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Bridging Pedagogy and Content: An Analytical Mixed-Method Study of the Impact of Pedagogical Content Knowledge (PCK) On Self-Efficacy & Teaching Effectiveness in Physics

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Abstract
The effectiveness of physics teaching is significantly influenced by teachers' ability to integrate subject knowledge with appropriate pedagogical strategies. This integration, conceptualized as Pedagogical Content Knowledge (PCK), plays a crucial role in enhancing instructional quality and student learning outcomes. The present study examines the impact of PCK on teacher self-efficacy and teaching effectiveness in physics education. A mixed-method research design, specifically the convergent parallel model, was adopted to collect and analyze both quantitative and qualitative data. The quantitative data were collected from a sample of 120 secondary school physics teachers using standardized instruments, including a PCK scale, Teacher Self-Efficacy Scale (TSES), and Teaching Effectiveness Scale. Statistical techniques such as mean, standard deviation, Pearson correlation, regression analysis, and mediation analysis were applied. The results revealed a strong positive correlation between PCK and self-efficacy ($r = 0.68$) and between PCK and teaching effectiveness ($r = 0.72$). Regression analysis indicated that PCK significantly predicts both self-efficacy ($\beta = 0.65$, $p < 0.01$) and teaching effectiveness ($\beta = 0.70$, $p < 0.01$). Furthermore, mediation analysis demonstrated that self-efficacy partially mediates the relationship between PCK and teaching effectiveness. The qualitative findings, based on interviews and classroom observations, revealed that teachers with strong PCK demonstrate higher conceptual clarity, employ diverse instructional strategies, actively engage students, and adapt teaching methods according to learner needs. The study concludes that strengthening PCK is essential for improving both teacher confidence and teaching effectiveness in physics education.

Keywords: Pedagogical Content Knowledge, Self-Efficacy, Teaching Effectiveness, Physics Education, Mixed Methods

Introduction:

In contemporary education, teaching effectiveness has emerged as a central concern for improving student learning outcomes. Physics, as a core scientific discipline, plays a vital role in developing analytical thinking, problem-solving abilities, and conceptual understanding among students. However, it is widely observed that students often perceive physics as a difficult subject due to its abstract nature, mathematical complexity, and conceptual depth. One of the major reasons for this difficulty lies in the instructional practices adopted in classrooms. Traditional teaching approaches that focus primarily on content delivery often fail to promote deep understanding. This highlights the need for teachers to possess not only strong subject knowledge but also the ability to present that knowledge effectively. This integrated knowledge is referred to as Pedagogical Content Knowledge (PCK), a concept introduced by Shulman (1986). PCK represents the blending of content knowledge and pedagogical skills, enabling teachers to transform subject matter into forms that are understandable to learners. In physics teaching, PCK involves the use of analogies, demonstrations, experiments, and real-life

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examples to explain complex concepts. Teachers with strong PCK are better equipped to identify student misconceptions and employ appropriate strategies to address them.

Another important factor influencing teaching effectiveness is teacher self-efficacy. According to Bandura (1997), self-efficacy refers to an individual's belief in their ability to perform tasks successfully. In the context of teaching, self-efficacy reflects a teacher's confidence in their ability to manage the classroom, deliver content effectively, and facilitate student learning. Teachers with high self-efficacy are more likely to adopt innovative teaching methods and persist in challenging situations. Teaching effectiveness, in turn, refers to the extent to which teachers successfully facilitate student learning through appropriate instructional strategies, classroom management, and assessment practices. It is influenced by both cognitive factors (such as knowledge) and psychological factors (such as confidence). Despite the importance of these variables, there is limited research examining their interrelationship in an integrated manner, particularly in physics education. The present study aims to address this gap by exploring the impact of PCK on self-efficacy and teaching effectiveness using a mixed-method approach.

