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Assessing Students' Physics-Science Literacy Skills on Impulse and Momentum Through Real-Life Activities

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Abstract

This research aims to analyze students' science literacy on the topic of impulse and momentum based on the Program for International Student Assessment (PISA) competencies. This study uses a descriptive approach involving 22 high school students. The instrument used consisted of three essay questions (constructed-response) developed based on real-world contexts and aligned with PISA science literacy indicators. Students' answers are assessed using a PISA-based scoring rubric to categorize the level of science literacy achievement. The research results show that students' science literacy achievements vary across each competency. The competence to explain phenomena scientifically and design and evaluate scientific investigations falls into the Fair category, while the competence to interpret scientific data and evidence scientifically falls into the Poor category. These findings indicate that students are relatively capable of recognizing and explaining physical phenomena and have a preliminary understanding of scientific investigations, but still struggle with interpreting data and accurately relating it to physical concepts. The implication of this research is the need to strengthen learning strategies that emphasize data interpretation skills, such as thru the analysis of experimental results, graphs, and context-based reasoning questions. Inquiry-based and problem-based learning approaches are recommended to support the more comprehensive development of science literacy. This study has limitations in the small sample size, the limited number of instruments, and the research context being conducted in only one school. Subsequent research is recommended to involve a larger sample and more diverse instruments.

Keywords: Science literacy; PISA; Impulse; Momentum; Essay assessment

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INTRODUCTION

One of the crucial life skills that should be possessed by students in the 21st century to keep up with development of technology and science is physics science literacy (Sumantri & Kholiq, 2020). Physics science literacy skills are used to identify scientific knowledge and draw evidence-based conclusions, so we can understand and make decisions about nature and the impact of human activities (Utami et al., 2022; Yunus et al., 2020). Physics science literacy is not only connected to the mastery of scientific concepts, but also includes the potential to understand, apply, and evaluate scientific information in everyday life. Science lesson are a means for students to learn independently and study the natural world apply it ini their daily lives (Zhang et al., 2010). Literacy helps students understand scientific concepts that can support techhnological developments in fields such as biotechnology, artificial intelligence, renewable energy, and others (Wen et al., 2020). In its application, physics science literacy training enables students to develop critically, analytically, and logical ways of thinking in seeking and verifyng information based on facts. It also encourages students to solve complex problem through data analysis based on experiene (Jufrida et al., 2019; Savitri et al., 2021). This can train students to contribute to social and economic life and improve decision-making for both individuals and society (Azura et al., 2021; Melinda et al., 2021).

The low level of physics science literacy in Indonesia indicates that most students require support in analyzing and applying these concepts to problem-solving. Physics science literacy skills are important competencies that play a significant role for humans because they help shape mindsets and behaviors and build caring and responsible characters. Based on PISA 2022 data, Indonesia ranks 59th with a score of 359, indicating that physics science literacy scores among Indonesian students remain below average (OECD, 2023). There was an increase in the PISA 2022 score to 359, but the average score decreased by 12 points, which is smaller than the global average decline. Indonesia's physics science literacy score increased in 2012 from 382 to 403 in 2015, then decreased to 396 in 2018 and declined further in 2022. In addition, only a small proportion of Indonesian students reach a high level of science literacy, while the majority remained below the basic level (Ramli et al., 2022).

In the PISA framework, science literacy is measured thru three main competencies, namely explaining phenomena scientifically, interpreting data and scientific evidence scientifically, and designing and evaluating scientific investigations (OECD, 2018). However, when reviewed from previous research, the operationalization of these three competencies remains varied. Some studies tend to measure only certain aspects, such as the ability to explain phenomena or interpret data, without comprehensively integrating the three competencies (M. Putri et al., 2026; Valio et al., 2025). Moreover, most studies use objective test instruments that have not yet fully captured student achievements at the sub-indicator level of each competency (Bashooir & Supahar, 2018; Gunawan & Mufit, 2024). On the other hand, research examining science literacy in the context of physics generally has not explicitly used assessment rubrics aligned with the PISA framework to produce structured student achievement profiles (M. Putri et al., 2026; Safira et al., 2025). Thus, there is still a need for an assessment approach that not only refers to PISA competencies conceptually but also operationalizes them technically thru validated instruments and rubrics.

In the learning of physics, physics science literacy plays an essential role because physics not only requires an understanding of formulas but is also a science that is closely related to natural phenomena that are often encountered in everyday life. This poses a challenge when the material being taught is abstract and conceptual. One area of physics that requires a good understanding of concepts is momentum and impulse. This subject matter not only requires mathematic ability, but also the student's ability to connect the conceptual ideas of force, change of momentum, and cause and effect relationships, as well as being able to apply concepts to real life situations.

Mapping student's abilities in physics science literacy tests is an important strategy for understanding how well students have mastered physics science literacy indicators. The results of these tests not only describe student's overall achievements but also reveal their weaknesses. This information is required in order to design more efficient physics education, especially to improve student's ability to argue, interpret data, and solve problems based on scientific competencies. Quantitative descriptive analysis is an appropriate approach for objectively describing student ability profiles. Through this approach, researchers can show score distributions, ability level trends, and comparisons between physics science literacy indicators. Descriptive analysis allows teachers and researchers to understand the factual conditions of students without testing the relationship between variables, so that the results obtained can be used as the basis for an accurate initial diagnosis.

