

Assess the effectiveness of digital platforms in facilitating content delivery and pedagogical strategies

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Abstract

Purpose: The integration of digital platforms in education offers new opportunities to enhance pedagogical content knowledge (PCK) among teachers. However, the effectiveness of these platforms in improving teaching performance is limited. This study aims to evaluate the effectiveness of digital platforms in facilitating content delivery and pedagogical strategies, with a focus on their impact on performance in PCK (R-PCK), which offers a more objective measure compared to self-perception-based assessments. Specifically, the study investigates how digital tools influence R-PCK concerning variables such as gender, age, work experience, the origin of the training center, and general skills, including Reading Comprehension and Logical Reasoning. **Methods:** This research utilized data from the 2022 National Unique Test (PUN) for primary education teachers across all 24 regions of Peru, encompassing a sample size of 94,665 participants, with 67.4% females and 32.6% males. The study employed quantitative methods to analyze the data, focusing on the impact of digital platforms on R-PCK. Statistical analyses were conducted to explore the correlations between R-PCK and various independent variables, including gender, age, work experience, and general skills. The research questions guiding this study were: How do digital platforms impact R-PCK among primary education teachers? Are there significant differences in R-PCK based on gender, age, and work experience when digital platforms are integrated? What role do general skills play in enhancing R-PCK through digital platforms? **Results:** Preliminary findings indicate significant variations in R-PCK related to gender, the origin of the pedagogical training center, and work experience in both public and private sectors. The study identified negative and statistically significant correlations between R-PCK and age, indicating that younger teachers tend to have higher R-PCK scores. Additionally, there were positive correlations between R-PCK and general skills, suggesting that teachers with better reading comprehension and logical reasoning skills are more likely to perform better in R-PCK assessments. **Conclusion:** This study hypothesizes that digital platforms can effectively bridge gaps in R-PCK by providing targeted pedagogical support and fostering a more dynamic learning environment. The findings have significant implications for educational policy and practice, emphasizing the need for tailored digital interventions to optimize teaching effectiveness and student outcomes.

Keywords: Pedagogical Content Knowledge, Digital Platforms in Education, Teacher Performance, Primary Education, Cognitive Skills Assessment, Educational Technology Integration

Introduction

The advent of digital technology has fundamentally transformed educational practices, introducing a wealth of tools and platforms aimed at enhancing both teaching and learning. Among these innovations, digital platforms have emerged as essential resources, enabling educators to deliver content more effectively and adapt their pedagogical strategies to better meet students' needs (Bates, 2015). As educational institutions increasingly embrace technology, the dynamics of classroom instruction are evolving, prompting a re-evaluation of traditional teaching methods and an exploration of how digital tools can augment the educational experience. This transformation is not merely a superficial shift; it signifies a profound change in how educators approach teaching and learning, necessitating new frameworks to assess teaching effectiveness in this digital landscape.

One of the core concepts in this reimagined educational framework is Pedagogical Content Knowledge (PCK), introduced by Shulman (1986). PCK plays a central role in effective teaching, representing the intersection of content expertise and pedagogy. It allows teachers to translate subject knowledge into accessible and meaningful learning experiences for students. PCK encompasses an understanding of how students learn specific content, what teaching approaches are most effective, and how to adapt instruction to meet the diverse needs of learners. Over the years, numerous studies have underscored the importance of PCK in improving teaching effectiveness and student learning outcomes (Kind, 2019; Park and Oliver, 2008). This focus on PCK

has led to significant advancements in teacher training and curriculum design, emphasizing the need for educators to possess not only deep subject knowledge but also the pedagogical skills necessary to facilitate effective learning.

However, most of the existing research evaluating PCK has relied on teachers' self-assessments, which may introduce biases and limit the objectivity of the findings (Depaepe et al., 2013). Self-reported measures can be influenced by various factors, including personal perceptions of competence and external pressures, leading to inflated assessments of one's abilities. This limitation highlights the necessity for more objective metrics to evaluate teaching effectiveness and the impact of various teaching strategies on student learning. To address this gap, Performance in PCK (R-PCK) offers a more objective metric by evaluating actual teaching performance and its impact on student learning. R-PCK moves beyond self-assessments to provide a framework for measuring the practical application of pedagogical content knowledge in real classroom settings. Despite its importance in educational research, studies focusing on R-PCK remain limited, especially in relation to digital platforms (König and Blömeke, 2012).