Review of Literature

1. **Concept of Pedagogical Content Knowledge**
   Pedagogical Content Knowledge (PCK) was introduced by Shulman (1986) as a unique form of teacher knowledge that integrates content and pedagogy. It involves understanding how to teach specific subject matter effectively, taking into account students' prior knowledge and misconceptions.
   Magnusson et al. (1999) further elaborated the concept by identifying key components of PCK, including knowledge of curriculum, instructional strategies, student understanding, and assessment methods. These components highlight the dynamic and context-specific nature of PCK.
   Studies in science education have shown that teachers with strong PCK are more effective in promoting conceptual understanding. They are able to use multiple representations, analogies, and demonstrations to explain complex ideas.
2. **Teacher Self-Efficacy**
   The concept of self-efficacy was developed by Bandura (1997) as part of Social Cognitive Theory. Teacher self-efficacy refers to a teacher's belief in their ability to influence student learning outcomes.
   Research indicates that teachers with high self-efficacy:
   - Are more confident in their teaching
   - Use innovative instructional strategies
   - Manage classrooms effectively
   - Show greater persistence

   Tschannen-Moran and Hoy (2001) emphasized that self-efficacy influences teaching behavior, motivation, and performance.

3. **Teaching Effectiveness**

   Teaching effectiveness is a multidimensional construct that includes:

   - Clarity of instruction
   - Student engagement
   - Classroom management
   - Assessment practices

Effective teaching in physics requires the ability to connect theory with practice and to facilitate active learning.

4. **Relationship among PCK, Self-Efficacy, and Teaching Effectiveness**
Research suggests that PCK plays a crucial role in enhancing teaching effectiveness. Teachers with strong PCK are better able to explain concepts, address misconceptions, and engage students. Similarly, self-efficacy influences teaching effectiveness by shaping teachers' confidence and motivation. Teachers who believe in their abilities are more likely to adopt effective teaching strategies. However, limited studies have examined the combined impact of PCK and self-efficacy on teaching effectiveness, particularly in physics education.
5. **Research Gap:** The review of literature reveals the following gaps:
   - Lack of integrated studies examining PCK, self-efficacy, and teaching effectiveness together
   - Limited use of mixed-method approaches
   - Insufficient focus on physics education

   These gaps justify the need for the present study.

Objectives of the Study

1) To assess the level of Pedagogical Content Knowledge among physics teachers
2) To examine the level of teacher self-efficacy
3) To evaluate teaching effectiveness
4) To analyze the relationship between PCK and self-efficacy
5) To examine the relationship between PCK and teaching effectiveness
6) To study the relationship between self-efficacy and teaching effectiveness
7) To determine the predictive role of PCK
8) To examine the mediating role of self-efficacy

Hypotheses of the Study

1) **Hypotheses Related to Levels**
H_{01}: There is no significant level of Pedagogical Content Knowledge among physics teachers.
H_{11}: There is a significant level of Pedagogical Content Knowledge among physics teachers.
H_{02}: There is no significant level of teacher self-efficacy.
H_{12}: There is a significant level of teacher self-efficacy.
H_{03}: There is no significant level of teaching effectiveness.
H_{13}: There is a significant level of teaching effectiveness.
2) **Hypotheses Related to Relationships**
H_{04}: There is no significant relationship between PCK and self-efficacy.
H_{14}: There is a significant positive relationship between PCK and self-efficacy.
H_{05}: There is no significant relationship between PCK and teaching effectiveness.
H_{15}: There is a significant positive relationship between PCK and teaching effectiveness.
H_{06}: There is no significant relationship between self-efficacy and teaching effectiveness.
H_{16}: There is a significant positive relationship between self-efficacy and teaching effectiveness.
3) **Hypotheses Related to Prediction**
H_{07}: PCK does not significantly predict self-efficacy.
H_{17}: PCK significantly predicts self-efficacy.
H_{08}: PCK does not significantly predict teaching effectiveness.

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H_{18}: PCK significantly predicts teaching effectiveness.

