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# IMPACT OF PEDAGOGICAL CONTENT KNOWLEDGE OF CHEMISTRY TEACHERS ON THEIR CLASSROOM PRACTICES

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## ABSTRACT

Pedagogical content knowledge of chemistry teachers is paramount so as to facilitate the conversion of content knowledge into teacher content knowledge so that long and complex concepts common in chemistry classes can be understood easily by students. These practices dovetail well with strong classroom practice, which provides an effective learning environment that helps students to understand such knowledge and, therefore, achieve improved results. The objectives of the present study were to: Determine the relationship and effect of pedagogical content knowledge of chemistry teachers on their classroom practices at the secondary level; and To analyse the difference between male and female teachers concerning the pedagogical content knowledge of chemistry teachers and their classroom practices at the secondary level. In this current study, a quantitative survey research design was adopted and the philosophy of the study was positivism, which constitutes the paradigm of the quantitative research. Sample include all secondary schools in the Punjab province. The research instrument used in this study was an open self-constructed five-point Likert scale based on a questionnaire. Descriptive analysis and inferential analysis were conducted using the Statistical Package for Social Sciences (SPSS) through regression analysis, Pearson correlation and independent sample t-test. Analyzing the results of the study the following conclusions were made: The study postulated that there was highly significant relationship between pedagogical content knowledge of Chemistry teachers and their practice in the classroom at secondary level. The Pearson value 0.122 indicates that there is a weak positive significant relationship between pedagogical content knowledge of chemistry teachers and their classroom practices at the secondary level. The findings indicate that there was highly significant difference in the PC knowledge of chemistry teachers and their practices between male and female teachers at the secondary level.

**Keywords**: pedagogical content knowledge, chemistry teachers, classroom practices, secondary level

## Introduction

Pedagogical content knowledge (PCK) has emerged as a pivotal framework in understanding the effectiveness of teaching practices, especially in specialized concern regions like chemistry. Seeing that its creation by way of Shulman (1986), PCK has been extensively diagnosed as the amalgamation of issue-specific information and pedagogical competencies, enabling instructors to supply content in approaches that

are understandable and significant to newcomers. Inside the context of chemistry, a subject characterised with the aid of summary principles, complicated theories, and microscopic methods, instructors' PCK plays a crucial function in facilitating college students' expertise, engagement, and achievement (Jammeh, Karegeya, & Ladage, 2024). The precise nature of chemistry as a technology discipline calls for teachers to own not most effective a deep knowledge of the content material however also the capability to convert this content material into teachable forms that deal with college students' prior knowledge, misconceptions, and numerous getting to know desires (Magnusson, Krajcik, & Borko, 1999). Therefore, the pleasant of teachers' PCK has an immediate impact on school room practices, shaping instructional strategies, scholar interactions, and usual getting to know outcomes. Chemistry coaching involves the interplay between macroscopic observations, submicroscopic representations, and symbolic expressions, which can be frequently tough for college kids to attach and recognize (Taber, 2002; Gabel, 1999). Teachers with strong PCK are adept at bridging those representational stages, using effective instructional techniques including fashions, analogies, demonstrations, and hands-on experiments to foster students' conceptual understanding (Van Driel, Verloop, & De Vos, 1998).

As an instance, explaining the particulate nature of matter, balancing chemical equations, or decoding chemical reactions demands that teachers count on college students' misconceptions and strategically deal with them through carefully designed training and scaffold mastering activities (type, 2009). Without sturdy PCK, instructors can also conflict to perceive learning demanding situations or fail to make use of appropriate pedagogical gear, main too fragmented understanding and limited pupil progress (Rollnick et al., 2008).The importance of PCK in shaping chemistry teachers' study room practices has been drastically highlighted in both advanced and growing contexts. Research indicates that powerful instructors integrate their content material know-how and pedagogical strategies to create meaningful gaining knowledge of studies that resonate with students' cognitive and emotional needs (type & Chan, 2019). As an example, teachers who own a high stage of PCK can use real-global examples, experiments, and problem-based mastering to make abstract concepts tangible and relatable (Loughran, Berry, & Mulhall, 2006). This capacity is specifically essential in chemistry, wherein students regularly war with topics along with chemical bonding, thermodynamics, and equilibrium because of their abstract and theoretical nature (Nicoll, 2001). PCK permits instructors to simplify complex ideas without compromising scientific accuracy, thereby improving students' vital questioning and hassle-fixing capabilities. in spite of its importance, the development and utilization of PCK among chemistry instructors remain uneven, influenced with the aid of factors which includes teachers' educational backgrounds, professional training, coaching enjoy, and get admission to resources (Ouch, & Shimizu, 2024). Research have shown that beginner instructors frequently exhibit limited PCK due to inadequate publicity to concern-specific pedagogical tactics in the course of their pre-carrier training (Abell, 2008; Nilsson, 2008). Conversely, skilled instructors tend to expand richer PCK over time as they mirror on their teaching practices, interact in expert improvement, and

