

Pedagogical Content Knowledge and Self-Efficacy in Bhutan's Pre-Service Teachers

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Abstract

This quantitative study investigated the perceptions of Pedagogical Content Knowledge (PCK) among pre-service teachers at Paro College of Education. Using purposive sampling, participants reported high perceptions of PCK ($M = 3.64$, $SD = 0.99$), indicating strong understanding and application of content knowledge in teaching. The competency level of participants also scored high ($M = 3.49$, $SD = 0.72$), reflecting effective integration of pedagogy and content knowledge in instructional practices. Suggestions for improving PCK were proactive, with a mean score of 3.95 ($SD = 0.75$). An analysis of variance revealed no significant difference between perceptions and competency levels; however, gender significantly influenced recommendations for enhancing PCK ($p = 0.02$). Independent t-tests supported this finding, and correlations among perceptions, competency, and improvement strategies were statistically significant, with p-values of 0.000, 0.203, and 0.054. These findings highlight the positive perceptions, high competency levels, and gendered differences in enhancing PCK, contributing valuable insights for future research and professional development in education.

Keywords: Competency, Pedagogical Content Knowledge, Perceptions, Pre-service Teachers, Paro College



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INTRODUCTION

Education in Bhutan was traditionally provided by the monastic bodies. It was purely focused on religious learning based on rote learning. On top of that, only a few children were enrolled. There were no other subjects, and it was all about learning our national language. Since our country is small and isolated, our exposure to the outside world came late. The growing influence of the British in the late nineteenth century influenced Ugyen Wangchuk (1907-1926) toward Western style education. Later on, in the 1960s, modern education and the fundamental education plan were introduced since it was realized that the small, isolated country needed to be able to communicate with the rest of the world. Thus, the third king made English the language of instruction. This laid the foundations for the network of primary, secondary, and post-secondary institutions spread across Bhutan today.

Bhutanese science education started with a curriculum borrowed from the neighboring country according to Department of Curriculum and Professional Development (DCPD, 2022). However, in 1986, the Royal Government of Bhutan (RGoB) replaced this curriculum by implementing a localized science curriculum founded on the principles of New Approach to Primary Education (NAPE). This localized curriculum was implemented with the intent to take account of the Bhutanese context and promote the teaching of science based on Bhutan's natural and social environment. However, it was revised in 2001 because the content was inadequate to tackle the challenges and demands of the 21st century. The content in it was insufficient to produce productive, competent and contributing citizens in this digitalized age (Royal Education Council

[REC, 2012). Science curriculum after going through different phases of review, it was finally revised from the point of science, technology, engineering, and mathematics (STEM) educational approach. The STEM has now become a global concern as well as fundamental for all the people across the globe. In order to address current social, economic and environmental issues, the content and instructional practices of various science disciplines are mostly taught in conjunction with other STEM disciplines in real-life authentic contexts (DCPD, 2022).

The researcher strongly believes that the quality of education depends on the quality of the curriculum. A quality curriculum ensures that all students have access to the same knowledge and skills, regardless of their background or socio-economic status. The vision of school science curriculum is to focus on dynamic goals and objectives and then connect with the teacher who will deliver this curriculum. Hence, to achieve this goal, the teachers' quality is also crucial. They are the ones who will deliver the content and determine the learners' achievement. Some qualities of a good teacher include skills in communication, listening, collaboration, adaptability, empathy and patience. Other characteristics of effective teaching include an engaging classroom presence, value in real-world learning, exchange of best practices and a lifelong love of learning. Along with many other traits, having strong content knowledge and pedagogical knowledge are vital for teachers. Teachers must be competent and confident in their field both academically and professionally, having the capacity to capture and hold students' interest (Sherab, 2009). The best teachers are those who have specialist subject knowledge and a real passion and enthusiasm for the subject they teach. Thus, it is clear that teacher educators and researchers have identified pedagogical content knowledge (PCK) as a critical component of the knowledge needed to teach (Shulman, 1987).

Research Objectives:

This research aimed to explore pre-service teachers' self-efficacy beliefs in PCK in primary science education. The objectives of this research project were to:

1. explore pre-service teachers' competency in Pedagogical Content Knowledge (PCK) in Science Education.
2. explore the ways to develop PCK in science teachers.

LITERATURE REVIEW

Concept of PCK

Pedagogical content knowledge (PCK) was first introduced by Shulman in mid 1980s and described as the synthesis of teachers' subject matter knowledge with their pedagogical knowledge (Cochran et al., 1993; Wangchuk & Pem, 2021). PCK is the basic skills required for the teachers to develop their teaching strategies and quality (Kultsum, 2017). According to Shulman (2003) as cited in (Kultsum, 2017) PCK is categorized as teacher's competencies and a part of teachers' professional criteria in some countries. Shulman (1987) noted that PCK is the combination of content and pedagogy in order to make the topic accessible to the different interests and abilities of learners. It is knowledge specific to teachers and that distinguishes teachers from any other profession. PCK helps teachers to make use of their content knowledge for the purpose of instruction (Guler-Nalbantoglu & Aksu, 2021).

Impact of PCK on teaching and learning.

