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LOW SCIENTIFIC LITERACY OF PHYSICS EDUCATION STUDENTS ON MECHANICAL ENERGY IN EVERYDAY CONTEXTS

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Abstract

Scientific literacy is a key competency for prospective physics teachers, particularly in connecting physics concepts to everyday phenomena. This study aims to examine the level of scientific literacy among Physics Education students on mechanical energy topics using real-life contexts. A descriptive quantitative approach was applied to a group of 30 undergraduate students enrolled in a physics teacher education program. Scientific literacy was assessed through context-based tasks focused on everyday mechanical energy phenomena. The results indicate that the average scientific literacy score was 37.33, placing it in the low category. In total, more than 60% of the students demonstrated low to very low levels of scientific literacy, suggesting that most participants have not yet developed sufficient competence in applying mechanical energy concepts to real-world situations. When analyzed by gender, female students had higher average scores than male students, although their performance was more variable. These findings reveal persistent challenges that prospective physics teachers face in interpreting and applying physics knowledge meaningfully in everyday contexts. The study underscores the importance of integrating context-based and literacy-oriented instructional approaches in physics teacher education programs to better equip future teachers with the skills necessary to promote scientific literacy among secondary school students.

Keywords: context of everyday life, mechanical energy, physics education, physics learning, physics education students, scientific literacy

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INTRODUCTION

Contemporary education emphasizes not only the mastery of theoretical knowledge but also the ability to apply scientific understanding in everyday life (Sanjaya, 2016). This paradigm is particularly relevant in physics learning, as physics plays a fundamental role in helping learners interpret natural phenomena encountered in daily experiences (Trianto, 2015). Consequently, physics instruction should prioritize both conceptual understanding and the application of concepts within real-world contexts (Depdiknas, 2006; Rusman, 2017). Within this framework, scientific literacy has emerged as a crucial competence in science education. Scientific literacy refers to an individual's capacity to engage with scientific issues, explain phenomena scientifically, interpret data and evidence, and evaluate or design scientific investigations as a reflective citizen (OECD, 2019).

In the context of 21st-century education, scientific literacy is essential as it encompasses critical thinking, evidence-based reasoning, and responsible decision-making in everyday life (Bybee, 2013). For physics education students, who are prospective teachers, scientific literacy is particularly important because it directly influences their ability to design meaningful learning experiences and foster students' understanding of physics concepts beyond rote memorization. Scientific literacy requires not only theoretical mastery but also the ability to relate physics concepts to everyday phenomena, thereby making learning contextual and meaningful. This competence enables prospective teachers to promote students' critical thinking and conceptual understanding through real-life examples. However, previous studies indicate that the scientific literacy of prospective physics teachers remains insufficient to meet the demands of contemporary science education, which emphasizes the application of knowledge in real-world contexts (Muhajir et al., 2021).

Although strong scientific literacy has been shown to enhance teachers' ability to explain physics concepts in practical and relevant ways (Muhajir et al., 2021), physics instruction often remains abstract and dominated by mathematical procedures, limiting meaningful understanding (Santika et al., 2022). Empirical evidence consistently shows that students are more accustomed to solving algorithmic physics problems involving calculations and formula substitution. When confronted with contextual or story-based problems, many students struggle to identify relevant concepts and interpret the situation's physical meaning (McDermott & Redish, 1999). This tendency suggests that students' conceptual understanding remains fragmented and theoretical, rather than integrated with scientific reasoning skills required for everyday decision-making (Bybee, 2013). Such conditions indicate a persistent gap between the acquisition of physics knowledge and its application in real-life contexts.

Mechanical energy is a fundamental concept in physics, closely linked to everyday experiences, including cycling up hills, transportation systems, and recreational activities (Nisbah et al., 2017; Turiman et al., 2014). Understanding mechanical energy enables learners to recognize the continuous energy transformations in daily life, making it a suitable domain for assessing scientific literacy (Gormally et al., 2012; Sujana et al., 2014). Despite its contextual relevance, research has reported that many prospective physics teachers hold misconceptions about work and energy, particularly regarding the principle of mechanical energy conservation (Ustari et al., 2024). Instructional practices that emphasize mathematical solutions over conceptual interpretation further exacerbate students' difficulties in connecting energy concepts to contextual phenomena (Wulandari et al., 2016; Hernani et al., 2018; Rusilowati et al., 2016). These findings suggest that students tend to rely on procedural and mechanistic approaches rather than reflective scientific reasoning, limiting their ability to construct scientific arguments, interpret data, and relate physics concepts to everyday situations (Fives et al., 2014; Jufrida et al., 2019).