4) **Hypothesis Related to Mediation**
   H_{09}: Self-efficacy does not mediate the relationship between PCK and teaching effectiveness.
   H_{19}: Self-efficacy mediates the relationship between PCK and teaching effectiveness.

Research Methodology

1. **Research Design:** The present study adopts a **mixed-method research design**, specifically the **convergent parallel design**, to examine the impact of Pedagogical Content Knowledge (PCK) on teacher self-efficacy and teaching effectiveness in physics. In this design, both quantitative and qualitative data are collected simultaneously, analyzed separately, and then integrated to provide a comprehensive understanding of the research problem. The quantitative component focuses on measuring relationships among variables using statistical techniques, while the qualitative component explores teachers' experiences, perceptions, and classroom practices. The integration of both approaches enhances the validity and depth of the findings.
2. **Population of the Study:** The population of the study consists of all secondary school physics teachers working in recognized schools. These include both government and private institutions. The population is considered appropriate because:
   - Secondary level is critical for conceptual understanding in physics
   - Teachers at this level deal with complex and abstract concepts
   - Instructional practices significantly influence student learning outcomes
3. **Sample and Sampling Technique:** A sample of **120 secondary school physics teachers** was selected for the study.
   Sampling Technique: Stratified Random Sampling was used
   Teachers were categorized based on:
   - Type of school (government/private)
   - Teaching experience
   - Gender

   From each category, participants were selected randomly to ensure representation and reduce bias.
   Justification of Sample Size:

- Adequate for statistical analysis (correlation, regression)
- Ensures reliability and generalizability of results

4. **Variables of the Study:** The study includes the following variables:
   A. **Independent Variable:** Pedagogical Content Knowledge (PCK)
   B. **Dependent Variable:** Teaching Effectiveness
   C. **Mediating Variable:** Teacher Self-Efficacy
5. **Tools and Instruments:** The following standardized and self-developed tools were used for data collection:
   5.1.Pedagogical Content Knowledge (PCK) Scale:
   - Developed by the researcher
   - Consists of items related to: Concept explanation, Use of teaching strategies & Handling misconceptions

- Likert scale format (5-point)

Reliability: Cronbach's Alpha = 0.86

Validity: Content validity ensured through expert review

5.2.Teacher Self-Efficacy Scale (TSES)

- Adapted from standard scale
- Measures: Classroom management, Instructional strategies & Student engagement

Reliability: α = 0.89

5.3. Teaching Effectiveness Scale:

- Measures actual teaching performance
- Includes:
  - Clarity of teaching
  - Student interaction
  - Use of teaching aids
  - Evaluation methods

Reliability: α = 0.84

5.4.Interview Schedule (Qualitative Tool)

- Semi-structured format
- Questions focused on:
  - Teaching experiences
  - Challenges in physics teaching
  - Strategies used in classrooms

6. **Data Collection Procedure:** The data collection was carried out in the following steps:
   a. Permission was obtained from school authorities
   b. Teachers were informed about the purpose of the study
   c. Consent was obtained from participants
   d. Questionnaires were distributed and collected
   e. Classroom observations were conducted
   f. Interviews were taken for qualitative insights

   Ethical considerations such as confidentiality, anonymity, and voluntary participation were strictly maintained.

7. **Data Analysis Techniques:**
   Quantitative Analysis:
   - Mean and Standard Deviation (to measure levels)
   - Pearson Correlation (to examine relationships)

- Regression Analysis (to study predictive effects)
- Mediation Analysis (to examine indirect effects)

Qualitative Analysis:

- Thematic Analysis
- Coding of responses
- Identification of patterns and themes

8. **Reliability and Validity of the Study:**

Reliability:

- Internal consistency measured using Cronbach's Alpha
- All tools showed high reliability (> 0.80)

Validity:

- Content validity ensured through expert consultation
- Construct validity maintained through theoretical framework

9. **Ethical Considerations**
- Participation was voluntary
- Confidentiality of data was maintained
- No personal information was disclosed
- Data used only for academic purposes

Data Analysis and Interpretation: This section presents the analysis of quantitative data collected from 120 secondary school physics teachers. Statistical techniques such as descriptive statistics, correlation, regression, and mediation analysis have been used to examine the relationships among Pedagogical Content Knowledge (PCK), teacher self-efficacy, and teaching effectiveness.

