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# Exploring students' beliefs about physics and learning physics in their first year of high school: a comparative study

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**Keywords:**
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Physics perceptions;
students' belief

**Abstract**

Understanding students' perceptions and beliefs about physics and physics learning is crucial for effective pedagogy. This study explores the alignment between students' perceptions of physics and expert viewpoints across various indicators. The study employed a non-experimental quantitative approach, with data collected using *The Colorado Learning Attitudes about Science Survey (CLASS)* to assess students' attitudes and beliefs. A total sampling technique was applied, involving 120 Grade X high school students as participants. The results show that the overall percentage of questions where a student agrees with the expert response (percent favorable score) is 42.824%, with a standard deviation of 11.187%. Among the categories analyzed, the highest scores are observed in problem-solving confidence and personal interest in physics, with agreement levels of 61.458% and 58.797%, respectively. However, the most critical issues are found in conceptual connection and the ability to apply physics understanding, where students score significantly lower. Gender-based comparisons reveal nuanced differences, underscoring the need for tailored instructional strategies. While efforts to enhance student confidence and interest are evident, challenges persist in fostering robust comprehension and practical application of physics concepts. Future research could expand on these findings with longitudinal designs and diverse cohorts to improve pedagogical practices in physics education.

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## Introduction

Physics, a cornerstone of natural science, is a fundamental discipline taught as a core subject in schools. It provides profound insights into the workings of the universe, offering explanations for natural phenomena and describing the behavior and interactions of matter and energy (Winter & Hardman, 2020). Beyond its role as an academic subject, physics fosters essential skills such as critical thinking, analytical reasoning, and problem-solving, making it indispensable in education. The teaching and learning process of physics in schools is an integral component of broader educational objectives, requiring continuous cycles of planning, implementation, and evaluation to ensure effective learning outcomes (Mayer, 2011). At its core, physics education aims to bridge the gap between theoretical knowledge and practical understanding, emphasizing the relevance of physics concepts to students' daily lives and helping them make sense of the world around them. This reflects the significant responsibility borne by physics educators.

Despite its significance, physics is often regarded by students and the public as a challenging and uninteresting subject (Redish, 2003). Many students perceive physics as overly abstract, filled with complex formulas, and detached from real-life applications, leading to disengagement and a lack of motivation to learn (Winter & Hardman, 2020). These perceptions often stem from traditional teaching approaches that emphasize rote memorization of equations and procedural problem-solving, commonly referred to as "plug and chug." While such methods may help students find correct answers, they often fail to cultivate a genuine understanding of underlying principles. Research has shown that students can perform well in calculations yet struggle to grasp the core concepts they are solving for, highlighting a significant gap in conceptual comprehension (Mazur, 1997, 2014; Rosengrant et al., 2009).

These challenges are further magnified by comparisons between physics and other science subjects, such as chemistry and biology, which are often perceived as more engaging and relatable. For instance, physics classes are frequently criticized for their heavy emphasis on mathematical calculations, making them less appealing to students (D. H. Putri & Pranata, 2023), particularly due to their heavy reliance on mathematical calculations. While mathematics is undeniably central to physics, serving as a language through which many phenomena are described, its integration into teaching must be carefully designed. Rather than being a barrier, mathematics should be leveraged as a tool to enhance students' understanding of physical concepts, fostering both interest and self-efficacy (Béchard et al., 2021).

Effective physics education involves more than transmitting knowledge about formulas and laws; it requires nurturing students' ability to see the relevance of physics in their everyday lives. Educators can play a pivotal role by demonstrating the connections between classroom lessons and real-world applications, emphasizing relationships between concepts, and fostering critical thinking and problem-solving skills (Docktor et al., 2016). A shift from rote learning to sense-making is essential, where students not only learn to apply equations but also understand the reasoning behind them. Prior studies have emphasized this need, revealing that students who merely focus on calculations often lack a genuine grasp of the concepts they represent (Cock, 2012; Rosengrant et al., 2009).

Another critical aspect of physics education is understanding students' perceptions and beliefs about the subject. These perceptions significantly shape how students approach learning and influence their academic engagement, achievement, and career choices (A. L. Putri et al., 2024). For many students, the way they perceive physics can either unlock its transformative potential or reinforce the notion that it is a subject to be endured rather than embraced. Recognizing and addressing these perceptions is key to fostering a positive learning experience and equipping students with the skills and confidence to excel. Physics education teaches more than just scientific principles—it instills valuable competencies such as logical reasoning, analytical problem-solving, and an understanding of complex systems, all of which are highly transferable to various career paths(Winter & Hardman, 2020).

