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How Epistemic Beliefs Shape Physics Self-Efficacy among Pre-service Science Teachers: The Mediating Role of Self-Regulative Behavior

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ABSTRACT

Purpose of the study: This study aimed to investigate whether self-regulative behavior mediates the relationship between epistemic beliefs and physics self-efficacy among pre-service science teachers.

Methodology: This study employed a correlational research design wherein a survey was conducted with 261 randomly selected Bachelor of Secondary Education major in Science students in a Philippine higher education institution. Analysis was conducted using Hayes' PROCESS macro version 4.2 in SPSS, applying bootstrapping procedures to test indirect effects.

Main Findings: Results revealed that self-regulative behavior partially mediates the relationship between epistemic beliefs and physics self-efficacy. The direct effect of epistemic beliefs on physics self-efficacy decreased but remained significant (B = 0.177, Boot SE = 0.079, 95% Boot CI [0.027, 0.335]), representing 48% of the total effect. The indirect effect through self-regulative behavior was also significant (B = 0.191, Boot SE = 0.040, 95% Boot CI [0.117, 0.273]), accounting for 52% of the total effect.

Novelty/Originality of this study: This study highlights self-regulative behavior as a mediator in physics self-efficacy, offering new insight into how epistemic beliefs translate into confidence. It informs teacher education by emphasizing the integration of epistemological sophistication and regulation strategies to enhance pre-service teachers' learning and teaching preparedness.

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1. INTRODUCTION

Physics education continues to present persistent challenges for learners, particularly in domains requiring abstract reasoning, conceptual change, and sustained problem-solving [1], [2]. These challenges are even more pronounced among pre-service science teachers, who must not only understand physics concepts but also develop the confidence to teach them effectively. Research consistently shows that physics self-efficacy plays a critical role in shaping persistence and instructional effectiveness [3]. However, such confidence does not emerge in isolation; it is shaped by deeper cognitive beliefs that influence how learners interpret information, approach complex tasks, and respond to uncertainty [4]. Among these foundational beliefs, epistemic beliefs have received considerable attention for their role in shaping learning processes and academic development.

Epistemic beliefs are perceptions of what knowledge is and where it comes from [5], [6]. For instance, knowledge for an individual could be certain or tentative, simple or complex, and handed down by authorities or constructed and justified by evidence. Influential work in the early times framed epistemic beliefs as a set of interrelated but distinct ideas that shape how learners approach information, learning tasks, and argumentation.

Perry's [7] scheme of intellectual and ethical development framed these beliefs as evolving from dualism, which emphasizes knowledge as certain and handed down, to commitment within relativism which stresses knowledge as uncertain and judgements require justification. Perry's interviews with undergraduates from Harvard University famously traced this trajectory as seen with their views of knowledge change alongside their academic experiences. Parallel lines of research reached a similar conclusion: sophisticated knowing involves recognizing the uncertainty of claims and the need for warranted justification [8], [9].

In physics education, epistemic beliefs shape how students make sense of complex ideas, resolve conflicting information, and decide what counts as a convincing explanation [10], [11]. Hofer and Pintrich [5] emphasized that epistemic beliefs influence not only how students interpret evidence but also the very ways they learn. Similarly, King and Kitchener's [12] reflective judgement model shows that learners progress when they move from dualistic thinking toward evaluating claims and justification, a process especially crucial in physics where uncertainty and model-based reasoning are central. Research in physics classrooms confirms these theoretical claims. According to Stathopoulou and Vosniadou [13], learners who believe that knowledge is fixed and handed down by authorities often approach physics as a set of formulas memorized rather than a system of ideas to be tested and justified. In contrast, those with more sophisticated beliefs are better equipped to engage in inquiry, critique experimental results, and adapt to conceptual change.

Extant literature highlighted the connection between students' epistemic beliefs and their confidence in learning science subjects, including physics. Mason and peers [14] found that sophisticated epistemic beliefs were positively related to self-beliefs and achievement in science. Similarly, Hofer and Pintrich [5] argued that these beliefs set the stage for how students approach learning, which in turn shapes their self-efficacy. Their confidence in handling tasks grows because they see physics as a system they can explore and make sense of. Klassen and Klassen [15] likewise noted that self-efficacy in the natural sciences is strengthened when learners perceive knowledge as something they can actively test and negotiate, not passively receive. These findings suggest that nurturing sophisticated beliefs can act as a foundation for building stronger self-efficacy in physics, especially in problem-solving and inquiry contexts.

