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How digital platforms improve teaching: comparing teacher performance across Peru

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ABSTRACT

This study addresses the challenge of enhancing pedagogical content knowledge (PCK) performance among primary education teachers in Peru, particularly in the context of increasing reliance on digital platforms. With significant regional and demographic disparities in access to digital resources, this research aims to evaluate the effectiveness of digital platforms in supporting teaching practices. Using a quantitative, cross-sectional design, the study analyzed data from the 2022 national unique test (PUN), which assesses cognitive and pedagogical skills among teachers, and a digital platform integration questionnaire (DPIQ) administered to 2,000 teachers. The findings revealed a positive correlation between digital platform usage and PCK performance, with younger and female teachers demonstrating higher scores. Urban teachers also outperformed their rural counterparts, highlighting regional disparities in digital access. The study concludes that integrating digital platforms into teaching practices can enhance PCK performance, but there is a need for targeted professional development and investment in digital infrastructure, particularly in underserved areas. Addressing these disparities is crucial to ensuring that all teachers can benefit from digital advancements, ultimately improving educational outcomes.

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1. INTRODUCTION

The integration of digital platforms into the education sector has sparked a transformative shift in teaching and learning practices across the globe. As technology continues to evolve, educational institutions are increasingly adopting digital tools to facilitate content delivery, enhance pedagogical strategies, and ultimately improve educational outcomes. These platforms, which include learning management systems (LMS), virtual classrooms, and interactive content creation tools, offer teachers and students new ways to engage with learning materials and collaborate in real-time. In recent years, there has been growing interest in understanding how these digital platforms impact pedagogical content knowledge (PCK) and teaching effectiveness, especially in regions where traditional methods of education have predominated for decades [1], [2]. The PCK, a concept first introduced by Shulman [3], represents the blending of subject matter expertise with effective teaching strategies. It allows educators to present complex concepts in ways that are

accessible and understandable to students, thereby enhancing the learning experience. PCK is widely recognized as a critical component of effective teaching, influencing not only how content is delivered but also how well students grasp and apply new knowledge [4], [5]. Despite its importance, the relationship between digital platforms and PCK remains underexplored, particularly in the context of primary education in developing countries.

In Peru, where education systems have traditionally relied on face-to-face instruction, the recent introduction of digital platforms has provided new opportunities to enhance teaching practices. This shift was accelerated by the COVID-19 pandemic, which forced schools to transition to remote learning almost overnight [6], [7]. The adoption of digital tools during this period has raised important questions about their effectiveness in supporting teachers' PCK [8]. Specifically, how do digital platforms influence PCK performance among primary education teachers? What role do variables such as gender, age, teaching experience, and cognitive skills play in this process? The findings of this study will contribute to the growing body of literature on educational technology integration, offering insights that can inform future policy decisions and teacher training programs. The rapid integration of digital platforms into educational settings has not only transformed the way content is delivered but also redefined the role of teachers in the classroom [9]. Educators are now expected to navigate a complex digital landscape, selecting and using appropriate tools to meet the diverse needs of their students [8]. However, the extent to which these platforms enhance teaching effectiveness, particularly in relation to PCK, remains an open question. This study aims to bridge this gap by investigating the relationship between digital platform usage and represented pedagogical content knowledge (R-PCK), while also considering the influence of demographic and cognitive variables.