This research seeks to uncover high school students' beliefs about physics as a subject and its relevance to daily life, along with their perceptions of the challenges and importance of problem-solving in physics learning. It also examines whether significant gender differences exist in these beliefs and perceptions and explores the implications for students' engagement, performance, and conceptual understanding in physics. These insights aim to inform and improve physics teaching practices and curriculum design.

**Method**

This study analyzed students' beliefs about physics and learning physics during their first year of high school using a survey approach, a non-experimental quantitative method. The population of this study comprised all 120 students in Grade X High School 1 Kerinci, distributed across four classes. A total sampling technique was employed, including all students as participants. The study began with data collection to uncover the initial conditions related to students' beliefs about physics and learning physics at the senior high school level. Prior to data collection, informed consent was obtained from all participants and their legal guardians. The consent process included detailed information about the study's objectives, the voluntary nature of participation, and assurances of confidentiality. Participants were informed that their responses would remain anonymous and used solely for research purposes.

Data were collected through a survey using The Colorado Learning Attitudes about Science Survey (CLASS) Version 3 (Adams et al., 2006). The CLASS V.3 questionnaire has been validated using interviews, reliability studies, and extensive statistical analyses of responses from over 5000 students. The questionnaire consists of 42 questions divided into 8 categories. Students were asked to respond from strongly agree to strongly disagree (five-point Likert scale). Interestingly, assessments are shown on percentage scale, where students' answers align or do not align with the views of experts or scientists. The "percent favorable score" is the percentage of questions where a student agrees with the expert response (Adams et al., 2006). The categories in the questionnaire relate to students' ideas about learning physics and problem-solving: real-world connection, personal interest, sense-making/effort, conceptual connections, applied conceptual understanding, problem-solving general, problem-solving confidence, and problem-solving sophistication. Each category involves 4 to 8 statements. Interestingly, one statement can be part of two different categories. Then there is one trap statement prepared (statement number 31) to eliminate responses from students who did not read the statement.

Descriptive and comparative quantitative methods are applied. Data collected using the CLASS V.3 questionnaire will be analyzed using descriptive statistics. Then the results are presented from various perspectives and categories to obtain a more comprehensive picture of students' beliefs about physics and learning physics. The percentage of student views matching those of experts or scientists can be classified into 4 levels or quartiles to facilitate a nuanced interpretation of the results as shown in Table 1.

**Table 1.** Percent Favorable Score Classification

| Percent Favorable Score ($\bar{x}$) | Quartile (Q) | Classification |
|---|---|---|
| $75\% \leq \bar{x} \leq 100\%$ | Q1 | Excellent |
| $50\% \leq \bar{x} < 75\%$ | Q2 | Good |
| $25\% \leq \bar{x} < 50\%$ | Q3 | Fair |
| $0 \leq \bar{x} < 25\%$ | Q4 | Poor |

Quartiles provide a structured framework for categorizing the data into distinct levels of agreement, ranging from excellent to poor, thereby enabling researchers to identify patterns and trends in students' perceptions more effectively.

Furthermore, the data are also compared based on gender. Gender comparison is processed using independent sample t-tests or Mann-Whitney U-tests. Meanwhile, comparisons between different classes are processed using ANOVA or Kruskal-Wallis tests. All tests are conducted with the assistance of SPSS software.

## Results and Discussion

Although seemingly simple, trap statements play a crucial role in enhancing response reliability. Based on the collected data, 48 students failed to pass the trap (40%), a significantly higher number compared to the 15% reported during the questionnaire development phase (Adams et al., 2006). Therefore, the data analysis will only involve responses from 72 students.

### *Descriptive Statistics*

The descriptive analysis results of the overall student data about their beliefs about physics and learning physics are presented in Table 2.

**Table 2.** Descriptive Statistic

| Data | Mean | | Std. Deviation | Skewness | |
|---|---|---|---|---|---|
| | Statistic | Std. Error | | Statistic | Std. Error |
| Overall. Students' Belief about Physics and Learning Physics | 42.824 | 1.318 | 11.187 | -1.278 | 0.283 |
| C1. Real World Connection | 50.347 | 2.862 | 24.283 | -0.597 | 0.283 |
| C2. Personal Interest | 58.797 | 3.378 | 28.659 | -0.373 | 0.283 |
| C3. Sense Making/Effort | 48.016 | 2.403 | 20.387 | -0.668 | 0.283 |
| C4. Conceptual Connection | 22.455 | 2.166 | 18.376 | 1.017 | 0.283 |
| C5. Applied Conceptual Understanding | 21.827 | 2.188 | 18.567 | 1.184 | 0.283 |
| C6. Problem Solving General | 53.472 | 2.572 | 21.825 | -0.833 | 0.283 |
| C7. Problem Solving Confidence | 61.458 | 2.881 | 24.444 | -0.949 | 0.283 |
| C8. Problem Solving Sophistication | 37.037 | 2.289 | 19.425 | 0.045 | 0.283 |