1. **Descriptive Statistics:** Descriptive statistics were computed to determine the levels of PCK, self-efficacy, and teaching effectiveness among physics teachers.

Table 1: Descriptive Statistics

Variable	N	Mean	SD	Interpretation
PCK	120	78.5	8.2	High
Self-efficiency	120	82.3	7.5	High
Teaching Effectiveness	120	80.1	6.9	High

Interpretation: The mean scores indicate that physics teachers demonstrate a relatively high level of Pedagogical Content Knowledge (M = 78.5), teacher self-efficacy (M = 82.3), and teaching effectiveness (M = 80.1). The standard deviation values are moderate, indicating that the data are fairly consistent with limited variability. This suggests that most teachers possess adequate knowledge, confidence, and teaching competence.

Correlation Analysis: Pearson's Correlation Coefficient was calculated to examine the relationships among the variables.

Table 2: Correlation Matrix

Variable	PCK	Self-efficiency	Teaching Effectiveness
PCK	1.00	0.68**	0.72**
Self-efficiency	0.68**	1.00	0.65**
Teaching Effectiveness	0.72**	0.65**	1.00

(**$p < 0.01$)

Interpretation:

- The correlation between PCK and self-efficacy ($r = 0.68$) is strong and positive.
- The correlation between PCK and teaching effectiveness ($r = 0.72$) is very strong and positive.
- The correlation between self-efficacy and teaching effectiveness ($r = 0.65$) is also strong and positive.

These results indicate that:

- Teachers with higher PCK tend to have higher confidence
- Teachers with higher PCK are more effective in teaching
- Teachers with higher self-efficacy demonstrate better teaching performance

Thus, all relationships are statistically significant at the 0.01 level.

2. Regression Analysis

Regression analysis was conducted to determine the predictive power of PCK on self-efficacy and teaching effectiveness.

3. Regression of PCK on Self-Efficacy

Table 6.3: Regression Results (PCK → Self-Efficacy)

Model	R	R^2	β	t-value	p-value
PCK	0.68	0.46	0.65	0.95	<0.01

Interpretation:

- The R^2 value (0.46) indicates that **46% of the variance in self-efficacy** is explained by PCK.
- The beta coefficient ($\beta = 0.65$) shows a strong positive effect.
- The result is statistically significant ($p < 0.01$).

This indicates that PCK is a strong predictor of teacher self-efficacy.

4. Regression of PCK on Teaching Effectiveness

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Table 6.4: Regression Results (PCK → Teaching Effectiveness)

Model	R	R^2	β	t-value	p-value
PCK	0.72	0.52	0.70	10.92	<0.01

Interpretation:

- The R^2 value (0.52) indicates that **52% of the variance in teaching effectiveness** is explained by PCK.
- The beta value ($\beta = 0.70$) indicates a strong impact.
- The result is highly significant ($p < 0.01$).

This shows that PCK is a powerful predictor of teaching effectiveness.

5. **Mediation Analysis:** Mediation analysis was conducted to examine whether teacher self-efficacy mediates the relationship between PCK and teaching effectiveness.

Table 6.5: Mediation Analysis

Path	Beta (β)	Significance
PCK → Self-Efficacy	**0.65**	**Significant**
Self-Efficacy → Teaching Effectiveness	0.40	Significant
PCK → Teaching Effectiveness (Direct)	0.70	Significant
PCK → Teaching Effectiveness (Indirect)	0.26	Significant

Interpretation: The results indicate that:

- **PCK significantly influences self-efficacy**
- **Self-efficacy significantly influences teaching effectiveness**
- **PCK has both direct and indirect effects on teaching effectiveness**

Since both direct and indirect effects are significant, partial mediation is confirmed.

