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Students' Attitudes and Challenges in Learning Physics: An Explanatory Sequential Mixed-Methods Study in Indonesian Secondary Schools

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Abstract
Problem solving skills need to be developed so that students can compete with the rapid advances in technology and science.The purpose of this study was to find the improvement and response of students after the application of the STEM-based Problem Based Learning (PBL) model on Ecology and Biodiversity material on students' problem solving skills. The research method used is quantitative with quasi experiment. The research subjects were students of class VII G as the experimental class and class VII H as the control class. The results of the study were STEM-based Problem Based Learning (PBL) on ecology and biodiversity material proved effective in improving students' problem solving skills, based on the results of the Mann-Whitney test which showed a significant difference between the experimental and control classes. The conclusion in this study is that the STEM-based Problem Based Learning (PBL) model effectively improves problem solving skills in ecology and biodiversity materials. Problem solving skills need to be developed so that students can compete with the rapid advances in technology and science.

Keywords: Problem Solving; Problem Based Learning (PBL); STEM.

INTRODUCTION

Science education plays a central role in developing students' intellectual, emotional, and social capacities, particularly in preparing them to face the rapid advancement of technology and global challenges (Darling-Hammond et al., 2020; Fausan et al., 2021). Science is not only a collection of facts but also a systematic way of investigating the natural world through observation, experimentation, and reasoning (Kraus, 2024; Urdanivia Alarcon et al., 2023). Among the branches of science, physics holds a unique position as it explains fundamental principles governing natural phenomena and technological innovations (May, 2023; Oliveira, 2014). However, despite its importance, physics has often been perceived by students as one of the most difficult and less attractive school subjects (Baran, 2016; Kanyesigye et al., 2022; Steidtmann et al., 2023). Students' negative attitudes toward physics have been identified as a major barrier to effective learning and a persistent challenge for educators worldwide.

Previous studies have consistently demonstrated that many students consider physics abstract, overly mathematical, and disconnected from everyday life, which negatively affects their engagement and achievement (Kervinen et al., 2020; Nair & Sawtelle, 2019). For example, the mathematical formulations and symbolic representations required in physics problem-solving often discourage students who struggle with quantitative reasoning (Edelsbrunner et al., 2023; Park, 2020). Moreover, the teaching approaches frequently adopted in physics classrooms tend to emphasize rote memorization and procedural calculation rather than fostering conceptual understanding, critical thinking, and inquiry-based learning (Von Korff et al., 2016; Xie et al., 2021). As a result, students frequently develop negative attitudes that reduce motivation, persistence, and willingness to pursue further studies in physics or related disciplines.

Attitude toward science in general, and toward physics in particular, has been widely studied within the field of science education. Attitudes encompass cognitive, affective, and behavioral components, influencing how students perceive, value, and engage with scientific learning (Kanyesigye et al., 2022; Mao et al., 2021; Wicaksono & Korom, 2023). Research has shown that positive attitudes correlate strongly with increased interest, self-efficacy, and academic performance, while negative attitudes are often linked with science avoidance and lower achievement (Ballen et al., 2017; Daker et al., 2021; İnce, 2023; Wicaksono & Korom, 2023). For instance, Osborne et al., (2003) highlighted that students' declining interest in science becomes particularly evident in secondary education, where physics is commonly viewed as boring, irrelevant, and difficult. These negative perceptions often persist into higher education, leading to a shortage of students pursuing physics-related careers (DeWitt et al., 2019; Kessels et al., 2006; Lock & Hazari, 2016).

Several factors have been identified as determinants of students' attitudes toward physics. These include students' prior knowledge and cognitive abilities, the perceived relevance of physics content, the teaching methods employed by teachers, and the classroom environment (Binder et al., 2019; Sheldrake et al., 2017; Smith et al., 2022; Uden et al., 2022). Teachers' instructional practices play a particularly significant role in shaping students' perceptions of physics. When instruction is overly abstract, teacher-centered, and examination-driven, students tend to disengage and form negative attitudes (Lee & Boo, 2022; Osborne et al., 2003; Von Korff et al., 2016). Conversely, inquiry-based, interactive, and contextually relevant teaching strategies have been found to improve students' enjoyment, understanding, and attitudes toward physics (Urdanivia Alarcon et al., 2023). Therefore, examining students' attitudes not only provides insights into their learning difficulties but also informs the development of effective pedagogical interventions.