Research on science literacy in physics education has developed in several main directions. First, research that focuses on the analysis of students' science literacy achievements. Adhari et al (2025)examined science literacy achievements in the competency aspect and found that the indicators of evaluating and designing investigations remain the main weaknesses of students in the topic of radioactivity. Meanwhile, Masithoh & Jauhariyah (2024) and Takda et al. (2023) mapped the profile of science literacy using specific instruments such as NoSLiT. However, these studies are generally broad in nature, thus not providing a specific picture of certain physics concepts such as impulse and momentum. Second, research that focuses on the development of educational devices and media. Azhary & Dewantara (2022) developed learning materials on the topic of impulse and momentum and tested their practicality and effectiveness. Sumantri (2020) developed a 3D page-flip based e-book to support students' science literacy. Although showing positive results, research in this group tends to focus on the product and media implementation, and has not yet thoroughly mapped the weaknesses in students' science literacy based on specific indicators as a basis for development. Third, research that focuses on the development and study of science literacy instruments. Putri (2023) emphasizes the importance of valid instruments to accurately measure science literacy, while Hadiastriani & Djarot (2024) examine the trends and developments of science literacy instruments thru bibliometric studies. However, these studies are more oriented toward the validity and development of instruments, and have not specifically integrated essay question formats with assessment rubrics based on science literacy indicators to produce detailed diagnostic profiles.

Based on these three groups, there is a research gap in the form of the limitations of instruments that can produce detailed diagnostic profiles of students' science literacy achievements at the sub-indicator level, particularly in the context of questions that represent real-life situations. The novelty of this research lies in the development and use of a set of constructed-response essay questions that are locally contextualized like road safety and sports activities and assessed using validated rubrics aligned with PISA-based science literacy indicators. This approach allows for the detailed and evidence-based profiling of student achievement on each sub-indicator, while also providing a stronger foundation for the design of targeted learning interventions. Based on the above description, this research aims to answer the following questions:

1. What is the profile of students' science literacy competency achievements in each PISA aspect (explaining phenomena, designing investigations, and interpreting data) in the topic of impulse and momentum?
2. Which sub-indicator shows the lowest achievement level in students' understanding?

METHOD

Research Design

This study uses a descriptive statistical design with a quantitative approach. Considering the limited number of participants (n=22), this study is positioned as a diagnostic pilot study to map the science literacy profiles of students in depth on the topics of impulse and momentum.

Participants

The research subjects consisted of 22 eleventh-grade students at a public high school in East Java Province, Indonesia. Participants were selected using purposive sampling techniques with the criterion of having completed the study of impulse and momentum material.

Instrument

This study used a physics science literacy test which consisted of three written questions that applied the context of impulse and momentum in everyday life. The questions were compiled according to physics science literacy indicators, which include the abilities: (1) explaining phenomena scientifically, (2) interpreting scientific data and evidence, and (3) designing and evaluating scientific investigations. Before use, the physics science literacy instruments are first validated by experts to ensure their content was appropriate and in line with the research objectives.

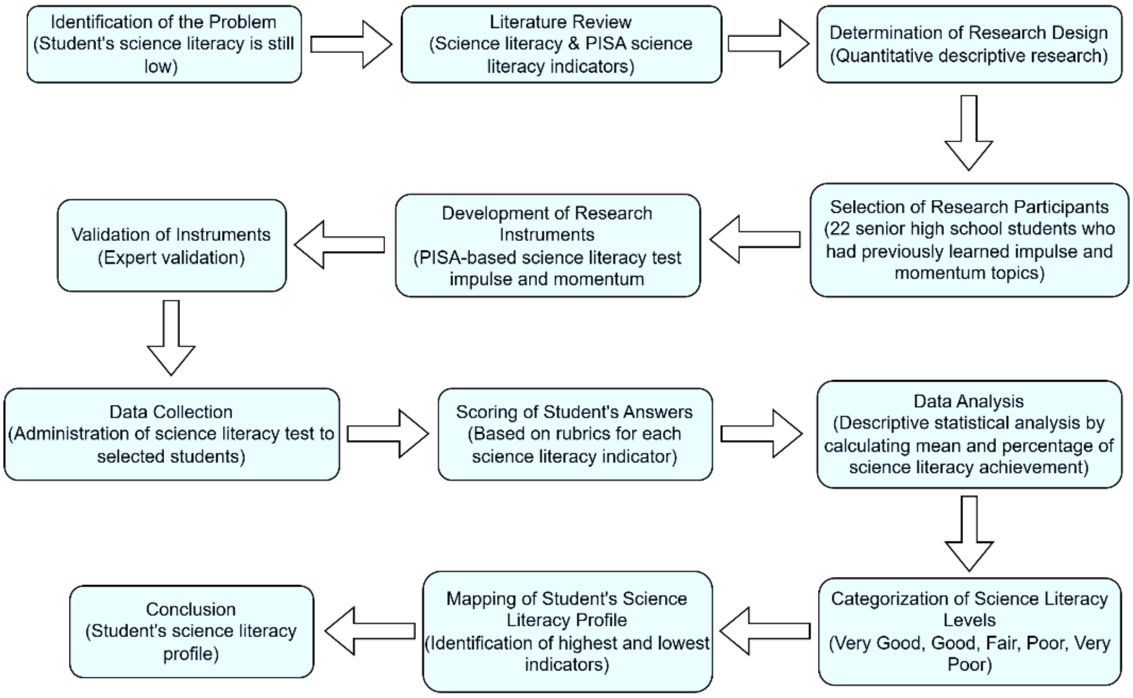


Figure 1. Research Flow

Table 1. PISA 2018 Physics science literacy Competency Indicators (Masithoh & Jauhariyah, 2024)

Physics science literacy Aspects	Sub-Indicators of Physics science literacy Competency
Explain phenomena scientifically	• Recall and apply relevant scientific concepts • Identify, use, and produce clear and accurate models and representations • Explain the possible implications of scientific knowledge in society
Design and evaluate scientific investigations	• Evaluate ways to scientifically explore the questions given • Describe and evaluate the various methods used by scientists to determine the validity and objectivity of data and a general statement.
Interpret data and evidence scientifically	• Convert data to another representation. • Analyze data, create interpretations, and draw conclusions.

Scoring and Reability

Students' answers are assessed using a scoring rubric with a score range of 0-5 for each question. To maintain the objectivity of the assessment on essay questions, the scoring process is carried out by two raters, measuring the level of agreement between raters (inter-rater reliability).