The results show that the overall percentage of questions where a student agrees with the expert response (percent favorable score) is found to be 42.824%, with a standard deviation of 11.187%. This percentage falls into quartile 3 (Q3) based on the classification in Table 1, indicating alignment between students and experts or scientists at a fair level.

Overall, the level of alignment between student perspectives and experts or scientists is at a fair level (Q3). This is supported by the majority of students falling into the same category (Q3), with 63.89% of all students, as shown in Figure 1, nearly approaching two-thirds of the total students. However, a significant number of students, 30.56%, fall into the good category (Q2) for alignment of perspectives. The remaining 5.56% are in the lowest quartile (Q4) or at a poor level. Unfortunately, based on the data from all statements, no students were found to have alignment with experts or scientists at the excellent level (Q1).

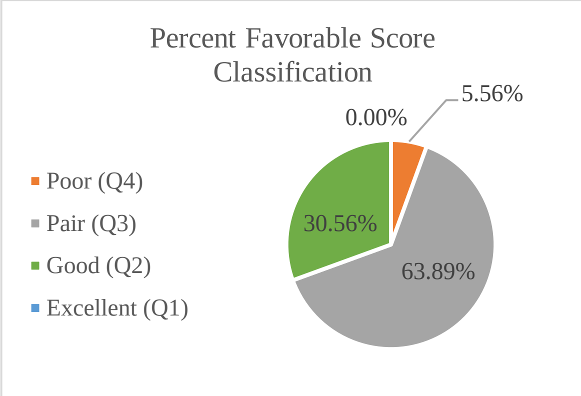



**Figure 1**. Percent Favorable Score Classification for Each Student

In addition to the overall perspective and the distribution of students based on levels, the discussion also focuses on each category. The results of the descriptive analysis for all categories are shown in Table 2. To illustrate the comparison of the mean for each category, the mean values are presented in a bar chart format as shown in Figure 2.

