

Epistemological Beliefs About Physics: A Comparison Between Physics and Biology Education Students

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Abstract

Epistemological beliefs play an important role in physics learning. This study compared epistemological beliefs about physics between Physics Education and Biology Education students after completing the required introductory physics course. A quantitative cross-sectional comparative survey design was employed involving all students from both programs at a single teacher education institution ($N = 47$, 20 Physics Education and 27 Biology Education students), predominantly of female students (80.9%). The Indonesian version of the Colorado Learning Attitudes about Science Survey (CLASS) was used to measure overall and categories of epistemological beliefs. Data were analyzed using descriptive statistics and the Mann–Whitney U test, with rank-biserial correlation reported as the effect size. Physics Education students demonstrated higher favorable CLASS scores than Biology Education students overall and across all categories. Significant differences were found for the overall CLASS score ($r_{rb} = 0.298$), Personal Interest ($r_{rb} = 0.288$), Conceptual Connections ($r_{rb} = 0.458$), and Applied Conceptual Understanding ($r_{rb} = 0.386$), with the largest effect observed in Conceptual Connections. Nevertheless, both groups showed relatively low favorable scores in Applied Conceptual Understanding and Problem-Solving Sophistication, indicating shared challenges in transferring conceptual knowledge and solving unfamiliar physics problems. These findings suggest that disciplinary orientation is associated with differences in epistemological beliefs about physics. However, because the study employed a cross-sectional design without baseline measurements, causal interpretations should be made with caution. The results highlight the need for introductory physics instruction that more effectively supports conceptual integration, knowledge transfer, and meaningful disciplinary contexts, particularly for students outside physics-related programs.

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INTRODUCTION

Epistemological beliefs are a key aspect of physics learning. Physics and physics learning involve various aspects such as conceptual understanding, the relationship between concepts and everyday experiences, sense-making, and problem solving. Epistemological beliefs influence these aspects, such as how students understand concepts, solve problems, and view the nature of physics as a science [1]. Epistemological beliefs also influence students' interest and motivation, as well as their active engagement in learning [2]–[4]. Beliefs range from expert-like beliefs to novice-like beliefs. Students with expert-like beliefs tend to understand concepts well, recognize relationships between concepts, interpret concepts, and can solve problems [4]. They also tend to view physics conceptually, rather than merely memorizing formulas.

Previous studies have revealed that students' beliefs often do not change significantly, even after taking physics courses in high school or college. Some studies have even found that beliefs become increasingly novice-like after taking physics courses. Studies in fields other than physics have also been widely conducted. Some of these studies found that students' beliefs tended to be less expert-like compared to physics students, particularly regarding real-world connections, personal interest, conceptual understanding, and problem-solving [5]. Conversely, physics students exhibit more expert-like beliefs, particularly concerning conceptual connections, confidence, and sophisticated problem-solving [6]. However, most research focusing on students' epistemological beliefs has primarily focused on surveys of a single group of students [7], their relationship with learning outcomes [8], [9], gender comparisons [10], [11], pre-post changes, and the effects of instructional interventions [6], [12], [13]. Studies examining differences across academic disciplines or student programs have also been conducted extensively. However, research specifically targeting different groups of pre-services teachers remains scarce.

Comparative studies have emerged as an intriguing topic and are now being explored from various perspectives. Mason & Bertram (2018) compared the epistemological beliefs of biology students with health science students [14]. They found that biology students' epistemological beliefs were stronger due to differences in the learning orientations. Subsequently, Mason (2021) compared majors relevant to physics with those not relevant to physics and identified an intriguing epistemological shift. Students in physics-relevant majors shifted toward an "expert-like", whereas those in non-physics-relevant majors shifted toward a "novice-like" [5]. In the context of prospective teachers, Chen et al. (2019) compared education majors with non-education majors and found that the epistemological beliefs of education majors were better [15]. Suárez et al. (2021) compared the epistemological beliefs of teachers with prospective physics teachers and found that the categories most aligned with experts in both groups were relatively the same, namely sense-making and problem-solving confidence [16]. However, prospective teachers' epistemological beliefs remain low regarding applied conceptual understanding and sophisticated problem-solving. In this study, the comparison focuses on the field of education, specifically comparing physics education with biology education.