The literature survey shows that teachers' PCK has a positive effect on the instructional quality and on the student progress (e.g., Baumer et al., 2010; Coe et al., 2014). Thus, it is important to stimulate the PCK since the initial teacher training (Kind, 2017; Sorge et al., 2017). More important, when dealing with subject matter, teachers' actions will be determined largely by their PCK, making PCK an essential component of craft knowledge. The role of teachers has a great influence on student learning (Darling-Hammond, 2000; McKenzie et al., 2005) and therefore studies researching teacher knowledge have great importance (Aydin, 2012). No doubt that a

teacher should be well-versed in 'knowledge of the subject matter' and able to present it in a way that captures and maintains students' interest while using innovative techniques to meet their requirements (Sherab, 2009). Teacher's content knowledge is a critical component in teaching (Lewthwaite & MacIntyre, 2003), to ensure teacher's work effectiveness (Robinson, 2017). It is argued that teachers with a well-developed knowledge in this area are in a better position to make sense of students' actions and beliefs and to develop strategies for addressing these ideas through instruction (Magnusson, Krajcik, & Borko, 1999 as cited in Lane, R., 2014). Students' success depends on what the teachers know about a subject and how he or she can impart to the students what he or she knows (Kola & Sunday, 2015). Shulman states that PCK distinguishes a teacher from a non-teaching content specialist in which the differentiation is reflected in the capacity of a teacher to transform the content knowledge he or she possess into forms that are pedagogically powerful and yet adaptive to the variations in ability and background presented by students. (p. 15)

To give an example, a scientist is not concerned with how to teach the subject, whereas teachers must make use of their PCK to make the subject understandable to students by using analogies and illustrations. Transforming one's understanding of content for the purposes of learners requires teachers to hold and have the ability to draw on various components of PCK (Halim & Meerah, 2002).

Ways to develop PCK

To effectively teach and study science, science teachers must also be knowledgeable about science learners, curricula, instructional tactics, and assessment. Therefore, it is important to orient teachers and let them put into practice during their initial training program (Abell et al., 2009). To develop PCK, teachers need to gain experience with respect to teaching particular topics in practice. Also, they need to gain an understanding of students' conceptions and learning difficulties concerning these topics (Lederman, Gess-Newsome & Latz, 1994). However, so far, not much is known from research about the process of PCK development among student teachers. Clearly, understanding of the development of PCK is necessary to design effective teacher education programs (De Jong & Van Driel, 2004).

Self-efficacy beliefs of teachers in teaching science

Self-efficacy is an individual's optimistic belief in their innate ability, competence or chances of successfully accomplishing a task and producing a favorable outcome. Albert Bandura (2019) defines it as a personal judgment of "how well one can execute courses of action required to deal with prospective situations". Expectations of self-efficacy determine whether an individual will be able to exhibit coping behavior and how long effort will be sustained in the face of obstacles. Individuals who have high self-efficacy will exert sufficient effort that, if well executed, leads to successful outcomes, whereas those with low self-efficacy are likely to cease effort early and fail. Tschannen-Moran and Woolfolk Hoy (2001) defined teacher efficacy as a teacher's "judgment of his or her capabilities to bring about desired outcomes of student engagement and learning, even among those students who may be difficult or unmotivated." (p.783).

Pre-service teachers' self-efficacy beliefs play a crucial role in their effectiveness as science educators. Understanding the factors that influence and shape these beliefs is essential for teacher education programs and curriculum development in science education. Numerous studies have examined pre-service teachers' self-efficacy beliefs in science education. Overall, research suggests that pre-service teachers often exhibit moderate levels of self-efficacy beliefs, indicating that they perceive themselves as moderately capable of teaching science effectively. However, there are variations in self-efficacy levels based on factors such as prior science experiences, pedagogical training, and support systems.

RESEARCH METHOD

The researcher has employed a positivist paradigm, deemed most suitable for exploring pre-service teachers' self-efficacy beliefs in pedagogical content knowledge (PCK) within science education. This paradigm facilitates the collection of empirical data through quantitative methods, focusing on generalizability, replicability, and statistical analysis. As positivism emphasizes objectivity and measurable outcomes, it aligns well with the use of quantitative research methods and purposive sampling techniques, which aim to establish causal relationships through statistical interpretation. Within this framework, a nonexperimental correlational research design has been adopted to examine the relationships between variables without manipulation. Additionally, the researcher engages in theory testing by formulating clear hypotheses and gathering data to validate or invalidate them (Creswell, 2017, p. 16).

The study population comprises final-year B.Ed. general pre-service teachers at Paro College of Education. A purposive sampling technique was used for selecting participants, allowing for the identification of individuals best suited to meet the research objectives (Cohen et al., 2007). Although the initial sample size, determined using Yamane's formula (Yamane, 1967), was calculated to be 83 from a total population of 105 with a $\pm 5\%$ margin of error, only 48 participants responded to the survey. Despite the lower response rate, the sample proportion exceeding 50% of the total population was considered reliable. Data was collected using a close-ended questionnaire distributed via Google Forms, which allows efficient outreach and ease of data coding (Gurbuz, 2017). The data collected were analyzed using SPSS (SPSS Statistics 22), Minitab, and Excel software for both descriptive and inferential statistical analysis (Cohen et al., 2007; Creswell, 2003). Theme development served as the main analytical outcome, contributing to clarity, accuracy, and consistency in data interpretation (Vaismoradi et al., 2016).

FINDING

Interpretation of Perception level of pre-service teachers' PCK in education

Table 01 highlights pre-service teachers' perceptions of Pedagogical Content Knowledge (PCK) in primary science education. For the item *"I know what pedagogical content knowledge is"*, 12.5% (n=6) strongly disagreed, 10.4% (n=5) disagreed, 37.5% (n=18) remained neutral, 33.3% (n=16) agreed, and 6.3% (n=3) strongly agreed. The majority agreed (33.3%) or remained neutral (37.5%). The mean score was 3.10 with a standard deviation (SD) of 1.09, indicating a moderate level of perception. Regarding the item *"I am aware that PCK is important for teachers to teach scientific concepts effectively to the students"*, 56.3% (n=27) agreed or strongly agreed, 10.5% (n=5) disagreed or strongly disagreed, and 33.3% (n=16) remained neutral. The mean score was 3.58 with an SD of 0.98, reflecting a high level of awareness.