Data Analysis

Test score data were analyzed descriptively to calculate the average score and percentage of student achievement in each aspect. The students' ability levels were then classified into the following categories:

Table 2 Physics science literacy Category Criteria

Score Range	Category
4.21 – 5.00	Very Good
3.41 – 4.20	Good
2.61 – 3.40	Fair
1.81 – 2.60	Poor
0.00 – 1.80	Very Poor

RESULTS AND DISCUSSION

Results

This study was conducted to determine the level of physics science literacy skills of high school students using essay questions in accordance with three indicators of science literacy, namely explaining phenomena scientifically, interpreting data and evidence, and designing and evaluating scientific investigations. According to the analysis of three aspects of science literacy, it was observed that student achievement showed significant variations in each indicator. In general, students' physics science literacy skills were in the Fair category. This provides an important picture of students' scientific thinking patterns and areas that need to be improved through learning interventions.

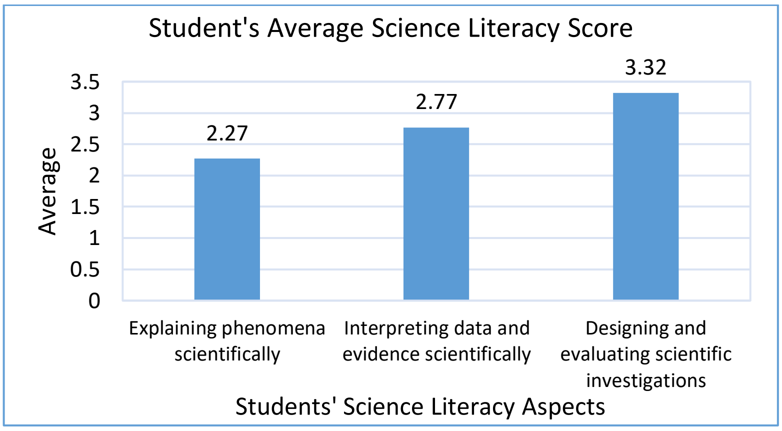


Figure 2. Student's Average Physics science literacy Score

The aspect of explaining phenomena scientifically obtained an average score of 2.27 and was an indicator of physics science literacy with Poor and lowest achievement among the three aspects. The low score on this indicator indicates that some students still have difficulty using scientific concepts or principles to explain phenomena that occur in everyday life. In terms of interpreting data and scientific evidence, the student's average score was 2.77, indicating that students had Fair abilities and performed better than in the previous aspect. Students are relatively capable of reading graphs, tables, and data patterns, although they are not yet fully optimal in drawing evidence-based conclusions. The aspect of designing and evaluating scientific investigations showed the highest score with an average of 3.32 and was categorized as Fair. This indicates that students have a better understanding of the steps of scientific investigation, including identifying variables, developing procedures, and determining tools and materials.

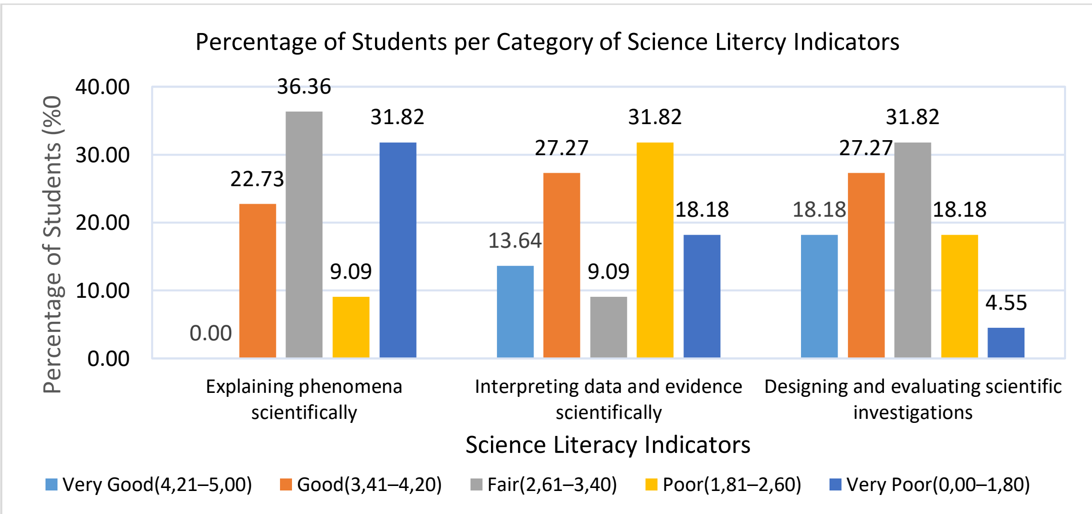


Figure 3. Percentage of Students per Category of Science Litercy Indicators

In the first question, which contains indicators of scientific literacy in explaining phenomena scientifically, students are asked to analyze the force and momentum experienced by a driver when not wearing a seat belt. Based on the assessment rubric, the maximum score is 5, which indicates a complete understanding of the concepts of inertia, momentum, change in momentum (Δp), and their relationship to impulse force $F = \frac{\Delta p}{\Delta t}$. For this indicator, the highest percentage was in the Fair category, at 36.36%, followed by the Very Poor category at 31.82%, and the Good category at 22.73%, while the Poor category was at 9.09%. No students achieved the Very Good category.

In the second question, which measured the ability to interpreting scientific data and evidence, students were asked to analyze changes in the momentum of a shuttlecock based on speed data before and after contact with the racket. The second indicator showed that the majority of students were in the Poor category, with a percentage of 31.8%. These results indicate that students' ability to interpret data-based information such as graphs, tables, or measurement results is still low. This problem is caused by a lack of practice in processing and reading observation data or suboptimal learning that requires students to draw conclusions from available evidence. This is followed by the Good category at 27.27%, which means that students have a fairly good ability to interpret data and are able to connect numerical information with scientific concepts. Meanwhile, Very Good category, at 13.64%, shows that only a small number of students are able to analyze data in depth. Then there is the Very Poor category, at 8.18%, and the Fair category, at 9.09%, which shows an uneven distribution of abilities.