Although research on students' attitudes toward science and physics has been conducted extensively across different countries, there remains a limited body of work focusing on the Indonesian context. Previous studies in Indonesia have emphasized students' low performance in physics and their difficulties in solving quantitative problems (Astalini et al., 2019; Maison et al., 2021; Soeharto & Csapó, 2022). However, relatively few studies have adopted a mixed-methods approach to comprehensively explore the interplay between cognitive challenges, affective perceptions, and classroom practices influencing students' attitudes toward physics. Most existing research relies either on quantitative survey data or small-scale qualitative observations, which may not fully capture the complexity of students' learning experiences (Maison et al., 2021; Tanti et al., 2020). This lack of integrated evidence creates a gap in understanding the specific factors shaping Indonesian students' attitudes and how these insights can inform teaching practices.

To address this gap, the present study employs an explanatory sequential mixed-methods design to investigate students' attitudes toward science subjects, with a particular emphasis on physics. The study aims to identify students' perceptions, challenges, and motivations in learning physics, as well as the instructional factors that contribute to these attitudes. By combining quantitative survey results with qualitative interview data, this research seeks to provide a deeper and more nuanced understanding of the reasons behind students' difficulties and the strategies needed to foster positive engagement with physics. Ultimately, the findings are expected to contribute to the ongoing discourse on improving physics education in Indonesia and offer implications for educators and policymakers seeking to enhance students' learning outcomes and interest in science.

METHODS

This study employed an explanatory sequential mixed-methods design, which integrates quantitative and qualitative approaches in a two-phase procedure to provide a more comprehensive understanding of the research problem (Johnson & Onwuegbuzie, 2004). In the first phase, quantitative data were collected through a structured questionnaire administered to secondary school students, followed by the second phase in which qualitative interviews were conducted to explain and elaborate upon the quantitative findings. The rationale for using this design lies in its capacity to capture not only the general trends in students' attitudes toward physics but also the underlying reasons and contextual factors influencing those attitudes (Draucker et al., 2020).

The participants of this study consisted of 60 students drawn from Indonesian secondary schools who had been exposed to science subjects, particularly physics. A purposive sampling strategy was applied to ensure that the selected participants represented students with varying levels of achievement and interest in physics. This approach was intended to capture diverse perspectives on the challenges and motivations associated with learning the subject. Ethical considerations were addressed by obtaining informed consent from all participants and assuring them of the confidentiality and anonymity of their responses in accordance with established research ethics guidelines (Cohen et al., 2017).

Data were collected using two primary instruments. The first was a closed-ended questionnaire consisting of 18 items designed to measure students' attitudes toward science and physics. The questionnaire was developed based on existing instruments in science education research and adapted to the Indonesian educational context. Items were structured on a five-point Likert scale, ranging from "strongly disagree" to "strongly agree," to capture students' perceptions across cognitive, affective, and behavioral dimensions (Crites et al., 1994; Joshi et al., 2015). The second instrument was a semi-structured interview protocol aimed at eliciting more detailed explanations of students' responses. The interview questions explored students' personal experiences, perceived difficulties, and suggestions for improving the teaching and learning of physics.

As part of the questionnaire design, several key indicators were identified to measure students' attitudes, including interest, enjoyment, study time, motivation, and perceptions of teacher explanations. Table 1 presents the indicators and corresponding response distributions from the survey.

