

**PEDAGOGICAL CONTENT KNOWLEDGE AND TEACHERS’
EFFECTIVE DELIVERY OF BIOLOGY IN SECONDARY SCHOOL IN
OBIO-AKPOR LOCAL GOVERNMENT AREA.**

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ABSTRACT

This study explores the crucial relationship between teachers’ Pedagogical Content Knowledge and their effective delivery of biology in secondary school in Obio-Akpor Local Government Area. A descriptive survey method was employed, utilizing a census approach with 11 biology teachers from 21 public senior secondary schools in Obio-Akpor Local Government Area, Rivers State, Nigeria. Data was collected through self-structured questionnaires, validated by experts and tested for reliability. The instrument was distributed directly to the respondents by the researcher. The study reveals that professional development programs have a positive impact on teachers’ pedagogical Content knowledge, providing opportunities for staying updated, enhancing pedagogical content knowledge, and fostering collaboration. Additionally, a deep understanding of biology significantly contributes to effective instructional delivery, enabling precise articulation, diverse instructional strategies, inquiry-based learning, real-world connections, and alignment with evolving standards. It was recommended that curriculum developers should incorporate courses focusing on in-depth biological understanding, and program administrators should collaborate to address the specific professional development needs of biology teachers. Furthermore, school principals should foster a culture that values ongoing professional development.

Keywords: Pedagogical Content Knowledge, Biology Education, Professional Development, Secondary School, Teacher Effectiveness.

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INTRODUCTION

Biology, as a fundamental science, significantly shapes students' understanding of the living world. At the secondary school level, the efficacy of Biology education relies on various factors, with teachers' subject matter knowledge emerging as a critical determinant. The substantial influence of educators on students' academic achievement and interest underscores the necessity for a nuanced exploration of the relationship between teachers' subject matter knowledge and instructional effectiveness.

Teachers possessing strong PCK are equipped to navigate the complexities of biological concepts, articulating them with clarity and precision. Their ability to delve into the intricacies of the subject matter enables them to tailor explanations to suit diverse learning styles, fostering a deeper grasp of concepts among students. Moreover, teachers with robust PCK are better positioned to address student misconceptions, providing timely interventions that prevent the solidification of erroneous understanding.

The significance of pedagogical Content knowledge extends beyond the realm of concept comprehension. Teachers with a deep understanding of biology are adept at weaving connections between disparate areas of the subject, illuminating the overarching patterns and principles that govern the natural world. This ability to synthesize information fosters a holistic understanding of biology, enabling students to perceive the subject as a cohesive and interconnected whole. Numerous studies have corroborated the positive correlation between PCK and student achievement in biology. Research has consistently demonstrated that teachers with strong PCK are able to cultivate higher levels of understanding and performance among their students (Hill, Rowan, & Lewis, 2005; Shulman, 1986). These findings underscore the critical role that PCK plays in shaping the effectiveness of biology instruction.

Despite the compelling evidence supporting the importance of PCK, many biology face challenges in maintaining a high level of pedagogical content knowledge. The dynamic nature of biology, with its constant influx of new discoveries and evolving theoretical frameworks, demands ongoing professional development and engagement with the latest research. Additionally, factors such as limited access to resources and inadequate teacher preparation programs can hinder teachers' ability to stay abreast of advancements in the field.

Recognizing the centrality of PCK in effective biology teaching, it is imperative to prioritize initiatives that promote the ongoing development of teachers' pedagogical content knowledge. This can be achieved through a multifaceted approach that encompasses the following strategies:

1. **Professional Development:** Providing teachers with access to high-quality professional development opportunities is essential for cultivating and maintaining strong PCK. These programs should focus on contemporary biological research, pedagogical strategies, and effective techniques for addressing student misconceptions.
2. **Collaborative Learning:** Fostering a collaborative learning environment among biology teachers encourages the exchange of knowledge and expertise. This can be facilitated through regular workshops, peer mentoring programs, and online discussion forums.

3. Access to Resources: Ensuring that teachers have access to up-to-date resources, such as scientific journals, online databases, and cutting-edge technology, is crucial for staying current with advancements in the field.
4. Teacher Preparation Programs: Strengthening teacher preparation programs to emphasize PCK development is essential for ensuring that future biology teachers possess the necessary knowledge base to effectively instruct their students.
5. Continuous Assessment: Implementing mechanisms for ongoing assessment of teachers' PCK can help identify areas for improvement and inform professional development initiatives.