This means:

- **PCK improves teaching effectiveness directly**
- **PCK also improves self-efficacy, which further enhances teaching effectiveness**

Qualitative Data Analysis and Interpretation: The qualitative component of the study was conducted to complement and enrich the quantitative findings by exploring teachers' lived experiences, perceptions, and classroom practices related to Pedagogical Content Knowledge (PCK), self-efficacy, and teaching effectiveness in physics. Data were collected through **semi-structured interviews and classroom observations** of selected participants. The data were analyzed using **thematic analysis**, which involved coding responses, identifying patterns, and developing key themes.

A. **Procedure of Qualitative Analysis:** The qualitative analysis followed a systematic process:

- **Transcription** of interview responses,
- **Open coding** to identify meaningful units of data
- **Categorization** of codes into themes
- **Theme development and interpretation**
- **Validation** through cross-checking responses

This process ensured that the findings were reliable, valid, and grounded in participants' experiences.

B. **Major Themes Identified:** Based on the analysis, four major themes emerged:

Theme 1: Conceptual Clarity and Subject Understanding: Teachers with strong Pedagogical Content Knowledge demonstrated a deeper understanding of physics concepts and were able to explain them clearly.

Illustrative Responses: "When I understand the concept thoroughly, I can explain it in multiple ways." "Students understand better when I simplify concepts using real-life examples."

Interpretation: This theme highlights that PCK enables teachers to transform complex and abstract physics concepts into understandable forms. Conceptual clarity not only improves teaching effectiveness but also enhances teacher confidence.

Theme 2: Use of Instructional Strategies: Teachers reported using a variety of teaching methods to make learning more engaging and effective.

Common Strategies Identified:

- Use of analogies and models
- Demonstrations and experiments
- Visual aids and simulations
- Problem-solving activities

Illustrative Responses: "I use experiments to explain difficult topics like electricity."
"Analogies help students relate physics concepts to daily life."

Interpretation: The use of diverse instructional strategies reflects strong PCK. Teachers who adapt their methods according to content and student needs are more effective in facilitating learning.

Theme 3: Student Engagement and Classroom Interaction: Teachers emphasized the importance of engaging students actively in the learning process.

Observations:

- Students asked questions
- Participation in discussions
- Increased interest during demonstrations

Illustrative Responses: "Students become more interested when I involve them in experiments." "Interactive teaching increases their understanding.

Interpretation: Student engagement is a key indicator of teaching effectiveness. Teachers with high self-efficacy are more confident in managing interactive classrooms, leading to better learning outcomes.

Theme 4: Adaptive Teaching and Reflective Practice: Teachers demonstrated flexibility in modifying their teaching strategies based on student understanding.

Illustrative Responses: "If students don't understand, I change my method."
"I reflect on my teaching and improve it regularly."

Interpretation: This theme reflects the dynamic nature of PCK and highlights the role of self-efficacy in encouraging reflective teaching practices. Teachers who adapt their methods are more effective in addressing diverse learning needs.

Integration with Quantitative Findings: The qualitative findings strongly support the quantitative results:

Results and Discussion: This section integrates and interprets the findings obtained from both quantitative and qualitative analyses. The results are discussed in relation to the objectives of the study, hypotheses, and existing literature to provide a comprehensive understanding of the impact of Pedagogical Content Knowledge (PCK) on teacher self-efficacy and teaching effectiveness in physics.

1. **Discussion of Descriptive Findings:** The descriptive analysis revealed that physics teachers possess relatively high levels of Pedagogical Content Knowledge (PCK), self-efficacy, and teaching effectiveness. This indicates that:

   - Teachers have a reasonable understanding of how to teach physics concepts effectively
   - Teachers feel confident in their teaching abilities
   - Teaching practices are generally effective in classroom settings

   These findings suggest that the sampled teachers are adequately prepared to handle the challenges of physics teaching. However, the presence of moderate variability indicates that there is still scope for improvement among some teachers.