2. LITERATURE REVIEW

The role of digital platforms in education has been the subject of extensive research over the past decade, with numerous studies exploring their impact on teaching and learning outcomes. Digital platforms offer a wide range of functionalities, from facilitating content delivery to enabling real-time communication and collaboration between students and teachers [1]. Research has shown that PCK is a key determinant of teaching effectiveness, influencing both student learning outcomes and teacher performance [10]. However, the integration of digital platforms into teaching practices has introduced new challenges and opportunities for educators, prompting scholars to investigate how these tools impact PCK. One of the most significant contributions to this field is the technological pedagogical content knowledge (TPCK) framework, developed by Koehler and Mishra [9]. This model extends the original PCK framework by incorporating technology as a critical component of effective teaching. Numerous studies have applied the TPCK framework to investigate how digital tools influence teaching effectiveness in various educational contexts. For example, a study by Park and Oliver [7] examined the impact of digital platforms on science teachers' PCK, finding that the use of interactive simulations and online resources enhanced teachers' ability to explain complex scientific concepts. Similarly, Boelens *et al*. [11] explored how digital tools supported differentiated instruction in diverse classrooms, concluding that platforms such as LMS and content creation tools allowed teachers to tailor their instructional strategies to meet the needs of individual students. These findings suggest that digital platforms have the potential to significantly enhance PCK, particularly when used strategically to support specific pedagogical goals.

Despite these positive outcomes, research also highlights several challenges associated with the integration of digital platforms into teaching practices. One of the primary concerns is the digital divide, which refers to the unequal access to technology and digital resources among students and teachers [12]. Additionally, teachers' familiarity with digital tools and their ability to use them effectively can vary widely, further complicating the integration process. Another area of concern is the potential for digital platforms to reinforce traditional, lecture-based teaching methods rather than promoting active, student-centered learning [13]. While digital tools offer opportunities for interactive and collaborative learning, research suggests that many teachers continue to use these platforms primarily for content delivery, replicating traditional instructional practices in a digital format [14]. This underscores the importance of professional development and training programs that equip teachers with the skills and knowledge needed to leverage digital tools effectively in their pedagogical practices [15]. The existing literature provides valuable insights into the potential of digital platforms to enhance PCK and teaching effectiveness. However, it also highlights several challenges that must be addressed to maximize the benefits of these tools. This study builds on the existing body of research by examining the impact of digital platforms on R-PCK in the context of primary education in Peru, with a focus on understanding how variables such as gender, age, teaching experience, and cognitive skills influence this relationship.

3. METHOD

3.1. Research design

This study employed a quantitative, cross-sectional research design to evaluate the effectiveness of digital platforms in enhancing PCK and its performance (R-PCK) among primary education teachers in Peru. The study was conducted from April to September 2023, focusing on analyzing the integration of digital platforms in teaching practices across 24 educational regions in Peru. Cross-sectional research is particularly well-suited for capturing a snapshot of relationships between variables at a specific point in time, making it an ideal approach for investigating the impact of digital platforms on teaching effectiveness. Sample Population The sample for this study was derived from the 2022 national unique test (PUN) dataset, provided by the Ministry of Education of Peru (Minedu). The total sample consisted of 94,665 primary education teachers who participated in the PUN. These teachers were selected from 24 different regions of Peru, ensuring that the sample was representative of the national population of primary school educators. The demographic composition of the sample is outlined in Table 1, which provides a detailed breakdown of key demographic variables, including gender, age, and educational background. The sample included 63,792 female teachers (67.4%) and 30,873 male teachers (32.6%). The average age of the participants was 42 years (SD=7.74). In terms of educational background, 32.2% of teachers were university graduates, 65.4% graduated from pedagogical institutes, and 2.5% had both types of qualifications. Teachers were further categorized based on their teaching experience in the public and private sectors. Experience levels ranged from no experience to over 10 years, as detailed in Table 2.

Table 1. Demographic characteristics of the sample

Variable	Category	Frequency (n)	Percentage (%)
Gender	Female	63,792	67.4
	Male	30,873	32.6
Age	Mean	42.00 years	-
	SD	7.74 years	-
Educational background	University	30,455	32.2
	Pedagogical institute	61,881	65.4
	Both	2,329	2.5

Table 2. Teaching experience of the sample

Experience (years)	Public sector (%)	Private sector (%)
No experience	22.3	42.2
Less than 2 years	10.1	11.2
2 to 5 years	26.4	23.9
6 to 10 years	24.8	13.2
More than 10 years	16.3	9.6

