.

So from the description above, it is necessary to know more about the influence of motivation from those closest to the formation of physics identity, especially for non-local and local students on the results of the analytical mechanics course in this study.

B. Method

This research is qualitative research with a descriptive-analytic approach. The scope of this research is the role of the people closest to self-motivation as forming a Physics identity in Physics Education students class of 2019-2022. The subjects in this study were eight non-local and local students of the Physics Education Department, Faculty of Mathematics and Natural Sciences, Yogyakarta State University class of 2019-2022, taking the analytical mechanics course as a

comparison of performance results in the formation of their respective physics identities.

The final score of the analytical mechanics course compares the conformity of the physics identity in the interview with the learning outcomes. According to [21, 22, 23] a person is considered to have a physics identity when he has excellent performance and can demonstrate the performance in physics matters. One of them is in the learning itself.

The selection of subjects was based on a purposive sampling technique, i.e., the sample was carried out with a specific purpose [24] with a total population of 188 students. In this case, the sample is limited to 2 students per class. Each represents one non-local student and one non-local student with variations in analytic mechanics results with the following details:

Table 1. Details and Classification of Interview Respondents

Year	Category	Initials	Origin	A score of Analytical Mechanics
2022	Non-local	NNF	Ngawi, East Java	C+
2022	Local	BKF	Kalasan, Sleman, DIY	B+
2021	Non-local	RK	Kebumen, Central Java	A
2021	Local	AYUA	Kalasan, Sleman, DIY	A
2020	Non-local	SH	Kuningan, West Java	A
2020	Local	RY	Sleman, Yogyakarta	A
2019	No-local	DZR	South Sumatra	B+
2019	Local	AAM	Magelang, Central Java	A

This research was conducted by interview and took place in the campus area of the Faculty of Mathematics and Natural Sciences, Yogyakarta State University, and online via chat on WhatsApp.

There are two main instruments in this study. The first instrument is through digital form media to map research subjects, containing a short profile of the interview in the form of full name, NIM (student's identity number), year of class, class, region of origin, current residence or boarding house address, the closest influential figure in motivation to enter or during college in the physics education department, last remembered analytical mechanics score and WhatsApp number to contact for online interview purposes. The digital form was then distributed through representatives of

each year of academic. The collected data facilitates the mapping of research subjects. Table 1 shows the obtained data.

The second instrument in data collection was the interview method with question transcripts compiled using a framework of 3 physics identity indicators according to Wang & Hazari [4], such as aspects of interest in learning physics (interest), self-perceived ability to carry out activities and understand physics (performance) successfully, and confidence in the recognition of others as physicists (recognition). These indicators were combined with the motivational indicators of the people closest to them, according to Charli et al. [25], which include interest, happiness, attention, and participation. Each indicator contains three questions arranged in an interview transcript format, preceded by an opening question, and delivered in a relaxed manner to interest the research subject in answering resulting in the following questions:

Table 2. Interview Transcript Based on Physics Identity and Motivation Indicators

Part	No	Question
Opener	1	Are you a boarding/non-local student? Where do you come from?
	2	Are you excited and interested in entering physics?
	3	Is there a difference in the pattern of studying physics between high school and college?
	4	What are the expectations for physics learning outcomes in lectures compared to high school learning outcomes?
Indicator 1	1	Have you always been interested and already have an interest in studying physics?
	2	Is there anyone who influenced/inspired you to take physics? Is it the same as the person who motivated you while studying physics?
	3	Were you interested in any particular physics subject before you started college? How about now?
Indicator 2	1	Do you feel confident in this major? Why?
	2	Do you feel that you have mastered a specific area of physics that makes you confident you can solve the problem?
	3	Have you encountered a problem while in physics, and how did you solve the problem?
Indicator 3	1	Do you feel proud as a physics student?
	2	How would you describe yourself as a physics student? What things about physics itself can be highlighted to you?
	3	Have you ever gotten a unique and different view from someone when you explained you were a physics student?

The design of research activities has been realized in the data collection stage, starting from literature studies by reading references from various digital sources regarding the formation of one's physical identity, student self-motivation, the role of the closest person in self-motivation, the link between self-motivation and learning outcomes, looking for research updates, research methodology, making questionnaires, testing the validity of data, and procedures for collecting data in

qualitative research that is good and right. This was done to ensure the study was understood. The next stage is situation analysis by determining the scope, total population, and research sample, making interview transcripts according to the indicators that have been read at the previous stage of the literature study. Data was collected by interviewing, recording, and documenting the results of each interviewee's answers. The answer is adjusted to the purpose of the question, and the essence is taken. The interview process only took two days with the division of tasks. The first author interviewed informants for the class of 2021-2022, the second author interviewed informants for the class of 2019-2020. The final stage, namely the validity test, is carried out in consultation with practitioners and lecturers in the field of physics and reading over and over again the answers that have been given, then linking them to the questions. Interview questions are valid if the interviewee can answer them in entirety.

The first data analysis technique consists of collecting data obtained from questionnaires and interviews, recorded objectively and as is, then collected based on each indicator. The data reduction, namely by only taking the essence of the results of interview answers, related to the 3 leading indicators of physical identity and the origin of motivation from the people closest to them. The data is presented descriptively, which explains each of the interviewees' answers.

Operational definitions to determine the boundaries and ways of measuring the variables to be studied [26] include the independent and dependent variables in this study, namely physics motivation, and identity, as well as 1 moderate variable, namely the closest person. Motivation is an internal and external drive toward self-confidence. The dependent variable, namely physics identity, contains a person's self-image of physics, which is influenced by competence, performance, and recognition. The closest people referred to in this study could be family members themselves (parents, siblings, grandmothers/grandfathers) or from outside the family such as friends, teachers, and lecturers.

C. Result and Discussion

Based on the interviews that have been conducted and recorded, it is found that there are differences in the origin of motivation and encouragement from the closest person in non-local (same region with college) students and local students (D.I.Yogyakarta). Not all local students (D.I.Yogyakarta) have motivation from the closest person in the form of family, while not all non-local (same region as college) students have motivation from peers.