As a result, their preparedness as future physics teachers to guide students meaningfully remains suboptimal. Moreover, higher education learning practices that predominantly emphasize mathematical-theoretical mastery have been identified as a contributing factor to low scientific literacy among physics education students (Ismail et al., 2023). Although numerous studies have examined scientific literacy in science education, empirical data on the scientific literacy of prospective physics teachers, assessed in everyday contexts, remain scarce, particularly regarding mechanical energy. Most existing research focuses on general literacy levels or on school students, leaving a gap in understanding of how well students of physics education can contextualize core physics concepts in real-world situations. Addressing this gap is essential, as prospective teachers' scientific literacy directly influences the quality of physics instruction they will provide.

This study makes a novel contribution by providing a focused description of physics education students' scientific literacy regarding mechanical energy in everyday-life contexts, thereby offering empirical evidence on how prospective teachers connect abstract physics concepts with real-world phenomena. By emphasizing mechanical energy, this study highlights a core topic in physics that is both conceptually fundamental and contextually rich. Accordingly, the objective of this study is to describe the scientific literacy skills of Physics Education students on mechanical energy concepts using everyday life contexts. Specifically, this research seeks to answer the following guiding question: *To what extent can prospective physics teachers apply mechanical energy concepts scientifically in real-world situations?* The findings of this study are expected to serve as a basis for evaluating and improving physics instruction in higher education and to inform the development of context-based learning strategies that enhance scientific literacy and better prepare future physics teachers for 21st-century educational demands.

LITERATURE REVIEW

Scientific Literacy

Scientific literacy is understood as an individual's ability to grasp scientific concepts and processes and to apply them to explain phenomena in everyday life (OECD, 2019). Scientific literacy not only requires mastery of scientific knowledge but also encompasses the ability to think critically, reason scientifically, and make decisions based on scientific evidence (Bybee, 2013). In this context, scientific literacy is understood as a skill that enables individuals to engage with developments in modern science and technology reflectively and responsibly, and to participate in social life (Holbrook & Rannikmae, 2009). Developing scientific literacy in the learning process focuses not only on cognitive aspects but also on students' ability to connect scientific concepts to real-life situations, thereby making learning more meaningful (Dragoş & Mih, 2015). Individuals with strong scientific literacy are expected to interpret scientific data, evaluate information, and understand the role of science in everyday decision-making (Fives et al., 2014). Therefore, scientific literacy is a crucial indicator in assessing the quality of science education and the readiness of the younger generation to face global challenges in science and technology (Gormally et al., 2012).

Scientific literacy is crucial for preparing students to meet the challenges of 21st-century learning, which demands higher-order thinking and scientific problem-solving skills (Muhajir, Masara, & Ramdani, 2021). Physics instruction that integrates everyday contexts has been shown to improve scientific literacy by helping students connect abstract concepts to real-life experiences. This phenomenon indicates that as income increases, consumption also rises, although not in the same proportion (Rahmawati et al., 2021). Furthermore, scientific literacy is necessary for prospective physics teachers to design meaningful, contextual, and relevant learning that meets students' needs in the modern era (Jufrida et al., 2019).