Digital platforms present unique opportunities to transform instructional strategies, making it essential to investigate their impact on R-PCK. These platforms can facilitate personalized learning, provide access to diverse educational resources, and promote collaborative learning environments, thereby enriching the teaching and learning experience. Figure 1 illustrates a modern classroom where teachers are using digital platforms for content delivery, symbolizing the integration of technology with pedagogy. This integration can enhance R-PCK by enabling teachers to utilize a variety of instructional strategies tailored to individual learners, fostering a more engaging and effective learning environment.



Figure 1: Image representing a modern classroom where teachers are using digital platforms for content delivery, symbolizing the integration of technology with pedagogy

Previous studies suggest that digital tools promote differentiated instruction and foster student engagement, leading to better academic outcomes (Harris et al., 2016; Koehler and Mishra, 2009). These digital resources not only provide innovative ways for teachers to present information but also encourage active learning by allowing students to interact with content in meaningful ways. For instance, platforms that incorporate multimedia elements can cater to various learning styles, thereby enhancing comprehension and retention. Furthermore, digital platforms offer teachers access to vast educational resources and collaborative networks, supporting their professional development and strengthening their PCK (Voogt et al., 2013). As educators engage with these resources, they can continually refine their pedagogical practices, ensuring that their instruction remains relevant and effective in the face of rapidly changing educational demands.

Problem statement

Despite the clear advantages associated with the integration of digital platforms, there is a growing need for research that objectively assesses their impact on teaching effectiveness, particularly in the context of R-PCK. While digital technology has revolutionized education, its role in enhancing teachers' pedagogical content knowledge remains underexplored. Most existing studies rely on self-perception, which may not accurately reflect teaching competence or performance. This reliance on subjective assessments can hinder the development of effective teacher training programs and educational policies aimed at improving teaching quality. Therefore, this study seeks to bridge this research gap by evaluating how digital platforms affect R-PCK in primary education teachers across Peru. The analysis is particularly relevant given the increasing reliance on digital tools in education and considers important variables such as gender, age, work experience, and general skills. Understanding these relationships is crucial for developing comprehensive professional development programs that address the specific needs of teachers in a digital age.

Context of the study

The context of this study is set against the backdrop of an educational system undergoing rapid technological changes. Teachers are required to adapt to digital platforms, yet how these tools influence actual teaching performance has yet to be thoroughly examined. This research aims to explore the multifaceted nature of this integration, focusing on how various demographic and professional characteristics influence the effective use of digital platforms in teaching.

In Peru, the increasing reliance on technology in education has prompted significant changes in instructional methodologies, yet many educators face challenges in adapting to these new tools. These challenges include a lack of adequate training, insufficient resources, and varying levels of comfort with technology among teachers. Understanding the impact of these platforms on R-PCK is critical for developing educational policies that support effective teaching and improved learning outcomes. It is imperative that future research not only explores the potential of digital tools but also identifies the barriers educators face in implementing them effectively.

Moreover, the study will consider how the intersection of digital platforms and R-PCK influences student learning outcomes. By evaluating teachers' performance in relation to the use of digital platforms, this research aims to provide insights that can inform educational practice and policy. Ultimately, addressing these multifaceted aspects will be crucial for enhancing R-PCK and, consequently, improving educational outcomes for students in primary education settings.

Materials and methods

Research design and approach

This study employed a quantitative approach with a descriptive and comparative methodology based on secondary data (Malhotra, 2010). The primary aim was to assess the impact of digital platforms on R-PCK among primary education teachers in Peru. The analysis focused on identifying relationships between R-PCK and variables such as gender, age, work experience, and general skills, including reading comprehension and logical reasoning.

Data collection

Data for this research were sourced from the National Unique Test (PUN) administered by the Ministry of Education of Peru (Minedu) in 2022. The PUN was designed to assess the cognitive skills, pedagogical content knowledge, curricular expertise, and disciplinary knowledge of primary education teachers applying for state employment. It serves as a standardized tool for teacher selection in Peru, ensuring a democratic and merit-based process for appointment. The study's sample consisted of teachers from all 24 regions of Peru, totaling 95,148 participants. Outliers were removed using the ± 2.5 standard deviation (SD) rule for the R-PCK variable, resulting in a final sample of 94,665 teachers. The demographic breakdown included 63,792 females (67.4%) and 30,873 males (32.6%). The average age for male teachers was $M_{age-male} = 41.8$ years ($SD = 7.62$), and for female teachers, it was $M_{age-female} = 42.5$ years ($SD = 7.96$). The PUN test comprised two subtests: General Skills and Pedagogical, Curricular, and Disciplinary Knowledge (R-PCK). The latter had a higher weighting, with 50 questions each worth 3 points (maximum score of 150), compared to 25 questions for General Skills, each worth 2 points (maximum score of 50). Table 1 outlines the composition of the test. The test was administered in a 3-hour and 45-minute session, with standardized procedures across all regions.