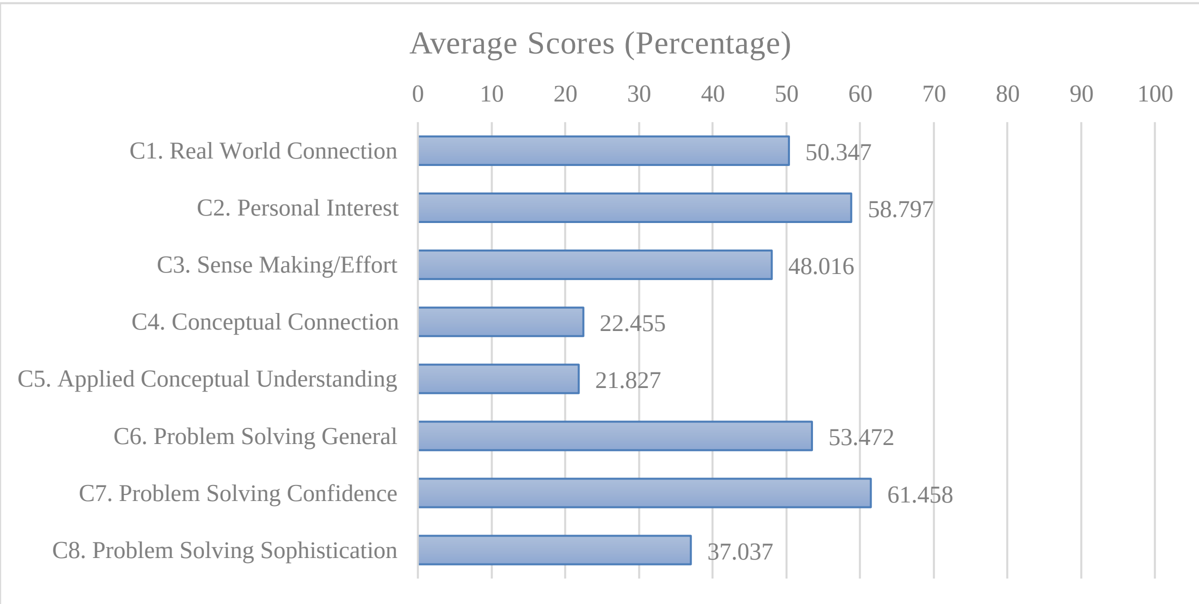



**Figure 2**. Average Scores for Each Category

Based on the data in Table 2 and Figure 2, it can be concluded that there are four indicators in quartile 2 or the good level (C7, C2, C6, and C1), two indicators in quartile 3 or the fair level (C3 and C8), and two indicators in quartile 4 or the poor level (C4 and C5). The same pattern is found, with none falling into quartile 1 or with student perspectives aligning excellently with experts or scientists based on indicators or categories.

Category 7 (C7. Problem Solving Confidence) is found to have the highest percent favourable score, which is 61.458%. The significant contribution to this percentage is the students' agreement with the expert view that nearly everyone is capable of understanding physics if they work at it (86.11%) and usually try to figure out a different way that works if they get stuck on a physics problem on their first try (81.94%). Despite the high alignment (excellent level) on these two ideas, there are other ideas in C7 with very low alignment percentages. For example, when confused in problem-solving, the majority of students choose to give up. Only 12.50% of students provide contrary answers aligned with the expert view. Interestingly, the statements with high and low values found are two related ideas but expressed in the form of two different statements, one positively and the other negatively framed. On one side, students choose to try another way, but on the other side, they tend to give up. This finding warrants further investigation with a more detailed approach to ensure students respond honestly and seriously.

Although having the highest percent favourable score, students' problem-solving confidence plays an important role in learning and thus needs improvement. However, it is important to understand that previous studies have revealed that the level of student confidence in answering questions or solving problems does not guarantee test scores (Pranata & Marshal, 2023). Other factors besides confidence influence the problem-solving process such as conceptual understanding, self-awareness (Pranata, Sastria, et al., 2023), motivation, problem-solving strategies (Pranata & Marshal, 2023), and so on. Various recommendations from previous studies regarding efforts to increase student confidence in learning and problem-solving have been provided, such as learning activities through experiments, guided inquiry (Pranata, 2023a), and utilizing technology-based simulations as confirmatory tools in learning physics (Pranata, 2023b). Experiments have been a crucial part of the scientific development cycle, so these activities should not be overlooked but rather integrated into the learning process. Furthermore, engaging in learning activities that can confirm students' ideas, perspectives, or responses to learning also has a positive impact on students, especially in boosting their confidence (Heydari et al., 2013).

The second-highest percent favourable score is found in category 2 (C2. Personal Interest), which is 58.797%. The perspective that learning physics changes my ideas about how the world works has the highest alignment in C2 (65.28%). This is followed by two perspectives with the same alignment percentage (63.89%), namely dissatisfaction until I understand why something works the way it does and the belief that studying physics is about learning knowledge that will be useful in life outside of school. Other statements are also not far from the average percentage in C2. The lowest alignment percentage is found concerning the habit of thinking about physics as part of the experience in everyday life (45.83%). The majority of students (54.17%) do not think about physics when going through daily life.

Students' interest in science, especially physics, should be the main focus of physics learning in schools. Interest in science is another form of students' curiosity about the universe through the door of physics. This interest is also an important part of students' scientific literacy (Swarat et al., 2012). Findings in the research show that the majority of students (63.89%) still have curiosity about the universe and realize that physics relates to their daily lives. However, issues related to interest in physics may be hampered because the majority of students (54.17%) still struggle to connect their experiences in daily life with physics concepts. This category of personal interest (C2) is related to the first category focusing on real-world connection (C1), which will be discussed next. Other studies also reveal the integrative role of other subjects, such as mathematics, in science subjects (Béchard et al., 2021; Ulandari et al., 2024).

Based on the findings in C2, it can be concluded that all stakeholders, especially educators, should consider students' personal interest in physics (or science). Educators need to implement learning activities that can maintain and enhance interest in learning physics and its connection with other subjects. One way is by highlighting the role that physics plays in students' everyday lives to help them feel the subject is relevant and worth studying (Winter & Hardman, 2020). Educators can consider activities and tasks in learning that are suitable for students' conditions (Renninger & Hidi, 2011) and vary various activities (Cahyani & Pranata, 2023; Swarat et al., 2012). Learning should be directed according to the context and background of students' lives (contextual learning) (Habig et al., 2018; Peşman & Özdemir, 2012), and learning through demonstrations using simple tools that are easily found can also be considered by educators (Kurniawan & Haka, 2023; Pranata et al., 2017; Sokoloff & Thornton, 1997).