Mechanical Energy

Mechanical energy is a combination of kinetic and potential energy and plays a crucial role in explaining various phenomena of motion in everyday life (Nisbah, Fadhilah, & Ramli, 2017). Understanding the concept of mechanical energy is necessary for individuals to scientifically interpret energy changes that occur in a physical system (Turiman et al., 2014). Mechanical energy is a fundamental concept that explains the relationship between work, force, and the law of conservation of energy (Santika et al., 2022). Although mechanical energy is fundamental, research indicates that students often struggle to fully understand the relationships among work, kinetic energy, potential energy, and mechanical energy (Wulandari et al., 2016). This difficulty is often caused by learning that emphasizes mathematical solutions rather than the underlying conceptual meaning (Ustari et al., 2024). This situation leads students to memorize formulas without understanding the underlying physical processes, resulting in limited conceptual understanding of mechanical energy (Nisbah et al., 2017). Learning about mechanical energy in everyday contexts has been shown to improve students' understanding by linking abstract concepts to real-life phenomena (Rahmawati et al., 2021). A context-based approach also encourages students to engage in deeper scientific reasoning to understand energy changes in various physical situations (Turiman et al., 2014). Therefore, reinforcing the concept of mechanical energy through contextual and meaningful learning is essential to improving the scientific literacy of prospective physics teachers (Santika et al., 2022).

METHOD

General Background

This study used a descriptive quantitative approach. This approach was chosen because the study did not aim to test hypotheses, compare treatments, or establish causal relationships among variables, but rather to describe and analyze the scientific literacy skills of physics education students regarding mechanical energy. In the descriptive quantitative approach, the data are numerical and analyzed using descriptive statistics to provide a realistic picture of students' ability to answer scientific literacy questions. The data consisted of scientific literacy test scores that reflect the ability to understand concepts, apply knowledge, and reason about physical phenomena in everyday life. Data analysis was conducted to determine the general level of scientific literacy skills, the distribution of skills across each scientific literacy indicator, and the trend in student achievement in linking the concept of mechanical energy to contextual situations. The analysis used descriptive statistics, including the mean, median, standard deviation, minimum, and maximum scores, as well as percentages of results in specific ability categories. The results of this analysis provide objective quantitative information on the profile of physics education students' scientific literacy skills in mechanical energy. The choice of a descriptive research design was based on the research objective: to obtain a realistic picture of students' scientific literacy skills without any treatment or intervention in the ongoing learning process. This approach enables researchers to determine the actual state of students' understanding and application of the concept of mechanical energy in everyday contexts. Furthermore, the descriptive-quantitative approach facilitates the presentation of research results in a systematic, concise, and understandable manner, thereby providing a basis for lecturers and study programs to evaluate and reflect on how to improve the quality of physics instruction in higher education.

Participants

The participants in this study were 30 undergraduate students enrolled in a Physics Education program, selected via simple random sampling. This sampling method was considered appropriate because the target population exhibited relatively homogeneous characteristics, particularly with respect to academic background. All participants had completed a basic physics course that included fundamental concepts of mechanical energy, such as kinetic energy, ensuring comparable prior knowledge among the students. This homogeneity supported the use of random sampling to obtain a representative subset of the population. The participant selection process began with distributing the research instrument via Google Forms to all Physics Education students who had completed the relevant coursework. Students who completed the instrument and met the inclusion criteria were listed as potential participants. From this pool, 30 students were randomly selected to form the final sample. This procedure was intended to minimize selection bias and ensure that the sample reasonably represented the broader population of physics education students.

Nevertheless, it is important to acknowledge the limitations associated with the relatively small sample size. While the sample was adequate for providing an initial descriptive overview of students' scientific literacy skills, the findings cannot be generalized to all physics education students. In addition, using a single assessment instrument with a limited number of items may not fully capture the complexity of scientific literacy across diverse contexts. Therefore, the results of this study should be interpreted cautiously and viewed as exploratory, serving as a foundation for future research involving larger samples and more comprehensive assessment instruments.

Data Collection Instruments and Procedures

The data in this study were collected using a scientific literacy test on mechanical energy, designed in a one-tier, multiple-choice format with 10 items. The test items were developed based on established scientific literacy indicators and embedded in everyday-life contexts, such as motion in soccer, skateboarding, roller coasters, and other familiar activities. These contexts were selected to assess students' ability to understand physics concepts, analyze energy transformations, and apply mechanical energy principles to real-world situations involving kinetic, potential, and mechanical energy. Each item was preceded by a stimulus in the form of a text or images to encourage qualitative reasoning rather than rote calculation. Scoring was conducted by assigning 10 points to each correct response and 0 to each incorrect response, with the total score representing students' overall scientific literacy performance.