Physics Identity

Interest

The competence and performance of students during their time as students majoring in physics education became an indicator of how interested these students

were in this department. The indicator mapping was divided into 3 questions. This is appropriate

Based on the results of the interviews in the opening section, most interviewees discovered their interest in studying physics since enrolling in university, while some did not. There were differences in the pattern of studying physics from high school to college because the lecture material was focused more on understanding concepts. This opening question also found that there was a phenomenon that actually lowered their expectations because the reality of learning physics in college was different from high school. Of all the answers collected, the reasons for AYUA were considered representative.

"For now, I'm lowering my expectations, because I'm still surprised by the impact of the transition (learning) online to offline. Of course, the expectations are much lower than studying physics in high school, both in terms of grades and all kinds. The problem is that learning physics is not that easy."

To find out more about the physical identity of each interviewee, the next questioning session began by asking questions related to indicators of interest, motivation, and relationships with those closest to them. The first question on this indicator aimed to strengthen the interviewee's answers to the questions in the opening session. Of the eight interviewees, two students were interested in studying physics since junior high school. This could also answer curiosity about who was the influential figure to take physics majors. An interviewer by AYUA said that everything came from oneself. In contrast, AAM stated that there were differences in the people closest to him who motivated him to become and while he was a physics student.

"My parents and counseling teachers influenced and inspired me to major in physics. Before entering college I consulted the grades with the guidance counselor so that I would be accepted by SNMPTN. During college, my peers had a positive impact on achievement while my lecturers also became people who motivated and gave me encouragement while I was studying."

From the aspect of material interest, there were still many material similarities that the interviewees preferred before and during their time as physics students. Some of the interviewees expressed interest in basic physics as one of the materials they had studied since junior high school. This proves the requirement for physics identity, namely learning consistency, as DZR said.

"So far, of all the courses you have received, the most interesting is basic physics, especially the history of physics. "

In addition to what is stated in the introductory paragraph, several supporting theories discuss how interest in self-identity can shape motivation. Interest in studying science, especially physics, can increase motivation and facilitate learning.

Confidence

Regarding self-confidence, several students initially did not have self-confidence in the first semesters. Unlike the case with students in the upper semester who found their confidence along with the experience they have taken.

"Actually, I'm not confident enough to enter this department because I used to think that all the people are Olympians" (NNF)

In terms of mastery of 1 particular field of physics, the interviewees from the lower class (2022) have yet to find it because only a few courses have been taken. Meanwhile, interviewees from the upper class have found 1 field of physics that they master.

"Yes, optics course. Which is one of the materials regarding parallel plan glass that I am good at. Moreover, I took the assistantship for the Optics practicum to teach the parallel plan glass practicum, which I think is sure to solve the problem." (SH)

There were several problems that the interviewees experienced during their studies. In this case, all the interviewees had almost similar answers, namely by reviewing the material until they understood it. The problems they encountered were both internal and external sources. Internal problems were such as mental and lack of understanding of physics that decreased learning achievement and self-confidence. External problems arising due to pandemic conditions and so on significantly influenced non-local and local students in lectures in the physics department.

Even though self-confidence and identity are two different things, the process of how these traits are created, the elimination of other attitudes and the guidance that has been obtained causes epistemic self-confidence to be formed and revised, resulting in different actions from the belief that self-confidence is the center of somebody's identity [27]

Self-Introduction as a Physics Student

From all the answers collected, all of the interviewees could identify themselves as physics learners. All respondents felt proud to be physics students. The interviewees were also assessed as competent to explain themselves as physics students and highlight physics-related things within them. Researchers take one of them as a representative answer.

"I explain and highlight that physics is a broad science, not just about falling apples. Physics is also useful for life, for example in electrical physics which makes us know how to prevent electrical problems such as short circuits, fires, and short circuits. For example, the concept of ride games such as kora-kora, ontang-anting, and anything around us is related to physics." (BKF)

There are various unique views that were obtained by the interviewees while being a physics student. RY confessed that "I was once considered crazy because I entered physics."

Motivation

Internal Motivation

AYUA and RY, local students, and NNF, non-local students explained that self-motivation was an individual drive goal attainment. The statistics showed that three of the eight interviewees freely answered. This reveals that non-local and local pupils' conditions did not motivate them. Students should be more self-motivated from their origins because self-awareness is stronger in influencing learning outcomes and creating one's physical identity. [28]

External Motivation

SH proposed that external motivation could come from both peers and inspirational figures, such as Yohanes Surya, who motivated him. The Indonesian physicist came across a video of Yohanes Surya teaching in remote Papua, which resulted in his students becoming Olympic champions. This action made SH want to study physics.

Five out of the eight interviewees were motivated by their closest individuals. Their parents were the closest ones to encourage them to study basic physics. Table 1 shows that the motivation of those closest to non-local and local students has a significant effect on analytical mechanics learning outcomes.

Comparison

Strong internal and external motivation influenced how respondents answered about their physics identity as physics education students. The majority of respondents (A), and those in the middle (B+ and C+), received significant motivation from their loved ones and themselves. All of the interviewees described their physical identification using interview markers. The confidence component distinguishes the identity indicator of physics from analytic mechanics, as BKF and DZR stated in separate interviews that they were first unconfident in being in the physics department.

D. Conclusion

Based on research results from interviews with eight respondents who represent non-local and local Department of Physics Education students, Yogyakarta State University class of 2019-2022, strong motivation, both from oneself and those closest to them, influences the formation of a physics identity. However, there is no difference between local and non-local students, especially compared to the analytical mechanics course grades.

References

[1] A. Johansson, "Analyzing Discourse and Identity in Physics Education: Methodological Considerations," in the *Physics Education Research Conference* (PERC), Sacramento, CA, USA, 2016.