The third and fourth-highest percent favourable scores are found in category 6 (C6. Problem Solving General) and category 1 (C1. Real World Connection), which are 53.472% and 50.437%, respectively. Both also fall into the good level but are close to the lower limit (50%). Similar to C7, a significant contribution to problem-solving general (C6) is also found to be related to students' belief that they are capable of understanding and solving physics problems when they try. Students' perspectives vary significantly when it comes to situations where they do not know the problem-solving procedures and the role of equations in problem-solving. When unaware of the procedure, students tend to give up on solving the problem. Only 12.50% do not give up and align with the expert view. Furthermore, alignment between students and experts is found to be only 11.11% for the role of equations. On the contrary, most students (88.89%) believe that physics equations are only for calculations and do not help in understanding. Previous studies have confirmed that problem-solving is related to the representational format of the given problem (Kohl & Finkelstein, 2005). Therefore, students are expected to become more familiar with various representations in physics learning, especially mathematical equations.

Furthermore, a significant contribution to the real-world connection category (C1) is shown by the alignment between students and experts regarding physics learning that can change their views on how the universe works (65.28%) and the importance of connecting personal experiences with physics topics to understand physics (65.28%). The direction is from experience to physics. Problems arise when statements are presented from the perspective of physics learning towards everyday life. The majority of students (87.50%) tend to believe that the physics material they learn has little connection with experiences in daily life. In other words, there is only 12.50% alignment between students and experts regarding the physics-experience relation in daily life. However, showing the relationship between physics and students' experiences is very important in learning. When physics learning can demonstrate this relationship, it enables students to engage in that discipline and build an identity that connects them to physics (Winter & Hardman, 2020). Therefore, physics teachers are responsible for discovering and demonstrating this relationship in the context of students' everyday experiences.

The discussion then moves to two categories in quartile 3 (fair level), namely sense-making/effort (C3) and problem-solving sophistication (C8). Their alignment percentages are 48.016% and 37.037%, respectively. Some problems related to sense-making/effort (C3) are indicated by students' belief in calculations rather than meaning-making (15.28%) and understanding the origins of equations (19.44%). For example, when students perform calculations but the results differ from predictions, students tend to not reanalyze the problem and view the results of calculations as correct. Students also perceive efforts to understand the origins of formulas or equations as time-consuming and unhelpful. Students believe it is important to understand an equation according to the expert view, with an alignment percentage of 65.28%. However, on average, for the six statements in the sense-making/effort category, the alignment is still in quartile 4 (fair level). Previous studies have shown that sense-making can be improved through learning using PhET simulations as they can demonstrate a phenomenon in various representations, including equations (Wieman et al., 2010).

Furthermore, some problems related to problem-solving sophistication (C8) are related to methods, abilities, and practices in problem-solving. Students believe that a particular method of problem-solving can only be applied to very similar problems (9.72%). This perspective differs from the expert view, which believes that it does not have to be identical but depends on the conditions and adapts the method to the problem. Abilities and confidence in problem-solving also distinguish between students and experts. Students give up when they feel incapable without trying (12.50%). Furthermore, students sometimes feel that they understand physics but cannot solve more difficult problems on the same content or topic (25.00%). This condition is related to the practice of problem-solving. These three statements contribute to the low average in C8. Previous studies on problem-solving suggest using practical tools that can measure the difference between novice and expert problem-solving performance in an authentic classroom (Docktor et al., 2016).

Unfortunately, there are still two other categories with lower averages which will be discussed next. The two categories with the lowest alignment levels are C4 (conceptual connection) and C5 (applied conceptual understanding). Both are in the lowest quartile (poor) with average percent favourable scores of 22.455% and 21.457%, respectively. This condition indicates that the main problems students face in learning physics are understanding concepts and applying them. Problems regarding conceptual understanding are based on students' belief that memorizing all information related to physics is burdensome and important for success in learning physics. Alignment between students and experts is only 8.33%. This means that the majority (more than 90%) of students disagree with the expert regarding this issue. Experts disagree with the activity of memorizing information in learning physics. Actually, it can be easy to see the formulae that students need as a list that just has to be memorized and recalled in an exam. It would be a shame to simply commit these equations to memory rather than use them to develop and strengthen understanding (Winter & Hardman, 2020).