The use of 10 items was considered sufficient for this exploratory, descriptive study, as each item was carefully constructed to represent distinct indicators of scientific literacy and key aspects of mechanical energy. However, it is acknowledged that a limited number of items may constrain the depth and breadth of scientific literacy measurement and may not fully capture students' reasoning across varied contexts. Therefore, the instrument was intended to provide an initial overview rather than a comprehensive assessment. Before data collection, the instrument was developed using a structured blueprint and underwent validation to ensure alignment among scientific literacy indicators, contextual scenarios, and the targeted physics concepts. Following validation, the instrument was administered online via Google Forms to Physics Education students who had completed the Basic Physics course and met the study criteria. Participants completed the test independently within a predetermined time frame under standardized instructions. Ethical considerations were addressed by informing participants of the study's purpose and ensuring their participation was voluntary. Students' responses were collected anonymously, and all data were used solely for research purposes, ensuring confidentiality and adherence to ethical research practices.

Data Analysis Techniques

Before use in data collection, the test instrument was validated through expert judgment. Validation was conducted by three experts with expertise in physics and physics education. The instrument's content validity was assessed using Aiken's V index, which measures the degree of expert agreement on the relevance of each test item to the measured indicators (Aiken, 1985). The Aiken's V value was calculated using Equation (1).

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

The s value is the difference between the assessors' score (r) and the lowest score on the validity assessment scale (l_o). The r score is the value assigned by each expert to each item on the assessment scale, where l_o a minimum score of 0. The variable n represents the number of assessors (validators), and c represents the maximum score on the validity assessment scale. An item is considered valid if its Aiken's V value exceeds 0.92. The threshold value of 0.92 was selected based on the number of assessors (3) and the 5-category assessment scale, as listed in Aiken's V critical value table. This criterion was used to ensure that each item had high levels of expert agreement regarding the instrument's content (Azwar, 2012).

Item validity was calculated using Aiken's V index, as shown in Equation (1). The obtained value served as the basis for determining the suitability of each item for use as a research instrument. Instruments that met the validity criteria were then tested for reliability to ensure internal consistency. Reliability was assessed using Cronbach's alpha. An instrument is considered reliable if its Cronbach's alpha is greater than 0.70, indicating good internal consistency and suitability for use in educational research (Streiner, 2003; Azwar, 2012). Instrument reliability was assessed using Cronbach's alpha in SPSS. Test data were first entered into SPSS, with each column representing one item and each row representing one respondent; scores were 1 for correct answers and 0 for incorrect answers. Next, reliability testing was performed by selecting Analyze > Scale > Reliability Analysis. All items were entered into the Items box, and the reliability model used was set to Alpha. Once the settings are complete, the analysis is run by pressing the OK button, which generates a Cronbach's Alpha value in the Reliability Statistics table. This value is then interpreted in light of the reliability criteria used to assess the instrument's internal consistency and suitability as a research measure, as shown in Table 1.

Table 1. Reliability test: Cronbach's Alpha

Cronbach's Alpha	Internal Consistency
$x \geq 0,9$	Excellent
$0,7 \leq x < 0,9$	Good
$0,6 \leq x < 0,7$	Acceptable
$0,5 \leq x < 0,6$	Poor
$x < 0,5$	Unacceptable

After the instrument was deemed valid and reliable, a test was administered to Physics Education students with similar income and expenditure levels. The test results were analyzed to characterize students' understanding of mechanical energy. Students' scientific literacy regarding mechanical energy was analyzed using descriptive statistics. This technique is used to quantitatively describe data characteristics based on test scores, without involving hypothesis testing. This analytical method aligns with the research objective of obtaining a general picture of students' scientific literacy in everyday contexts (Sugiyono, 2019). Data analysis included calculating measures of central tendency and dispersion. Measures of central tendency consist of the mean, median, and mode. The mean reflects overall scientific literacy, whereas the median indicates the tendency of the middle value and is influenced by extreme values. The most frequently occurring score has the greatest impact. Furthermore, dispersion was assessed using the standard deviation to quantify variation in students' scientific literacy skills. A high standard deviation indicates greater variability in students' abilities, whereas a low standard deviation indicates relatively homogeneous ability (Arikunto, 2013).