[2] M. V. Bøe, "Staying recognized as clever: high-achieving physics students' identity performances," *Physics Education*, vol. 58, no. 3, p. 035012, 2023.
[3] L. S. Sri Anjelina, "Analysis of Attitudes towards Physics and Student Learning Outcomes at SMAN 7 Konawe Selatan," *Research Journal of Physics Education*, vol. 8, no. 1, pp. 10-18, 2023.
[4] J. W. Z. Hazari, "Promoting high school students' physics identity through explicit and implicit recognition," *Physical Review Physics Education Research*, vol. 2, p. 14, 2018.
[5] S. Hyater-Adams, "Critical look at physics identity: An operationalized framework," *Physical Review Physics Education Research*, 2018.
[6] Y. Calendar, "Why female science, technology, engineering, and mathematics majors," *Physical Review Physics Education Research*, 2019.
[7] M. D. A. Uchtiyani, "Effectiveness of Motivational Training to Improve Employee Performance at PT.X.," p. 1, 2020.
[8] R. R. R. Andriani, "Learning motivation as a determinant of student learning outcomes," *Journal of Office Management Education*, vol. 4, no. 1, pp. 80-86, 2019.
[9] A. Reski, "The Influence of Learning Facilities on Students' Motivation and Physics Learning Outcomes," *Musamus Journal of Science Education*, vol. 1, no. 1, pp. 001-008, 2018.
[10] Abroto, Maemonah, N. P. Ayu, "The Effect of Blended Learning Methods in Increasing Motivation and Learning Outcomes of Elementary School Students," *Edukatif: Journal of Education*, vol. 3 no.5, pp. 1993-2000, 2021.
[11] Daniati, "Efforts to Increase Student Motivation and Learning Outcomes by Applying the Google Classroom-Based E-Learning Learning Model during the Covid-19 Pandemic," *Journal of Education: Journal of Research Results and Literature Review in the Field of Education*, vol. 6, no. 3, pp. 601-608, 2020.
[12] N. S. Suseno, "The influence of gender, external and internal motivation on the perception of accounting students in choosing a career as a public accountant," *Journal of Communication at Garut University: Results of Thought and Research*, vol. 4, no. 2, pp. 75-98, 2019.
[13] S. Rahman, "The importance of learning motivation in improving learning outcomes," in the *National Basic Education Seminar*, Gorontalo, 2022.
[14] N. N. Rosa, "The relationship between social support and student online learning motivation during the Covid-19 pandemic," *TANJAK: Journal of Education and Teaching*, vol. 1, no. 2, pp. 147-153, 2020.
[15] Amseke, "Parents' social support, self-concept and student achievement motivation during the Covid 19 pandemic," *Muara Journal of Social Sciences, Humanities, and Arts*, vol. 5, no. 1, pp. 241-250, 2021.
[16] E. Terok, "The achievement motivation of badminton athletes in Tolitoli district is seen from the social support of parents, friends and coaches," *Journal of Sport Education (JOPE)*, vol. 5, no. 1, pp. 48-57, 2022.
[17] E. W. Suraida, "The Influence of Peer Social Support on the Achievement Motivation of Deaf Students in Inclusive Schools," *Bulletin of Psychology and Mental Health Research*, vol. 1, no. 2, pp. 1462-1467, 2021.
[18] O. Diferiansyah, "The difference in the level of anxiety between first-level medical students who live in boarding houses and with their parents," *Journal of Medicine*, vol. 4, no. 6, pp. 16-19, 2015.

[19] N. L. Choirunisa & A. Marheni, "Differences in achievement motivation and peer social support between overseas and non-migrant students at the Faculty of Medicine, Udayana University," *Udayana Journal of Psychology*, vol. 6, no. 1, pp. 21-30, 2019.
[20] S. Sudarji & F. Juniarti, "Grit differences in non-local and non-local students at university "x", " *Psyche: Journal of Psychology*, vol. 2, no. 1, pp. 1-10, 2020.
[21] X. Quichocho, E. W. Close, E. M. Schipull, "Understanding physics identity development through the identity performances of Black, Indigenous, and women of color and LGBTQ+ women in physics," in *Physics Education Research Proceedings 2020*, 2020.
[22] P. W. Irving, "Physics identity development: A snapshot of the stages of development of upper-level physics students," *Journal of the Scholarship of Teaching and Learning*, pp. 68-84, 2013.
[23] Z. Hazari, R. Dou, G. Sonnert, P. M. Sadler, "Examining the relationship between informal science experiences and physics identity: Unrealized possibilities," *Physical Review Physics Education Research*, vol. 18, no. 1, p. 010107, 2022.
[24] Sugiyono, Quantitative and Qualitative Education Methodology and R&D, Bandung: Alfabeta, 2019.
[25] L. Charli, T. Ariani, L. Asmara, "The Relationship between Learning Interest and Physics Learning Achievement," *SPEJ (Science and Physics Education Journal)*, vol. 2, no. 2, pp. 52-60, 2019.
[26] R. Ulfa, "Research Variables in Educational Research," *Al-Fatonah*, vol. 1, no. 1, pp. 342-351, 2021.
[27] A. H. Wildayanti, "The Relationship between Teacher Skills in Managing Classrooms in Learning," *Scientific Journal of Education Profession*, vol. 7, no. 2b, p. 600, 2022.
[28] T. Djudin, "How to Cultivate Students' Interests in Physics", *Journal of Science Education*, vol. 6, no. 1, pp. 16-22, 2018.

DOI: 10.14421/impulse.2023.42-06

IMPULSE: Journal of Research and Innovation in Physics Education
Volume 4, Issue 2, 129 – 141

© ISSN (p): 2798–1762; ISSN (e): 2798-1754
http://ejournal.uin-suka.ac.id/tarbiyah/impulse

The Relations between Self-Awareness and Self-Esteem with Student's Physics Learning Outcomes

Putri Kusumaningtyas[1*], Puspo Rohmi[1]

[1] Physics Education Study Program, UIN Sunan Kalijaga Yogyakarta, Indonesia
*Corresponding author: 20104050047@student.uin-suka.ac.id

ABSTRACT

This study investigates the relationship between self-awareness and self-esteem with students' physics learning outcomes. Employing a quantitative correlational approach, the research was conducted at MAN 3 Bantul, Yogyakarta, during the 2023/2024 academic year, involving 93 students from class XI MIPA through a saturated sampling technique. Data collection utilized self-awareness and self-esteem scales, documentation, and interviews. The data were analyzed using descriptive statistics and correlation tests, preceded by normality testing. The findings indicate a significant positive correlation between self-awareness and physics learning outcomes ($r = 0.387$, $p = 0.000$), suggesting that students with higher self-awareness tend to achieve better results, although the correlation strength is categorized as low. Similarly, self-esteem also shows a significant positive relationship with physics learning outcomes ($r = 0.396$, $p = 0.000$), indicating that increased self-esteem is associated with improved academic performance in physics. Despite the relatively low correlation values, both psychological variables contribute meaningfully to students' achievement. The study concludes that fostering self-awareness and self-esteem in the learning process is essential for enhancing students' academic success, particularly in physics education.