The next problem is the understanding of the relationship between concepts and equations (9.72%) and seeing equations only for calculation (11.11%), which are also very low. Mathematics (equations) plays an important role in exploring and learning physics. Knowing the equation is a far cry from relating it to phenomena in the world, and only once the mathematics is given meaning does it become elegant (Winter & Hardman, 2020). Other statements are also low, and only one statement in category C4 has a percent favourable score of more than 50%, which is related to students' efforts to solve problems in exams even without remembering equations.

Regarding the application of concepts, problems related to students' perceptions that concepts or methods cannot be applied to other topics with different situations (9.72%), giving up when encountering difficult problems (12.50%), and the way to solve physics problems is to find formulas and plug in numbers (16.67%). Experts have the opposite view, but only a small percentage of students share the same view (shown in the percentages in brackets).

Issues related to understanding and applying concepts are not new in physics learning. Such problems have been recognized for a long time, with most learning processes failing to guide students to understand concepts (Hestenes & Halloun, 1985; Mazur, 1997; Wieman & Perkins, 2006). Various recommendations to solve these problems have been provided, such as peer instruction (Crouch & Mazur, 2001; Mazur, 1997, 2014), inquiry-based learning (Pranata, 2023a), learning using technology (Pranata, 2023a, 2023b; Pranata & Seprianto, 2023), and project-based learning (Pranata, Sundari, et al., 2023; Pranata & Kusayang, 2024).

***Comparative: Percent Favorable Score Based on Gender***

Based on average favourable scores by gender, it can be compared how male and female students perceive physics and physics learning for each indicator (Figure 3).

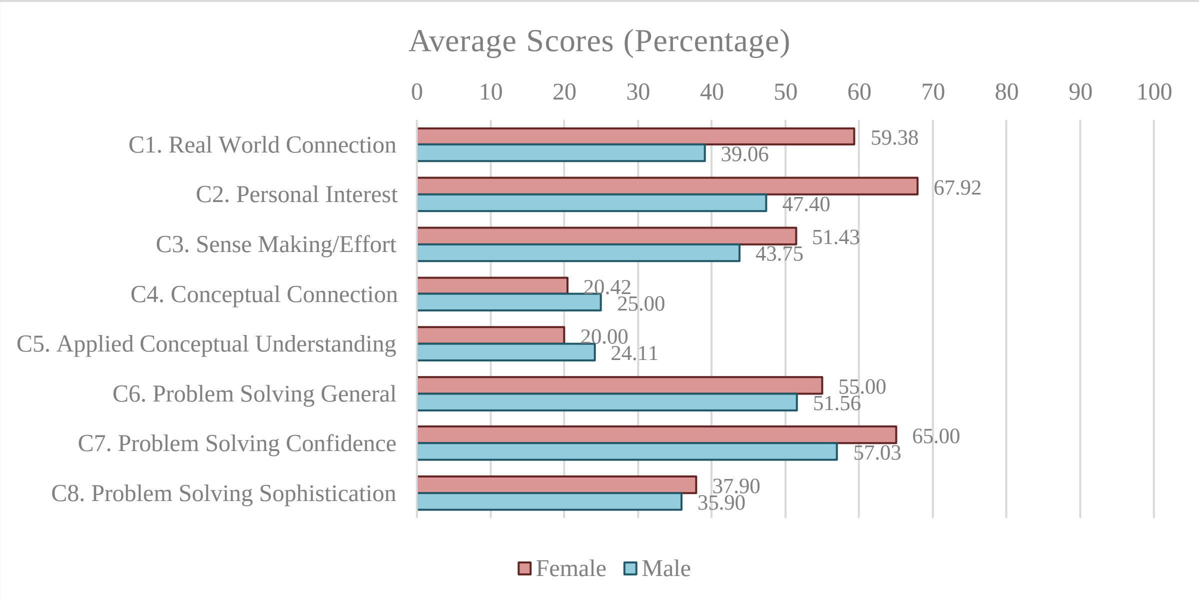



**Figure 3.** Average Score Based on Gender

Female students have higher average favourable scores in six out of eight indicators, namely C1, C2, C3, C6, C7, and C8. Whereas the other indicators (C4 and C5) are found to have favorable scores for male students. Unfortunately, indicators C4 (conceptual connection) and C5 (applied conceptual understanding) are the two indicators with the lowest Percent Favourable Scores.