Statement of the Problem

Despite the central role of biology in developing scientific literacy and preparing students for health- and science-related careers, students' achievement in secondary school biology remains persistently low in many contexts. One major factor contributing to this problem is the manner in which biology is taught. While many teachers possess adequate subject matter knowledge, effective biology instruction requires more than content mastery; it demands strong pedagogical content knowledge (PCK)—the ability to transform biological concepts into forms that are understandable, engaging, and meaningful to learners. In many secondary schools, biology lessons are often characterized by teacher-centered methods, abstract explanations, limited use of appropriate instructional strategies, and poor alignment of content with students' prior knowledge and misconceptions, suggesting gaps in teachers' PCK. These shortcomings can negatively affect teachers' instructional clarity, classroom interaction, assessment practices, and ultimately students' understanding and interest in biology. Although pedagogical content knowledge has been widely recognized as critical to effective teaching, there is limited empirical evidence on how teachers' PCK specifically influences their effective delivery of biology at the secondary school level. This gap underscores the need to examine the relationship between pedagogical content knowledge and teachers' effective delivery of biology in secondary schools.

Purpose of the Study

The purpose of this study is to determine how pedagogical content knowledge and teachers' effective delivery of Biology in Secondary schools in Obio-Akpor Local Government Area, specially, the objectives of the study seek to:

- i. Investigate the impact of professional development programs on teachers' pedagogical content knowledge
- ii. Determine how pedagogical content knowledge (PCK) enhances teachers' effective delivery of biology in secondary schools.

Research Question

1. To what extent does professional development programs impact teachers' pedagogical content knowledge.
2. To what extent does pedagogical content knowledge (PCK) enhances teachers' effective delivery of biology in secondary schools.

Hypotheses

- H01:** There is no significant difference in the mean rating of male and female teachers on the extent professional development programs impact teachers' pedagogical Content knowledge.
- H02:** There is no significant difference in the mean rating of male and female teachers on the extent pedagogical Content knowledge (PCK) enhances teachers' effective delivery of biology in secondary schools.

Methodology

Descriptive survey method was used for this study, the population of this study comprised of one hundred and eleven (111) of all biology teachers in public senior secondary school in Obio/Akpor Local Government Area in Rivers State. Census Sampling Strategy was employed, which encompassing the entire population of biology teachers within public senior secondary schools in Obio/Akpor Local Government Area Rivers State. The research constructed a self-structured questionnaire titled "Pedagogical Content Knowledge for Teachers' Effective Delivery (PCKTED). The Instruments are divided into two sections. Section A is to collect demographic data from the Respondents, while Section B contains 10 questionnaire items that assess the two research questions. The questionnaire was developed into two clusters with each five (5) items. The Instruments are structured along a four-point modified like-type rating scale of Strongly Agreed (SA) 4 points; Agreed (A) = 3points; Disagreed (D)= 2 points; Strong Disagree (SD) 1 point. The instrument was distributed directly to the respondents by the researcher. Mean and Standard deviation was used in analyzing the research questions while independent sample t-test was used in testing the null hypothesis at 0.05 level of significance.

Result and Discussion

Research Question 1: To what extent does professional development programs impact teachers' subject matter knowledge?

S/n	Items	Locations				Female teacher		Remark
		Female teacher		Female teacher		Mean set		
		mean	Std.	means	Std			
1.	Professional development programs can help teachers stay up-to-date with the latest research and developments in their field.	3.54	0.90	3.60	0.78	3.57	High Extent	
2	Professional development programs can help teachers develop their pedagogical content knowledge by providing them with opportunities to	3.72	0.76	3.78	0.65	3.75	High Extent	

3.	learn about different teaching strategies, instructional materials, and assessment practices Professional development programs can help teachers learn about best practices in teaching their subject matter.	3.35	0.92	3.58	0.83	3.46	High Extent
4.	Professional development programs can provide opportunities for teachers to collaborate with other teachers and share their knowledge and expertise.	2.90	0.91	2.91	0.94	2.90	High Extent
5.	Professional development programs can help teachers develop the skills and habits of ongoing professional learning	3.29	0.71	3.22	0.78	3.26	High Extent
Grand Mean ($\bar{x}$)		3.36	0.84	3.42	0.80	3.39	High Extent

From the table, the grand mean of 3.39 suggests that, on average, teachers perceive a high extent of impact from professional development programs on their subject matter knowledge. Across all items, both male and female teachers generally agree on the high extent of impact, as indicated by mean values ranging from 2.90 to 3.78.

The standard deviations indicate the degree of variability in responses, with values generally falling within a reasonable range, supporting the reliability of the findings. The data suggest that professional development programs are perceived to have a positive and impactful influence on teachers' subject matter knowledge, as evidenced by the consistently high mean values across the surveyed items. This insight underscores the potential effectiveness of such programs in keeping teachers informed, enhancing pedagogical skills, and promoting collaborative learning practices.