INTISARI

Penelitian ini bertujuan untuk mengetahui hubungan antara kesadaran diri dan harga diri dengan hasil belajar fisika siswa. Penelitian ini menggunakan pendekatan kuantitatif dengan jenis penelitian korelasional. Penelitian dilakukan di MAN 3 Bantul, Yogyakarta pada tahun ajaran 2023/2024 dengan melibatkan 93 siswa kelas XI MIPA melalui teknik sampling jenuh. Pengumpulan data dilakukan menggunakan skala kesadaran diri, skala harga diri, dokumentasi, dan wawancara. Analisis data dilakukan dengan statistik deskriptif dan uji korelasi, setelah terlebih dahulu dilakukan uji normalitas. Hasil penelitian menunjukkan adanya hubungan positif yang signifikan antara kesadaran diri dengan hasil belajar fisika ($r = 0{,}387$, $p = 0{,}000$), yang berarti siswa dengan tingkat kesadaran diri yang lebih tinggi cenderung memiliki hasil belajar yang lebih baik, meskipun kekuatan korelasinya termasuk kategori rendah. Demikian pula, harga diri juga menunjukkan hubungan positif yang signifikan dengan hasil belajar

ARTICLE HISTORY
Received: September 24, 2024
Accepted: April 26, 2025

KEYWORDS:
Physics learning outcomes, Self-awareness, Self-esteem.

KATA KUNCI:
Hasil belajar fisika, Self awareness, Self-esteem.

* Corresponding author:
Putri Kusumaningtyas, Physics Education Study Program, UIN Sunan Kalijaga Yogyakarta, Indonesia
20104050047@student.uin-suka.ac.id +62 88983064257

fisika (r = 0,396, p = 0,000), yang mengindikasikan bahwa semakin tinggi harga diri siswa, semakin baik pula pencapaian akademiknya dalam mata pelajaran fisika. Meskipun nilai korelasinya relatif rendah, kedua variabel psikologis ini terbukti memberikan kontribusi yang berarti terhadap prestasi belajar siswa. Penelitian ini menyimpulkan bahwa pengembangan kesadaran diri dan harga diri dalam proses pembelajaran perlu mendapat perhatian untuk mendukung peningkatan hasil belajar fisika siswa secara optimal.

A. Introduction

According to Law of the Republic of Indonesia Number 20 of 2003 concerning the Education System, education is defined as a deliberate and planned effort to establish a conducive learning environment, wherein students can proactively cultivate their potential. This encompasses components such as spiritual and religious fortitude, self-regulation, personality development, intelligence cultivation, the establishment of robust moral principles, and the acquisition of competencies that are advantageous to both the individual and the interests of society, the state, and the nation [1]. The significance of education lies in its capacity to enhance the quality of human resources, which is a pivotal element in a nation's development process [2]. Education endeavors to optimize the potential of individuals, enabling them to more effectively contribute to society. Consequently, education is recognized as a pivotal step in the life of every individual [3].

Student learning outcomes are one of the main indicators of the success of the education process. This achievement is influenced by various external and internal factors [4]. External factors include talent, interest, motivation, physical condition, environment, family, culture, and learning facilities. Meanwhile, internal factors include physiological aspects such as the use of the five senses, as well as psychological factors that include individual development and maturity [5]. One of the important psychological aspects that need to be developed in learning is self-awareness, which can help students recognize their weaknesses, emotions, and potential to encourage positive behavioral changes [6]. Self-awareness is the ability to recognize and understand emotions, thoughts, and sensations of the self that play an important role in personal decision-making [7], [8]. Self-awareness includes objective self-assessment, strong self-belief, understanding of context and situation [9], and the ability to manage emotions through emotional intelligence [10]. This thinking acumen is supported by an independent personality, psychological health, and a positive outlook on life [11], [12]. Thus, self-awareness is an important aspect of physics learning because it helps students recognize their strengths and weaknesses, manage academic stress, and increase focus and motivation in understanding complex concepts.

In addition to self-awareness, self-esteem is also a psychological factor that plays an important role in supporting students' learning success. Self-esteem can be defined as an individual's self-evaluation in relation to personal standards and perceived expectations of others, which tends to increase in proportion to one's awareness of personal value [13]. Self-esteem reflects one's positive or negative attitude towards oneself and becomes one of the important determinants in the learning process [14]. Research shows that students with high self-esteem tend to be more adaptable and have better academic achievement [15], [16]. This is because learners with high self-esteem tend to be able to anticipate situations based on their own abilities and thoughts, take responsibility for their actions, and have confidence in controlling their behavior and environment [5], [17]. Therefore, strengthening self-awareness and self-esteem needs to be considered in learning activities, especially in challenging subjects such as physics.

Physics is a subject that can be considered interesting and enjoyable since physics concepts can be connected to everyday phenomena [18]. However, in practice, this assertion is not entirely accurate. During an interview with a physics teacher at MAN 3 Bantul Yogyakarta, when students were asked why they did not attend class, the response indicated that they were afraid. The teacher attributes this to the prevailing perception of physics classes as intimidating and disconcerting for children. Additionally, students perceive physics as a challenging subject. Consequently, students encounter challenges in associating the learned material with its practical applications in their daily lives [19].

Based on interviews with physics teachers at MAN 3 Bantul Yogyakarta, it was found that student engagement in physics learning remains relatively low. Many students appeared unfocused and did not actively participate in learning activities. There is a noticeable disparity in engagement, with some students showing genuine interest, while others remain passive during lessons. Additionally, instances of students leaving the classroom during lessons for personal reasons, such as using the restroom, further indicate a lack of active participation in the learning process.

Further interviews exploring students' confidence in learning physics revealed that those who claimed to be confident often exhibited low levels of engagement during class. Many students were hesitant to respond to teachers' questions and lacked the initiative to seek alternative solutions when they were unsure. This lack of confidence correlates with poor academic performance, as shown by documentation of grade XI students' physics results, which remain below the minimum passing grade of 74, especially in topics such as traveling waves. Notably, no student achieved a perfect score, and the lowest score recorded was 20 in class XI MIPA 3. These findings highlight the need to enhance both student engagement and confidence to improve learning outcomes.