In the statement *"I know that adequate PCK has a positive impact on students' learning outcome"*, 67.8% (n=33) agreed or strongly agreed, 10.4% (n=5) disagreed or strongly disagreed, and 20.8% (n=10) remained neutral. The average mean score was 3.83 with an SD of 0.99, indicating a strong perception of PCK's positive impact on learning outcomes. For the item *"PCK should be introduced and included during the early training program"*, 75% (n=36) agreed or strongly agreed, 20.8% (n=10) remained neutral, and 4.2% (n=2) disagreed. The mean score was 3.89 with an SD of 0.90, suggesting a positive response to including PCK in early training.

Finally, on the item *"PCK is vital for effective teachers"*, 58.4% (n=28) agreed or strongly agreed, 6.3% (n=3) disagreed, and 35.4% (n=17) remained neutral. The mean score was 3.81 with an SD of 1.00, indicating a generally positive perception of PCK's importance for teacher effectiveness.

Perception level of pre-service teacher in PCK in primary science education

The data interpretation reveals that pre-service teachers hold a generally positive perception of Pedagogical Content Knowledge (PCK) in primary science education. While 12.5% strongly disagree and 10.4% disagree about knowing what PCK is, a majority either agree (33.3%) or remain neutral (37.5%), with a mean score of 3.10. A significant 56.3% agree or strongly agree that PCK is important for teaching science effectively, though 33.3% remain neutral, resulting in a mean of 3.58. Most respondents (67.8%) agree or strongly agree that PCK positively impacts students' learning, with a mean of 3.83. Additionally, 75% support the inclusion of PCK in early training, with only 4.2% disagreeing (mean = 3.89). Regarding PCK's role in teacher effectiveness, 58.4% agree or strongly agree, while 35.4% remain neutral (mean = 3.81). Overall, the average mean score of 3.64 suggests a high level of perception among pre-service teachers about the significance of PCK in science education.

Table 1. Perception level of pre-service teacher in PCK in primary science education

Items	Frequency & Percentage					Mean	Standard Deviation	Level of perception
	SD	D	N	A	SA			
I know what pedagogical content knowledge is.	12.5 (6)	10.4 (5)	37.5 (18)	33.3 (16)	6.3 (3)	3.10	1.09	High
I am aware that PCK is important for teachers in order to teach scientific concepts effectively to the students.	4.2 (2)	6.3 (3)	33.3 (16)	39.6 (19)	16.7 (8)	3.58	.98	High
I know that adequate PCK has positive impact on students learning outcome.	2.1 (1)	8.3 (4)	20.8 (10)	41.7 (20)	27.1 (13)	3.83	.99	High
PCK should be introduced and included during the early training program.	4.2 (2)	0	20.8 (10)	52.1 (25)	22.9 (11)	3.89	.90	High
PCK is vital for effective teachers.	2.1 (1)	4.2 (2)	35.4 (17)	27.1 (13)	31.3 (15)	3.81	1.00	High
Average						3.64	.99	High

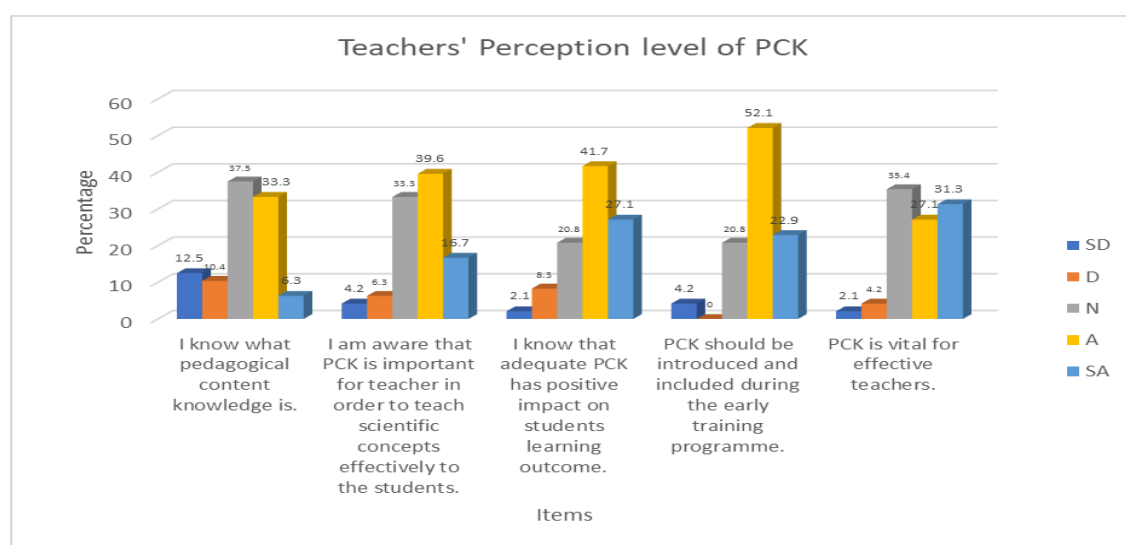


Figure 1. Graph representation of teachers' perception level of PCK

Table 1 as visualized in Figure 1 illustrates the competency level of pre-service teachers in Pedagogical Content Knowledge (PCK) in primary Science education. Mean scores range from 3.27 to 3.83, suggesting a relatively high level of competence. For the statement “I am competent to teach primary science effectively,” 56.2% (n=27) either agree or strongly agree, while 6.3% (n=3) disagree and 37.5% (n=18) remain neutral. However, some data points for related responses appear unclear or inconsistent. Regarding scientific concepts familiarity, 33.3% either disagree or strongly disagree, 8.3% (n=4) disagree, and 58.3% (n=28) remain neutral, with a mean of 3.27 and SD of 0.64. The statement “I can create a positive classroom culture to support science learning” had a mean of 3.58 and SD of 0.64. Pre-service teachers feel capable of using diverse teaching approaches (mean = 3.52, SD = 0.71), and 50.1% (n=24) believe they can develop various strategies to understand science (mean = 3.45, SD = 0.77). A high 68.8% (n=33) feel confident in assessing student performance (mean = 3.83, SD = 0.72). Moreover, they also believe in adapting teaching for learners with varied abilities (mean = 3.62, SD = 0.73). The overall mean score of 3.49 and SD of 0.72 reflect a consistently high competency perception among pre-service teachers.