adapt their practise based totally on college students' getting to know desires (Park & Oliver, 2008). However, the connection between PCK and classroom practices is not linear; it requires non-stop mirrored image, experimentation, and refinement to align academic strategies with evolving curricular standards and scholar expectancies (Gess-Newsome, 2015). Consequently, expertise the ways in which chemistry instructors' PCK affects their study room practices is important for informing instructor training programs, professional development initiatives, and curriculum reforms (Sarkar, et al., 2024).

School room practices, as a reflection of teachers' PCK, encompass various dimensions, consisting of lesson making plans, educational strategies, assessment methods, and classroom interactions. Teachers with nicely-advanced PCK are much more likely to design training which might be pupil-focused, inquiry-based totally, and aligned with the gaining knowledge of dreams of chemistry schooling (Cochran, DeRuiter, & King, 1993). They're additionally adept at using formative and summative exams to diagnose students' know-how, provide feedback, and modify their coaching techniques therefore (Shulman, 1987). For example, in coaching stoichiometry, teachers with sturdy PCK may employ diagnostic tests to perceive college students' misconceptions approximately the mole concept and eventually layout sports that sell conceptual clarity through hands-on experimentation and visual representations (Arslan, 2019). Furthermore, such teachers foster interactive and inclusive classroom environments where students are advocated to invite questions, have interaction in discussions, and increase scientific reasoning abilities (Lee, 2017). The impact of PCK on chemistry teachers' practices is further stimulated via the contextual and cultural factors inside instructional settings (Jain, Ling, & Jin, 2024). In useful resource-limited environments, instructors may face challenges along with constrained access to laboratory system, academic materials, and expert assist that may prevent the powerful software of PCK (Rollnick, Bennett, Rhemtula, Dharsey, & Ndlovu, 2008). Nevertheless, teachers with strong PCK often demonstrate resilience and creativity in overcoming such obstacles by way of the use of domestically available assets and designing alternative educational techniques (Mavhunga & Rollnick, 2013). As an instance, an instructor would possibly use household materials to simulate chemical experiments or rent storytelling and analogies to explain abstract ideas, thereby making learning extra available and attractive for college kids (Jin, 2019). Such adaptability underscores the dynamic nature of PCK and its important function in permitting instructors to navigate the complexities of classroom preparation (Bwalya, Rutegwa, & Mapulanga, 2024).

Empirical research have continually shown an effective correlation between instructors' PCK and student gaining knowledge of results in science education (Baumert et al., 2010; Lee & Luft, 2008). In chemistry, teachers who possess well-advanced PCK are much more likely to foster students' conceptual knowledge, medical literacy, and hobby in pursuing technological know-how-related careers (type, 2014). For example, a look at by using Mthembu and Ngema (2020) observed that scholars taught through teachers with high PCK established extra improvements in their knowledge of chemical equilibrium and reaction kinetics in comparison to those taught through teachers with