3.2. Research instruments

Two primary research instruments were used to collect data for this study. The PUN is a standardized assessment administered by the Minedu to evaluate cognitive and pedagogical skills among primary school teachers. The test consists of two subtests. General skills subtest subtest assesses cognitive abilities such as reading comprehension and logical reasoning. It includes 25 multiple-choice questions, each worth 2 points, with a maximum obtainable score of 50 points. Pedagogical, curricular, and disciplinary knowledge subtest evaluates teachers' pedagogical knowledge, focusing on their ability to apply content knowledge in a teaching context. The subtest includes 50 multiple-choice questions, each worth 3 points, with a maximum obtainable score of 150 points. Teachers were required to score a minimum of 84 points for satisfactory curricular evaluation. The PUN test was administered uniformly across the 24 regions of Peru, with a total test duration of 3 hours and 45 minutes. Digital platform integration questionnaire (DPIQ): to supplement the PUN data, a custom-designed questionnaire was distributed to a subsample of 2,000 teachers. The DPIQ assessed the frequency of digital platform usage, types of platforms utilized (e.g., LMS, content creation tools), and perceived effectiveness of these tools in enhancing pedagogical practices. The questionnaire included both closed-ended and Likert scale questions to capture quantitative data on digital platform usage and teacher perceptions.

3.3. Data collection procedures

The data collection process involved two distinct phases. First is secondary data request, formal requests for access to the PUN dataset were made through Minedu's virtual desk. The data was provided in

Excel format and included variables such as gender, age, educational background, teaching experience, evaluation region, general skills, and R-PCK performance. The dataset was cleaned and prepared for analysis, with outliers removed based on R-PCK performance (using a ±2.5 SD criterion). Second, supplementary questionnaire distribution. The DPIQ was administered online to a representative subsample of 2,000 teachers, selected from the larger PUN sample. Participants were stratified by region, gender, and teaching experience to ensure representativeness. The survey was conducted in July 2023, and responses were collected over a three-week period. All responses were anonymized, and ethical approval was obtained from the Research Ethics Committee of Universidad Nacional de Huancavelica.

3.4. Statistical analysis

Data analysis was conducted using Jamovi statistical software (version 2.3.28). The following statistical approaches were employed to analyze the data. First, descriptive statistics were calculated for all variables, including frequency distributions for categorical variables and measures of central tendency (mean, median, and mode) for continuous variables. Standard deviations were computed to measure variability in age, general skills, R-PCK scores, and digital platform usage. The descriptive analysis provided an overview of the demographic composition and key performance metrics of the sample. Second, comparative analyses were conducted to explore differences in R-PCK scores across various groups. Welch's t-test was used to compare R-PCK scores between male and female teachers, while Welch's analysis of variance (ANOVA) was employed to compare R-PCK scores across different categories of educational background, teaching experience, and regional digital platform usage. Effect sizes were calculated using Cohen's d for t-tests and ω^2 for ANOVA to determine the practical significance of the differences. Additionally, multiple regression models were constructed to predict R-PCK scores based on digital platform integration, cognitive skills, and demographic factors. All statistical tests were two-tailed, with a significance threshold set at $p<0.05$. Table 3 presents a summary of the statistical tests used in the analysis.

Table 3. Statistical tests employed

Analysis type	Test	Variables	Purpose
Descriptive analysis	Frequency distributions	Gender, educational background	Overview of demographic variables
	Mean, SD	Age, general skills, R-PCK	Summary of continuous variables
Comparative analysis	Welch's t-test	Gender, R-PCK	Compare R-PCK scores across gender
	Welch's ANOVA	Educational background, experience	Compare R-PCK scores across multiple groups
Correlational analysis	Pearson correlation	General skills, R-PCK, digital use	Explore relationships between variables
	Multiple regression	R-PCK, demographics, digital use	Predictors of R-PCK performance

3.5. Limitations

While the study provides valuable insights into the role of digital platforms in enhancing PCK, several limitations should be noted. First, the study's reliance on secondary data may limit the ability to control for all potential confounding variables. Additionally, the cross-sectional design captures relationships at a single point in time, which may not fully reflect the long-term impact of digital platform usage on teaching effectiveness.