Findings from the Competency level of pre-service teachers on PCK in Science education

The findings from the competency level of pre-service teachers in Pedagogical Content Knowledge (PCK) in primary Science education revealed that the pre-service teachers perceive to have a relatively high level of competency in PCK in primary Science education, with mean scores ranging from 3.27 to 3.83. This indicates a positive perception of their competence in various aspects of teaching primary Science. While 56.2% of respondents agree or strongly agree that they are competent to teach primary Science effectively, there is a small percentage (6.3%) who disagree. However, a significant proportion (37.5%) remained neutral, indicating some uncertainty about their teaching effectiveness. There is a range of perceptions regarding familiarity with scientific concepts, with 33.3% of respondents either disagree or strongly disagree. However, 58.3% of respondents remained neutral on this statement, indicating a lack of strong agreement or disagreement. Pre-service teachers generally believe they can create a positive classroom culture to support science learning, with a mean score of 3.58. This indicates a high level of perception regarding their ability to establish a conducive learning environment. Using diverse teaching approaches:

Many pre-service teachers feel capable of using a wide range of teaching approaches, with a mean score of 3.52. This suggests their confidence in employing diverse instructional strategies to cater to different learning styles and needs. Developing understanding of the subject: A significant majority of pre-service teachers (50.1%) believe they have various ways and strategies to develop their understanding of the science subject, indicating a high level of perception in this aspect. Pre-service teachers generally feel confident in their ability to assess student performance in the classroom, with a mean score of 3.83. This suggests their perceived competency in evaluating and measuring student learning outcomes effectively. Adapting teaching style to different learners: Pre-service teachers believe they can adapt their teaching style to different learners with varied abilities, with a mean score of 3.62. This indicates their perceived ability to tailor their instructional approaches to meet the diverse needs of their students.

Interpretating the data of the Competency level of pre-service teachers in PCK in primary Science education

Table 03 shows that pre-service teachers perceive themselves to have a high level of competency (M=3.49 & SD=.72) in various aspects of pedagogical content knowledge (PCK) in primary Science education. They express confidence in teaching effectively (M=3.58, SD=.73), thinking like experts (M=3.04, SD=.77), being familiar with scientific concepts (M=3.27, SD=.64), creating a positive classroom culture (M=3.58, SD=.64), using diverse teaching approaches (M=3.52, SD=.71), relating scientific concepts to everyday life (M=3.50, SD=.74), developing their

understanding of the subject($M=3.45$, $SD=.77$), assessing student performance($M=3.83$, $SD=.72$), and adapting their teaching style to different learners($M=3.62$, $SD=.73$).

Competency level of pre-service teachers in PCK in primary Science education

The findings from the data regarding the competency level of pre-service teachers in Pedagogical Content Knowledge (PCK) in primary Science education revealed that pre-service teachers perceive themselves to have a high level of competency in various aspects of PCK in primary Science education. The mean score of 3.49 and standard deviation of 0.72 indicate a generally positive perception of their competence in this area. Similarly, preservice teachers express confidence in their ability to teach effectively, with a mean score of 3.58 and standard deviation of 0.73. This suggests that they believe they have the necessary skills and knowledge to deliver quality instruction in primary Science education. Respondents feel familiar with scientific concepts, as indicated by a mean score of 3.27 and standard deviation of 0.64. This suggests that they have a solid understanding of the subject matter they will be teaching. And they believe they can create a positive classroom culture, as reflected by a mean score of 3.58 and standard deviation of 0.64. This indicates their perceived ability to establish an environment conducive to learning and student engagement.

Further, the respondents indicate a high level of competency in using diverse teaching approaches, with a mean score of 3.52 and standard deviation of 0.71. This suggests that they feel equipped to employ a variety of instructional strategies to cater to different learning styles and needs. Likewise, pre-service teachers perceive themselves as capable of relating scientific concepts to everyday life, with a mean score of 3.50 and standard deviation of 0.74. This indicates their perceived ability to make connections between science content and real-world applications. The respondents feel competent in developing their own understanding of the subject, as indicated by a mean score of 3.45 and standard deviation of 0.77. This suggests their commitment to continuous learning and improvement in the field of primary Science education. Pre-service teachers express confidence in their ability to assess student performance, with a mean score of 3.83 and standard deviation of 0.72. This indicates their perceived competency in evaluating student learning and progress effectively. Adapting teaching style to different learners: The respondents believe they can adapt their teaching style to different learners, as reflected by a mean score of 3.62 and standard deviation of 0.73. This suggests their perceived ability to tailor their instructional approaches to meet the diverse needs of their students.