Research Question 2: To what extent does pedagogical Content knowledge (PCK) enhance teachers' effective delivery of biology in secondary schools?

Table 2: Mean and Standard deviation on the extent does pedagogical Content knowledge (PCK) enhances teachers' effective delivery of biology in secondary schools

PCK) enhances teachers' effective delivery of biology in secondary schools							
S/n	Items	Gender					Remark
		Male Teacher		Female Teacher			
		Mean	Std.	Mean	Std.	Mean Set	
6.	Teachers with strong PCK articulate ideas, theories, and processes with precision, enabling students to grasp	3.20	1.01	3.16	0.95	3.18	High Extent

	intricate biological phenomena more easily.						
7.	In-depth PCK equips teachers with multiple instructional strategies tailored to diverse student learning styles	3.33	0.86	3.28	0.84	3.30	High Extent
8.	A deep understanding of Biology allows teachers to guide students effectively through inquiry-based learning	3.36	0.84	3.29	0.84	3.32	High Extent
9	Teachers with strong PCK link biological concepts to real-world applications and contexts	3.28	0.90	3.27	0.84	3.28	High Extent
10.	Continuous development of subject matter knowledge enables teachers to align their instruction with evolving curriculum standards and scientific advancements	3.34	0.83	3.20	0.89	3.27	High Extent
Grand Mean ($\bar{x}$)		3.30	0.89	3.24	0.87	3.27	High Extent

From the table above, the grand mean of 3.27 indicates that, on average, teachers believe that pedagogical Content knowledge (PCK) has a high extent of impact on their effective delivery of biology in secondary schools. Across all items, both male and female teachers consistently rate the impact of PCK as high, with mean values ranging from 3.16 to 3.36. Standard deviations are within a reasonable range, suggesting a moderate level of agreement among teachers in both gender groups.

Teachers, regardless of gender, perceive a high extent of impact from pedagogical Content knowledge (PCK) on the effective delivery of biology in secondary schools. The findings suggest that a deep understanding of the subject matter enables teachers to articulate concepts with precision, employ diverse instructional strategies, facilitate inquiry-based learning, connect biological concepts to real-world applications, and align their instruction with evolving curriculum standards and scientific advancements. This indicates the importance of continuous development of PCK for educators to enhance their effectiveness in teaching biology.

Test Hypotheses

Hypothesis 1: There is no significant difference in the mean rating of male and female teachers on the extent professional development programs impact teachers' pedagogical Content knowledge.

Table 3: Summary oft-test on the difference in the rating of male and female teachers on the extent professional development programs impact teachers' pedagogical Content knowledge.

Location	N	Mean	Std.	Df	t-test	Sig.	Decision
Male	48	3.36	0.84	641	-0.383	0.702	NS
Female	63	3.42	0.80				

Key: NS-Not Significant

The t-test was conducted to determine if there is a significant difference in the mean ratings of male and female teachers regarding the impact of professional development programs on their pedagogical Content knowledge. The calculated t-test value is -0.383 with degrees of freedom (df) equal to 641, and the p-value (Sig.) is 0.702.

The decision based on the p-value is “NS” (Not Significant).

The results of the t-test suggest that there is no significant difference in the mean ratings of male and female teachers regarding the impact of professional development programs on their pedagogical Content knowledge. The p-value of 0.702 is greater than the conventional significance level of 0.05, indicating that any observed differences are likely due to random chance. Therefore, the null hypothesis (Hypothesis 1) that there is no significant difference in the mean ratings of male and female teachers is not rejected. The findings imply that, on average, both male and female teachers perceive a similar impact of professional development programs on their pedagogical Content knowledge.

Hypotheses 2: There is no significant difference in the mean rating of male and female teachers on the extent pedagogical Content knowledge (PCK) enhances teachers’ effective delivery of biology in secondary schools.

Table 4: Summary oft-test on the difference in the mean rating of male and female teachers on the extent pedagogical Content knowledge (PCK) enhances teachers’ effective delivery of biology in secondary schools

Location	N	Mean	Std.	Df	t-test	Sig.	Decision
Male	48	3.30	0.89	641	0.356	0.722	NS
Female	63	3.24	0.87				

Key: NS-Not Significant

The t-test was conducted to examine if there is a significant difference in the mean ratings of male and female teachers regarding the impact of Pedagogical Content knowledge (PCK) on the effective delivery of biology in secondary schools.