2. **Discussion of Relationship between PCK and Self-Efficacy:** The correlation analysis revealed a strong positive relationship between PCK and teacher self-efficacy ($r = 0.68$). This finding indicates that teachers with higher levels of PCK tend to exhibit greater confidence in their teaching abilities. This relationship can be explained by the fact that:

   - Teachers who understand content deeply feel more secure while teaching
   - Knowledge of effective teaching strategies enhances confidence
   - Successful teaching experiences reinforce self-belief

   This finding is consistent with the theoretical framework of **Albert Bandura (1997)**, who emphasized that mastery experiences are a key source of self-efficacy. It also aligns with previous studies that highlight the role of professional knowledge in shaping teacher confidence.

3. **Discussion of Relationship between PCK and Teaching Effectiveness:** The study found a very strong positive relationship between PCK and teaching effectiveness ($r = 0.72$). This indicates that teachers with strong PCK are more effective in facilitating student learning. This can be attributed to the following factors:

   - Ability to simplify complex concepts
   - Use of appropriate instructional strategies
   - Effective handling of student misconceptions
   - Integration of theory with real-life applications

These findings support the views of **Lee Shulman (1986)**, who argued that PCK is essential for effective teaching. The results also align with empirical studies suggesting that PCK significantly contributes to improved instructional quality and student outcomes.

4. **Discussion of Relationship between Self-Efficacy and Teaching Effectiveness:** A strong positive relationship was observed between teacher self-efficacy and teaching effectiveness ($r = 0.65$). This suggests that teachers who believe in their abilities tend to perform better in classroom settings.
   Teachers with high self-efficacy:
   - **A.** Are more confident in managing classrooms
   - **B.** Use innovative teaching methods
   - **C.** Encourage student participation
   - **D.** Persist in challenging situations

This finding is consistent with previous research indicating that self-efficacy is a critical determinant of teaching performance.

5. **Discussion of Predictive Role of PCK:** Regression analysis revealed that PCK significantly predicts both self-efficacy ($\beta = 0.65$) and teaching effectiveness ($\beta = 0.70$).
   This implies that:
   a. Improvements in PCK can lead to increased teacher confidence
   b. Enhanced PCK directly contributes to better teaching performance

The high R^2 values (0.46 and 0.52) indicate that a substantial proportion of variance in self-efficacy and teaching effectiveness is explained by PCK. These findings highlight the importance of focusing on PCK development in teacher training programs.

6. **Discussion of Mediation Effect of Self-Efficacy:** The mediation analysis confirmed that self-efficacy partially mediates the relationship between PCK and teaching effectiveness.
   This means that:

- PCK influences teaching effectiveness directly
- PCK also influences self-efficacy, which in turn enhances teaching effectiveness

Thus, self-efficacy acts as a psychological mechanism through which PCK impacts teaching performance. This finding provides deeper insight into the teaching-learning process by explaining how knowledge translates into effective practice.

7. **Integration of Quantitative and Qualitative Findings:** The integration of findings reveals a strong alignment between quantitative results and qualitative insights.

- Quantitative data showed strong relationships among variables
- Qualitative data provided evidence of how these relationships operate in real classrooms

For example:

- Teachers with high PCK reported greater confidence (self-efficacy)
- Classroom observations confirmed effective teaching practices
- Teachers described using adaptive strategies, which aligns with high teaching effectiveness

This triangulation enhances the validity and reliability of the study.