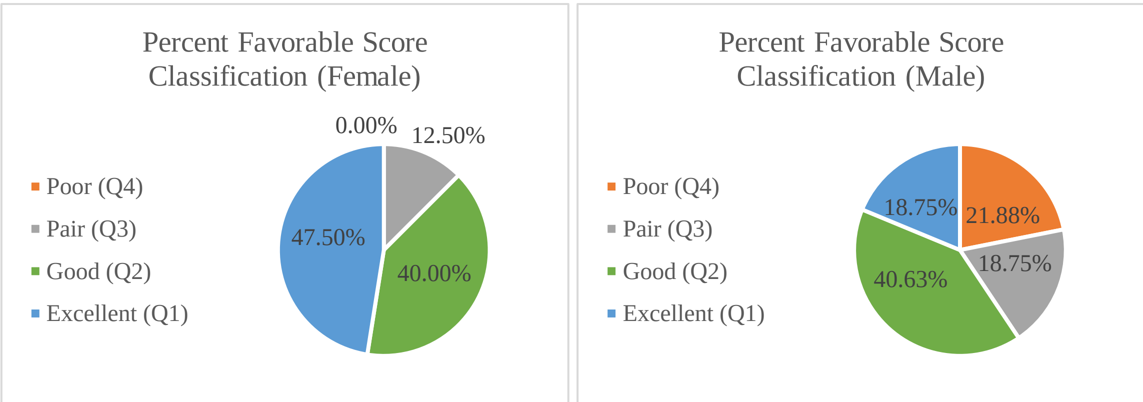
Although differences are found based on the average Percent Favourable Score values, these differences cannot be concluded as significant or not. The significance of differences can be determined through a comparative test, namely the Mann-Whitney U-Test. The results are shown in Table 3.

**Tabel 3.** Mann-Whitney U-Test: Test Statistics[a]

| | Overall | C1 | C2 | C3 | C4 | C5 | C6 | C7 | C8 |
|---|---|---|---|---|---|---|---|---|---|
| Mann-Whitney U | 517.50 | 364.00 | 400.50 | 542.50 | 591.50 | 559.50 | 575.50 | 542.00 | 591.50 |
| Wilcoxon W | 1046.00 | 892.00 | 928.50 | 1070.00 | 1412.00 | 1380.00 | 1104.00 | 1070.00 | 1120.00 |
| Z | -1.394 | -3.309 | -2.770 | -1.136 | -0.588 | -0.962 | -0.747 | -1.220 | -0.574 |
| Asymp. Sig. (2-tailed) | 0.163 | **0.001** | **0.006** | 0.256 | 0.556 | 0.336 | 0.455 | 0.222 | 0.566 |

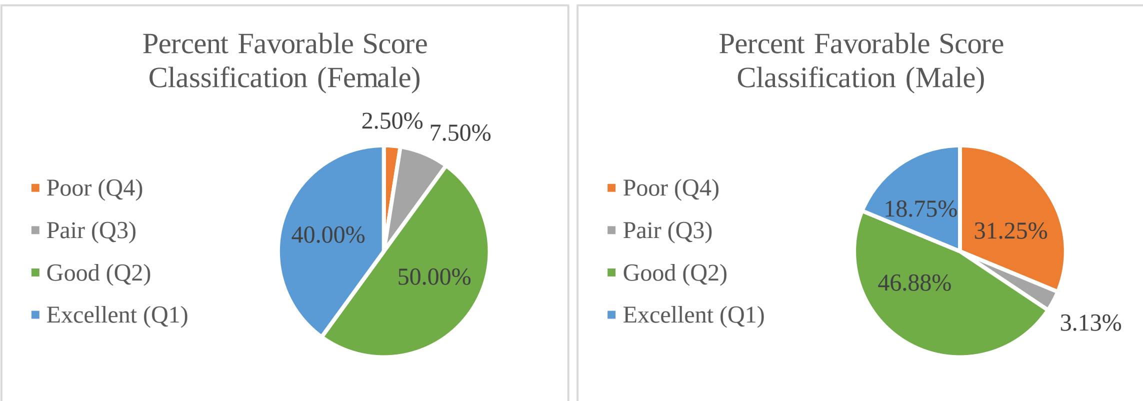
a. Grouping Variable: Gender

Comparative tests using the Mann-Whitney U-Test based on gender show that overall, no significant differences are found between male and female students' views on physics and physics learning. However, based on the comparative test results for each indicator, significant differences are found only in indicators 1 and 2 (C1 and C2). Differences in indicators C3-C8 are not significant. Comparative tests for C1 and C2 found significant values for both smaller than 0.05, namely 0.001 for C1 (real world connection) and 0.006 for C2 (personal interest). The magnitude of the average percent favourable score differences found are 20.31% and 20.52% for C1 and C2, respectively.