The third indicator, which measures the ability to design and evaluate scientific investigations, shows relatively better results than the previous two indicators. The highest percentage is in the Fair category at 31.82%, followed by the Good category at 27.72%. This indicates that most students have adequate basic skills in designing investigation procedures and evaluating scientific investigations. This is followed by the Very Good category at 18.18%, which is the highest percentage compared to the previous two categories. This indicates that students' abilities, such as determining variables, organizing experimental steps, or assessing the accuracy of procedures, are more developed than their conceptual and interpretive abilities. These results illustrate that practical experience, demonstrations, or inquiry-based activities in the classroom have a positive contribution to students' investigative abilities. However, there are still other categories, namely Poor at 18.18% and Very Poor at 4.55%, which indicate that a small number of students still have difficulty understanding the scientific process as a whole.

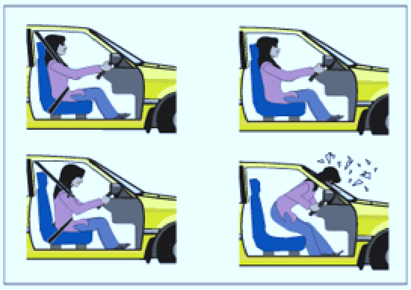
Discussion

Based on the Figure 2, the aspect of explaining phenomena scientifically obtained an average score of 2.27 and was an indicator of physics science literacy with Poor and lowest achievement among the three aspects. This obstacle occurs because students are not yet accustomed to connecting physics concepts with real contexts or lack practice in scientific reasoning-based problem solving. This condition is in line with the results of previous research conducted by Suryawati and Osman (2017), which states that scientific explanation is a competency that requires a deep understanding of concepts, so that many students do not understand when faced with contextual phenomena. This study is also reinforced by Sunni and Sunarto's findings (2023), indicating that the ability to explain phenomena is the lowest aspect of physics science literacy evaluation in high school level because it is still affected by learning implementation and the proximity of the contett to the student's environment.

In terms of interpreting data and evidence scientifivally in Figure 2, the student's average score was 2.77, indicating that students had Fair abilities and performed better than in the previous aspect. Students are relatively capable of reading graphs, tables, and data patterns, although they are not yet fully optimal in drawing evidence-based conclusions. These results are consistent with the findings of Islami and Setiawan (2025) that Indonesian students' data interpretation skills, such as reading graphs or data, are still at an intermediate level, mainly because learning activities involving data analysis have not been carried out consistently. Another study by Nirfayanti (2022) and Zulaiha (2021) found that students are able to recognize patterns and read graphs/tables quite well, but their ability to interpret data scientifically and draw conclusions is still relatively low. Therefore, even though this aspect is higher than the other two aspects, improvement is still needed through inquiry and experiment-based analysis activities.

In the Figure 2, the aspect of designing and evaluating scientific investigations showed the highest score with an average of 3.32 and was categorized as Fair. This indicates that students have a better understanding of the steps of scientific investigation, including identifying variables, developing procedures, and determining tools and materials. The high achievement in this aspect is most likely influenced by the students' experience of participating in practical activities at school. A study conducted by Akbar et al (2024) shows that students who participate in guided inquiry-based practical activities acquire much higher conclusion-drawing skills than students who participate in verification-based practical activities. This supports the interpretation that the relatively high average score in the aspect of designing and evaluating scientific investigations in this study is influenced by student experience.

STIMULUS 1



When driving, we are advised to use seatbelts first to keep our bodies safe in case of an accident. When the car is moving, the driver has the same speed as the car. The seatbelt protects us from collisions or when the car suddenly brakes. Our bodies will not be thrown out of the car during a collision because the seatbelt keeps us in the same position. Imagine if the driver didn't wear a seatbelt? Of course, our bodies will be thrown forward and experience a very fatal impact. For that reason, we are advised to use seat belts to reduce the risk of severe injuries.

1. When the driver does not wear a seatbelt, analyze the forces and momentum on the driver's body!

Figure 4. Question about indicators explaining phenomena scientifically

In the first question, which contains indicators of scientific literacy in explaining phenomena scientifically, students are asked to analyze the force and momentum experienced by a driver when not wearing a seat belt. Based on the assessment rubric, the maximum score is 5, which indicates a complete understanding of the concepts of inertia, momentum, change in momentum (Δp), and their relationship to impulse force $F = \frac{\Delta p}{\Delta t}$. For this indicator, the highest percentage was in the Fair category, at 36.36%, followed by the Very Poor category at 31.82%, and the Good category at 22.73%, while the Poor category was at 9.09%. No students achieved the Very Good category. ==This results indicates that student's ability to explain physical phenomena is still remain intermediate level, meaning that students are capable enough to recognize basic concepts but are not yet fully able to relate them to everyday situations in a comprehensive and systematic manner. However, the existence of students in the Very Poor and Poor categories shows that almost half of the total students still have difficulty understanding physics concepts, and this pattern shows a gap in ability among students, where some students already understand the concepts well, but others are still lagging behind.

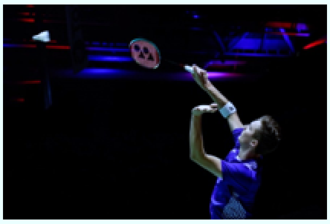
Tubuh pengemudi akan terus bergerak maju dengan kecepatan awal mobil akibat inersia, dan saat terjadi benturan, tubuh akan mengalami gaya yang sangat besar dalam waktu singkat.

Figure 5. Student answers in the Fair Category

The answer above is an example of an answer that falls into the Fair category because the student has correctly identified the concept of inertia, such as explaining that the body continues to move at the initial speed of the car and answering that there is a large force in a short time, even though they have not explained the mathematical relationship or the concept of momentum change. However, the student has not met the Good and Very Good categories because they have not explained the concept of momentum or momentum change (Δp), have not explained the relationship between impact force and $F = \frac{\Delta p}{\Delta t}$ and have not explained the physical mechanism of how a collision occurs. Thus, the student has demonstrated a basic conceptual understanding, but is not yet able to provide a complete and interconnected scientific explanation, in accordance with the characteristics of high-level science literacy.