Both physics education and biology education students take introductory physics courses as part of their curriculum. Nevertheless, the two programs are embedded in different disciplinary cultures. Physics education generally emphasizes mathematical modeling, abstraction, general principles, and analytical problem solving, whereas biology education tends to emphasize contextual reasoning, complex systems, and phenomenological explanations. These differences may shape students' perspectives on physics and physics learning over time. At the same time, an alternative explanation should also be considered. Students who choose physics education may already possess more expert-like epistemological beliefs before entering the program because of self-selection based on their prior interests, experiences, or confidence in physics. Therefore, any observed differences between the two groups cannot be attributed solely to disciplinary culture. Rather, they may reflect the combined influence of students' initial characteristics and their subsequent learning experiences within each discipline.

Although previous comparative studies have examined students from different academic disciplines, comparisons between prospective physics teachers and prospective biology teachers remain limited. This comparison is particularly important because both groups receive introductory physics instruction but pursue different disciplinary trajectories. Examining their epistemological beliefs may therefore provide insights into how disciplinary orientation relates to students' beliefs about physics and help instructors design introductory physics courses that better address the needs of different teacher education programs.

This study was conducted at a single Indonesian Islamic higher education institution (IAIN Kerinci), where both physics education and biology education programs require students to complete comparable introductory physics courses. This institutional context provides a relatively consistent curriculum and learning environment, allowing disciplinary differences to be examined while minimizing variation arising from institutional factors. Nevertheless, because the participants were drawn from a single institution, the findings should be interpreted with caution and may not fully represent students from other universities or educational contexts.

Therefore, this study aims to compare the epistemological beliefs about physics between physics education and biology education students after taking introductory physics courses. The comparison focuses on both the overall epistemological and its categories.

METHODS

This study employed a quantitative cross-sectional comparative survey design. Epistemological beliefs about physics were measured once, after participants had completed the introductory physics course. Accordingly, the study was designed to compare the epistemological belief profiles of two groups rather than to examine changes resulting from instruction or to establish causal effects of disciplinary training.

Participants came from two teacher education programs, namely physics education and biology education, at the same university, the State Islamic Institute of Kerinci. Because participants were surveyed only after completing the introductory physics course, the study cannot distinguish differences attributable to prior self-selection into academic programs from those potentially associated with disciplinary learning experiences. Therefore, the findings should be interpreted as comparisons between existing student groups rather than evidence of causal effects. Total sampling was applied in data collection. The number of participants in the study was all students in both programs after taking the introductory physics course, totaling 47 students divided into 20 physics education students and 27 biology education students. Most students were female, accounting for 80.85% of all participants. By program, 85% of physics education students were female, and 77.78% of biology education students were female.

To collect data on epistemological beliefs about physics, an instrument developed by Adams et al. (2006) was used, namely the Colorado Learning Attitudes about Science Survey (CLASS) [1]. This instrument measures students' beliefs regarding physics and physics learning. The instrument consists of 42 items divided into 8 categories, as shown in Table 1. Each category represents a different dimension in how students view physics and physics learning.

Table 1. CLASS Categories

Code	Categories	Number of Item
C1	Real World Connection	4
C2	Personal Interest	6
C3	Sense Making/Effort	7
C4	Conceptual Connections	6
C5	Applied Conceptual Understanding	7
C6	Problem Solving General	8
C7	Problem Solving Confidence	4
C8	Problem Solving Sophistication	6

CLASS measures the extent to which students' beliefs align with those of expert physicists using a 5-point Likert scale, ranging from strongly agree to strongly disagree. The method of analyzing students' responses to each CLASS item is unique. While survey instruments are typically analyzed by calculating item means or averages, the CLASS instrument is calculated based on the similarity of students' responses to the expert consensus summarized by Adams et al. (2006). There are three response categories: favorable (when students' responses match those of experts), unfavorable (when students' responses differ from those of experts), and neutral. The average and scores for each category are calculated as the percentage of favorable responses.