For future physics teachers, the link is even more critical. Their epistemic beliefs influence not only how they learn but also how they project confidence in teaching and modelling scientific reasoning [16]. A teacher who believes that physics is tentative and evidence-based is more likely to empower students, conveying that persistence and reasoning matter more than immediate right answers. As Bandura [17] underscored, self-efficacy grows through mastery experiences and social persuasion; if teachers themselves embrace and model sophisticated knowing, they create classrooms where confidence and resilience can thrive. Thus, clarifying the pathways that link epistemic beliefs to physics self-efficacy is critical for preparing competent and confident future science educators.

Self-regulative behavior presents itself as a plausible mediator in this relationship. According to models of self-regulated learning, regulation functions as the bridge connecting beliefs with outcomes, including academic performance [18], [19]. This has also been exemplified by the mediation models proposed by several studies [20]-[22]. Epistemic beliefs shape how learners interpret tasks and select strategies, while self-regulative behaviors determine whether these beliefs lead to meaningful mastery experiences. For pre-service teachers, engaging in effective self-regulation is essential for building not only their own physics competence but also the pedagogical confidence required to model good learning strategies to their future students. Empirical evidence has consistently shown that students with stronger regulation skills achieve higher levels of academic performance and self-efficacy [23], [24]. In physics education, where sustained problem-solving and conceptual integration are vital, regulation could determine whether sophisticated epistemic beliefs result in robust self-efficacy.

Although prior studies indicate that epistemic beliefs influence how students approach learning [12], [13], [25], the mechanisms through which these beliefs translate into physics self-efficacy remain underexplored. Moreover, while self-regulation has been linked to higher self-efficacy [26], it is not yet clear as to how it serves as a mediating variable that connects epistemic beliefs to confidence in learning physics. This lack of integrated investigation leaves a conceptual and empirical gap in understanding how cognitive and motivational factors jointly contribute to the development of self-efficacy in pre-service science teachers.

The present study addresses this gap by proposing and testing a mediation model, as illustrated in Figure 1, in which self-regulative behavior bridges epistemic beliefs and physics self-efficacy. By explicitly examining both the direct effect of epistemic beliefs and the indirect effect through self-regulation, this research provides a more nuanced understanding of the processes that foster confidence in physics learning. Unlike prior studies that have examined these constructs in isolation, this study combines theoretical and empirical perspectives to clarify how learners' beliefs about knowledge and their regulatory practices jointly influence self-efficacy.

Situating this research in the context of science teacher education underscores its practical importance. Physics is often considered one of the most difficult subjects for pre-service teachers, and low self-efficacy can hinder both learning outcomes and future teaching effectiveness [1], [2]. By elucidating the pathways linking epistemic beliefs, self-regulative behavior, and physics self-efficacy, this study aims to inform teacher preparation programs that emphasize epistemological sophistication and strategic regulation as foundational skills for developing resilient, competent, and confident future physics educators.

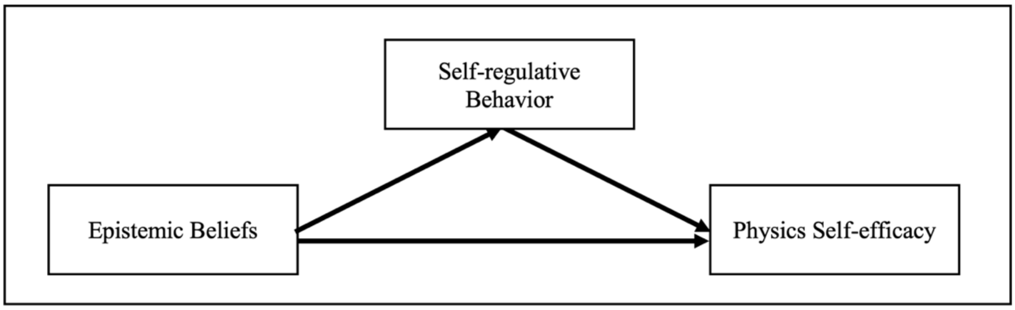

Figure 1. The proposed mediation model

2. RESEARCH METHOD

This study employed a correlational research design to examine the relationships among epistemic beliefs, self-regulative behavior, and physics self-efficacy among BSEd Science students. Specifically, a mediation analysis was conducted to determine whether self-regulative behavior mediates the relationship between epistemic beliefs and physics self-efficacy. A random sampling technique was utilized to enhance the representativeness of the sample and reduce selection bias. A complete list of enrolled BSEd Science students was obtained from the college, and participants were selected using a computer-generated randomization procedure. Through this process, 261 BSEd Science students from a higher education institution in the Eastern Visayas region of the Philippines were included in the study.