confined PCK. further, Rollnick and Mavhunga (2016) stated that focused expert development packages focusing on PCK appreciably greater instructors' academic effectiveness and college students' instructional overall performance in chemistry. Those findings highlight the want for ongoing efforts to bolster instructors' PCK thru based training, mentorship, and collaborative gaining knowledge of opportunities (Chuene, & Singh, 2024). Given the important position of PCK in shaping chemistry teachers' school room practices, it is imperative to discover how instructors gather, broaden, and observe their PCK in numerous educational contexts. Such an exploration can provide precious insights into the demanding situations and possibilities related to coaching chemistry efficaciously, particularly in environments wherein sources and expert help are restricted. Moreover, it can inform the design of trainer education applications that emphasize the integration of content material understanding and pedagogical competencies, ensuring that instructors are well-prepared to cope with the complexities of chemistry training (Van Driel & Berry, 2012). By means of fostering teachers' PCK, schooling structures can decorate the nice of chemistry teaching and studying, ultimately contributing to college students' scientific literacy and educational achievement (Hlaela, & Jita, 2024). The pedagogical content know-how of chemistry teachers plays a pivotal role in shaping their lecture room practices, influencing educational techniques, scholar engagement, and gaining knowledge of effects. Teachers with nicely-evolved PCK are higher geared up to address the challenges of coaching abstract and complex chemistry standards, creating meaningful learning experiences that promote conceptual information and clinical reasoning. But, the improvement and application of PCK are stimulated by means of various factors, such as instructors' professional backgrounds, coaching experience, and contextual constraints (Buma, Sibanda, & Rollnick, 2024). Therefore, understanding the impact of PCK on chemistry teachers' practices is important for advancing teacher schooling, professional improvement, and curriculum reforms geared toward enhancing the pleasant of chemistry schooling. So, the purpose of this look at became to find out the relationship and impact of pedagogical content information of chemistry instructors on their classroom practices at secondary stage, and also check the difference among male & girl concerning pedagogical content material expertise of chemistry instructors and their school room practices at secondary stage.

**Methodology**

A quantitative survey research design was employed in this study, with positivism as the philosophical paradigm underpinning the quantitative research. The population consisted of all secondary schools in the Punjab province. There are a total of 8,786 schools, with 7,951 chemistry teachers, including 3,704 male and 4,247 female teachers (School Information System, 2024). A simple random sampling technique was utilized to select a sample from the population. A total of 460 schools were randomly chosen, followed by the selection of 477 chemistry teachers, comprising 212 male and 265 female teachers, also selected randomly. The study's instrument was a self-developed five-point Likert scale questionnaire. The validity of the questionnaire was established through expert opinions, while reliability was ensured via pilot testing. The Cronbach’s

Alpha values for the pedagogical content knowledge of chemistry teachers and classroom practices were 0.821 and 0.830, respectively, indicating adequacy for further analysis. Inferential statistics, including regression analysis, Pearson correlation, and independent sample t-test, were used to analyze the data through SPSS.

**Data Analysis**

**Table 1** ***Effect of pedagogical content knowledge of chemistry teachers on their classroom practices at secondary level***

| **Model Summary[b]** | | | | |
|---|---|---|---|---|
| Model | R | R Square | Adjusted R Square | Std. Error of the Estimate |
| 1 | .122[a] | .015 | .013 | .35084 |
| a. Predictors: (Constant), Pedagogical Content Knowledge | | | | |
| b. Dependent Variable: Classroom Practice | | | | |

The above table illustrates the effect of pedagogical content knowledge of chemistry teachers on their classroom practices at secondary level. The R-square 0.015 and standard error value 0.35 shows that the variability observed in the independent variable (pedagogical content knowledge) has a significant effect on dependent variable (classroom practice) is explained by the regression model.

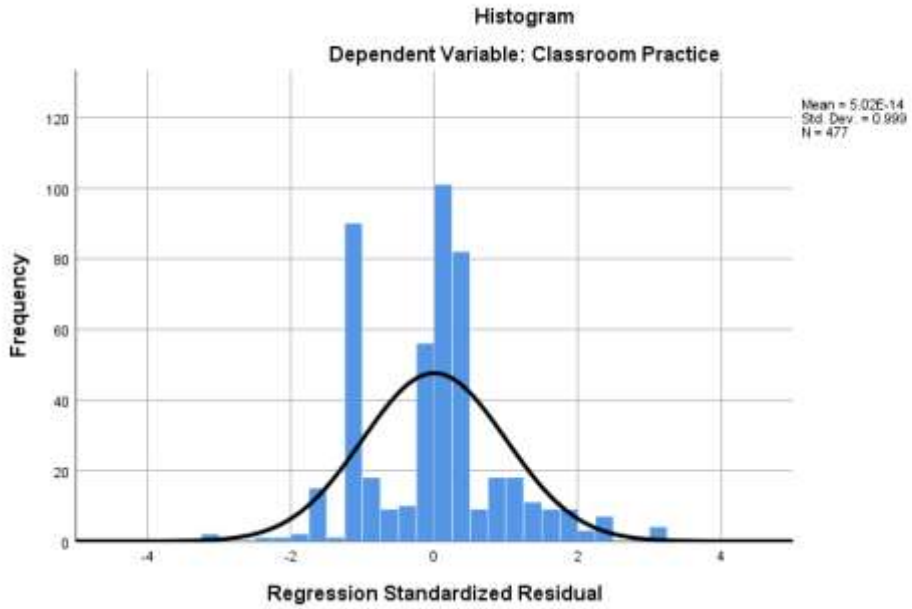
**Table 2** ***Effect of pedagogical content knowledge of chemistry teachers on their classroom practices at secondary level***