The original CLASS instrument is in English. Before being used in the study, the CLASS items were translated into Indonesian by the first author and validated by three physics experts who are also proficient in English. The Indonesian translation was then back-translated into English by an English language expert to compare the translated version with the original version, ensuring no distortion of item meaning.

The instrument was administered following a basic physics course via a paper-based survey. The aim was to ensure that each student completed the survey under the supervision of an instructor

within a limited timeframe (15–20 minutes). Each student was informed about the purpose of the CLASS assessment and the voluntary nature of participation, with no additional academic credit awarded for completing it.

Student response data were analyzed descriptively and comparatively. Descriptive analysis is presented through the average percentage of favorable responses and percentages across all categories, standard deviation, and data distribution. Data are presented in tables and boxplots to illustrate the initial comparison of epistemological beliefs about physics between physics education and biology education students. Subsequently, data distribution is assessed using skewness, kurtosis, and the Shapiro-Wilk test for normality, along with Levene's test for homogeneity, to test the assumptions. Comparative tests were conducted using an independent samples t-test if the data were normal or a Mann-Whitney U test if the data were not normal. Effect sizes were also reported. For the t-test, the effect size is given by Cohen's d. For the Mann-Whitney test. These comparisons were specified a priori based on the theoretical structure of the CLASS instrument, in which each category represents a distinct dimension of students' epistemological beliefs about physics rather than repeated measurements of the same construct. Therefore, each category was analyzed as a separate planned comparison. To facilitate interpretation, statistical significance was considered together with effect size estimates.

RESULTS AND DISCUSSION

The descriptive results show the percentage of favorable responses for all participants and each group, both on average and by category. The results for all students are shown in Table 2, and the mean percentage of favorable responses is represented in Figure 1. The average percentage of favorable responses for all students was found to be 41.20, with a standard deviation of 12.86. Category C2 regarding personal interest was found to have the highest favorable percentage score with a mean of 59.57. Personal interest was also an indicator with a relatively high percentage in a previous study of high school students [7]. This was followed by C1 and C3 regarding real-world connection and sense-making/effort. The categories with the lowest favorable scores were found in C5 (applied conceptual understanding), C8 (problem-solving sophistication), and C4 (conceptual connections), with means of 27.66, 29.08, and 36.88, respectively. These three categories were also found to be the lowest for high school students [7] and master's degree students [17], although in a slightly different order. Applied conceptual understanding was also found to be the lowest in studies at the high school level, with a favorable score percentage of 21.83. As one solution to the low scores in the conceptual connections and applied conceptual understanding categories, Hull et al. (2016) recommended implementing a reformed curriculum, specifically a combination of Matter and Interactions (M&I) and Tutorials in Introductory Physics (TIPs).

Table 2. CLASS Descriptive Statistic Results for All Students

% Favorable Score	Mean		Std. Deviation	Skewness		Kurtosis	
	Statistic	Std. Error		Statistic	Std. Error	Statistic	Std. Error
Average	41.20	1.88	12.86	0.24	0.35	0.97	0.68
C1	55.85	5.00	34.27	-0.29	0.35	-1.14	0.68
C2	59.57	4.78	32.74	-0.43	0.35	-0.97	0.68
C3	50.46	3.91	26.78	0.00	0.35	-0.86	0.68
C4	36.88	3.76	25.76	0.29	0.35	-0.84	0.68
C5	27.66	3.23	22.17	1.06	0.35	1.44	0.68
C6	43.88	3.95	27.07	0.55	0.35	-0.83	0.68
C7	43.62	4.27	29.24	0.36	0.35	-0.74	0.68
C8	29.08	3.64	24.93	0.95	0.35	0.44	0.68