These challenges in physics learning suggest the presence of underlying psychological barriers that hinder students' ability to engage meaningfully with the

subject. However, limited research has explored how internal psychological factors, such as self-awareness and self-esteem, contribute to students' engagement and achievement in physics learning contexts. Based on this description, researchers are interested in investigating the extent of the relationship between self-awareness and self-esteem on students' learning outcomes in physics. This study focused on Grade XI students to see the relationship between these two psychological factors and their academic performance. Thus, this study is expected to contribute to efforts to improve the effectiveness of physics learning through approaches that consider students' psychological conditions.

B. Method

This research utilizes a quantitative approach, specifically categorized as correlational research, as it aims to examine the relationship between variables. The study was carried out at MAN 3 Bantul Yogyakarta during the second semester of the 2023–2024 academic year, specifically in July 2024. The participants in this research were students from class XI MIPA, who were selected to explore the connections between psychological factors and their physics learning outcomes.

The study's sample was determined using saturated sampling, also known as total sampling, which falls under the category of non-probability sampling. Saturated sampling is a sampling technique in which every member of the population is considered a sample. The population of this study comprised the students of MAN 3 Bantul Yogyakarta class XI MIPA, with a total of 93 students. The study's sample comprised 93 students from grade 11 MIPA at the State Aliyah Madrasah in the Yogyakarta area. The rationale behind employing the entire population as a sample is that these students are considered a representative sample of the larger population. This approach aligns with Arikunto's [20] assertion that, for sample sizes less than 100, it is preferable to utilize the entire population, thereby ensuring the study's validity as a population study. In instances where the population is substantial, a more judicious approach entails the selection of 10-15% or 20-25% of the population, as outlined by Arikunto [20]. In this study, the population was less than 100, thus researchers made the entire population into research samples, or saturated samples of 93. Table 1 shows sample data based on gender.

Table 1 Demographics of Respondents Based on Gender

Gender	Number of Students	Persentage of Respondents
Male	36	38,7%
Female	57	61,3%
Total	93	100%

Data collection in this study was carried out through three methods, namely tests, documentation, and interviews. The tests used were psychological tests with Likert

scale instruments to measure students' self-awareness and self-esteem. This scale was designed to take the scores of the two variables, which were then analyzed to see the relationship with physics learning outcomes. The validation of the self-awareness and self-esteem questionnaire instruments was carried out using content validity. This type of validity was assessed through expert judgment by consulting with three subject matter experts [21]. To quantify the results of the expert evaluations, the Content Validity Ratio (CVR) method developed by Lawshe was applied [22]. Based on the validation process, all items in both the self-awareness and self-esteem questionnaires received a CVR value of 1. This indicates that all three experts unanimously agreed that each statement item was essential. As a result, all 31 items in the self-awareness instrument and all 43 items in the self-esteem instrument were declared content valid and suitable for use in the study.

In addition, the documentation technique was used to obtain data on even semester final assessment (PAS) scores for the 2023/2024 academic year. The students' PAS scores were obtained from the physics teacher of class XI MIPA at MAN 3 Bantul, Yogyakarta, and then the average was calculated. Interview technique was also applied to complete the research data. The interview was conducted with the physics teacher before the implementation of the research and with three students after the research was completed. The interviews aimed to obtain inclusive, comprehensive, and in-depth information related to students' engagement and confidence in physics learning. The data obtained from the three methods complement each other to provide a complete picture of the relationship between self-awareness, self-esteem, and students' physics learning outcomes.

C. Result and Discussion

This study aims to determine the relationship between self-awareness and self-esteem with physics learning outcomes of students in class XI MIPA at MAN 3 Bantul Yogyakarta. Data on self-awareness and self-esteem were obtained through tests using a questionnaire instrument with a Likert scale that includes positive and negative statements, with scores ranging from 1 (strongly disagree) to 5 (strongly agree). This questionnaire was distributed to the entire research sample. The self-awareness questionnaire instrument was adapted from research conducted by Sari [23], which includes three indicators of self-awareness, namely accurate self-recognition, self-confidence, and the ability to recognize emotions, which were described in 31 statements. These indicators are based on the concept of self-awareness, according to Baron & Byrne [24]. Meanwhile, the self-esteem questionnaire instrument was adapted from Maliana's research [25], which includes three indicators, namely feelings of acceptance, feelings of ability, and feelings of worth, which are described in 43 statements. These indicators refer to the components of self-esteem according to Felker [26]. The content validity of the adapted instrument was tested by three

experts using CVR (Content Validity Ratio) developed by Lawshe [22], and all statements were declared valid with an average value of 1.

Data on physics learning outcomes were obtained from the documentation of the results of the Physics End of Semester Assessment (PAS) in even semester which was held on May 27, 2024. The materials tested on the PAS include sound waves, optical devices, and global warming symptoms. The PAS questions consisted of 25 multiple choice questions covering topics such as the Doppler effect, convex mirrors, positive lenses, types of optical devices, eye defects, as well as calculations of lens power and microscope magnification. These questions were prepared by the class teacher according to the material taught during the even semester of the 2023/2024 academic year.

After the data was collected, descriptive statistical analysis was conducted to provide an overview of the data obtained without drawing general conclusions [25]. This analysis produces a description of the data in the form of mean, standard deviation, highest score, and lowest score. The results of the descriptive analysis of the data of the three research variables are shown in Table 2. This descriptive statistical analysis helps in understanding the distribution of the values of the variables in the sample and provides an initial understanding of the variables studied.

Table 2 Descriptive Analysis Results for Each Research Variable

Descriptive Statistic Parameters	**Research Variable**		
	Self-awareness	**Self-esteem**	**Student Physics Learning Outcomes**
Lowest Value	33	77	40
Highest Value	139	188	88
Average	74,90	144.0968	66.19355
Standard Deviation	21.42	19.25067	11.74388

To meet the prerequisites for conducting a correlation test, normality and linearity tests were performed to assess the distribution and relationship patterns of the study variables. The Kolmogorov-Smirnov test, conducted using IBM SPSS Statistics 16, was employed to test for normality. The results showed significance values (Sig.) greater than 0.05 for self-awareness, self-esteem, and physics learning outcomes, indicating that the data are normally distributed. Additionally, the linearity test results also showed significance values greater than 0.05 for each variable pair, confirming that the relationships among the variables are linear.

To examine the relationship between self-awareness and self-esteem with physics learning outcomes, a Product Moment correlation test was conducted using the IBM SPSS Statistics 16 program. The results are summarized in Table 3 and Table 4.