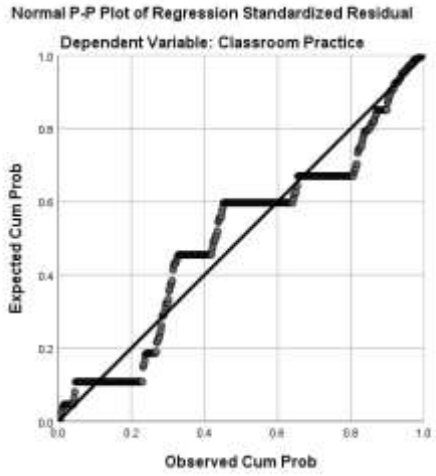
| **ANOVA[a]** | | | | | | |
|---|---|---|---|---|---|---|
| Model | | Sum of Squares | df | Mean Square | F | Sig. |
| 1 | Regression | .885 | 1 | .885 | 7.190 | .008[b] |
| | Residual | 58.467 | 475 | .123 | | |
| | Total | 59.352 | 476 | | | |
| a. Dependent Variable: Classroom Practice | | | | | | |
| b. Predictors: (Constant), Pedagogical Content Knowledge | | | | | | |

The above table illustrates the value of Mean square 0.123, F-value 7.190 and p-value 0.008 which shows that significant effect and pedagogical content knowledge of chemistry teachers reliably predict teachers' classroom practices at secondary level.

**Table 3** ***Effect of pedagogical content knowledge of chemistry teachers on their classroom practices at secondary level***

| **Coefficients[a]** | | | | | |
|---|---|---|---|---|---|
| | Unstandardized Coefficients | | Standardized Coefficients | t | Sig. |
| | B | Std. Error | Beta | | |
| Constant | 3.395 | .191 | .122 | 17.761 | .000 |
| Pedagogical Content Knowledge | .117 | .043 | | 2.681 | .008 |
| a. Dependent Variable: Classroom Practice | | | | | |




The above table illustrates the effect of pedagogical content knowledge of chemistry teachers on their classroom practices at secondary level. The B-value 0.122, t-value 2.68 and p-value 0.008 shows that there was highly significant effect of pedagogical content knowledge of chemistry teachers on their classroom practices at secondary level.

**Table 4** ***Relationship between pedagogical content knowledge of chemistry teachers and their classroom practices at secondary level***

| **Correlations** | | | |
|---|---|---|---|
| | | Pedagogical Content Knowledge | Classroom Practice |
| Pedagogical Content Knowledge | Pearson Correlation | 1 | .122** |
| | Sig. (2-tailed) | | .008 |
| | Sum of Squares and Cross-products | 65.194 | 7.596 |
| | Covariance | .137 | .016 |
| | N | 477 | 477 |

| | | | |
|---|---|---|---|
| Classroom Practice | Pearson Correlation | .122** | 1 |
| | Sig. (2-tailed) | .008 | |
| | Sum of Squares and Cross-products | 7.596 | 59.352 |
| | Covariance | .016 | .125 |
| | N | 477 | 477 |
| **. Correlation is significant at the 0.01 level (2-tailed). | | | |

The above table illustrates the relationship between pedagogical content knowledge of chemistry teachers and their classroom practices at secondary level. The Pearson value 0.122 shows that there weak positive significant relationship between pedagogical content knowledge of chemistry teachers and their classroom practices at secondary level.