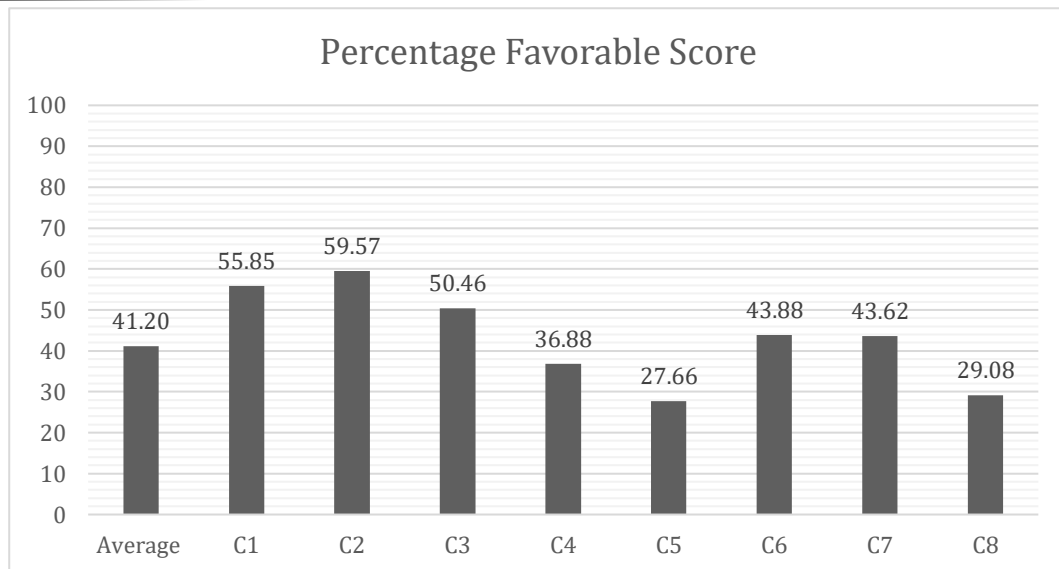


Figure 1. Mean Percentage Favorable Score

Next, the descriptive statistics focused on two distinct groups of students (physics and biology education majors), as shown in Table 3 and the distribution of students' favorable scores in each group is represented by raincloud plots in Figure 2.

Table 3. CLASS Descriptive Statistic Results for Students Group

% Favorable Score	Group	Mean		Std. Deviation	Skewness		Kurtosis		Shapiro-Wilk	
		Statistic	Std. Error		Statistic	Std. Error	Statistic	Std. Error	Statistic	p-value
Average	1	45.73	2.61	11.68	1.55	0.51	3.23	0.99	0.86	0.01
	2	37.85	2.48	12.86	-0.24	0.45	-1.06	0.87	0.93	0.08
C1	1	62.50	6.66	29.80	-0.52	0.51	-0.67	0.99	0.89	0.02
	2	50.93	7.12	37.00	-0.07	0.45	-1.35	0.87	0.88	0.01
C2	1	70.83	6.93	31.00	-1.22	0.51	0.93	0.99	0.83	0.00
	2	51.23	6.16	32.00	-0.01	0.45	-1.12	0.87	0.92	0.05
C3	1	51.43	5.52	24.70	0.22	0.51	-1.21	0.99	0.89	0.03
	2	49.74	5.52	28.67	-0.08	0.45	-0.78	0.87	0.96	0.28
C4	1	50.00	5.27	23.57	0.12	0.51	-0.47	0.99	0.92	0.12
	2	27.16	4.46	23.18	0.54	0.45	-0.99	0.87	0.86	0.00
C5	1	37.14	5.22	23.36	1.29	0.51	1.34	0.99	0.84	0.00
	2	20.64	3.60	18.73	0.74	0.45	0.31	0.87	0.88	0.01
C6	1	50.00	5.59	25.00	0.57	0.51	-0.98	0.99	0.87	0.01
	2	39.35	5.41	28.10	0.72	0.45	-0.61	0.87	0.90	0.01
C7	1	45.00	6.44	28.79	0.89	0.51	0.02	0.99	0.83	0.00
	2	42.59	5.79	30.08	0.05	0.45	-1.19	0.87	0.89	0.01
C8	1	36.67	6.69	29.91	0.46	0.51	-0.70	0.99	0.92	0.10
	2	23.46	3.70	19.20	1.22	0.45	2.30	0.87	0.85	0.00