Table 1. Composition of the National Unique Test for Primary Education Teachers

Subtest	Number of Questions	Value of Each Question	Maximum Score	Minimum Score Required for Curricular Evaluation
General Skills	25	2	50	---
Pedagogical, Curricular, and Disciplinary Knowledge (R-PCK)	50	3	150	84
Total	75	---	200	110

Note: Adapted from Minedu (2022).

Statistical analysis

The statistical analysis aimed to evaluate the relationship between digital platforms and R-PCK, as well as the influence of other variables such as gender, age, and general skills. The analysis was conducted in three stages:

Descriptive analysis

Basic descriptive statistics were calculated to summarize the demographic characteristics of the sample and the distribution of R-PCK scores.

Comparative analysis

This method was used to compare R-PCK scores across different demographic groups, such as gender, age categories, and work experience in public versus private sectors.

Correlational analysis

Pearson's correlation coefficient was employed to assess the strength and direction of relationships between R-PCK scores and independent variables like general skills, gender, and age. All statistical procedures were performed using the Jamovi statistical software (Version 2.3.28), a comprehensive tool that facilitates data analysis and interpretation. The results provided insights into how digital platforms and demographic factors contribute to variations in R-PCK, offering a foundation for future educational policy improvements.

Results

Demographic distribution of participants

The study sample consisted of 94.665 teachers, showcasing a significant gender disparity among the participants. Specifically, the results indicated that 32.6% of the teachers were male, while a predominant 67.4% were female (Table 2 and Figure 2). This gender imbalance is reflective of broader trends in the teaching profession, where a higher percentage of female educators can be observed. In terms of educational backgrounds, the majority of the teachers (65.4%) graduated from pedagogical institutes, while 32.2% graduated from universities, and a mere 2.5% reported having attended both types of institutions (Table 2). This data suggests that the teaching workforce is largely composed of individuals who have pursued education through pedagogical institutes, which are often geared towards practical teaching skills. Such a profile raises questions about the potential impact of educational background on pedagogical approaches and effectiveness in teaching.

Table 2: Descriptive Information Table of the Study Variables

Variables	Statistics	Frequency or Mean	or Percentage or SD
N		94.665	
Independent Variables			
Categorical Variables			
Teacher's Gender			
Male		30.873	32.6%
Female		63.792	67.4%
Teacher's Background			
Both		2.329	2.5%
Only Institute		61.881	65.4%
Only University		30.455	32.2%
Ordinal Variables			
Teaching Experience in the Public Sector			
2 to 5 years		25.019	26.4%
6 to 10 years		23.483	24.8%
Less than 2 years		9.576	10.1%
More than 10 years		15.467	16.3%
No experience		21.120	22.3%
Teaching Experience in the Private Sector			
2 to 5 years		22.584	23.9%
6 to 10 years		12.467	13.2%
Less than 2 years		10.568	11.2%
More than 10 years		9.090	9.6%
No experience		39.956	42.2%
Scale Variables			
Teacher's Age (Mean, SD)		42.00	7.745%
General Skills of the Teacher (Reading Comprehension and Logical Reasoning) (Mean, SD)		31.37	9.00%
Criterion Variable:			
Performance in Pedagogical Content Knowledge (R-PCK) (Mean, SD)		72.80	22.05%

Note. The maximum score obtainable on the general skills test was 50 points on a raw scale. ** The maximum score obtainable in PCK was 150 points on the raw scale. Scalar variables such as age, General Skills, and R-PCK showed skewness and kurtosis values below ± 1 .