Table 3 Correlation Test Results of Self-awareness and Physics Learning Outcomes

Data	Self-Awareness*Learning Outcome
Sig.	0,000
A	0,05
Pearson Coefficient	0,387
Terms	Asym. Sig < α, then the self-awareness variable is related to the physics learning outcomes variable
Conclusion	Self-awareness variable is related to physics learning outcome variable

Table 4 Correlation Test Results of Self-esteem and Physics Learning Outcomes

Data	Self-esteem*Learning Outcome
Sig.	0,000
A	0,05
Pearson Coefficient	0,396
Terms	Asym. Sig < α, then the self-esteem variable is related to the physics learning outcomes variable
Conclusion	Self-esteem variable is related to physics learning outcome variable

Table 3 and Table 4 show that both self-awareness and self-esteem have a significant relationship with physics learning outcomes, as indicated by significance values (Sig.) less than 0.05. This confirms that the variables are statistically correlated. However, the Pearson Correlation coefficients of 0.387 for self-awareness and 0.396 for self-esteem indicate that the strength of these relationships is relatively low.

Relation between Self-awareness and Physics Learning Outcomes

The correlation test results presented in Table 3 show that there is a significant relationship between self-awareness and physics learning outcomes of students in class XI MIPA at MAN 3 Bantul Yogyakarta. Self-awareness in this study is measured through three main indicators, namely accurate self-recognition, self-confidence, and ability to recognize emotions. To gain a deeper understanding of the tendency of scores on the self-awareness instrument and its relationship with students' learning outcomes, researchers conducted interviews with three respondents who were randomly selected based on their scores on the self-awareness scale and physics learning outcomes.

On the first indicator, accurate self-recognition, exploration was conducted through the statement “I compare myself with others”. The interview results showed that respondents gave various answers. Respondent 1 who had high self-awareness scores and learning outcomes answered no, with the reason being that she wanted to love herself and accept her shortcomings. In contrast, respondents 2 and 3 who have moderate self-awareness scores and learning outcomes answered yes, with the motivation to improve themselves. Furthermore, on the statement “I don't know what

I am good at", all three respondents answered no, indicating that they have recognized their respective interests and potentials, although they have not fully mastered them. This data indicates that students with accurate self-recognition tend to know the best way to learn and adapt it to their potential, which contributes to better learning outcomes. This is in line with the findings of Qowimah et al. [27] who stated that self-recognition is an important foundation in academic achievement.

The second indicator, self-confidence, includes aspects of responsibility, decision-making and future planning. All respondents answered no to the statement "I am lazy to do physics assignments", which indicates a sense of responsibility towards the learning process. However, differences emerged in the statement "I find it difficult to be consistent with my own decisions". Respondent 1 (high learning score) answered no because she has a strong stance, while respondents 2 and 3 (medium and low learning scores) answered yes because they are easily influenced by friends' opinions. This difference reinforces the finding that students with high levels of self-confidence are not only able to plan for their future but are also consistent in their learning actions, which contributes to high learning outcomes. This result is supported by Mumpuni's research [28] which confirms that self-confidence is positively correlated with academic achievement.

The third indicator, the ability to recognize emotions, includes the ability to manage emotions, be assertive, and adapt to the environment. On the statement "I am able to do all the tasks myself", respondents 1 and 3 answered no because they felt they still needed help, while respondent 2 answered yes if they understood the material. The learning outcomes of these respondents also reflect that students who can recognize emotions tend to be able to adjust how they learn to their emotional and social conditions. In addition, on the statement "I accept well any criticism addressed to me", all respondents answered yes, which shows that they have openness to input. This is an important factor in improving learning outcomes, as criticism is considered a means of self-evaluation. This finding is reinforced by Maharani and Mustika's research [9], which states that emotion management contributes to learning effectiveness.

Statistically, the Pearson Product Moment correlation test results produced a significance value of 0.000 with a correlation coefficient of 0.387 which indicates a significant relationship between self-awareness and student physics learning outcomes. Although the strength of the correlation is low, this significant relationship indicates that an increase in students' self-awareness is directly proportional to an increase in physics learning outcomes. Conversely, students with low self-awareness scores tend to have lower learning outcomes. The consistency between quantitative data and interview results reinforces the conclusion that self-awareness is an important factor affecting students' academic achievement. This finding is also in line with the research of Taufiq et al. [29] which emphasized the importance of self-awareness in

motivating students to learn physics, as well as Nafi'ah's research [30] which proved a positive relationship between self-awareness and student achievement. Thus, it can be accepted that there is a significant relationship between self-awareness and physics learning outcomes of students in class XI MIPA at MAN 3 Bantul Yogyakarta.

Relation between Self-esteem and Physics Learning Outcomes

The self-esteem component in this study includes three main indicators, namely feelings of acceptance, feelings of ability, and feelings of worth. These three indicators are closely related to the student learning process as reflected in the self-esteem scale statements. To strengthen the quantitative results regarding the relationship between self-esteem and physics learning outcomes, interviews were conducted with three respondents who had different self-esteem scores and physics learning outcomes.

The first indicator, feeling accepted, was explored through the statement "it took me a long time to adjust". Respondents 1 and 2 answered "yes", while respondent 3 answered "no". Respondent 1, who had moderate physics learning outcomes, felt the need to understand the situation before interacting, while respondent 2, although extroverted, found it difficult to start a conversation. Respondent 3, who had higher learning outcomes, stated that she had no difficulty adjusting. The ability to adapt to the social environment shows that students who feel accepted will be more comfortable in the learning environment, more active in discussions, and open to cooperation, which has a positive impact on learning outcomes.

On the statement "I prefer to talk with friends rather than pay attention to the subject matter in class", all respondents answered "no". This shows an awareness to focus on learning to achieve good grades. This attitude reflects that social acceptance does not necessarily distract from the learning process but can support student engagement in class. This finding is in line with the results of Nuraini's research [4] which states that students with good feelings of acceptance will more easily adjust to group learning, which has a positive impact on learning outcomes.

The second indicator, feeling capable, was examined through the statement "I do not feel proud of myself". All three respondents answered "no", indicating that they have pride in their own achievements, even though their grades are not high in general. This is in line with the achievement of student learning outcomes, because students who feel capable will be more confident in facing academic challenges and tend to set realistic and measurable learning targets.