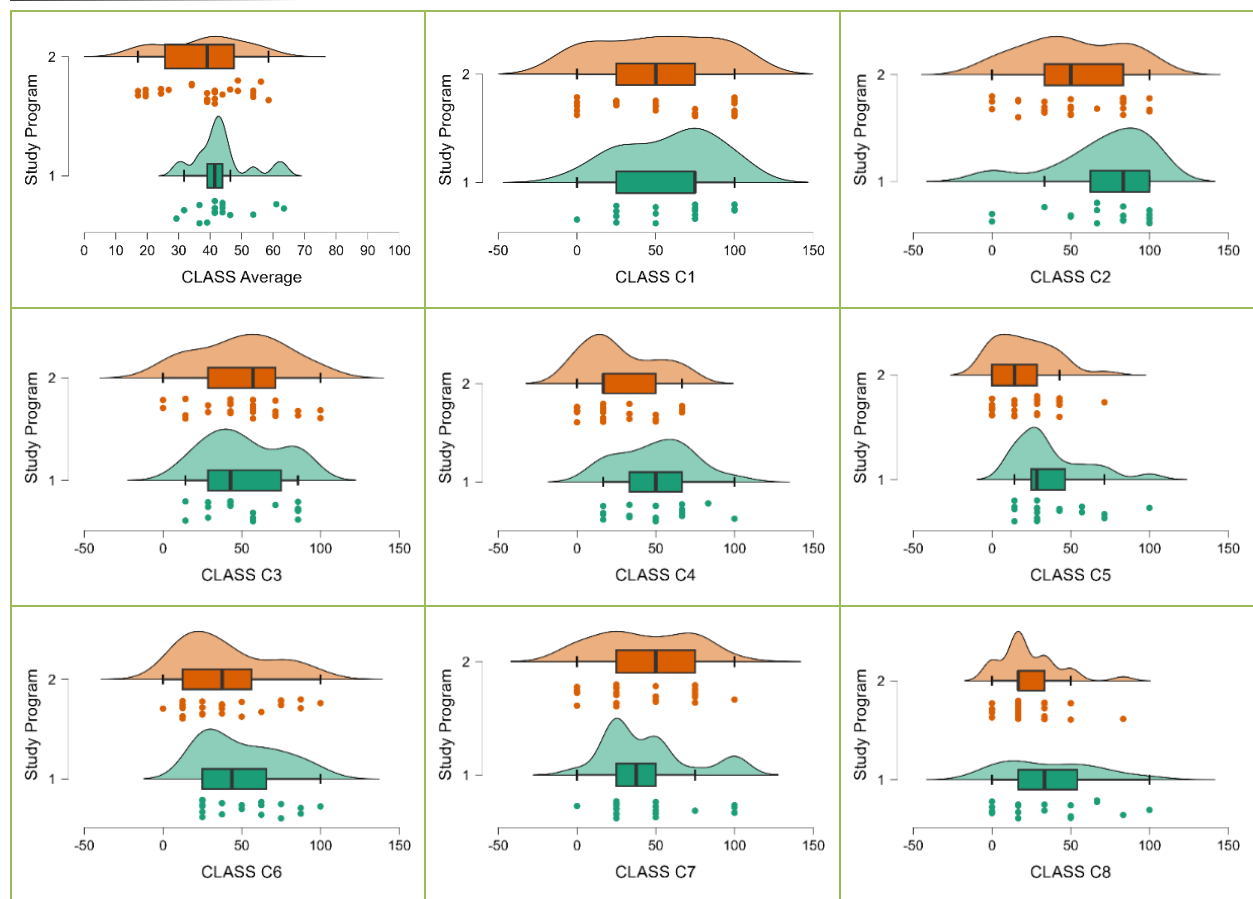


Figure 2. Raincloud Plots CLASS Averages and Categories (Study Group 1 = Physics Education Students and Study Group 2 = Biology Education Students)

Based on the data in Table 3, physics education students (Group 1) have a higher percentage of favorable CLASS scores compared to biology education students, both in terms of the average and the CLASS categories. This finding is also confirmed by the raincloud plots in Figure 2, where the green plots for Group 1 are more concentrated toward the right side of the horizontal axis compared to the orange plots. This finding indicates that physics education students tend to have better expert-like beliefs about physics and physics learning compared to biology education students after taking an introductory physics course. Although differences were found, both groups showed relatively high mean favorable percentage scores in several categories such as personal interest (C2) and real-world connection (C1). Both groups of students also showed relatively low scores in the categories of applied conceptual understanding (C5) and problem-solving sophistication (C8).