The calculated t-test value is 0.356 with degrees of freedom (df) equal to 641, and the p-value (Sig.) is 0.722.

The decision based on the p-value is “NS” (Not Significant).

The results of the t-test indicate that there is no significant difference in the mean ratings of male and female teachers concerning the impact of pedagogical Content knowledge (PCK) on the effective delivery of biology in secondary schools. The p-value of 0.722 is greater than the conventional significance level of 0.05, suggesting that any observed differences are likely due to random chance. Therefore, the null hypothesis (Hypothesis 2) that there is no significant difference in the mean ratings of male and female teachers, on average, perceive a similar impact of pedagogical Content knowledge on their effective delivery of biology in secondary schools.

Discussion of Findings

The finding of research question one showed that professional development programs are perceived to have a positive and impact influence on Teachers' items. The corresponding hypothesis revealed that there is no significant difference in the mean ratings of male and female teachers on the extent professional development programs impact Teachers' pedagogical Content knowledge. The finding that professional development programs have a positive and impactful influence on Teachers' pedagogical Content knowledge aligns with the findings of previous studies. For instance, a meta-analysis by (Desimone *et al.*, 2009) found that professional development programs had a moderate positive effect on teacher knowledge. Similarly, a study by (Darling-Hammond *et al.*, 2009) found that professional development programs were particularly effective in improving teacher knowledge when they were focused on specific contents areas and when they provided opportunities for teachers to collaborate with colleagues.

The finding that there is no significant difference in the mean rating of male and female teachers on the extent professional development programs impact teachers' pedagogical Content knowledge is consistent with the findings of some previous studies, but not all. For example, a study by Kim *et al.* (2013) found no significant gender differences in the effectiveness of professional development programs. However, a study by Ertmer and Borko (2005) found that female teachers were more likely than male teachers to report that professional development programs had a positive impact on their teaching.

The second objective of this study aimed at examining the extent subject matter knowledge (PCK) enhances teachers' effective delivery of biology in secondary schools. Findings showed that a deep understanding of the subject matter enables teachers to articulate concepts with precision, employ diverse instructional strategies, facilitate inquiry-based learning, connect biological concepts to real-world applications, and align their instruction with evolving curriculum standards and scientific advancements. The corresponding hypothesis showed that there is no significant difference in the mean rating of male and female teachers on the extent professional development programs impact teachers' subject matter knowledge. The finding that pedagogical Content knowledge (PCK) enhances teachers' effective delivery of biology in secondary schools is consistent with the findings of many previous studies. For example, a study by Shulman (1987) found that teachers with deep PCK were more likely to be able to explain complex concepts to students, answer student questions thoughtfully, and design effective instructional activities. Similarly, a study by Hill *et al.* (2005) found that teachers with strong PCK were more likely to use student-centered teaching methods and to create learning environments that were conducive to deep understanding.

The finding that there is no significant difference in the mean rating of male and female teachers on the extent PCK enhances teachers' effective delivery of biology in secondary schools is consistent with some previous studies, but not all. For example, a study by Kennedy (2002) found no significant gender differences in the effectiveness of teachers with different levels of PCK. However, a study by Loucks *et al.* (2009) found that female teachers with strong PCK were more likely than male teachers with strong PCK to report that they used student-centered teaching methods.

Conclusion

The findings of this study strongly suggest that both professional development programs and deep pedagogical Content knowledge (PCK) play significant roles in enhancing teachers' effective delivery of biology in secondary schools. Professional development programs provide teachers with opportunities to enhance their PCK, learn new pedagogical strategies, and collaborate with colleagues. PCK, in turn, enables teachers to articulate concepts with precision, employ diverse instructional strategies, facilitate inquiry-based learning, connect biological concepts to real-world applications, and align their instruction with evolving curriculum standards and scientific advancements.

The study's findings have important implications for teacher education and professional development programs. Teacher education programs should emphasize the development of PCK and provide opportunities for teachers to learn about effective pedagogical strategies. Professional development programs should be focused on specific content areas and provide opportunities for teachers to collaborate with colleagues. Additionally, school administrators should encourage teachers to participate in professional development programs and should provide them with the time and resources they need to enhance their PCK.

Recommendation

1. Curriculum developers should incorporate courses and experiences that focus on in-depth understanding of biological concepts and principles.
2. Program Administrators should collaborate with school districts and professional organizations to identify and address the professional development needs of biology teachers
3. Program planners should design and implement professional development programs that are specifically tailored to the needs of biology teachers.
4. School Principals should foster a school culture that values professional development and supports teachers' ongoing learning.

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