**Table 5** ***Difference between male & female regarding pedagogical content knowledge of chemistry teachers and their classroom practices at secondary level***

| **Variables** | | Levene's Test for Equality of Variances | | t-test for Equality of Means | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **F** | **Sig.** | **t** | **df** | **Sig. (2-tailed)** | | |
| | **Gender** | | | | | | **Mean** | **S.D.** |
| Pedagogical Content Knowledge | Male | 10.794 | .001 | -8.821 | 475 | .000 | 4.2333 | .34807 |
| | Female | | | -8.803 | 458.536 | .000 | 4.5116 | .33941 |
| Classroom Practice | Male | 62.920 | .000 | 3.655 | 475 | .000 | 3.9694 | .30534 |
| | Female | | | 3.721 | 473.413 | .000 | 3.8523 | .38150 |

The above table illustrates the difference between male & female regarding pedagogical content knowledge of chemistry teachers and their classroom practices at secondary level. The male teachers' pedagogical content knowledge (M=4.233; SD=0.34) while female teachers' (M=4.51; SD=0.34), t-value 8.821, and p-value 0.000 shows highly significant difference among the groups. While on the other hand, the male teachers' classroom practices (M=3.96; SD=0.30), while female teachers' (M=3.85; SD=0.38), t-value 3.65, p-value 0.000 also shows highly significant difference among the groups. The results shows that there was highly significant difference between male & female teachers regarding pedagogical content knowledge of chemistry teachers and their classroom practices at secondary level.

**Discussion**

The pedagogical content material understanding (PCK) of chemistry teachers extensively affects their school room practices on the secondary level through enabling them to convert complicated, abstract content into understandable paperwork. Instructors with sturdy PCK hire strategies inclusive of models, analogies, experiments, and actual-life examples to address pupil misconceptions and facilitate conceptual know-how (Type, 2009). Powerful PCK permits instructors to bridge the macroscopic, submicroscopic, and symbolic representations of chemistry, enhancing college students' engagement and critical questioning abilities (Taber, 2002; Gabel, 1999).

Conversely, inadequate PCK can lead to fragmented education, restricting college students' hold close of difficult topics like chemical bonding or stoichiometry (Rollnick et al., 2008).

There is a considerable dating between the pedagogical content information (PCK) of chemistry teachers and their study room practices at the secondary degree. Teachers with well-developed PCK effectively combine content knowledge and pedagogical techniques to create significant and engaging gaining knowledge of reports, improving college students' conceptual knowledge and problem-solving skills (Nkundabakura, et al., 2024). Research suggests that strong PCK allows teachers to pick out and deal with students' misconceptions via focused educational methods, consisting of inquiry-primarily based gaining knowledge of and actual-world programs (Van Driel, Verloop, & De Vos, 1998; Loughran, Berry, & Mulhall, 2006). This courting highlights that teachers with strong PCK can drastically beautify classroom interactions, educational great, and scholar results, especially in subjects as abstract and complicated as chemistry (Mazibe, 2024).

Differences among male and female chemistry teachers regarding pedagogical content expertise (PCK) and their lecture room practices at the secondary level were found in diverse studies. Research shows that male and lady instructors may also rent unique teaching techniques and lecture room interactions because of variations in pedagogical approaches, verbal exchange patterns, and perceptions of pupil needs (kind, 2009; Park & Oliver, 2008). As an instance, woman instructors are often found to recognition greater on scholar-centered techniques and fostering collaborative mastering environments, even as male instructors may lean towards content material-centered and lecture-primarily based strategies (Van Driel & Berry, 2012). However, those differences are often context-dependent and influenced by factors which include revel in, training, and get right of entry to resources (Flores-Castro, Campos-Nava, Ramirez-Diaz, & Moreno-Ramos, 2024). Typical, each male and woman teachers with robust PCK demonstrate powerful school room practices that decorate student learning consequences while provided with ok professional development opportunities.

**Conclusion**

In conclusion, pedagogical content knowledge (PCK) plays a critical role in shaping the instructional practices of chemistry teachers at the secondary level, directly impacting students' understanding and academic success. Teachers with well-developed PCK can effectively bridge abstract concepts with practical teaching strategies, addressing misconceptions and fostering conceptual clarity through models, experiments, and real-world examples. The significant relationship between PCK and classroom practices highlights its importance in enhancing instructional quality, student engagement, and learning outcomes. Gender-based differences in PCK and teaching approaches suggest that male and female teachers may exhibit varying pedagogical strategies; however, both can achieve effective teaching when provided with appropriate training and professional development opportunities. These findings underscore the need for continuous efforts to strengthen PCK through targeted teacher education programs,

mentorship, and reflective practices. By doing so, education systems can empower teachers to overcome instructional challenges and improve the quality of chemistry education. Ultimately, fostering strong PCK among teachers benefits both teaching effectiveness and students' scientific literacy, preparing them for future academic and professional pursuits.

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