Table 1. Indicators and Students' Responses to Attitudes toward Science and Physics

Indicator	Response Category 1 (n)	Response Category 2 (n)	Total (n)
Interest in science subjects	35	25	60
Enjoyment in learning physics	18	42	60
Time spent studying physics	30	30	60
Desire to deepen knowledge in physics	10	40	50*
Teacher's explanation of subject matter	45	–	45*
Total	–	–	60

**Note: Variation in totals reflects differences in the number of valid responses for certain items.*

To ensure the validity and reliability of the instruments, expert judgment was sought from three science education specialists, who reviewed the questionnaire items for clarity, content relevance, and cultural appropriateness. A pilot test was also conducted with a small group of students, and necessary revisions were made based on their feedback. Reliability analysis of the questionnaire using Cronbach's alpha yielded coefficients above the recommended threshold of 0.70, indicating acceptable internal consistency (George & Mallery, 2019). Triangulation was achieved by comparing and integrating data from both quantitative and qualitative sources, thereby enhancing the credibility of the findings (Denzin, 2017).

Quantitative data were analyzed using descriptive statistics, including frequency distributions and percentages, to identify general patterns in students' attitudes toward physics. The results from the survey informed the development of interview questions for the qualitative phase. Qualitative data from interviews were analyzed using thematic analysis following the Miles et al., model, which involves data reduction, data display, and conclusion drawing (Miles et al., 2014). Coding was conducted iteratively, and emerging themes were compared with quantitative results to ensure convergence and complementarity. The integration of quantitative and qualitative findings was conducted during the interpretation phase, enabling a richer and more nuanced understanding of the factors influencing students' attitudes toward physics.

By employing this methodological approach, the study not only quantifies students' general perceptions but also provides explanatory insights into the contextual, pedagogical, and affective factors that shape these attitudes. This integration strengthens the overall validity of the study and contributes to developing practical implications for improving physics education in Indonesia.

RESULTS AND DISCUSSION

Students' Interest in Science and Physics

The survey results revealed that 55% of students expressed a positive interest in science (IPA), while 13% reported disliking it, and 32% were neutral. However, when focusing specifically on physics, approximately three-quarters of students stated that they did not enjoy the subject. The main reasons identified were the excessive use of formulas, high cognitive demands, lack of engagement, and negative perceptions of teachers as being overly strict or unapproachable. In contrast, a smaller group (25%) showed interest in physics, often highlighting their enjoyment of numerical problem-solving and appreciation for fewer memorization tasks compared to biology or chemistry.

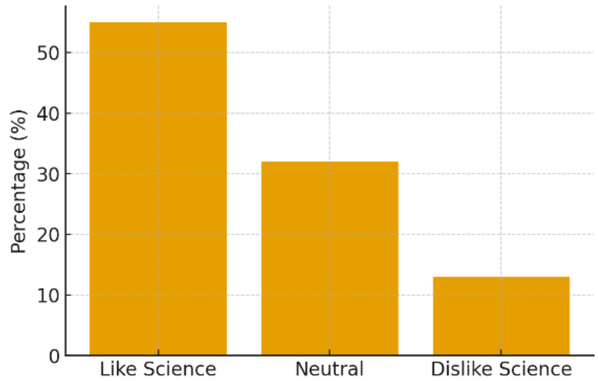

Figure 1. Students' Interest in Science (IPA)

These findings are consistent with earlier studies that emphasized the widespread perception of physics as abstract and difficult (Angell et al., 2004; Salta & Tzougraki, 2004). Similar to our results, Potvin and Hasni (2014) reported that students' interest in science significantly declines at higher levels of schooling, particularly in physics. Moreover, Barmby et al. (2008) confirmed that students often consider physics less enjoyable compared to other science subjects, largely due to its association with mathematics. Our study adds to this body of evidence by showing that these negative perceptions remain highly prevalent in the Indonesian context, where physics is still considered one of the most difficult science subjects by 63% of respondents.

Time Allocation and Learning Practices in Physics

With regard to study time, 39% of students reported spending only 30 minutes per day studying physics, while others indicated that their learning time was limited to class hours or homework assignments. This suggests that many students do not allocate sufficient time for consistent practice, which contributes to poor conceptual understanding and problem-solving difficulties.