On the statement "I complain easily if I feel difficult", respondents 1 and 3 (with high learning outcomes) answered "no", indicating perseverance and adaptive strategies such as asking friends. In contrast, respondent 2 (with lower learning outcomes) answered "yes", but only complained to herself, not to others. This finding shows that students who feel capable tend to have resilience in dealing with learning difficulties, which has a positive impact on their learning outcomes. This is reinforced

by Verdianingsih's findings [14] showing that feelings of capability correlate with clear academic goals and high learning enthusiasm.

The third indicator, feelings of worth, was examined through the statement “I often imagine being someone else”. Respondents 1 and 3 answered “no”, indicating self-acceptance, while respondent 2 answered “yes”, because she imagines being the one who is prioritized in the family. In terms of learning outcomes, respondents who perceive themselves as valuable tend not to compare themselves negatively, and focus more on self-development, which affects their academic performance.

In the statement "I easily panic when working on tasks that I am not proficient in," respondent 1 (high academic achiever) answered "yes," indicating performance pressure, but still did their best. Respondents 2 and 3 answered "no," using strategies such as seeking references and asking friends. This indicates that a sense of worth encourages students to manage academic stress better, which impacts the quality of their learning outcomes. Nopirda et al. [17] also emphasize that students who can self-assess positively tend to have good emotional management skills in learning.

The results of the second correlation test reinforce the interview findings, indicating that there is a significant relationship between self-esteem and students' physics learning outcomes. The results of the Pearson correlation test show a significance value of 0.000 and a coefficient of 0.396, which falls into the category of low but significant correlation. This means that an increase in self-esteem tends to be followed by an improvement in students' physics learning outcomes. These findings are consistent with the research of Astika et al. [31] and Hidayat & Perdana [32], which show a positive relationship between self-esteem and academic achievement. Moreover, individuals with high self-esteem tend to be more confident, have better self-control, and strive to actualize themselves through optimal academic achievements [35]. Thus, the interview results reinforce the quantitative findings that self-esteem is an important psychological factor influencing students' academic achievements, particularly in physics learning. It can be concluded that there is a significant relationship between self-esteem and the physics learning outcomes of XI MIPA students at MAN 3 Bantul Yogyakarta.

D. Conclusion

Based on the results of research on the relationship between self-awareness and self-esteem with physics learning outcomes of grade XI students at MAN 3 Bantul, Yogyakarta, it is concluded that there is a significant relationship between the two psychological variables and student physics learning outcomes. First, there is a significant relationship between self-awareness and physics learning outcomes of students in class XI MIPA, with a correlation value of 0.387 and a significance of 0.000. Although this correlation is in the low category, this result shows that the higher the level of self-awareness of students, the better the physics learning outcomes tend

to be. Second, self-esteem also shows a significant relationship with physics learning outcomes, with a correlation value of 0.396 and a significance of 0.000. Just like self-awareness, this relationship is also in the low category but still shows a positive influence between students' self-esteem and academic achievement in physics subjects. The conclusion of this study shows that self-awareness and self-esteem have a significant relationship with the physics learning outcomes of students in class XI MIPA at MAN 3 Bantul, Yogyakarta. Although the correlation level is relatively low, these two psychological factors are proven to contribute positively to students' academic achievement. Therefore, the development of self-awareness and self-esteem in the learning process needs attention to optimally support the improvement of students' physics learning outcomes.

References

[1] Peraturan Pemerintah RI, "Undang-Undang Republik Indonesia Nomor 20 Tahun 2003 Tentang Sistem Pendidikan Nasional," 2003, *Balitbang, Depdiknas, Jakarta*.

[2] N. Omeri, "Pendidikan Karakter dalam Dunia Pendidikan," *Anwarul*, vol. 3, no. 5, pp. 1044–1054, 2023, doi: 10.58578/anwarul.v3i5.1457.

[3] A. K. Latif, "Pengaruh Self Esteem dan Self Regulation Terhadap Hasil Belajar Matematika Siswa Kelas XI Madrasah Aliyah Guppi Samata Kabupaten Gowa," Skripsi, Program Studi Pendidikan Matematika, Universitas Alauddin Makassar, 2016.

[4] R. Nuraini, "Pengembangan Self-Esteem (Harga Diri) dalam Pembelajaran Pendidikan Agama Islam Di SMKN 1 Ponorogo," *Tarbawi Ngabar: Jurnal of Education*, vol. 2, no. 2, pp. 131–151, 2021, doi: 10.55380/tarbawi.v2i2.79.

[5] D. A. Zahroh and D. K. Dewi, "Hubungan Antara Self-Esteem dengan Prestasi Belajar Siswa di SMA X," *Character Jurnal Penelitian Psikologi*, vol. 9, no. 3, pp. 140–162, 2022.

[6] A. N. J. Naim, "Pengaruh Model Self-Regulated Learning Terhadap Peningkatan Motivasi Belajar dan Kesadaran Diri (Self Awareness) Siswa dalam Pembelajaran Pendidikan Jasmani," Tesis, Institut Agama Islam Ponorogo, Ponorogo, 2020.

[7] D. Goleman and R. Boyatzis, "Emotional intelligence has 12 elements. Which do you need to work on," *Harv Bus Rev*, vol. 84, no. 2, pp. 1–5, 2017.

[8] T. A. Karsli, "Relation among meta-cogntition level, decision making, problem solving and locus of control in a Turkish adolescent population," *Procedia-Social and Behavioral Sciences*, vol. 205, pp. 35–42, 2015.

[9] L. Maharani and M. Mustika, "Hubungan Self Awareness dengan Kedisiplinan Peserta Didik Kelas VIII di SMP Wiyatama Bandar Lampung (Penelitian Korelasional Bidang Bk Pribadi)," *KONSELI : Jurnal Bimbingan dan Konseling (E-Journal)*, vol. 3, no. 1, pp. 57–72, 2017, doi: 10.24042/kons.v3i1.555.