Table 2. Distribution of value ranges (categories)

Value Range	Category
0-20	Very Low
21-40	Low
41-60	Moderate
61-80	High
81-100	Very High

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In addition to descriptive statistics, students' scientific literacy scores were categorized to facilitate interpretation. Score categorization was based on the ranges shown in Table 5, which groups students' scientific literacy skills into five categories: very low, low, medium, high, and very high. This classification was used to examine how students' scientific literacy develops more systematically. Furthermore, analyses were conducted by student gender to provide an overview of trends in scientific literacy skills within each group. This analysis aims to describe the distribution and variation in students' scientific literacy data, without conducting inferential analyses or statistical tests for differences. All analysis results are presented in tabular and narrative form to facilitate data interpretation and to serve as a basis for discussing physics learning theory and prior research findings (Sugiyono, 2019; Arikunto, 2013).

RESULTS

Results of the Test Instrument Suitability Test

Before the instrument was used to collect research data, a content validity test was conducted to ensure that the test items aligned with the cognitive aspects being measured. This content validity test involved three experts (validators) using Aiken's V formula. The results of the content validity calculations for the 10 test items are presented in Table 3.

Table 3. Validity test result Aiken's V

No.	V_{count}	V_{table}	Information
1.	0.950	0.9	Valid
2.	0.933	0.9	Valid
3.	0.942	0.9	Valid
4.	0.925	0.9	Valid
5.	0.967	0.9	Valid
6.	0.933	0.9	Valid
7.	0.942	0.9	Valid
8.	0.942	0.9	Valid
9.	0.942	0.9	Valid
10.	0.942	0.9	Valid

Based on the results in Table 3, Aiken's V coefficient for the ten questions assessed by three experts (expert judgment) ranged from 0.925 to 0.967. According to Azwar (2012), a question item is considered to have good content validity if Aiken's V exceeds 0.92. The threshold value of 0.92 is determined using the number of assessors (up to 3) and the 5 assessment scale categories in Aiken's V critical value table. Given that all coefficients exceed 0.92, it can be concluded that each item on the instrument reflects high expert agreement regarding the content's relevance and is therefore valid and suitable for measuring students' scientific literacy. In addition to the validity test, a reliability test was also conducted to determine the instrument's consistency when used repeatedly. This reliability test was conducted using Cronbach's alpha in SPSS on 10 questions. The results of the reliability test are summarized in Table 4.

Table 4. Reliability test result of Cronbach's Alpha

Cronbach's Alpha	N of Items
0,963	10

According to the SPSS output in Table 4, the Cronbach's alpha was 0.963. According to Streiner (2003), according to the reliability classification criteria, this value falls into the Excellent (High-Stakes Testing) category because it is in the range x > 9. This value also exceeds the minimum threshold of 0.70 required for educational research, indicating excellent internal consistency and reliability.

Results of the Analysis of Student Concept Understanding

Data on the results of respondents' answers to each item on the instrument are presented in Table 5. This table presents the distribution of scores for 30 respondents across the 10 questions.

Table 5. Respondents' scores on each question item

No.	Name	Gender	Item										Total Value
			1	2	3	4	5	6	7	8	9	10	
1	MN	Male	10	0	0	0	0	0	0	0	0	0	10
2	BPR	Male	10	0	10	0	0	0	0	0	0	0	20
3	HHA	Male	10	0	10	0	0	0	10	0	10	0	40
4	DEP	Female	0	0	0	10	10	0	0	0	0	0	20
5	PCK	Female	0	0	0	10	10	0	0	0	0	0	20
6	MBT	Male	10	0	0	0	10	0	0	10	0	0	30
7	NU	Female	10	0	0	0	0	0	10	0	0	0	20
8	LP	Female	10	0	0	0	0	0	0	10	10	10	40
9	JRK	Male	10	0	10	0	0	0	0	0	0	0	20
10	FU	Female	0	0	10	0	10	0	10	10	10	10	60
11	AM	Female	10	0	10	0	0	0	0	0	0	0	20
12	ZM	Male	10	0	0	0	0	0	10	10	0	0	30
13	MCR	Male	10	0	10	0	0	0	0	10	0	0	30
14	DL	Female	10	10	0	0	10	10	0	0	0	10	50
15	FI	Male	10	0	0	10	0	0	0	0	0	0	20