The results of this study are aligned with the findings of several previous studies, which indicate that scientific literacy skills in explaining phenomena scientifically are still in the moderate to low category. The research by Wulandari (2016)reported that the competency in explaining phenomena scientifically was in the Fair category, meaning that students were not yet able to connect scientific concepts with real phenomena. In addition, Walker & Nouri (2025) found that the average ability of students to explain phenomena scientifically was low, indicating that students had difficulty connecting scientific knowledge with real phenomena. Sunni & Sunarti (2023) found similar results in their study of high school students' physics science literacy in the context of flooding, where the competency in explaining scientific phenomena was in the moderate category, indicating that students still had difficulties applying physics concepts to explain everyday events.

STIMULUS 2



In badminton, an athlete performs a smash so that the shuttlecock comes at high speed. The smash is done to deliver a counter-attack to the opponent with the aim of scoring points. Before the athlete performs the smash, the shuttlecock moves toward the athlete at a speed of 20 m/s, and after being hit, the shuttlecock reverses direction at a speed of 45 m/s. At that moment, there is only a brief contact force between the shuttlecock and the racket lasting 0.005 seconds.

2. Based on the speed data before and after the smash, analyze the change in the shuttlecock's momentum and explain how this relates to the magnitude of the impulse given by the racket.

Figure 6. Question about indicators in interpreting data and evidence

In the second question, which measured the ability to interpreting scientific data and evidence, students were asked to analyze changes in the momentum of a shuttlecock based on speed data before and after contact with the racket. The second indicator showed that the majority of students were in the Poor category, with a percentage of 31.8%. These results indicate that students' ability to interpret data-based information such as graphs, tables, or measurement results is still low. This problem is caused by a lack of practice in processing and reading observation data or suboptimal learning that requires students to draw conclusions from available evidence. This is followed by the Good category at 27.27%, which means that students have a fairly good ability to interpret data and are able to connect numerical information with scientific concepts. Meanwhile, Very Good category, at 13.64%, shows that only a small number of students are able to analyze data in depth. Then there is the Very Poor category, at 8.18%, and the Fair category, at 9.09%, which shows an uneven distribution of abilities.

jadi perubahan momentum (Δp) shuttlecock sebanding dengan besar impuls(I) yang diberikan oleh raket

Figure 7. Student answers in the Poor Category

The answer above is an example of a student's answer that falls into the Poor category, indicating that the student only provided a minimal explanation, namely stating that there was a change in momentum and impulse, but did not include numerical data or fully apply mathematical principles. The student's answer did identify the concept that a change in momentum is related to impulse ($I=\Delta p$), but the interpretation was still declarative, not analytical. The student has not calculated the change in velocity and has not written down the value of the change in momentum, thus failing to demonstrate the ability to process quantitative data as required by the physics science literacy indicator. In addition, the student has not linked the relationship between Δp and contact time (Δt = 0,005 s) to explain how impulse produces a large force in a short time, which is a key element in the rubric for a higher score.

These findings are aligned with other physics science literacy studies, which show that students' ability to interpret data and evidence is also low. Ashari et al (2023) found that students' indicators of scientific data and evidence interpretation were in the low category, suggesting that students have difficulty reading and drawing conclusions from the data presented. Furthermore, research by Cahyani et al (2024) found that the ability to interpret data and evidence was in the very Low category compared to other categories, illustrating the challenges students face in processing numerical information and scientific data representations. Similar findings were also reported by Safira et al (2025), in which the competency of interpreting data and scientific evidence showed the lowest achievement percentage compared to other physics science literacy competencies. These findings reinforce the results of the current study that students' ability to interpret data and scientific evidence is low and needs to be strengthened through more systematic and data-based learning strategies.

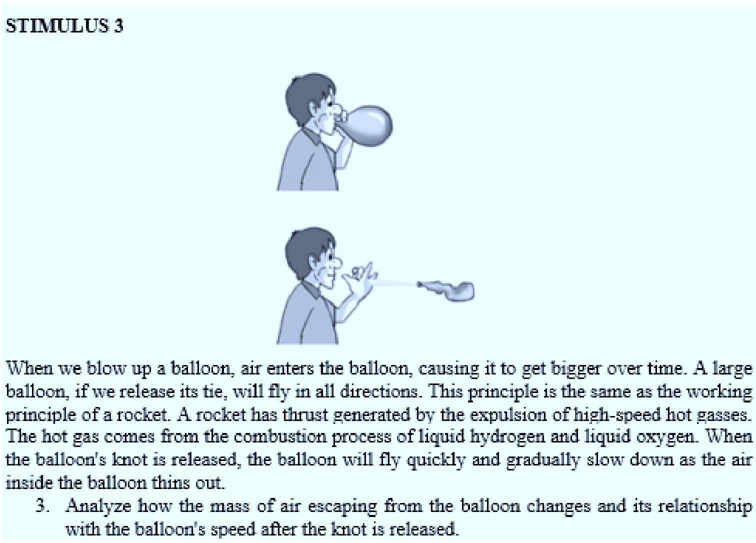


Figure 8. Question about indicator for designing and evaluating scientific investigations

The third indicator, which measures the ability to design and evaluate scientific investigations, shows relatively better results than the previous two indicators. The highest percentage is in the Fair category at 31.82%, followed by the Good category at 27.72%. This indicates that most students have adequate basic skills in designing investigation procedures and evaluating scientific investigations. This is followed by the Very Good category at 18.18%, which is the highest percentage compared to the previous two categories. This indicates that students' abilities, such as determining variables, organizing experimental steps, or assessing the accuracy of procedures, are more developed than their conceptual and interpretive abilities. These results illustrate that practical experience, demonstrations, or inquiry-based activities in the classroom have a positive contribution to students' investigative abilities. However, there are still other categories, namely Poor at 18.18% and Very Poor at 4.55%, which indicate that a small number of students still have difficulty understanding the scientific process as a whole.