Returning to the differences between the two groups of students, the average percentage favorable scores differed, with a mean of 45.73 for physics education students and 37.85 for biology education students. Furthermore, the standard deviations for both groups were found to be relatively similar (11.68 and 12.86), indicating comparable variation in responses between the two groups. Differences in mean percentage favorable scores were found across all categories, with scores for physics education students being higher. The largest differences were found in categories such as conceptual connections (C4), personal interest (C2), and applied conceptual understanding (C5). On the other hand, the three categories with the smallest differences in favorable percentage scores were sense making/effort (C3), problem-solving confidence (C7), and problem-solving general (C6).

Differences in expert-like beliefs about physics and physics learning suggest that academic disciplinary background likely influences how students view physics and physics learning. Physics education students tend to be better able to see the connections between physics concepts, have a stronger personal interest, and are better able to apply conceptual understanding. Meanwhile, biology education students tend to view physics content as consisting of separate concepts and are not yet able to apply conceptual understanding effectively. Several interesting findings suggest that physics

learning should be directed toward sense-making and problem-solving, regardless of students' disciplinary backgrounds. This should even be a serious concern for the discipline of physics.

Although differences were found between the two groups of students, the significance of these differences can be determined through further comparative tests. Prior to that, assumption testing was conducted to determine the appropriate type of comparative test. Assumptions were tested for normality and homogeneity. The normality test was performed using the Shapiro-Wilk test and is presented alongside the descriptive statistics in Table 3. The results indicate that most of the data sets are not normally distributed (the Shapiro-Wilk p-value is shown in bold). Homogeneity was then tested using Levene's Test, and the results are shown in Table 4. The results of Levene's Test indicate that the variances between physics education students and biology education students are relatively homogeneous ($p > 0.05$), both for the mean and for the categories, except for C8 ($p < 0.05$).

Table 4. Test of Equality of Variances (Levene's)

CLASS Score	F	df ₁	df ₂	p
Average	1.251	1	45	0.269
C1	1.171	1	45	0.285
C2	0.215	1	45	0.645
C3	0.405	1	45	0.528
C4	0.164	1	45	0.687
C5	0.629	1	45	0.432
C6	0.141	1	45	0.709
C7	0.667	1	45	0.418
C8	7.37	1	45	0.009

Based on the assumption test, it was determined that the comparison of the percentage of favorable scores between the two data groups was conducted using the Mann-Whitney U test. The results are shown in Table 5. The results of the Mann-Whitney U test indicate that there is a significant difference in the average percentage of favorable CLASS scores between the two groups ($U=350.5$, $p=0.042$). The difference was not only statistically significant but also practically meaningful (rank-biserial correlation = 0.298), indicating a moderate separation between the two student groups. This finding suggests that physics education students and biology education students hold significantly different epistemological beliefs about physics and learning physics after taking a basic physics course. In other words, physics education students possess more expert-like beliefs compared to biology education students. This study is consistent with previous research that found significant differences between physics and non-physics students [9].

Table 5. Mann-Whitney U Test Results

CLASS Score	Statistic	df	p	Rank-Biserial Correlation
Average	350.5		0.042	0.298
C1	318		0.148	0.120
C2	367.5		0.017	0.288
C3	275.5		0.457	-0.076
C4	405.5		0.001	0.458
C5	380.5		0.008	0.386
C6	341		0.062	0.198
C7	278		0.434	-0.011
C8	334.5		0.077	0.246