No.	Name	Gender	Item										Total Value
			1	2	3	4	5	6	7	8	9	10	
16	RF	Male	10	0	10	0	0	0	0	0	10	0	30
17	F	Male	10	0	10	0	10	0	0	0	0	0	30
18	IS	Female	10	0	0	0	0	0	0	0	10	0	20
19	NM	Male	10	10	10	10	10	10	0	10	10	0	70
20	ATM	Female	10	0	0	10	10	10	0	0	10	0	50
21	MN	Female	10	10	0	10	10	10	10	0	0	0	60
22	SA	Male	0	10	10	10	0	10	0	10	10	0	60
23	LDC	Male	10	0	10	0	10	10	0	0	10	0	50
24	T	Female	10	0	0	0	10	10	0	0	10	0	40
25	ZBY	Male	10	0	10	10	0	0	0	10	0	0	40
26	DA	Male	10	0	10	0	0	0	0	10	10	0	40
27	RP	Female	10	10	0	0	10	0	0	10	10	10	50
28	ZKA	Male	10	0	10	10	10	10	0	0	0	0	50
29	AAM	Female	10	10	10	10	10	10	0	0	10	0	70
30	EA	Female	10	0	0	0	0	0	10	0	10	0	30
Total			260	60	150	100	130	90	60	90	140	40	1120

Based on Table 5, the total score for all respondents was 1120. Across items, question 1 had the highest success rate, with respondents achieving a total score of 250. Conversely, question 10 demonstrated the highest difficulty or the lowest understanding, with the lowest score of 40. This indicates variation in students' conceptual understanding across the points tested in the material. Furthermore, the data obtained from respondents' answers to each test item, along with their categorization, are presented in Table 6. This table presents the distribution of scores from 30 respondents on 10 questions assessing students' conceptual understanding, both individually and as a class. To facilitate analysis, the following table summarizes the frequency distribution and percentages based on student understanding categories.

Table 6. Frequency distribution results and the percentage of students' conceptual

No.	Category	Frequency (f)	Percentage (%)
1.	High	2	6.67 %
2.	Moderate	9	30 %
3.	Low	12	40 %
4.	Very Low	7	23.33 %
Total		**30**	**100 %**

Based on Table 6, the majority of students were classified as Low (12 respondents, 40%). Cumulatively, 63.33% of students fell into the "Low" and "Very Low" groups, indicating that the majority of respondents had not yet achieved the ideal level of conceptual mastery. Only 6.67% of students (2 respondents) reached the High category, with a maximum score of 70. This finding indicates a significant gap in conceptual understanding among students, with most respondents still requiring intensive reinforcement on the test material. Furthermore, to provide a general overview of the overall distribution of student conceptual understanding data, a descriptive statistical analysis was conducted, as summarized in Table 7.

Table 7. Results of descriptive statistical analysis

Statistics	Score
Number of Respondents	30
Minimum	10
Maximum	70
Mean	37.33
Median	30
Mode	30
Standard Deviation	16.3

Table 7 shows the results of the analysis of 30 respondents. The highest score achieved by students was 70, while the lowest was 10. The average (mean) score for students' conceptual understanding was 37.33, with the median and most frequently occurring score (mode) being 30. The standard deviation of 16.3 indicates a relatively wide range of responses among respondents. Overall, the average score of 37.33 indicates that students' conceptual understanding remains below the maximum score. In addition to the general analysis, this study also grouped the data to compare conceptual understanding by gender. The results of the descriptive analysis by gender are presented in Table 8.

Table 8: Descriptive analysis by gender

Gender	N	Mean	SD
Male	15	33.333	13.452
Female	15	41.333	18.848

According to Table 8, respondents were evenly divided between males (15) and females. There was a quite visible difference in the average scores, where female students had an average score (Mean) of 41.333, while male students had 33.333. This indicates that, in this sample, female students tended to have higher conceptual understanding than male students. However, the female group also had a larger Standard Deviation (18.848) than the male group (13.452), which means that the distribution of scores among female students was more varied (heterogeneous).