Table 2. Competency level of pre-service teachers in PCK in primary Science education

Items	SD	D	N	A	SA	Mean	Standard Deviation	Level of perception
I am competent to teach primary science effectively.	0	6.3 (3)	37.5 (18)	47.9 (23)	8.3 (4)	3.58	.73	High
I can think about the subject matter like an expert.	4.2 (2)	14.6 (7)	54.2 (26)	27.1 (13)	0	3.04	.77	High
I am familiar with scientific concepts.	0	8.3 (4)	58.3 (28)	31.3 (15)	2.1 (1)	3.27	.64	High
I can create a positive classroom culture to support science learning.	0	2.1(1)	43.8(21)	47.9 (23)	6.3 (3)	3.58	.64	High
I can use a wide range of teaching approaches in a classroom setting.	0	6.3 (3)	41.7 (20)	45.8 (22)	6.3 (3)	3.52	.71	High

Items	SD	D	N	A	SA	Mean	Standard Deviation	Level of perception
I can relate scientific concepts to everyday life experiences. ⁶	0	6.3 (3)	45.8 (22)	39.6 (19)	8.3 (4)	3.50	.74	High
I have various ways and strategies of developing my understanding of science subject.	0	10.4 (5)	39.6 (19)	43.8 (21)	6.3 (3)	3.45	.77	High
I know how to assess student performance in a classroom.	0	2.1 (1)	29.2 (14)	52.1 (25)	16.7 (8)	3.83	.72	High
I can adapt my teaching style to different learners with varied abilities.	0	4.2 (2)	39.6 (19)	45.8 (22)	10.4 (5)	3.62	.73	High
Average						3.49	.72	High

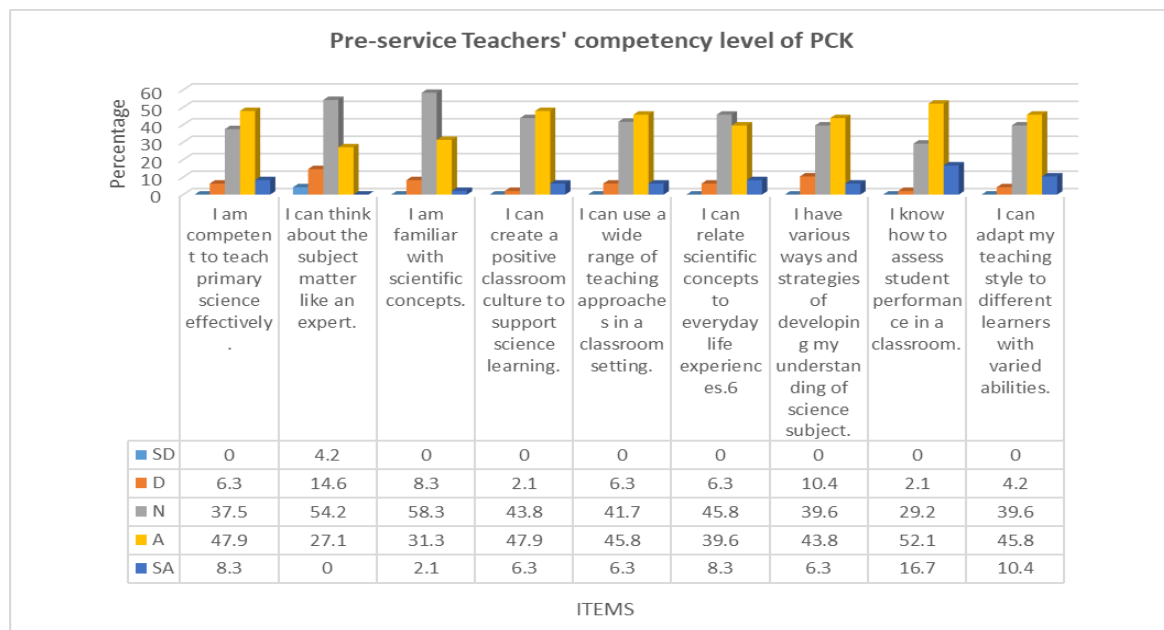


Figure 2. Graph representation of pre-service teachers' competency level of PCK

Ways to develop PCK in pre-service teachers in primary science education

Table 3 shows perceived strategies to improve PCK in pre-service teachers in primary science education. "Introducing PCK during the initial training period will help develop my PCK", 79.2%(n=38) respondents either agree or disagree with the statement. However, 4.2% (n=2) respondents disagree, and 16.7% (n=8) respondents remained neutral. The overall mean score of 4.04 and SD of .79 indicates the highest level of perception among the items in this dataset. Similarly, "Professional development (PD) can help me improve my PCK in primary science", a

significant majority of pre-service teachers believe that professional development (PD) can help them improve their PCK in primary science with the mean score 3.93 and SD of .66; 79.2%(n=38) either agree or strongly disagree, 18.8% (n=9) respondents remained neutral, 2.1% (n=1) respondent totally disagree. The mean score of 3.93 indicates a high level of perception. Followed by the statement "Feedback from science teachers will enable me to excel in PCK", many respondents agree or strongly agree that feedback from science teachers will enable them to excel in PCK. The mean score of 3.91 and SD of .76 indicate a high level of perception. Finally, it is observed that a significant majority of respondents agree or strongly agree (77.9% (n=35) that collaborating with other educators will help develop their PCK. The mean score of 3.91 and SD of .79 indicate a high level of perception "Collaborating with other educators will help develop my PCK"

The average perception score for ways to improve PCK in pre-service teachers in primary science education is 3.95, indicating a high level of perception overall. The standard deviation of 0.75 suggests relatively low variability in the responses, indicating a consistent perception among the respondents. It also shows a high level of perception regarding these strategies, emphasizing their importance in enhancing their teaching abilities.