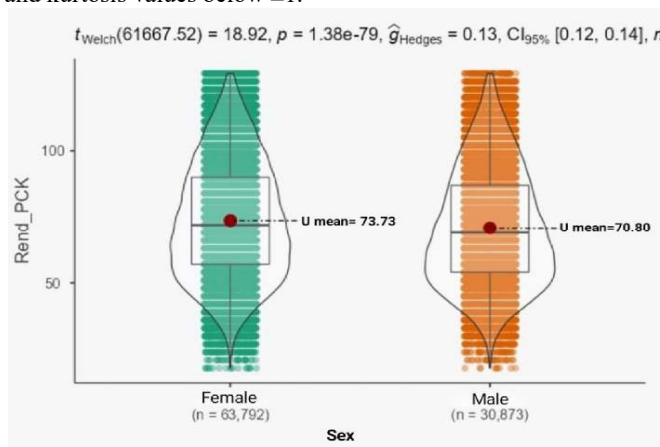


Figure 2: Comparative analysis of the R-PCK variable based on gender and background as independent variables. Note. The effect sizes considered in the test \hat{g}_{Hedges} are: small = 0.20; medium = 0.50; large ≥ 0.80 ; for the FWelch test, they are considered: small = 0.01; medium = 0.06; large ≥ 0.14 (Dominguez-Lara, 2018).

Teaching experience in different sectors

Further exploration into the teaching experience reveals a nuanced picture of the participants' professional journeys in both public and private sectors. When assessing public sector experience, the data showed that 22.3% of the teachers reported having no experience, while 10.1% had less than two years, 26.4% had between two to five years, 24.8% had six to ten years, and 16.3% had more than ten years of experience (Table 2, Figure 3, 4 and 5). In contrast, the results for private sector experience indicated a notable 42.2% of teachers had no experience, which is significantly higher compared to the public sector. Among those with experience in the private sector, 11.2% had less than two years, 23.9% had two to five years, 13.2% had six to ten years, and 9.6% had more than ten years of experience (Table 2, Figure 3, 4 and 5). This disparity in experience across sectors suggests that a majority of teachers in the sample are primarily focused on public education, which could have implications for their familiarity with diverse teaching environments and methodologies.

Age and general skills of teachers

In terms of age, the average teacher in the sample was found to be 42 years old, with a standard deviation of 7.745 years. This average indicates a relatively mature teaching workforce, which might correlate with a wealth of experience, both in terms of teaching practice and in navigating educational challenges over time. Additionally, the study assessed general skills, focusing on reading comprehension and logical reasoning. The average score for general skills among the teachers was 31.37, with a standard deviation of 9.00, suggesting variability in the skill levels within the cohort (Table 2). Such a score provides insight into the cognitive capabilities of the teaching staff, which are critical for effective teaching and fostering student learning. A correlation between age and general skills may also be inferred, where older teachers might have more developed skills, although the data would need further analysis to substantiate this assumption.

Performance in pedagogical content knowledge

The criterion variable for this study was the Performance in R-PCK, which recorded an average score of 72.80 with a standard deviation of 22.05 (Table 2). This score indicates a generally low to moderate level of pedagogical content knowledge among the teachers in the sample, suggesting that there may be room for improvement in their understanding of effective teaching strategies and subject matter integration. The variability in scores, as indicated by the standard deviation, implies that while some teachers possess a solid grasp of R-PCK, others may struggle significantly.

This outcome raises important questions about the professional development opportunities available to teachers, particularly in enhancing their pedagogical knowledge and skills. Given that R-PCK is critical for effective teaching, addressing these gaps could significantly impact educational outcomes, emphasizing the need for tailored professional development programs that cater to the diverse backgrounds and experiences of teachers.