(a) (b)

**Figure 4.** Percent Favorable Score Classification for C1 (Real World Connection): (a) Female and (b) Male Students




(a) (b)

**Figure 5.** Percent Favorable Score Classification for C2 (Personal Interest): (a) Female and (b) Male Students

The differences found can be confirmed based on the distribution of scores for both indicators by gender as shown in Figures 4 and 5. Figure 4 shows the distribution of classification percentages of agreement between female and male students' views and experts for the realworld connection indicator. The diagram in Figure 4a shows that 87.50% of female students are in quartiles 1 (Excellent) and 2 (Good). A lower percentage of male students, namely 59.38%, are found to be in quartiles 1 and 2 as shown in Figure 4b. Furthermore, no female students are in quartile 4 (Poor). In comparison, there are 21.88% of male students in quartile 4. Based on the review of the collected data, two ideas triggering the biggest differences are found. First, views related to physics learning can change our ideas about how the universe or world works. There is 82.5% agreement between female students' views and experts on this idea. The percentage of agreement is much lower between male students and experts, at 43.8%. The difference in percentage agreement reaches 38.8%. Second, views related to reasoning in understanding physics concepts that can be applied in everyday life. Almost the same as the previous idea, the percentage of agreement for females is higher compared to males with experts. However, the difference in percentage is smaller, at 20.6%.

Next, Figure 5 shows the distribution of classification percentages of agreement between female and male students' views and experts for the personal interest indicator. The diagram in Figure 5a shows that although there are students (2.5%) in quartile 4 (Poor), a higher percentage (90% of female students) are already in quartiles 1 (Excellent) and 2 (Good). On the other hand, the number of male students in quartile 4 is higher compared to the previous indicator, reaching 31.25% of male students as shown in Figure 5b. The number in quartiles 1 and 2 also slightly increased compared to the previous indicator, reaching 65.63%. Then, based on the review of the collected data, several triggers for these differences are found. First, related to the idea of students often thinking about physics and its connection to their daily experiences (a difference of 30.6%). Second, related to the idea of their goals in learning physics to apply it in their lives outside of school (a difference of 26.3%).

These differences indicate that female students have better views compared to male students on both indicators. This finding contradicts previous studies, where females were found to be less expert in most categories, including these two categories (Adams et al., 2006). Therefore, these findings need to be further explored through more comprehensive studies.

**Conclusion**

Based on the analysis and discussion, it can be concluded that students' views and beliefs about physics and physics learning still differ significantly from those of experts or scientists. The level of agreement (percent favorable score) only reaches 42.824%. Among the categories analyzed, the highest scores are observed in problem-solving confidence (C7) and personal interest in physics (C2), with agreement levels of 61.458% and 58.797%, respectively. However, the most critical issues are found in conceptual connection (C4) and the ability to apply physics understanding (C5), where students score significantly lower. These findings indicate that educators should prioritize shifting the focus of physics teaching toward fostering a deeper understanding and application of core concepts.

To address the issues of conceptual understanding and practical application, interactive learning strategies such as Peer Instruction can be implemented effectively. Peer Instruction promotes conceptual understanding by encouraging active engagement, peer discussion, and immediate feedback. Teachers can use conceptually challenging multiple-choice questions during lessons, paired with discussions where students explain their reasoning to peers. This approach not only deepens conceptual connections but also nurtures collaborative problem-solving skills. Additionally, integrating simulations such as PhET in inquiry-based learning environments can enhance students' ability to apply physics concepts. These tools allow students to explore and visualize abstract concepts interactively, bridging the gap between theory and practical application. Teachers should consider designing project-based learning.

Despite the robustness of the findings, this study has limitations in sample size, school level, and geographical scope. Future studies should explore comparative analyses across various grade levels and schools. Longitudinal research designs can help trace changes in students' views and beliefs about physics throughout their education. Furthermore, experimental studies could investigate the impact of specific interactive teaching strategies, such as Peer Instruction, on improving conceptual understanding and physics applications. These investigations will contribute valuable insights into refining physics pedagogy to address student learning needs more effectively.

## Credit Authorship Contribution Statement

**Ogi Danika Pranata**: Conceptualization, Methodology, Statistical Analysis, Writing – review & editing. **Seprianto:** Conceptualization, Project administration, Supervision. **Mustika Candra Dewi**: Data Collection-Conversion, Writing – original draft. **Fadilla Gusvina**: Data Collection-Conversion, Writing – original draft.

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