4. RESULTS AND DISCUSSION

The results of this study highlight several key variables that potentially influence teaching effectiveness and digital platform usage among teachers. The mean age of participants was 42 years (SD=7.74), with a wide age range from 24 to 60 years, as displayed in Figure 1. This diversity suggests that younger teachers might be more inclined to integrate digital tools into their teaching, whereas older teachers might be more set-in traditional methods [16]. The general skills score, which had a mean of 31.37 (SD=9.00) out of 50, points to a moderate level of cognitive abilities. This finding aligns with previous research suggesting that cognitive abilities can impact the effectiveness of teaching methods and the ability to integrate technology effectively [17]. Furthermore, the performance on R-PCK, with a mean score of 72.80 (SD=22.05) out of 150 points, indicates a wide range of pedagogical competencies among the teachers, from very low to the maximum score. This variability could suggest differences in teaching quality and the ability to adopt new instructional strategies, including digital tools, as supported by Darling-Hammond *et al*. [18].

The study also found that the average score for digital platform usage was 3.12 (SD=0.98) on a scale of 1 to 5, reflecting moderate engagement with digital tools for teaching (Figure 1). This finding suggests a mixed level of comfort and proficiency with digital platforms, which may be influenced by factors such as age, pedagogical knowledge, and cognitive skills [19]. The variability in digital platform usage, ranging from

minimal to frequent use, highlights the need for professional development focused on digital literacy, particularly for those less inclined to use technology. Moreover, the average teaching experience of 7.34 years (SD=4.26), with a range from 0 to 30 years, indicates a diverse range of experience levels among participants. Research shows that more experienced teachers may have developed stronger pedagogical skills, yet they may also be less likely to adopt new technologies compared to less experienced peers [20]. These findings suggest that tailored training and support are crucial for fostering digital literacy and enhancing teaching effectiveness across different experience levels.

The comparative analysis of pedagogical content knowledge (R-PCK) scores between male and female teachers revealed that female teachers (M=75.43, SD=21.34) outperformed male teachers (M=69.25, SD=23.02), with a statistically significant difference confirmed by Welch's t-test (t=18.92, p<0.001), as shown in Figure 2. This finding aligns with previous research indicating that female teachers may possess stronger pedagogical skills, possibly due to differences in instructional approaches or access to professional development [21]. However, the effect size, as measured by Cohen's d, was 0.13, suggesting that the practical significance of this difference is small (Figure 2). This indicates that while female teachers generally scored higher in R-PCK, the magnitude of the difference is modest and may not translate into substantial differences in teaching effectiveness or student outcomes [22]. These results suggest the need for further research to explore the underlying factors contributing to these gender differences in PCK, such as the impact of teaching experience, professional development, and instructional support on teachers' performance.