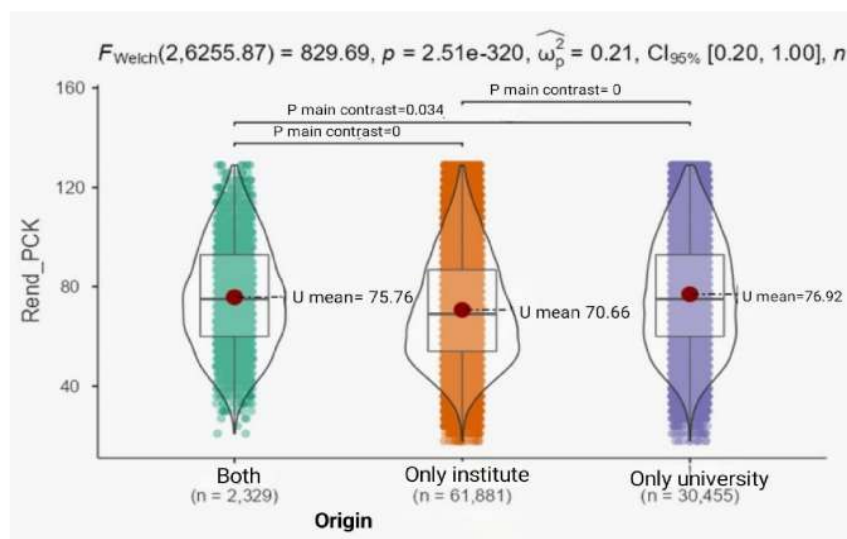


Figure 3: Comparative analysis of the R-PCK variable based on origin as independent variables. Note. The effect sizes considered in the test \hat{g} _Herges are: small = 0.20; medium = 0.50; large \geq 0.80; for the FWelch test, they are considered: small = 0.01; medium = 0.06; large \geq 0.14 (Domínguez-Lara, 2018).

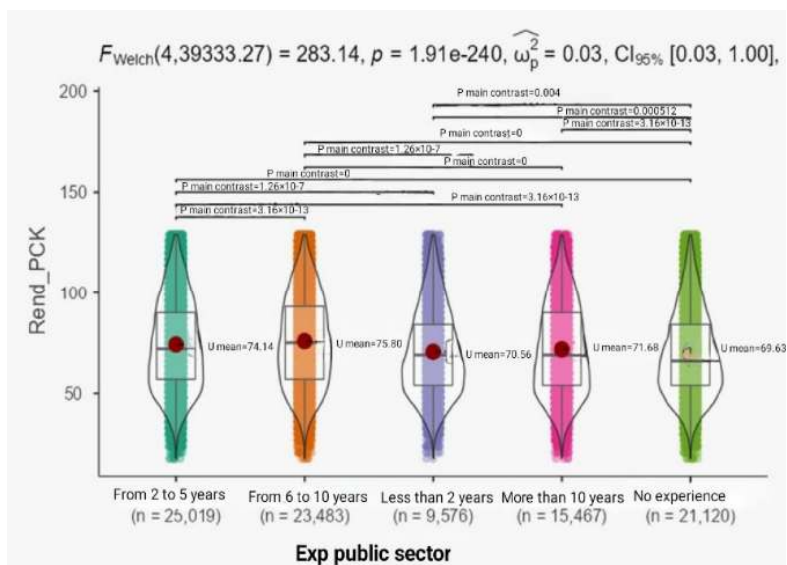


Figure 4: Comparative analysis of the R-PCK variable based on public sector as independent variables. Note. The effect sizes considered in the test \hat{g} Herges are: small = 0.20; medium = 0.50; large ≥ 0.80 ; for the FWelch test, they are considered: small = 0.01; medium = 0.06; large ≥ 0.14 (Domínguez-Lara, 2018).

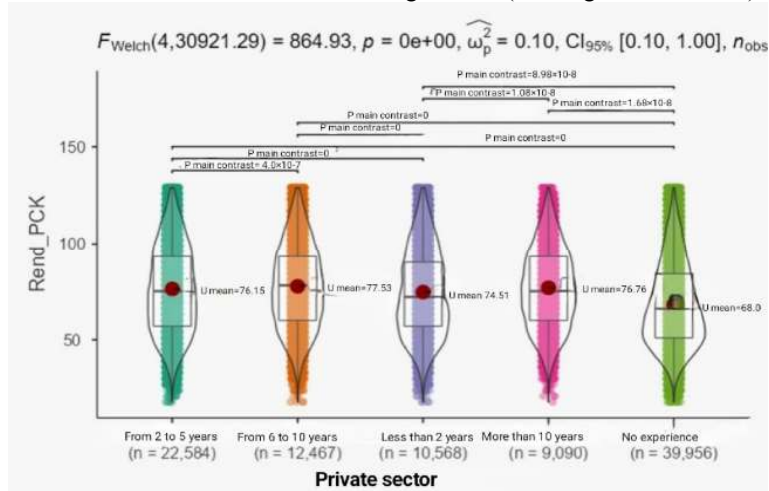


Figure 5: Comparative analysis of the R-PCK variable based on private sector as independent variables. Note. The effect sizes considered in the test \hat{g} Herges are: small = 0.20; medium = 0.50; large ≥ 0.80 ; for the FWelch test, they are considered: small = 0.01; medium = 0.06; large ≥ 0.14 (Domínguez-Lara, 2018).