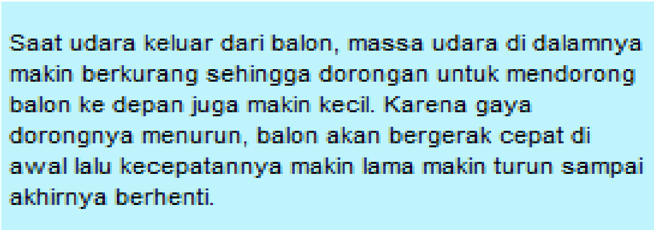

Saat udara keluar dari balon, massa udara di dalamnya makin berkurang sehingga dorongan untuk mendorong balon ke depan juga makin kecil. Karena gaya dorongnya menurun, balon akan bergerak cepat di awal lalu kecepatannya makin lama makin turun sampai akhirnya berhenti.

Figure 9. Student answers in the Fair Category

Based on the physics science literacy category, the example answer above falls into the Fair category. The student demonstrates a fairly good conceptual understanding of the phenomenon of balloon motion as an analogy for the working principle of a rocket. The student states that the longer the air escapes from the balloon, the less air mass remains inside the balloon, resulting in a smaller thrust force. The balloon, which initially moves quickly, will gradually slow down until it finally stops. From the aspect of designing and evaluating scientific investigations, the students' answers demonstrate their ability to identify the cause-and-effect relationship between changes in the mass of air inside the balloon and changes in the thrust force that affects the speed of the balloon's movement. However, students have not yet reached the stage of designing an investigation by explicitly linking this phenomenon to the law of conservation of momentum and the concept of air mass flow rate. This indicates that students' evaluative abilities are still descriptive in nature and have not yet reached the level of quantitative analysis.

Findings regarding indicators for designing and evaluating scientific investigations indicate that the majority of students in the Fair and Good categories are in line with other studies that also report moderate achievements in similar competencies. For example, research at SMA Negeri 1 Rasau Jaya shows that around 56.68% of students achieved the "Fair" category on this indicator, which reflects students' ability to determine variables and design basic investigation procedures adequately (Sari et al., 2025). Research on elementary school students by Nurjanah et al (2025) also found that the aspect of designing scientific investigations was in the Moderate category, indicating that scientific investigation skills were not yet optimal but were already above the low level. Furthermore, a study by Agustya et al (2023) reported that the competencies of evaluating and designing scientific investigations received a percentage of around 62%, indicating a medium achievement consistent with the results of this study, where students were able to achieve adequate performance in the design and evaluation of scientific investigations.

When compared overall, students' science literacy achievements show variation in each indicator. The indicator for explaining phenomena scientifically and designing and evaluating scientific investigations falls into the Fair category, while the indicator for interpreting data and evidence scientifically falls into the Poor category. This pattern indicates that students are relatively capable of recognizing and explaining phenomena and have a preliminary understanding of the relationships between variables, but still struggle to interpret data and relate it to physics concepts accurately. Difficulties with the indicator for interpreting data and scientific evidence suggest that students are not yet accustomed to integrating mathematical skills with conceptual understanding, particularly in the context of quantitative analysis.

Meanwhile, the achievement on the indicator for explaining scientific phenomena, which still falls into the moderate category, indicates that students' conceptual understanding has not yet developed deeply and remains partial. These findings align with the character of science education in many schools, which tends to emphasize hands-on activities without being balanced by reflective discussions and the reinforcement of scientific reasoning (Morris, 2025; Surif et al., 2020). As a result, students have learning experiences, but they are not yet fully able to connect those experiences with concepts and data interpretation comprehensively.

The implication of these findings is the need to strengthen learning that balances the three aspects of science literacy, namely the ability to explain phenomena, interpret data, and design and evaluate investigations. Approaches such as inquiry-based learning, problem-based learning, and contextual phenomenon-based learning can serve as alternatives to train students' abilities in integrating concepts, data, and experiences in a cohesive manner literacy (Aripin & Mufit, 2025; Mutasam & Susilo, 2020). Thus, physics education is expected not only to focus on activities but also on the comprehensive development of scientific thinking skills.

CONCLUSION

Based on the research findings, the science literacy profile of students in the three PISA aspects shows varied achievements, where the indicators of explaining phenomena scientifically and designing and evaluating scientific investigations fall into the Fair category, while the indicator of interpreting data and evidence scientifically falls into the Poor category. Thus, the indicator with the lowest achievement is interpreting scientific data and evidence, which indicates that students still face difficulties in interpreting data and relating it to physics concepts. The implication of these findings is the need to strengthen learning that emphasizes data interpretation skills, such as thru graph analysis, experimental results, and contextual reasoning-based questions. Approaches such as inquiry-based learning and problem-based learning can be used to optimally integrate conceptual understanding with data analysis. This study has limitations in the small sample size (n=22), the limited number of instruments (three questions), the single school context, and the potential subjectivity in rubric-based assessments. Therefore, future research is recommended to involve a larger sample and a more diverse set of instruments.

RECOMMENDATION

This study has several limitations, including the relatively small number of participants and the limited number of essay questions used to measure science literacy. Therefore, future research is recommended to involve larger and more diverse samples, develop more comprehensive physics science literacy instruments, and examine the effectiveness of specific instructional models or learning media in improving students' physics science literacy on other physics topics.

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AUTHOR CONTRIBUTIONS STATEMENT

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Laila Rahma Arifah	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓	
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Budi Jatmiko	✓	✓	✓	✓			✓	✓		✓	✓			
Binar Kurnia Prahani	✓	✓	✓	✓			✓	✓		✓	✓			

CONFLICT OF INTEREST STATEMENT
Authors state no conflict of interest.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author upon reasonable request.