DISCUSSION

The results of the content validity analysis using Aiken's V coefficient indicate that all ten items developed in this study meet the criteria for strong content validity. The Aiken's V values obtained ranged from 0.925 to 0.967, exceeding the commonly recommended minimum threshold in educational research. These results reflect a high level of expert agreement regarding the alignment between test items, scientific literacy indicators, and the mechanical energy concepts being assessed. Furthermore, the high validity values suggest that the contextual stimuli, question wording, and conceptual accuracy were considered appropriate and relevant for measuring scientific literacy in physics education (Aiken, 1985; Azwar, 2012). In addition to content validity, the instrument demonstrated excellent internal consistency, as indicated by a Cronbach's alpha value of 0.963. This value falls within the "very high" reliability category, suggesting that the items consistently measure the same construct of scientific literacy related to mechanical energy. High reliability supports the use of the instrument for descriptive quantitative analysis in physics education research, although reliability alone does not guarantee comprehensive coverage of all dimensions of scientific literacy (Streiner, 2003; Sugiyono, 2019).

The analysis of students' responses revealed substantial variation in item performance, indicating uneven mastery of mechanical energy concepts. Items classified as less cognitively demanding, such as Question 1, received the highest total score, suggesting that most students answered questions involving basic or familiar concepts correctly. In contrast, items requiring deeper analysis, interpretation of contextual information, or integration of multiple energy concepts, such as Question 10, showed markedly lower scores. Rather than indicating a cognitive deficit, this pattern reflects students' limited exposure to instructional practices that emphasize higher-order thinking and contextual reasoning in physics learning (Laelandi et al., 2022). These findings suggest that the participants' physics instruction may place greater emphasis on procedural problem-solving and formula application than on qualitative analysis and the conceptual interpretation of everyday phenomena. When learning activities predominantly focus on algorithmic exercises, students may become proficient in routine calculations but less prepared to analyze real-world situations that require scientific reasoning and interpretation of energy transformations.

This instructional emphasis can contribute to the observed gap between students' understanding of basic mechanical energy concepts and their ability to apply those concepts in context-based scientific literacy tasks. Regarding gender differences, female students obtained a higher average score than male students; however, this comparison is strictly descriptive. Given the small sample size and the absence of inferential statistical testing, no conclusions can be drawn regarding gender-related differences in scientific literacy. The observed variation merely describes the distribution of scores within this sample and should not be interpreted as evidence of systematic or causal differences between male and female students.

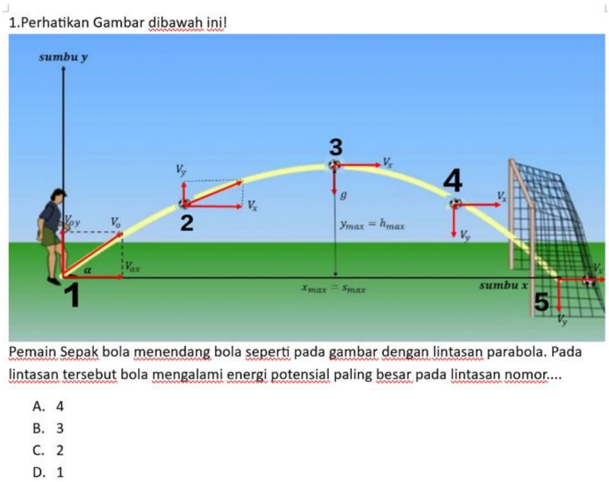

Figure 1. Question number 1

In contrast, question number 10 received the lowest score, indicating that it is more difficult and requires deeper reasoning and application of mechanical energy concepts in specific contexts. Here is question number 10 in Figure 2.

Figure 2. Question number 10

The results of this study are consistent with previous findings, indicating that students often experience

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difficulties with context-based problems that require complex analysis and the simultaneous integration of multiple physics concepts (OECD, 2019; Hake, 1998). As shown in Table 7, the majority of respondents were classified in the low category (40%, 12 students), followed by the very low category (23.33%, 7 students). Overall, 63.33% of students demonstrated levels of conceptual understanding below the expected standard. These results indicate that most students have not yet developed adequate scientific literacy, particularly in understanding and applying physics concepts in everyday contexts. Rather than attributing these outcomes to individual psychological factors, the findings can be interpreted in relation to prevailing instructional practices. Prior research has shown that physics learning at the tertiary level often emphasizes routine problem-solving and procedural fluency, which may limit students' opportunities to engage with application-oriented and integrative problems (Wieman & Perkins, 2005). Consequently, students may demonstrate a surface-level understanding of concepts while struggling to interpret real-world phenomena using scientific reasoning (OECD, 2019). This gap between theoretical mastery and contextual application is a central challenge in developing scientific literacy.