Strategies to improve PCK in pre-service teachers in primary science education

The findings from the interpretation of the data on strategies to improve Pedagogical Content Knowledge (PCK) in pre-service teachers in primary science education reveals a significant majority of respondents (79.2%) agreed that introducing PCK during the initial training period would help develop their PCK. This indicates a high level of perception among the respondents regarding the effectiveness of early exposure to PCK. Similarly, the majority of pre-service teachers (79.2%) believed that professional development opportunities could help them improve their PCK in primary science. This finding highlights the importance of ongoing training and learning experiences to enhance teaching abilities. Further, respondents generally agreed or strongly agreed (3.91 mean score) that receiving feedback from science teachers would enable them to excel in PCK. This suggests that feedback plays a crucial role in supporting pre-service teachers' professional growth and development in the context of primary science education.

Likewise, Tabel 4 shows that a significant majority of respondents (77.9%) agreed that collaborating with other educators would help develop their PCK. This finding emphasizes the value of collaboration and teamwork in fostering effective teaching practices and enhancing PCK. Overall, the average perception score of 3.95 indicates a high level of perception among the pre-service teachers regarding the effectiveness of these strategies to improve PCK in primary science education. The relatively low standard deviation of 0.75 suggests a consistent perception among the respondents, indicating a shared understanding of the importance of these strategies. These findings highlight the significance of early exposure to PCK, professional development opportunities, feedback, and collaboration in enhancing the teaching abilities of pre-service teachers in primary science education.

Table 3. Ways to improve PCK in pre-service teachers in primary science education

Items	Frequency & Percentage					Mean	Standard Deviation	Level of perception
	SD	D	N	A	SA			
Introducing PCK during the initial training period will help develop my PCK.	0	4.2 (2)	16.7 (8)	50 (24)	29.2 (14)	4.04	.79	Highest
Professional development (PD) can help me improve my PCK in primary science.	0	2.1 (1)	18.8 (9)	62.5 (30)	16.7 (8)	3.93	.66	High

Items	Frequency & Percentage					Mean	Standard Deviation	Level of perception
	SD	D	N	A	SA			
Feedback from science teachers will enable me to excel PCK	0	2.1 (1)	27.1 (13)	47.9 (23)	22.9 (11)	3.91	.76	High
Collaborating with other educators will help develop my PCK.	0	4.2 (2)	22.9 (11)	50 (24)	22.9 (11)	3.91	.79	High
Average						3.95	.75	High

Table 4. Overall Mean and Standard Deviation of the three variables

Variables	Mean	Standard Deviation	Level
Perception on PCK	3.64	.99	High
Competency level	3.49	.72	High
WDPCK	3.95	.75	High

Comparison of independent variables (PCK, PPCK, WDPCK) across gender

Table 5 shows an ANOVA (Analysis of Variance) analysis examining the independent variables (PCK, PPCK, WDPCK) based on gender. The ANOVA results for PCK indicate that there is no significant difference between groups based on gender. The Sum of Squares, Mean Square, and F-value are all very low, and the p-value (0.89) exceeds the typical threshold for statistical significance ($p < 0.05$). Similarly, the ANOVA results for pre-service teachers' competency level on PCK indicate that there is no significant difference between groups based on gender. The Sum of Squares, Mean Square, and F-value are relatively low, and the p-value (0.54) exceeds the typical threshold for statistical significance. Further, the ANOVA results for Ways to Improve PCK suggest a significant difference between groups based on gender. The Sum of Squares, Mean Square, and F-value are relatively high, and the p-value (0.02) falls below the typical threshold for statistical significance (e.g., 0.05). This indicates that there is evidence to support the hypothesis that gender has an impact on ways to improve PCK.

Hypothesis

H₁: *The gender has an impact on ways to develop PCK in pre-service teachers in primary science education*

Table 5. ANOVA of independent variables (PCK, PPCK, WDPCK) by gender

		Sum of Squares	Df	Mean Square	F	Sig.
Perception on Pedagogical Content Knowledge (PCK)	Between Groups	0.01	1	0.01	0.01	0.89
	Within Groups	28.08	46	0.61		
	Total	28.09	47			
PCK Competency	Between Groups	0.08	1	0.08	0.36	0.54
	Within Groups	10.03	46	0.21		
	Total	10.11	47			

		Sum of Squares	Df	Mean Square	F	Sig.
Ways to improve PCK	Between Groups	1.64	1	1.64	5.15	0.02
	Within Groups	14.68	46	0.31		
	Total	16.332	47			

Result from Independent sample t-test on PCK, perceptions, and WDPCK

Table 6 provides the results of an independent samples t-test analysis, including Levene's Test for Equality of Variances and the T-test for Equality of Means. Levene's test results indicate that the assumption of equal variances for PCK is valid since the p-value (0.60) exceeds the typical threshold for significance (e.g., 0.05). The t-test results for perception on PCK show that there is no significant difference in means between the compared groups. The t-value is -0.13, and the p-value (0.89) exceeds the typical threshold for significance.

Similarly, the Levene's test results indicate that the assumption of equal variances for Perception is valid since the p-value (0.83) exceeds the typical threshold for significance. The T-test results for Competency show that there is no significant difference in means between the groups compared. The t-value is 0.61, and the p-value (0.56) exceeds the typical threshold for significance. And similarly, Levene's test results indicate that the assumption of equal variances for WDPCK is valid since the p-value (0.84) exceeds the typical threshold for significance. However, the t-test results for WDPCK indicate a significant difference in means between the compared groups. The t-value is -2.27, and the p-value (0.02) falls below the typical threshold for significance.

The result suggests that there are no significant differences in means between the groups for Perception and competency. However, there is a significant difference in means between the groups for WDPCK, indicating that this variable has an impact on the groups being compared.