Furthermore, differences were demonstrated based on the CLASS categories. Out of 8 categories, there were 3 categories with significant differences between the two groups, namely conceptual connections (C4), personal interest (C2), and applied conceptual understanding (C5). The significant differences were accompanied by moderate effect sizes for Conceptual Connections (rank-biserial correlation = 0.458), Applied Conceptual Understanding (rank-biserial correlation = 0.386), and Personal Interest (rank-biserial correlation = 0.288), indicating meaningful practical differences between the two student groups. These findings align with the three categories that showed the largest differences in mean percentage favorable. Because separate statistical tests were conducted for the overall CLASS score and each CLASS category, the possibility of inflated Type I error should be considered when interpreting statistically significant findings. However, these comparisons were specified a priori based on the theoretical dimensions of the CLASS instrument rather than exploratory analyses. Therefore, the results are interpreted in conjunction with the magnitude and consistency of the observed differences rather than statistical significance alone.

There was a significant difference in the Conceptual Connections (C4) category ($U = 405.5$, $p = 0.001$), with Physics Education students showing a 22.86 percentage-point higher mean favorable score than Biology Education students (Table 3). This indicates that physics education students are more likely to view physics as a collection of interconnected concepts. Conversely, biology education students appear to still struggle with recognizing conceptual connections among physics concepts. This finding is directly reflected by statement item number 6: “Knowledge in physics consists of many disconnected topics.” The favorable percentage score for this item reached 85.00% for physics education students, whereas biology education students had a favorable percentage score of only 33.33%. Other items showing differences relate to the negative view that physics involves only memorization and mathematical calculations. Only a small proportion of biology students recognized that physics is not merely memorization (18.52%) or mathematical calculations (33.33%). A more positive perspective, aligned with expert views, was demonstrated by students regarding this issue. Physics education students have recognized that physics is not merely memorization (40.00%) or mathematical calculations (55.00%). Although not as good as or close to the experts’ views, the percentage is better than that of biology students. This finding is supported by the conclusions of previous research revealing that after studying physics, students tend to be able to recognize the relationships between concepts; the longer they study physics, the better their conceptual connection [19]. The difference of more than twenty percentage points in Conceptual Connections suggests that many biology education students continue to perceive physics knowledge as fragmented rather than conceptually integrated. Such beliefs may limit their ability to transfer knowledge across topics, construct coherent explanations, and apply principles in unfamiliar contexts. Since conceptual integration is central to meaningful learning in physics, this gap may have long-term implications for how future biology teachers use physics to explain biological phenomena.

Furthermore, regarding the personal interest indicator (C2), a significant difference was also found ($U = 367.5$, $p = 0.017$), with Physics Education students showing a 19.60 percentage-point higher mean favorable score than Biology Education students (Table 3). Physics education students demonstrated significantly higher personal interest in physics compared to biology education students. The largest differences were found on items 14, 25, and 30. Physics education students tended to exhibit near-expert levels on these three items, namely recognizing the benefits of learning outside the classroom, enjoying the physics learning process, and possessing physics reasoning skills useful in daily life, in that order. Previous studies confirm that attitudes toward physics are positively correlated with students’ enjoyment of learning. Students who enjoy learning science more tend to have more “expert-like” attitudes [13]. Findings in this study indicate that academic identity and disciplinary proximity to physics influence students’ interest in physics learning. Physics is a central part of their academic identity, whereas for biology education students, physics is likely viewed more as a supporting course. As an alternative solution, Crouch et al. (2018) recommend a reform for physics courses specifically tailored to the life sciences and medicine, namely Introductory Physics for Life Sciences (IPLS) [20]. They demonstrated that IPLS is effective in maintaining and enhancing interest and attitudes toward physics learning, particularly among students who were initially less interested. Although both groups demonstrated relatively favorable beliefs, the approximately twenty-point

difference in Personal Interest suggests substantially different orientations toward physics learning. For physics education students, physics represents their disciplinary identity, whereas for biology education students it functions primarily as a supporting subject. This distinction is pedagogically important because personal interest has consistently been associated with persistence, engagement, and willingness to invest effort in learning physics.