The study measured three key variables: epistemic beliefs, physics self-efficacy, and self-regulative behavior. In assessing the respondents' beliefs about the nature of knowledge and knowing (domain-general epistemological beliefs), the Epistemological Beliefs Survey (EBS) by Wood and Kardash [27] was utilized. EBS involved items related to the structure of knowledge, attainability of objective truth, speed of knowledge acquisition, knowledge construction and modification, and characteristics of successful students. The survey was rated on a Likert scale ranging from 1 (do not agree at all) to 7 (completely agree). In the present study, the scale demonstrated excellent internal consistency, with a Cronbach's alpha of .911. For the self-efficacy of the respondents in physics, the Physics Self-efficacy Questionnaire (PSEQ), a tool developed by Lindstrøm and Sharma [28], was administered in the study. The PSEQ has five items, and each item is rated on a Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). For this scale, the Cronbach's alpha is .913 which also demonstrated excellent internal consistency. The self-regulative behavior of the respondents was measured through the Self-regulated Learning Strategies (SRLS) component of the Motivated Strategies for Learning Questionnaire by Pintrich and De Groot [26]. The SRLS has two constructs such as cognitive strategy use and self-regulation. With a total number of items of 22, the SRLS used a seven-point Likert-type scale ranging from 1 (very untrue of me) to 7 (very true of me). The Cronbach's alpha for this scale is 0.866, which demonstrated a good internal consistency.

The process began with the securing of formal permission from the university president to conduct the study. Prior to the data collection, the respondents were provided with a briefing about the purpose, scope, and significance of the research. Informed consent was obtained to guarantee that participation was voluntary and that ethical standards were upheld. The survey questionnaires were administered in person. After which, data were stored securely and analyzed in accordance with the ethical guidelines set by the university's institutional review board (IRB) to ensure confidentiality and responsible research practice.

The data gathered from the survey were analyzed using the Statistical Package for the Social Science (SPSS) version 22. Hayes' PROCESS macro version 4.2 was employed to test the hypothesized mediation model. Prior to the mediation analysis, all key assumptions of multiple regression were checked. The scatterplot of standardized residuals against predicted values indicated that the relationship between the predictors and the dependent variable was linear, while the normal probability plot and histogram of residuals showed that the errors were approximately normally distributed. Standardized residuals ranged between -2.89 and 2.57, and Cook's distance values were well below the threshold of 1, suggesting the absence of influential outliers. Collinearity statistics (VIF=1.268; tolerance=.789) and a condition index below 30 confirmed that multicollinearity was not an issue. The residual scatterplot demonstrated homoscedasticity, and the Durbin-Watson value of 1.627 fell within the acceptable range, indicating independence of errors. These diagnostics provide assurance that the assumptions underlying multiple regression were satisfied. Descriptive statistics were computed to summarize the key study variables, while intercorrelations were examined to identify the relationships among these variables. PROCESS

Model 4 was utilized to assess mediation effects. To ensure robustness of the estimates, bootstrapping procedures with 5,000 resamples were conducted, providing bias-corrected confidence intervals for indirect effects.

3. RESULTS AND DISCUSSION

The correlation analysis revealed meaningful associations among the three key variables examined. As shown in Table 1, epistemic beliefs demonstrated significant positive links with both physics self-efficacy (r=.288, p<.01) and self-regulative behavior (r=.459, p<.01). Similarly, physics self-efficacy was positively associated with self-regulative behavior (r=.389, p<.01). Mean scores reflected generally high levels of the three key variables.