8. **Comparison with Previous Studies:** The findings of the present study are consistent with previous research: Supports **Shulman's (1986)** concept of PCK as a core component of teaching:

- Aligns with **Bandura's (1997)** theory of self-efficacy
- Confirms findings of studies linking teacher knowledge with instructional effectiveness

However, the present study extends existing research by:

- Integrating PCK, self-efficacy, and teaching effectiveness
- Using a mixed-method approach
- Focusing specifically on physics education

9. **Implications of the Findings**: The findings of the study have significant implications:
   For Teacher Education:
   1. Emphasis on developing PCK
   2. Integration of theory and practice

   For Classroom Practice:

- Use of innovative teaching strategies
- Focus on student-centered learning

   For Policy Makers:

- Need for professional development programs
- Inclusion of PCK-based training modules

10. **Summary of Results and Discussion:** The study clearly demonstrates that:

- PCK is a strong predictor of both self-efficacy and teaching effectiveness
- Self-efficacy enhances teaching performance
- Both cognitive and psychological factors contribute to effective teaching

Conclusion: The present study aimed to examine the impact of Pedagogical Content Knowledge (PCK) on teacher self-efficacy and teaching effectiveness in physics through a mixed-method approach. The findings provide substantial evidence that effective teaching is not merely a function of subject knowledge but a result of the integration of content expertise, pedagogical skills, and psychological confidence. The study revealed that physics teachers generally possess a high level of PCK, self-efficacy, and teaching effectiveness. More importantly, strong positive relationships were found among these variables. PCK emerged as a significant predictor of both teacher self-efficacy and teaching effectiveness, indicating its central role in shaping instructional quality. The mediation analysis further demonstrated that self-efficacy acts as a partial mediator between PCK and teaching effectiveness. This finding highlights that while PCK directly enhances teaching performance, it also indirectly contributes by strengthening teachers' confidence. Thus, effective teaching is the outcome of both cognitive competence and psychological readiness. The qualitative findings supported the quantitative results by providing deeper insights into classroom practices. Teachers with strong PCK demonstrated better conceptual clarity, used diverse instructional strategies, engaged students actively, and adapted their teaching methods based on learner needs. These practices contributed significantly to effective teaching. Overall, the study confirms that strengthening PCK is essential for improving both teacher confidence and teaching effectiveness in physics education. It emphasizes that teacher development programs should focus not only on content knowledge but also on pedagogical skills and self-belief.

Educational Implications and Recommendations: The findings of the study have important implications for teacher education, classroom practices, and educational policy.

1. **Implications for Teacher Education**: Teacher education programs should place greater emphasis on the development of Pedagogical Content Knowledge.
   Training programs should integrate subject knowledge with teaching methods
   Pre-service teachers should be exposed to real classroom situations
   Emphasis should be placed on handling student misconceptions
   Developing PCK during teacher training will prepare teachers to handle complex classroom situations effectively.
2. **Implications for Professional Development**: In-service training programs should focus on continuous professional development.
   - Workshops on innovative teaching strategies
   - Training on the use of experiments and technology in physics teaching
   - Programs to enhance teacher self-efficacy

   Regular professional development will help teachers update their knowledge and improve their teaching practices.

3. **Implications for Classroom Practices**: Teachers should adopt student-centered and activity-based teaching methods.
   Use of demonstrations and experiments
   Encouraging student participation
   Use of real-life examples to explain concepts
   Such practices will enhance student engagement and improve learning outcomes.
4. **Implications for Curriculum Design**: Curriculum developers should incorporate elements that promote PCK.

- Inclusion of practical activities
- Emphasis on conceptual understanding
- Integration of theory with real-life applications

A well-designed curriculum can support effective teaching and learning.

5. **Implications for Educational Policy:** Policy makers should recognize the importance of teacher quality in improving education.
   - **A.** Investment in teacher training programs
   - **B.** Development of assessment systems for teaching effectiveness
   - **C.** Encouragement of research in teaching practices

Policies focusing on teacher development will lead to long-term improvement in education.

Limitations of the Study:

Despite its contributions, the study has certain limitations:

- The sample size was limited to 120 teachers
- The study focused only on physics teachers
- Data were collected from a specific region

These limitations may affect the generalizability of the findings.

Suggestions for Further Research:

Future research can expand the scope of the study in the following ways:

- Conduct studies with larger and more diverse samples
- Compare results across different subjects
- Use experimental designs to establish causality
- Explore additional variables such as teacher motivation and student achievement

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