Table 6. Independent Samples Test

Levene's Test for Equality of Variances		t-test for Equality of Means							95% Confidence Interval of the Difference	
		F	Sig.	T	Df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Perception on PCK	Equal variances assumed	.28	.60	-.13	46.0	.89	-.04	.27	-.58	.50
	Equal variances not assumed			-.13	16.5	.89	-.04	.27	-.60	.53
Competency level	Equal variances assumed	.05	.83	.61	46.0	.55	.10	.16	-.23	.42
	Equal variances not assumed			.60	16.2	.56	.10	.16	-.25	.44
WDPCK	Equal variances assumed	.04	.84	-2.27	46.0	.03	-.44	.19	-.83	-.05
	Equal variances not assumed			-2.45	18.6	.02	-.44	.18	-.82	-.06

Correlations between Perception on PCK, competency level, and WDPCK

Table 7 presents the Pearson correlation coefficients between the variables PCK (Pedagogical Content Knowledge), Perception, and WDPCK (Ways to Improve PCK).

The correlation coefficient between perception on PCK and Competency level is 0.280, indicating a positive but weak relationship. However, the p-value (0.054) is slightly above the conventional threshold for statistical significance (e.g., 0.05). Therefore, the correlation between Perception and competency is not considered statistically significant. Similarly, the correlation coefficient between Perception on PCK and WDPCK is 0.327, indicating a positive and moderate relationship. Moreover, the p-value (0.023) falls below the conventional threshold of 0.05, indicating a statistically significant correlation between perception on PCK and WDPCK at the 0.05 level. The correlation coefficient between Competency level and WDPCK is 0.486, indicating a positive and relatively strong relationship. Additionally, the p-value is less than 0.001, indicating a highly statistically significant correlation between Perception and WDPCK at the 0.01 level.

Overall, the correlations suggest that there is a significant positive relationship between PCK and WDPCK, as well as between Perception and WDPCK. However, the relationship between PCK and Perception, while positive, is not statistically significant at the conventional level of significance.

Table 7. Correlations between PCK, Perceptions, and WDPCK

		Perception on PCK	Competency level	WDPCK
Perception on PCK	Pearson Correlation	1	.280	.327*
	Sig. (2-tailed)		.054	.023
	N	48	48	48
Competency level	Pearson Correlation	.280	1	.486**
	Sig. (2-tailed)	.054		.000
	N	48	48	48
WDPCK	Pearson Correlation	.327*	.486**	1
	Sig. (2-tailed)	.023	.000	
	N	48	48	48

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

DISCUSSION

The perception level of pre-service teachers' Pedagogical Content Knowledge (PCK) in primary science education is an important aspect to consider as it can influence their teaching practices and effectiveness in the classroom. Several studies have explored this topic, providing insights into the perceptions of pre-service teachers regarding PCK in science education. A study by Davis and Krajcik (2005) examined pre-service elementary teachers' beliefs about effective science teaching. The findings revealed that many pre-service teachers held misconceptions about science teaching and lacked a deep understanding of PCK. This highlights the need for targeted interventions and training programs to enhance pre-service teachers' perception and understanding of PCK. In another study by Dostal and English (2019), pre-service elementary teachers' beliefs about science teaching and learning were explored.

The findings indicated that pre-service teachers who had positive beliefs and perceptions about science teaching were more likely to implement effective instructional strategies in their classrooms. This suggests that fostering positive perceptions of PCK in pre-service teachers can positively impact their teaching practices. Furthermore, a study by Cheung and Ng (2012) investigated the PCK development of pre-service teachers during their teacher education program. The results showed that pre-service teachers' perceptions of PCK increased significantly after completing a science education course. This highlights the potential impact of targeted training and education programs in improving pre-service teachers' perception of PCK. Additionally, a study by

Loughran et al. (2004) examined the perceptions of pre-service science teachers regarding PCK. The findings revealed that preservice teachers' beliefs and perceptions about PCK influenced their instructional decision-making and pedagogical practices. This emphasizes the importance of addressing pre-service teachers' perceptions and beliefs about PCK to enhance their teaching effectiveness.

Impact of Teacher's pedagogical content knowledge in teaching and students' learning

Teachers' Pedagogical Content Knowledge (PCK) plays a crucial role in shaping their instructional practices and has a direct impact on students' learning outcomes. PCK refers to teachers' understanding of how to effectively teach specific subject content, including the ability to select appropriate instructional strategies, anticipate student misconceptions, and provide meaningful explanations. The following discussion explores the ways in which teachers' PCK influences teaching and students' learning, drawing on relevant literature.

One key aspect of teachers' PCK is their ability to select and use appropriate instructional strategies. A study by Magnusson et al. (1999) highlighted that teachers with strong PCK are more likely to use instructional strategies that promote active student engagement and foster deep understanding of the content. They are better able to choose activities, demonstrations, and discussions that effectively convey complex scientific concepts. This selection of appropriate strategies enhances students' engagement and facilitates their learning. Teachers' PCK also enables them to identify and address student misconceptions effectively. By understanding common misconceptions that students may hold, teachers can design targeted instructional interventions to help students overcome these misconceptions. In a study by Windschitl et al. (2008), it was found that teachers who possess strong PCK in science education were more successful in recognizing and addressing students' misconceptions, leading to improved conceptual understanding among students.

Similarly, the current study also indicates that the pre-service teachers have a high level of perception level ($M=3.64$, $SD=.99$) which signifies that with the high level of perceptions will have a great impact on the students' learning as numerous literatures pointed out. Moreover, teachers' PCK influences their ability to provide meaningful explanations and make connections between abstract concepts and real-world applications. They can draw on their content knowledge and pedagogical expertise to relate complex scientific concepts to students' prior knowledge and everyday experiences. This aspect of PCK is vital for promoting students' understanding and engagement. A study by Gess-Newsome (1999) highlighted that teachers with strong PCK were more effective in providing explanations that bridged the gap between abstract concepts and concrete examples, enhancing students' learning experiences.