REFERENCES

Adhari, D., Fatmawati, S., Asie, Y. P., & Suhartono, S. (2025). Profil literasi sains peserta didik SMA dimensi kompetensi pada pembelajaran fisika. *Jurnal Inovasi Pendidikan Sains (JIPS), 6*(2), 46–53. https://doi.org/10.37729/jips.v6i2.6170

Agustya, N. E., Niswati, M., & Jauhariyah, R. (2023). Analysis of the science literacy competency profile of high school students on limited energy sources. *Kappa Journal, 7*(3), 363–367. https://doi.org/10.29408/kpj.v7i3.23212

Akbar, J., Djakariah, & Rumengan, S. (2024). Pengaruh pembelajaran praktikum kimia berbasis inkuiri terbimbing terhadap keterampilan menyimpulkan siswa pada materi kelarutan dan hasil kali kelarutan. *SCIENING: Science Learning Journal, 5*(2), 213–220. https://doi.org/10.53682/slj.v5i2.11261

Aripin, N., & Mufit, F. (2025). The role of problem-based learning in developing science literacy and 21st-century skills in high school students. *Formatif: Jurnal Ilmiah Pendidikan MIPA, 15*(1), 269–284. https://doi.org/10.30998/formatif.v15i1.27799

Ashari, S. E., Rachmadiarti, F., & Herdyastuti, N. (2023). Analysis of the science literacy profile of students at state junior high school. *International Journal of Recent Educational Research, 4*(6), 889–898. https://doi.org/10.46245/ijorer.v4i6.340

Azhary, Y., & Dewantara, D. (2022). Impulse and momentum linear teaching materials with Al-Quran verses to practice problem solving skills of students: Practicality and effectiveness. *Jurnal Inovasi Pendidikan Fisika dan Riset Ilmiah, 6*(2), 87–94. https://doi.org/10.30599/jipfri.v6i2.1304

Azura, F., Jatmiko, B., Ibrahim, M., Hariyono, E., & Prahani, B. (2021). A profile of scientific literacy of senior high school students on physics learning. *Journal of Physics: Conference Series, 2110*, Article 012029. https://doi.org/10.1088/1742-6596/2110/1/012029

Bashooir, K., & Supahar, S. (2018). Validitas dan reliabilitas instrumen asesmen kinerja literasi sains pelajaran fisika berbasis STEM. *Jurnal Penelitian dan Evaluasi Pendidikan, 22*(2), 219–230. https://doi.org/10.21831/pep.v22i2.19590

Cahyani, D. K., Nugroho, A. S., Nizarrudin, & Hayat, M. (2024). Analisis kemampuan literasi sains dan berpikir kritis siswa SMP pada pembelajaran IPA. *PENDIPA Journal of Science Education, 8*(3), 593–600. https://doi.org/10.33369/pendipa.8.3.593-600

Gunawan, M. S., & Mufit, F. (2024). Design and validity of an e-assessment four tier multiple choice to assess science literacy skills of senior high school students. *Physics Learning and Education, 2*(1), 28–38. https://doi.org/10.24036/ple.v2i1.97

Hadiastriani, Y., & Djarot, P. (2024). Mapping research trends on development of scientific literacy assessment: A bibliometric analysis. *Jurnal Pendidikan Biologi Indonesia, 10*(1), 211–222. https://doi.org/10.22219/jpbi.v10i1.31136

Islami, N. P., & Setiawan, A. M. (2025). Development of disaster mitigation interactive e-modules based on socio-scientific issues (SSI) to facilitate junior high school students' science literacy. *Prisma Sains: Jurnal Pengkajian Ilmu dan Pembelajaran Matematika dan IPA IKIP Mataram, 13*(3), 602–618. https://doi.org/10.33394/j-ps.v13i3.14384

Jufrida, J., Basuki, F. R., Kurniawan, W., Pangestu, M. D., & Fitaloka, O. (2019). Scientific literacy and science learning achievement at junior high school. *International Journal of Evaluation and Research in Education, 8*(4), 630–636. https://doi.org/10.11591/ijere.v8i4.20312

Masithoh, N. D., & Jauhariyah, M. (2024). Analisis profil kompetensi literasi sains peserta didik yang diukur menggunakan instrumen berbasis kelas pada materi energi terbarukan. *Inovasi Pendidikan Fisika, 13*(3), 184–190.

Melinda, V., Hariyono, E., Erman, E., & Prahani, B. (2021). Profile of students' scientific literacy in physics learning during COVID-19 pandemic. *Journal of Physics: Conference Series, 2110*, Article 012031. https://doi.org/10.1088/1742-6596/2110/1/012031

Morris, D. L. (2025). Rethinking science education practices: Shifting from investigation-centric to comprehensive inquiry-based instruction. *Education Sciences, 15*, Article 73. https://doi.org/10.3390/educsci15010073

Mutasam, U., & Susilo, H. (2020). Penerapan pembelajaran sains berbasis inquiry based learning terintegrasi nature of science terhadap literasi sains. *Jurnal Pendidikan: Teori, Penelitian, dan Pengembangan, 5*(10), 1467–1472.

Nirfayanti, N., Setiawan, D., & Adawiah, R. (2022). Analisis proses berpikir induktif siswa SMA dalam. *Jurnal Ilmiah Pendidikan Matematika, 10*(1), 83–94. https://doi.org/10.31941/delta.v10i1.1587

Nurjanah, I., Fauzi, A., & Widia. (2025). Profil literasi sains siswa sekolah dasar pada Kurikulum Merdeka: Analisis fenomena, penyelidikan dan interpretasi data. *JPK: Jurnal Pendidikan dan Kebudayaan, 2*(4), 32–40. https://doi.org/10.56842/jpk.v2i4

OECD. (2018). *PISA 2018 assessment and analytical framework*. OECD Publishing.