The third category with a significant difference was Applied Conceptual Understanding (C5) ($U = 380.5$, $p = 0.008$), with Physics Education students showing a 16.50 percentage-point higher mean favorable score than Biology Education students (Table 3). Although the difference was significant, the percentage of favorable scores in both groups was relatively low, at 37.14 and 20.64 for physics and biology education students, respectively. These scores indicate that the ability or confidence in applying conceptual understanding of physics to new situations remains a challenge for both groups, particularly biology education students. The largest differences were found on several items, one of which was also item number 6, as in C4 (conceptual connection). Another item found to differ significantly was item number 22 regarding the ability to apply concepts in problem-solving. Forty percent of physics education students and 18.52% of biology education students stated they were able to solve problems even when the problems differed from those previously discussed. Although the percentages are both low, the difference between them is quite noticeable and contributes to the difference in the “applied conceptual understanding” category. Alternative teaching approach that can be used to support the application of concepts is project-based learning, such as developing and presenting a physics poster [21]–[23]. Despite the statistically significant difference between the two groups, the favorable percentages remained below 40% for physics education students and approximately 20% for biology education students. These values indicate that applying conceptual knowledge to unfamiliar situations remains challenging even for students specializing in physics education. Therefore, the observed difference should not obscure the broader educational concern that both groups have yet to develop robust transferable conceptual understanding.

Although favorable score percentages also differed for other categories, both groups held relatively similar epistemological beliefs regarding other categories (real-world connection, sense-making/effort, and the three categories related to problem-solving). In other words, no significant differences were found between the student groups in these categories. Both groups were still able to see the relevance of physics to daily life and real-world phenomena (C1), had relatively similar tendencies in their efforts to understand physics concepts and the importance of thinking processes during physics learning (C3), and held relatively similar views regarding the strategies, self-confidence, and challenges in problem-solving (C6–C8).

These findings indicate that academic disciplinary differences influence how students view physics and physics learning, particularly regarding interest in physics, interconceptual relationships, and the application of concepts. Physics education students tend to align more closely with expert perspectives on these aspects. This is because physics education students engage more actively with the conceptual structure of physics, are accustomed to interconceptual relationships, and view physics as a coherent system of knowledge. On the other hand, biology education students tend to view physics as a supporting course because it is not their primary field of study; consequently, their perspectives on physics are not as well-developed as those of physics education students.

Furthermore, students’ epistemological beliefs can also be explored by focusing on learning activities through experiments [24]. This is because experiments are integral to the scientific disciplines of physics, biology, and other sciences. Previous studies have confirmed that students’ epistemological beliefs regarding experiments are relatively high after participating in physics learning activities through experiments [25]. Previous studies have also revealed that a positive learning environment shapes students’ beliefs, and these beliefs support students’ ability to manage and enhance their physics learning processes [4]. Every student develops in a different way, but the key is how students are actively engaged in learning [18]. Furthermore, learning models that have been proven to enhance epistemological beliefs can serve as alternatives for implementation, such as modeling instruction [26], investigative science learning environment (ISLE) [27], interactive learning [6], and problem-based instruction [28].

CONCLUSION

This study identified meaningful differences in epistemological beliefs between physics education and biology education students. Physics education students demonstrated more expert-like beliefs than biology education students. Significant differences were primarily found in the categories of Personal Interest, Conceptual Connections, and Applied Conceptual Understanding, indicating that physics education students have a higher interest in physics, are better able to see connections between concepts, and are more adept at applying their conceptual understanding of physics. However, both groups showed relatively similar tendencies in the aspects of real-world connection, sense making/effort, and problem-solving clusters. Although physics education students demonstrated more expert-like beliefs overall, both student groups showed consistently low favourable scores in Applied Conceptual Understanding and Problem-Solving Sophistication. This finding suggests that developing transferable conceptual understanding and sophisticated problem-solving remains a common challenge in introductory physics instruction regardless of students' disciplinary background.

These findings should be interpreted with appropriate caution because the study employed a cross-sectional design in a single institution with a relatively small sample. Consequently, the observed differences should be interpreted as associations rather than evidence of causal effects of disciplinary training. The findings suggest that introductory physics courses, particularly for biology education students, should provide greater opportunities for students to connect concepts across topics, apply conceptual knowledge to unfamiliar situations, and experience physics through contexts that are meaningful to their disciplinary interests.

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