Table 1. Descriptive statistics and Pearson correlation results

	1	2	3
1. Epistemic Beliefs	-		
2. Physics Self-efficacy	.288**	-	
3. Self-regulative Behavior	.459**	.389**	-
M	5.223	2.972	5.037
SD	0.752	0.961	0.709

*N = 261. **p < 0.01*

The regression results collectively highlight the mediating role of self-regulative behavior between epistemic beliefs and self-efficacy. As shown in Table 2, epistemic beliefs first showed a significant positive association with self-efficacy (B=0.369, p<.001). However, when self-regulative behavior was entered into the model, the coefficient for epistemic beliefs decreased to B=0.177, p<.05, while self-regulative behavior itself exerted a strong positive influence on self-efficacy (B=0.441, p<.001). This reduction in the direct effect of epistemic beliefs, coupled with the significant pathway through self-regulative behavior, suggests that students' regulation of their learning explains how their epistemic views translate into stronger physics self-efficacy. To further illustrate these findings, Figure 2 presents the mediation model with corresponding path coefficients.

Table 2. Results of the mediation effect test

Independent Variables	Model 1: DV = SE		Model 2: DV = SB		Model 3: DV = SE	
	B	t	B	t	B	t
Epistemic Beliefs	.369	4.847***	.434	8.324***	.177	2.169*
Self-regulative Behavior					.441	5.088***
R^2	.083		.211		.167	
F	23.490***		69.294***		25.819***	

Note: DV = Dependent Variable, SE = Self-efficacy, SB = Self-regulative Behavior
***p < 0.01; ***p < 0.001*

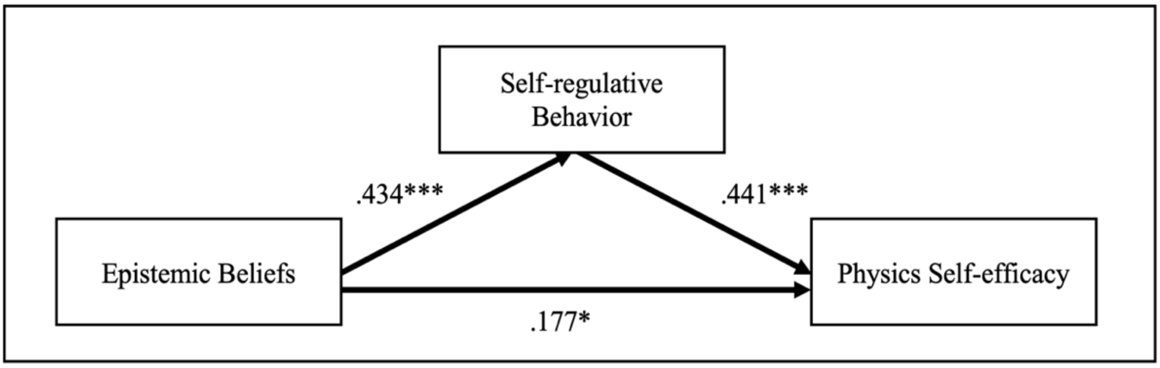

Figure 2. Path coefficients of the mediation model

Moreover, the result of the bootstrapping procedure in Table 3 revealed that the direct effect of epistemic beliefs decreased but remained significant (B=0.177, Boot SE=0.079, 95% Boot CI [0.027, 0.335]), representing 48% of the total effect. The indirect effect through self-regulative behavior was also significant (B=0.191, Boot SE=0.040, 95% Boot CI [0.117, 0.273]), accounting for the remaining 52%. Since the bootstrap confidence interval for both direct and indirect effects did not include zero, the relationship between epistemic beliefs and physics self-efficacy is partially mediated by self-regulative behavior.

Table 2. Bootstrap estimates of the mediation effects of self-regulative behavior

Epistemic Beliefs – Physics Self-efficacy	Effect	Boot SE	Boot LLCI	Boot ULCI	Ration to Total Effect
Total Effect	.368	.076	.219	.518	
Direct Effect	.177	.079	.027	.335	48%
Indirect Effect	.191	.040	.117	.273	52%