The predominance of low and very low categories further suggests that students have limited experience with learning activities that promote active knowledge construction and contextual reasoning. Instruction that relies heavily on memorizing formulas and repetitive exercises may not adequately support students in connecting concepts of mechanical energy to everyday phenomena (Bybee, 2013; Yuliati, 2017). As a result, students tend to approach problems procedurally, without engaging in qualitative analysis or conceptual interpretation, which are essential components of scientific literacy. Descriptive statistics presented in Table 8 reinforce this interpretation. The average scientific literacy score of 37.33, along with median and mode values of 30, indicates that most students have not achieved the minimum expected level of scientific literacy. The wide range of scores and relatively high standard deviation (16.3) reflect substantial variability in students' ability to relate physics principles to everyday situations. This variability suggests uneven learning outcomes, which may arise from differences in exposure to context-based instruction and opportunities for higher-order thinking during learning (Turiman et al., 2012).

The descriptive gender analysis in Table 9 shows that female students obtained a higher mean score than male students. However, this comparison is purely descriptive and does not imply statistically significant or causal gender differences. The relatively large standard deviations in both groups indicate substantial heterogeneity within each group, suggesting that individual differences in learning experiences and academic preparation may play a more prominent role than gender alone. Therefore, these findings should be interpreted cautiously and not as evidence of inherent gender-based differences in scientific literacy. Taken together, the findings highlight specific weaknesses in students' ability to analyze contextual problems, integrate multiple physics concepts, and apply mechanical energy principles to real-world situations. These weaknesses point to the need for instructional practices in physics education that place greater emphasis on context-based learning, conceptual discussion, and authentic problem-solving. Although this study is limited by its small sample size and reliance on objective test instruments, the use of validated and reliable measures provides a meaningful descriptive overview of students' current scientific literacy levels (Streiner, 2003; Sugiyono, 2019). Future research is recommended to involve larger and more diverse samples and to employ mixed-methods approaches, such as interviews and diagnostic assessments, to gain deeper insights into students' misconceptions and reasoning processes in physics learning (Saputra & Arifin, 2024; Wibowo, 2023).

CONCLUSION

This study provides important insights into the scientific literacy of Physics Education students regarding mechanical energy. Overall, the findings indicate that prospective physics teachers experience considerable difficulty in connecting theoretical physics concepts with everyday phenomena, highlighting a persistent gap between conceptual knowledge and its contextual application. This gap reflects learning experiences that continue to prioritize procedural and mathematical problem-solving over conceptual reasoning and the interpretation of real-world situations, which are central components of scientific literacy. The use of a validated and reliable context-based assessment instrument strengthens the credibility of these findings and demonstrates the feasibility of assessing scientific literacy through everyday life scenarios. The results further suggest that students' scientific literacy varies widely, indicating uneven learning outcomes and the need for instructional approaches that accommodate diverse levels of understanding. Descriptive differences observed between male and female students should be interpreted cautiously, as they reflect score distributions rather than inferential or causal relationships. Based on these findings, physics teacher education programs should place greater emphasis on curriculum designs that integrate mechanical energy concepts with authentic, everyday contexts. Instructional practices should include qualitative problem analysis, guided discussion of physical meaning, and tasks that require students to interpret phenomena rather than merely apply formulas. Incorporating context-based assessments, reflective questioning, and collaborative problem-solving activities can help prospective teachers develop the scientific reasoning skills necessary for meaningful physics instruction. In conclusion, strengthening scientific literacy in physics education requires a shift toward learning experiences that explicitly link concepts to real-world applications. Such an approach is essential for preparing future physics teachers who can design engaging, relevant, and scientifically meaningful learning environments for their students.

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