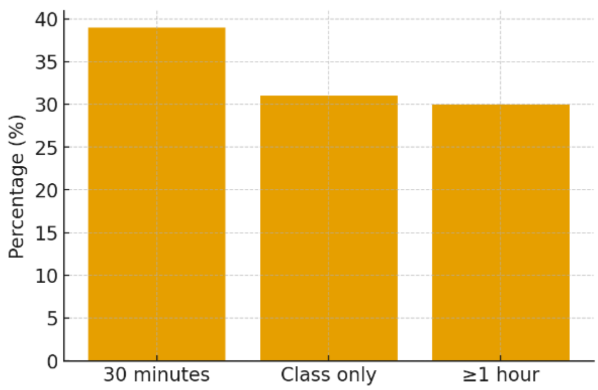

Figure 2. Daily Time Allocation for Studying Physics

Previous research has shown that effective engagement in physics requires frequent practice, active learning strategies, and extended exposure to problem-solving tasks (Freeman et al., 2014; Hattie, 2008). The limited time reported in this study aligns with findings by Kaya and Boyuk (2011), who noted that students' attitudes and performance in science are closely related to the amount of effort and time invested. Compared to those studies, our findings highlight the particular challenge in Indonesia, where students' learning outside the classroom is minimal, often due to lack of motivation and insufficient teacher scaffolding.

Teacher Explanations and Instructional Approaches

Another significant finding concerns students' perceptions of their teachers' explanations. Many students reported dissatisfaction with how physics lessons were delivered, describing them as unengaging and overly formula-based. Teacher-centered approaches, such as lecturing and rote problem-solving, were found to discourage participation and limit students' ability to connect physics concepts with real-life contexts.

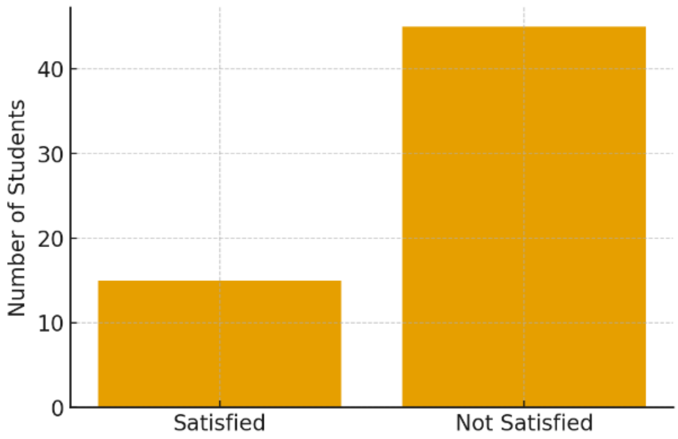

Figure 3. Students' Perceptions of Teacher Explanations

This result resonates with Mohammed (2022), who argued that traditional didactic teaching methods in science are ineffective in fostering interest and deep understanding. Osborne et al., (2003), also emphasized that inquiry-based and context-driven pedagogies can significantly enhance student engagement. Our findings reinforce this argument, suggesting that in the Indonesian context, teachers' reliance on conventional methods continues to hinder students' positive attitudes toward physics.

Students' Motivation and Desire to Pursue Physics Further

The data also revealed that more than half of the respondents expressed no desire to study physics in greater depth, citing difficulties and lack of enjoyment as primary reasons. This result supports previous findings by Hamerski et al. (2022), who showed that negative attitudes in secondary school often discourage students from pursuing physics at higher levels. Similarly, Osborne et al. (2003) highlighted that declining motivation in physics has long-term consequences, contributing to fewer students choosing physics-related careers.