Based on the results, epistemic beliefs meaningfully shape students' confidence to learn and perform in physics. This means they alter how students construe the nature of knowledge and the demands of physics tasks. Muis [29] argues that beliefs about the certainty, source, and justification of knowledge act as cognitive-affective filters: they determine what information students attend to, how they interpret difficulty, and the standards they adopt when setting goals and judging progress (i.e., epistemic beliefs influence task perception and standards). This theoretical pathway explains why more sophisticated epistemic beliefs – for example, viewing knowledge as tentative, complex, and justified by evidence – are associated with higher academic motivation and adaptive control beliefs that bolster self-efficacy. Empirically, reviews and large-scale studies have linked epistemic beliefs to motivation, strategy use, and achievement across domains [29]-[31], and Bandura's [17] social cognitive account clarifies why those cognitions translate into stronger efficacy: beliefs shape mastery interpretations, attributions, and the weighting of vicarious and social feedback that together form efficacy judgements. In the physics context specifically, students who treat physics knowledge as coherent but revisable are less likely to see conceptual struggle as evidence of inability and more likely to interpret successes and incremental gains as mastery experiences – the most powerful source of self-efficacy – thereby supporting the positive association observed between epistemic beliefs and physics self-efficacy.

The results also highlighted that self-regulative behavior explains how epistemic beliefs affect self-efficacy. What this comes down to is that sophisticated beliefs could promote deep-level processing strategies to which individuals learn [32], which in turn could produce the micro-experiences and feedback loops that build confidence. Looking into Muis' [25], [31] integrative model, epistemic beliefs are positioned as antecedent conditions that inform the standards learners set and the metacognitive operations they deploy; those operations (planning, monitoring, help-seeking, and adaptive strategy use) are the proximal behaviors that produce successful task performance and mastery interpretations. Empirical studies examining mediation pathways have found that facts of self-regulated learning (SRL) – including behavioral regulation and metacognitive monitoring – mediate links between epistemic beliefs and outcomes such as achievement and motivation [20], [30].

These findings extend existing research by situating the interplay of epistemic beliefs and self-regulative behavior within the context of pre-service physics education. Although previous studies have linked epistemic beliefs to motivation, learning strategies, and achievement more broadly, the mechanisms through which these beliefs influence confidence in domain-specific tasks have been less examined. By highlighting the role of regulatory behaviors in shaping students' engagement and mastery interpretations in physics, the study offers a deeper, context-sensitive perspective on how cognitive and motivational processes interact, thereby refining theoretical models of epistemic beliefs and self-regulated learning for applied educational settings.

In a practical sense, the partial mediation observed in the results highlights the importance of fostering both sophisticated epistemic beliefs-such as viewing knowledge as evolving and justified through evidence-and strong self-regulative skills, including goal setting, self-monitoring, and reflective evaluation. Educators and curriculum designers can use these insights to develop interventions that integrate metacognitive training with physics instruction. By explicitly teaching students how to plan, monitor, and adjust their learning strategies, instructors may strengthen both their epistemic understanding and their self-efficacy. In a broader sense, these results underscore the interconnectedness of cognition, motivation, and self-regulation in scientific learning, suggesting that supporting one domain can enhance performance across the others.

Future studies could examine the causal pathways among epistemic beliefs, self-regulation, and self-efficacy using longitudinal or experimental designs to determine how these constructs influence one another over time. Researchers might also explore domain-specific variations, comparing physics with other STEM areas to assess whether the mediating role of self-regulation is consistent across disciplines. Additionally, qualitative approaches-such as think-aloud protocols or learning diaries-could provide richer insight into how students enact self-regulative strategies in real learning contexts. Investigating contextual factors, such as classroom climate, instructional style, or the use of digital learning tools, may further clarify how external supports interact with internal belief systems to shape students' confidence and learning behaviors in physics.

4. CONCLUSION

Taken together, the findings articulate how pre-service science teachers' ways of knowing and ways of managing their learning jointly shape their confidence in learning and eventually teaching physics. The study underscores the functional interdependence of epistemic beliefs, self-regulative behavior, and physics self-efficacy within this teacher preparation context. Beliefs about the nature of knowledge orient teacher candidates toward particular modes of engagement, self-regulative strategies enact those orientations in practice, and the resulting experiences consolidate a sense of efficacy that will influence their future instructional choices.

The mediation model confirms that the relationship between epistemic beliefs and self-efficacy is partially mediated through self-regulative behavior – revealing a dynamic process where cognition, motivation, and metacognition co-construct confidence in both learning and teaching physics. Cultivating sophisticated epistemic understanding among pre-service teachers is therefore both a philosophical and pedagogical imperative. Physics teacher education that explicitly integrates epistemic reflection with structured self-regulation training through evidence evaluation and metacognitive monitoring can foster resilient, self-efficacious educators equipped to nurture scientific thinking in their future students.

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