OECD. (2023). *PISA 2022 results (Volume I): The state of learning and equity in education*. OECD Publishing. https://doi.org/10.1787/53f23881-en

Putri, F. A., & Mufit, F. (2023). Analysis of students' scientific literacy on work and energy as well as momentum and impulse. *Jurnal Penelitian Pendidikan IPA, 9*(12), 10583–10589. https://doi.org/10.29303/jppipa.v9i12.5990

Putri, M., Fitria, D., Nurlaini, & Berutu, N. (2026). Validity and reliability of science literacy assessment instruments for measuring science competencies in the context of PISA 2025 using the Rasch model. *Jurnal Pendidikan Fisika, 14*. https://doi.org/10.26618/n0sjn231

Ramli, M., Susanti, B. H., & Yohana, M. P. (2022). Indonesian students' scientific literacy in Islamic junior high school. *International Journal of STEM Education for Sustainability, 2*(1), 45–52. https://doi.org/10.53889/ijses.v2i1.33

Safira, L., Aulliyah, A., Farah, A., & Permana Suwarna, I. (2025). Evaluation of physical science literacy assessment instrument based on PISA 2025: A secondary school needs analysis. *COMPTON Jurnal Ilmiah Pendidikan Fisika, 11*(2), 178–195. https://doi.org/10.30738/cjipf.v11i2.20167

Sari, S. W., Yokhebed, & Tenriawaru, A. B. (2025). Analisis kemampuan literasi sains pada materi virus kelas X di SMA Negeri 1 Rasau Jaya. *Jurnal Pendidikan MIPA, 15*(3), 1222–1231. https://doi.org/10.37630/jpm.v15i3.3201

Savitri, E. N., Amalia, A. V., Prabowo, S. A., Rahmadani, O. E. P., & Kholidah, A. (2021). The effectiveness of real science mask with QR code on students' problem-solving skills and scientific literacy. *Jurnal Pendidikan IPA Indonesia, 10*(2), 209–219. https://doi.org/10.15294/jpii.v10i2.29918

Sumantri, F. N., & Kholiq, A. (2020). Pengembangan ELS-3D (E-book literasi sains berbasis 3D page flip) pada materi momentum dan impuls. *Inovasi Pendidikan Fisika, 9*(3), 479–483.

Sunni, F. M., & Sunarti, T. (2023). Profil kompetensi literasi sains siswa SMA konteks fenomena bencana banjir Kabupaten Lamongan. *Inovasi Pendidikan Fisika, 12*(3), 11–17.

Surif, J., Ibrahim, N. H., & Mokhtar, M. (2020). Conceptual and procedural knowledge in problem solving. *Procedia - Social and Behavioral Sciences, 56*, 416–425. https://doi.org/10.1016/j.sbspro.2012.09.671

Suryawati, E., & Osman, K. (2017). Contextual learning: Innovative approach towards the development of students' scientific attitude and natural science performance. *Eurasia Journal of Mathematics, Science and Technology Education, 14*, 61–76. https://doi.org/10.12973/ejmste/79329

Takda, A., Arifin, K., & Tahang, L. (2023). Profil kemampuan literasi sains peserta didik SMA berdasarkan Nature of Science Literacy Test (NoSLiT). *Jurnal Penelitian Pendidikan Fisika, 8*(1), 19–27. https://doi.org/10.36709/jipfi.v8i1.7

Tulaya, & Wasis. (2020). Analisis kemampuan literasi sains peserta didik SMA/MA di Kabupaten Sumenep. *Inovasi Pendidikan Fisika, 9*(3), 417–427.

Utami, S. H., Marwoto, P., & Sumarni, W. (2022). Analisis kemampuan literasi sains pada siswa sekolah dasar ditinjau dari aspek konten, proses, dan konteks sains. *Jurnal Pendidikan Sains Indonesia, 10*(2), 380–390. https://doi.org/10.24815/jpsi.v10i2.23802

Valio, F., Safira, L., Aulliyah, U., & Permana Suwarna, I. (2025). Development of a science literacy test for junior high school students based on the PISA 2025 framework. *Jurnal Pendidikan MIPA, 26*(3), 1377–1405. https://doi.org/10.23960/jpmipa.v26i3.pp1377-1405

Walker, K. I., & Nouri, N. (2025). Phenomenon-based learning and storylines in K-12 science education: A systematic review of current research, implementation, and future directions. *Frontiers in Education, 10*, Article 1648234. https://doi.org/10.3389/feduc.2025.1648234

Wen, C.-T., Liu, C.-C., Chang, H.-Y., Chang, C.-J., Chang, M.-H., Fan Chiang, S.-H., Yang, C.-W., & Hwang, F.-K. (2020). Students' guided inquiry with simulation and its relation to school science achievement and scientific literacy. *Computers & Education, 149*, Article 103830. https://doi.org/10.1016/j.compedu.2020.103830

Wulandari, N. (2016). Analisis kemampuan literasi sains pada aspek pengetahuan dan kompetensi sains siswa SMP pada materi kalor. *Edusains, 8*(1), 66–73. https://doi.org/10.15408/es.v8i1.1762

Yunus, R., Asniati, M., & Anwar, C. (2020). Development of Google Form based on scientific literacy principles for junior high school students in heat material. *Journal of Physics: Conference Series, 1467*, Article 012055. https://doi.org/10.1088/1742-6596/1467/1/012055

Zhang, B., Looi, C.-K., Seow, P., Chia, G., Wong, L.-H., Chen, W., So, H.-J., Soloway, E., & Norris, C. (2010). Deconstructing and reconstructing: Transforming primary science learning via a mobilized curriculum. *Computers & Education, 55*(4), 1504–1523. https://doi.org/10.1016/j.compedu.2010.06.016

Zulaiha, F., & Kusuma, D. (2021). Analisis kemampuan literasi sains peserta didik SMP di Kota Cirebon. *Jurnal Pendidikan Fisika dan Teknologi, 7*(2). https://doi.org/10.29303/jpft.v7i2.3049