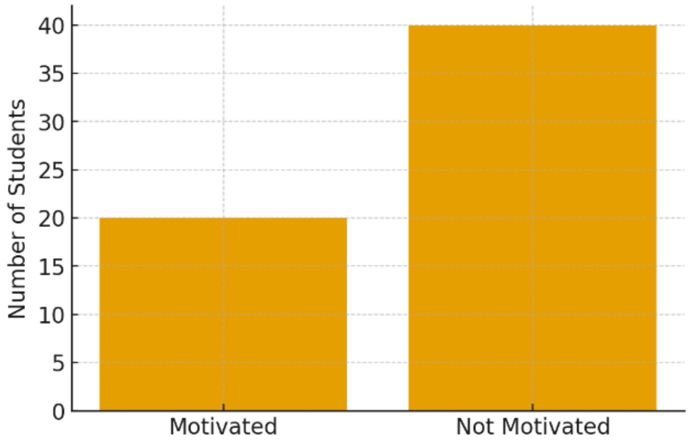

Figure 4. Students' Motivation to Pursue Physics Further

What distinguishes this study is the evidence that negative attitudes toward physics are not only associated with abstract content and mathematical demands but also strongly influenced by teacher–student interaction. Students reported that teachers' perceived strictness and lack of empathy reinforced their disinterest, a finding that adds a socio-affective dimension to existing discussions in the literature.

Integration of Quantitative and Qualitative Findings

By combining survey data with interview insights, the study provides a comprehensive picture of students' attitudes. Quantitative results showed clear patterns of disinterest and minimal study time, while qualitative responses explained these results in terms of emotional and social factors, such as fear of strict teachers, boredom due to repetitive numerical exercises, and the absence of varied instructional strategies. This integration confirms that students' attitudes toward physics cannot be fully explained by cognitive difficulties alone but must also account for affective and contextual influences (Osborne et al. 2003; Potvin & Hasni, 2014).

Novelty of the Study

The novelty of this study lies in its focus on Indonesian secondary students using an explanatory sequential mixed-methods design, which has been rarely applied in this context. While previous research often relied on either surveys or small-scale qualitative observations, this study integrates both approaches to reveal not only the prevalence of negative attitudes but also the reasons behind them. The socio-affective dimension particularly the role of teacher student interaction emerges as a critical factor that has not been sufficiently emphasized in earlier Indonesian studies.

Implications for Pratice

The findings suggest several practical implications. First, teachers should adopt more student-centered, inquiry-based approaches that connect physics with real-life applications, thereby reducing its perceived abstractness. Second, professional development programs for physics teachers should emphasize communication skills, empathy, and the creation of supportive classroom environments. Third, policymakers and curriculum designers should consider integrating interactive and digital learning resources to enhance students' engagement. By addressing both cognitive and affective dimensions, these strategies could significantly improve students' attitudes toward physics and their willingness to pursue it further.

Limitations and Future Research

Despite its contributions, this study has several limitations. The sample size of 60 students, although sufficient for exploratory analysis, limits the generalizability of the findings across Indonesia. The reliance on self-reported questionnaires may also introduce response bias.

Additionally, the study focused primarily on students' perspectives, without systematically examining teachers' instructional practices or school-level contextual factors. Future research should employ larger, more representative samples and incorporate classroom observations to triangulate findings. Longitudinal studies would also be valuable in exploring how students' attitudes evolve over time and whether specific interventions can reverse negative perceptions of physics.

CONCLUSION

This study concludes that students' attitudes toward physics are shaped by a complex interplay of cognitive, affective, and social-contextual factors, with the majority perceiving physics as difficult, abstract, and overly mathematical, leading to limited interest, minimal study time, and low motivation to pursue the subject further. Quantitative results highlighted clear patterns of disinterest and inadequate engagement, while qualitative insights revealed underlying emotional and relational issues such as fear of strict teachers, boredom with repetitive numerical exercises, and the absence of varied instructional strategies. The integration of these findings underscores that negative attitudes toward physics cannot be explained by cognitive difficulties alone but are also influenced by affective perceptions and teacher–student interactions, a dimension often underexplored in prior studies. The novelty of this research lies in its use of a mixed-methods approach within the Indonesian context to capture both statistical trends and nuanced explanations, thereby offering a more holistic understanding of students' challenges. These findings have important implications for practice, suggesting that improving physics education requires not only strengthening students' conceptual and problem-solving skills but also fostering supportive, engaging, and inquiry-based learning environments that can transform negative attitudes into motivation and sustained interest.

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