Comparison among parameters by using correlation matrix

The comparison in R-PCK of groups formed by public sector work experience (exp public sector) found an FWelch value = 283.14 associated with a p-value of < 0.001 and a medium effect size ($(\omega_p^2) \hat{=} 0.03$; 95% CI [0.03, 1.00]). In contrast, the comparison in R-PCK of groups formed by private sector work experience (exp private sector) found an FWelch value = 864.93 associated with a p-value of < 0.001 and a medium effect size ($(\omega_p^2) \hat{=} 0.10$; 95% CI [0.10, 1.00]). Figure 6 presents the analysis of group comparisons by gender and teacher background conducted using the statistical software Jamovi. The analysis used the Welch's t-test and Welch's F-test. The results of comparing R-PCK by gender showed a high t-value of 18.92 with an associated p-value of < 0.001 and a small effect size (\hat{g} Herges=0.13; 95% CI [0.12, 0.14]). These values indicate the presence of differences between men and women regarding R-PCK. However, a small effect size is reported, so the results should be taken with healthy caution. The analysis of differences in teachers' R-PCK based on their background was found to be significant. The FWelch statistic = 829.69 was high and associated with a p-value of < 0.001 and a large effect size ($(\omega_p^2) \hat{=} 0.21$; 95% CI [0.20, 1.00]). It is concluded that the teacher's background, whether only institute, university, or both, presents differences in R-PCK, meaning that at least one group of teachers, according to their background, differs in their R-PCK.

Figure 6 presents the correlation matrix created using the statistical software Jamovi. The correlations between age and R-PCK ($r = -0.186$, $p < 0.01$) and between age and General Skills ($r = -0.256$, $p < 0.01$) indicate negative and statistically significant coefficients. These results suggest that older teachers develop lower R-PCK, as is the case with General Skills, and vice versa. On the other hand, General Skills and R-PCK showed a positive and statistically significant correlation. According to these values, high scores in General Skills also correlate with high scores in R-PCK, and vice versa.

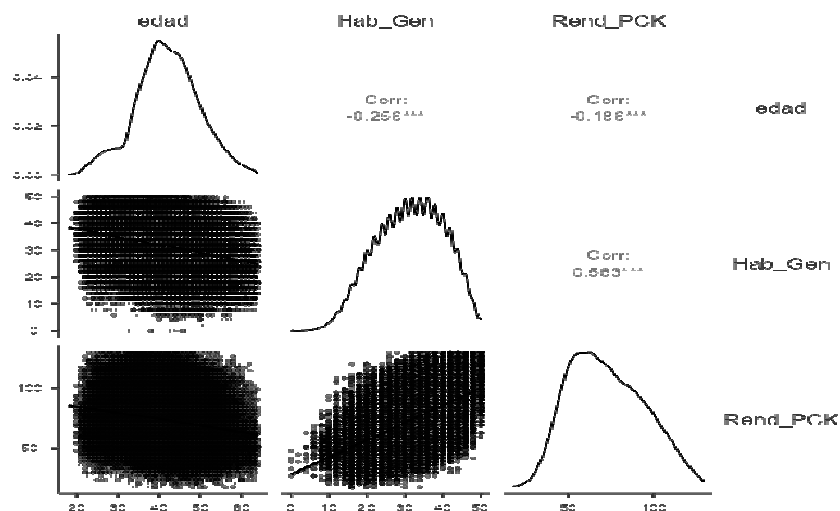


Figure 6: Correlation matrix and density of the variables R-PCK (Rend PCK), General Skills (Hab Gen), and Teacher's Age. Note. *** $p < 0.001$.

Discussion

This study offers valuable insights into the various factors influencing the pedagogical content knowledge (R-PCK) of primary education teachers, particularly examining the relationships with gender, age, background, and work experience. The findings align with the existing literature that has explored these relationships but also present novel contributions, particularly in the use of a performance-based measure of R-PCK. The results revealed that demographic variables such as gender and age, as well as professional experience in both public and private sectors, significantly correlate with R-PCK. However, the effect sizes varied, indicating that while relationships may exist, their practical significance may differ across the variables studied (Akram et al., 2021; Bakar et al., 2020; Bilici and Güler, 2016).