Additionally, teachers' PCK impacts their assessment practices, enabling them to design assessments that align with the learning objectives and accurately measure students' understanding. They can develop appropriate assessment tasks and rubrics that effectively evaluate students' conceptual understanding, skills, and application of knowledge. In a study by Hill et al. (2004), it was found that teachers with strong PCK were more likely to design assessments that reflected the complexity of the subject matter and provided valuable feedback to guide students' learning.

Similarly, the current study also found out pre-service teachers have a high level of competency in various aspects of PCK in primary Science education.

Competency level of pre-service teachers in PCK in primary Science education

The competency level of pre-service teachers in Pedagogical Content Knowledge (PCK) in primary Science education is an important factor that can significantly impact their effectiveness as future educators. The following discussion explores the competency level of pre-service teachers in PCK and its implications for primary Science education, with references to relevant literature.

Research indicates that pre-service teachers' competency level in PCK can vary and has implications for their ability to teach Science effectively.

Thus, the current study also found out that the competency of the pre-service teachers possesses high level ($M=3.49$, $SD=.72$). The pre-service teachers with a higher level of competency in PCK are more likely to have a deeper understanding of scientific concepts and principles. They can effectively connect scientific concepts to real-world applications and provide meaningful explanations to students. A study by Abell (2008) emphasized the importance of pre-service teachers' PCK in helping them develop a strong conceptual understanding of science and promoting students' conceptual learning. Moreover, pre-service teachers' competency in PCK influences their ability to identify and address student misconceptions. Teachers with strong PCK are better equipped to anticipate and address common misconceptions that students may have, thereby promoting more accurate and meaningful understanding of science concepts. This finding is supported by research conducted by Windschitl et al. (2008), who found that pre-service teachers with higher levels of PCK were more successful in recognizing and addressing student misconceptions.

The competency level of pre-service teachers in PCK also has implications for their ability to effectively assess student learning in science. Teachers with higher levels of competency in PCK can design assessment tasks that align with learning objectives and provide meaningful feedback to students. They are better able to assess students' conceptual understanding and skills in science. A study by Magnusson, Krajcik, and Borko (1999) highlighted the importance of pre-service teachers' competency in PCK for designing effective assessments that reflect the complexity of science content.

In conclusion, the competency level of pre-service teachers in PCK plays a vital role in their effectiveness as future educators in primary Science education. A higher level of competency in PCK is associated with more effective instructional practices, deeper understanding of scientific concepts, better identification and addressing of student misconceptions, and the ability to design meaningful assessments. It is crucial for teacher education programs to focus on developing and enhancing pre-service teachers' competency in PCK to ensure quality Science education in primary schools.

Perceptions on Ways to develop PCK in Pre-service teachers

Developing pedagogical content knowledge (PCK) in pre-service teachers is crucial for their effectiveness in the classroom. PCK refers to the integration of subject matter knowledge, pedagogical knowledge, and knowledge of learners in order to make informed decisions about teaching specific content. Provide pre-service teachers with focused training that integrates subject matter knowledge and pedagogical strategies. This can include modeling effective teaching practices, analyzing and deconstructing exemplary lessons, and engaging in collaborative discussions about teaching strategies (Ball et al., 2008). Observation of expert teachers can help pre-service teachers develop a deeper understanding of how to effectively teach specific content areas (Ingersoll & Strong, 2011). Provide opportunities for pre-service teachers to engage in authentic teaching experiences, such as microteaching or field placements, where they can apply their subject matter knowledge and pedagogical skills in real classroom settings. These experiences allow for reflection and refinement of their teaching practices (Grossman et al., 2009). Encourage pre-service teachers to engage in reflection and self-assessment of their teaching practices. This can be done through regular journaling, video recordings of their lessons, or structured reflection prompts. Reflection helps pre-service teachers identify areas for improvement and refine their pedagogical decision-making. Foster collaborative learning environments where pre-service teachers can interact and share their experiences with peers. Collaborative learning allows for the exchange of ideas, perspectives, and teaching strategies, promoting the development of PCK (Grossman et al., 2009). Incorporate technology into teacher education programs to support the development of PCK. Technology-enhanced learning experiences can provide pre-service teachers

with opportunities to explore and implement innovative pedagogical strategies, fostering their content knowledge and teaching skills (Niess, 2011).

CONCLUSION

The research highlights the significant impact of teachers' Pedagogical Content Knowledge (PCK) on teaching and students' learning outcomes. Teachers with strong PCK possess the ability to select appropriate instructional strategies, address student misconceptions effectively, provide meaningful explanations, and design assessments that accurately measure students' understanding. These aspects of PCK contribute to enhanced student engagement, deeper conceptual understanding, and improved learning experiences. Similarly, pre-service teachers' competency in PCK in primary Science education plays a crucial role in their effectiveness as future educators. Higher levels of competency in PCK are associated with a deeper understanding of scientific concepts, better identification and addressing of student misconceptions, and the ability to design meaningful assessments. To develop and enhance PCK in pre-service teachers, several strategies can be implemented. These include providing focused training that integrates subject matter knowledge and pedagogical strategies, observing and learning from expert teachers, engaging in authentic teaching experiences, encouraging reflection and self-assessment, fostering collaborative learning environments, and incorporating technology into teacher education programs. By implementing these strategies, teacher education programs can effectively support the development of pre-service teachers' PCK and ensure quality Science education in primary schools.

Overall, the research underscores the importance of PCK in teaching and learning, emphasizing the need for teacher educators and institutions to prioritize the development of PCK in pre-service teachers. By equipping future educators with strong PCK, we can enhance instructional practices, promote deeper conceptual understanding, and facilitate meaningful learning experiences for students. This research contributes to the broader understanding of the crucial role of teachers' PCK and its implications for improving education in the primary Science domain.

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