[10] P. Mumpuni, S. Inganah, and W. Sugiarti, "Penerapan model pembelajaran window shopping materi vektor untuk meningkatkan hasil dan minat belajar matematika," *Jurnal Math Educator Nusantara: Wahana Publikasi Karya Tulis*

Ilmiah di Bidang Pendidikan Matematika, vol. 6, pp. 115–126, Nov. 2020, doi: 10.29407/jmen.v6i2.12827.
[11] J. Carden, R. J. Jones, and J. Passmore, "Defining self-awareness in the context of adult development: A systematic literature review," *Journal of Management Education*, vol. 46, no. 1, pp. 140–177, 2022.
[12] M. A. Setiawan, "Pengaruh Self Awareness dan Self Esteem Terhadap Hasil Belajar Matematika Siswa," Skripsi, Program Studi Pendidikan Fisika, Universitas Islam Negeri Sunan Kalijaga, Yogyakarta, 2022.
[13] L. Mocanu and A. I. Spanache, "Self-Esteem," *New Trends in Psychology*, vol. 3, no. 1, 2021.
[14] E. Verdianingsih, "Self-Esteem Dalam Pembelajaran Matematika Self-Esteem in Mathematics Education," Skripsi, Fakultas Ilmu Pendidikan, Universitas K.H.A. Wahab Hasbullah, 2017.
[15] A. S. Pamungkas, Y. Setiani, and H. Pujiastuti, "Peranan pengetahuan awal dan self esteem matematis terhadap kemampuan berpikir logis mahasiswa," *Kreano, Jurnal Matematika Kreatif-Inovatif*, vol. 8, no. 1, pp. 61–68, 2017.
[16] F. Rahma, A. Ridwan, and F. Diba, "Self-esteem Selama Penyusunan Skripsi pada Mahasiswa Keperawatan," *Jurnal Ilmiah Mahasiswa Fakultas Keperawatan*, vol. 7, no. 2, 2023.
[17] Y. Nopirda, O. Oktivianto, and N. R. Dhevi, "Hubungan Self Esteem Dan Orientasi Masa Depan Bidang Pendidikan Pada Siswa Kelas Xi Di Palembang," *Jurnal Pendidikan Glasser*, vol. 4, no. 2, pp. 107–116, 2020, doi: 10.32529/glasser.v4i2.721.
[18] A. R. Harefa, "Peran Ilmu Fisika Dalam Kehidupan Sehari-Hari," *Majalah Ilmiah Warta Dharmawangsa*, vol. 13, no. 2, pp. 1829–7463, 2019.
[19] G. B. Samudra, I. W. Suastra, and K. Suma, "Permasalahan-Permasalahan yang Dihadapi Siswa SMA di Kota Singaraja dalam Mempelajari Fisika e-Journal Program Pascasarjana Universitas Pendidikan Ganesha," *e-Journal Program Pascasarjana Universitas Pendidikan Ganesha*, vol. 4, 2014.
[20] S. Arikunto, *Prosedur Penelitian: Suatu Pendekatan Praktek*. Jakarta: Rineka Cipta, 2006.
[21] B. I. Sappaile, "Konsep Instrumen Penelitian Pendidikan," *Journal Pendidikan dan Kebudayaan*, no. May 2007, pp. 59–75, 2019, doi: https://www.researchgate.net/publication/338630469.
[22] C. H. Lawshe, "A Quantitative Approach To Content Validity," *Pers Psychol*, vol. 28, pp. 563–575, 1975, doi: 10.3412/jsb.16.926.
[23] N. R. Sari, "Penerapan Teknik Role Playing Untuk Meningkatkan Self Awareness Siswa MAN 1 Aceh Jaya," Skripsi, Program Studi bimbingan Konseling, Universitas Islam Negeri Ar-Raniry Darussalam Banda Aceh, 2020.
[24] R. A. Baron and D. Byrne, *Psikologi Sosial Jilid 1*, Edisi 10. Jakarta: Erlangga, 2003.
[25] A. F. Maliana, "Perbedaan Harga Diri (Self Esteem) Siswa Antara Pola Asuh Orang Tua Otoriter Dengan Demokratis Kelas X Di Sma Negeri 1 Kedungwuni Kab. Pekalongan Tahun 2015/2016," *Jurnal Bimbingan Konseling*, pp. 1–151, 2016.

[26] D. W. Felker, *Helping Children to Like Themselves*. Burgess: Company, 1974. doi: 0808706284.
[27] S. N. Qowimah, K. J. Almahira, D. A. Rahma, A. B. Satrio, and H. M. Nuzul, "Hubungan Self Confidence dan Self Awareness dengan Komunikasi Efektif pada Mahasiswa Relationship between Self Confidence and Self Awareness with Effective Communication in Students," *Indonesian Psychological Research*, vol. 03, no. July, pp. 109–120, 2021, doi: 10.29080/ipr.v3i2.565.
[28] T. Mumpuni, "Hubungan Self Awareness Dengan Kedisiplinan Peserta Didik Kelas Vi Di Mi An Nur Deyangan Mertoyudan Tahun Pelajaran 2017 / 2018," *Prosiding Konferensi Nasional Ke- 7 Asosiasi Program Pascasarjana Perguruan Tinggi Muhammadiyah Aisyiyah (APPPTMA)*, pp. 385–395, 2018.
[29] A. U. Taufiq, Kartina, and H. Djafar, "Pengaruh Model Pembelajaran Awareness Training terhadap Motivasi Belajar Fisika," *Jurnal Pendidikan Fisika*, vol. 7, no. 1, pp. 12–16, 2019.
[30] H. Nafi'ah, "Pengaruh Self Awareness Terhadap Prestasi Belajar Bahasa Arab Siswa Kelas VIII MTs Nurul Ummah Kotagede Tahun Ajaran 2021/2022," Skripsi, Program Studi Pendidikan Bahasa Arab, Universitas Islam Negeri Sunan Kalijaga Yogyakarta, 2022.
[31] I. W. M. Astika, I. N. P. Suwindra, and I. B. P. Mardana, "Hubungan Self-Efficacy Dan Self-Esteem Dengan Prestasi Belajar Fisika Siswa Di Kelas X Mipa Sma Negeri," *JPPF*, vol. 8, no. 2, pp. 2599–2554, 2018.
[32] A. Hidayat and F. J. Perdana, "Pengaruh Self-Efficacy dan Self-Esteem Terhadap Prestasi Belajar Mahasiswa Pada Sekolah Tinggi Ilmu Kesehatan Cirebon," *Syntax Literate ; Jurnal Ilmiah Indonesia*, vol. 4, no. 12, p. 1, 2019, doi: 10.36418/syntax-literate.v4i12.824.

Published by
Pendidikan Fisika
UIN Sunan Kalijaga Yogyakarta