A noteworthy outcome of this research is the gender disparity observed in R-PCK. Although previous studies have reported conflicting evidence regarding the influence of gender on PCK, the findings in this study suggest that female teachers demonstrate higher R-PCK compared to their male counterparts, albeit with a small effect size. This outcome supports the findings of several researchers (Arslan, 2015; Cetin-Dindar et al., 2018; Genç and Akilli, 2017; Irwanto et al., 2022; Kavanov et al., 2015; Mapulanga et al., 2022; Park et al., 2020; Rahman et al., 2022; Schmid et al., 2021), which suggest a favorable influence of gender on teaching effectiveness. However, the small effect size cautions against overgeneralization, indicating that other factors may also play a substantial role in shaping R-PCK (Cetin-Dindar et al., 2018). It raises critical questions about the systemic influences affecting teaching practices, such as the support and resources available for female educators or differences in pedagogical approaches between genders.

The study also identified a significant inverse correlation between age and R-PCK, suggesting that younger teachers may possess a higher R-PCK. This finding is consistent with literature that supports the hypothesis of age influencing PCK (Akram et al., 2021; Bilici and Güler, 2016; Haroun et al., 2016) and contrasts with studies that refute this claim (Bakar et al., 2020; Irwanto et al., 2022; Mapulanga et al., 2022; Rahman et al., 2022). Younger teachers may be more attuned to contemporary pedagogical methods and curricular innovations, as they have likely received more recent training, which aligns with evolving educational paradigms (Bilici and Güler, 2016). This trend emphasizes the necessity for ongoing professional development programs tailored to teachers of all ages, particularly those with more experience who might benefit from refreshed methodologies or contemporary pedagogical strategies (Akram et al., 2021). Furthermore, the analysis of teaching experience in public and private sectors revealed critical insights into the professional landscape of educators. The predominance of teachers focused on public education suggests a need for comprehensive training programs that address the unique challenges and pedagogical demands of different educational environments (Haroun et al., 2016). The results showed a higher percentage of teachers with no experience in the private sector compared to the public sector, which may indicate a limited exposure to diverse teaching methods

and student demographics (Park et al., 2020). Such disparities in experience may impact teachers' readiness to adapt their teaching practices to varied contexts. Thus, promoting cross-sector experience could enrich teachers' pedagogical repertoires and enhance their overall R-PCK (Cetin-Dindar et al., 2018).

Interestingly, the correlation between general skills and R-PCK was found to be positive and statistically significant. This relationship highlights the cognitive demands placed on educators and their influence on teaching effectiveness. High scores in general skills, particularly in reading comprehension and logical reasoning, corresponded with higher R-PCK scores, underscoring the importance of robust foundational skills in enabling effective teaching (Bilici and Güler, 2016). These findings suggest that teacher preparation programs should not only focus on pedagogical strategies but also emphasize the development of essential general skills that contribute to teachers' overall effectiveness (Akram et al., 2021). As noted, while R-PCK exhibited significant relationships with various demographic and professional factors, the variability in scores, as indicated by the standard deviation, signals a pressing need for targeted professional development initiatives.

This study adds to the growing body of literature on R-PCK by employing a performance-based measure and examining a diverse array of influencing factors. Although some relationships, such as those involving gender and age, did not exhibit strong evidence based on effect sizes, they nonetheless provide a foundation for further exploration into how these variables interact with pedagogical content knowledge (Rahman et al., 2022). Additionally, the findings advocate for professional development programs that are sensitive to the varying backgrounds and experiences of teachers, particularly those that foster cross-sector experiences and build essential general skills. Ultimately, addressing these multifaceted aspects will be crucial for enhancing R-PCK and, consequently, educational outcomes for students in primary education settings (Haroun et al., 2016; Park et al., 2020).

Conclusions

This study highlights the significant impact of digital platforms on R-PCK among primary education teachers in Peru, revealing that effective integration of these tools enhances teaching effectiveness and student outcomes. Key findings indicate that teachers who leverage digital resources demonstrate higher levels of R-PCK, with younger educators exhibiting a greater ability to utilize technology effectively than older counterparts. Additionally, the study underscores the importance of ongoing professional development to address barriers such as inadequate training and resource access, suggesting that tailored support can empower educators to improve their pedagogical strategies in an increasingly digital landscape. Overall, the research emphasizes the need for educational policies that promote the effective use of digital technology to foster quality instruction and enhance learning experiences for students.

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Conflict of interest

Authors declared no conflict of interest each other.

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