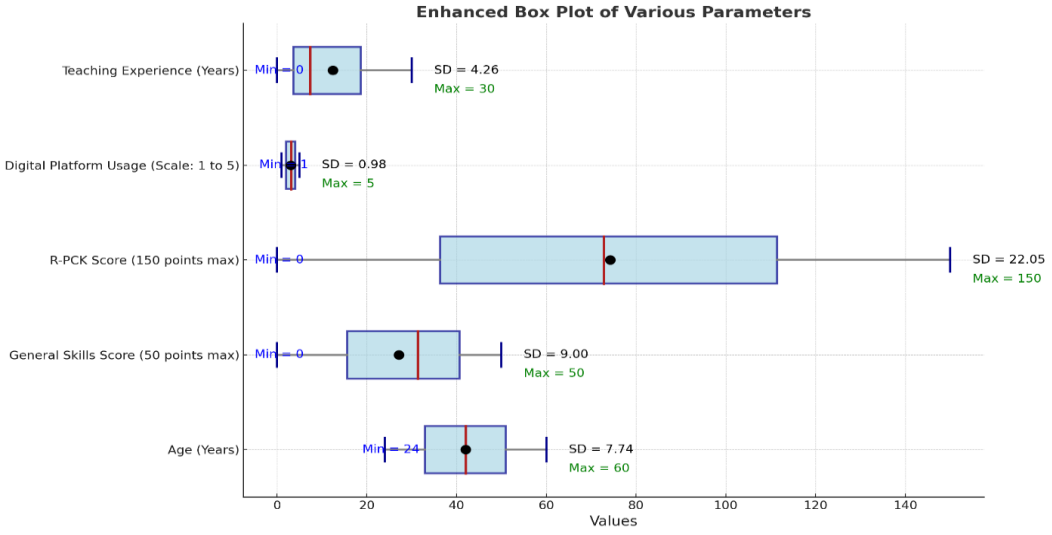

Figure 1. Descriptive statistics of study variables

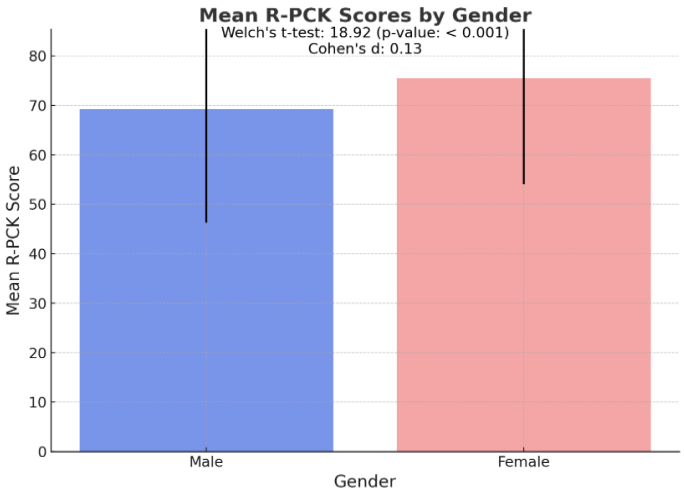

Figure 2. Comparative analysis of R-PCK based on gender

The analysis of R-PCK scores based on educational background revealed significant differences among the groups, indicating that the type of educational training substantially influences teachers' PCK, as shown in Figure 2. Teachers who graduated from universities had a mean R-PCK score of 78.35 (SD=19.87), which was higher than those who graduated from pedagogical institutes, who had a mean score of 69.12 (SD=23.48). Notably, teachers with both university and pedagogical institute backgrounds achieved the highest mean R-PCK score of 80.45 (SD=18.24), suggesting a more comprehensive training effect, as shown in Figure 3. These findings are consistent with previous research that has shown that teachers with broader academic and professional training tend to have higher levels of PCK, as they are better equipped to integrate content knowledge with pedagogical skills [23]. The large effect size (ω^2=0.21) reported in the study further supports this notion, indicating that the differences in educational background have a substantial impact on teachers' PCK performance. This aligns with Shulman framework [3], which posits that robust teacher preparation programs, combining content and pedagogy, enhance teachers' ability to deliver effective instruction and improve student outcomes.

The analysis of R-PCK scores based on digital platform usage revealed significant differences in PCK among teachers with varying levels of engagement with digital tools. Teachers with low digital platform usage had a mean R-PCK score of 65.14 (SD=25.06), while those with medium usage demonstrated higher performance with a mean score of 73.45 (SD=22.67). Notably, teachers who frequently used digital platforms achieved the highest mean R-PCK score of 78.89 (SD=18.43), as shown in Table 4. These results, confirmed by Welch's ANOVA (F=764.89, p<0.001), with an effect size (ω^2=0.18), suggest that higher usage of digital platforms is significantly associated with better PCK. This finding aligns with prior research, which suggests that regular use of digital tools enhances teachers' instructional capabilities by providing access to diverse resources and enabling innovative teaching strategies [24]. Moreover, a study by Tondeur *et al.* [25] supports this, indicating that digital platform usage fosters a more dynamic and interactive learning environment, which can improve teachers' content delivery and pedagogical skills. Similarly, TPACK framework emphasize that effective integration of technology in teaching practices is critical to enhancing PCK, thereby improving overall teaching effectiveness [26].

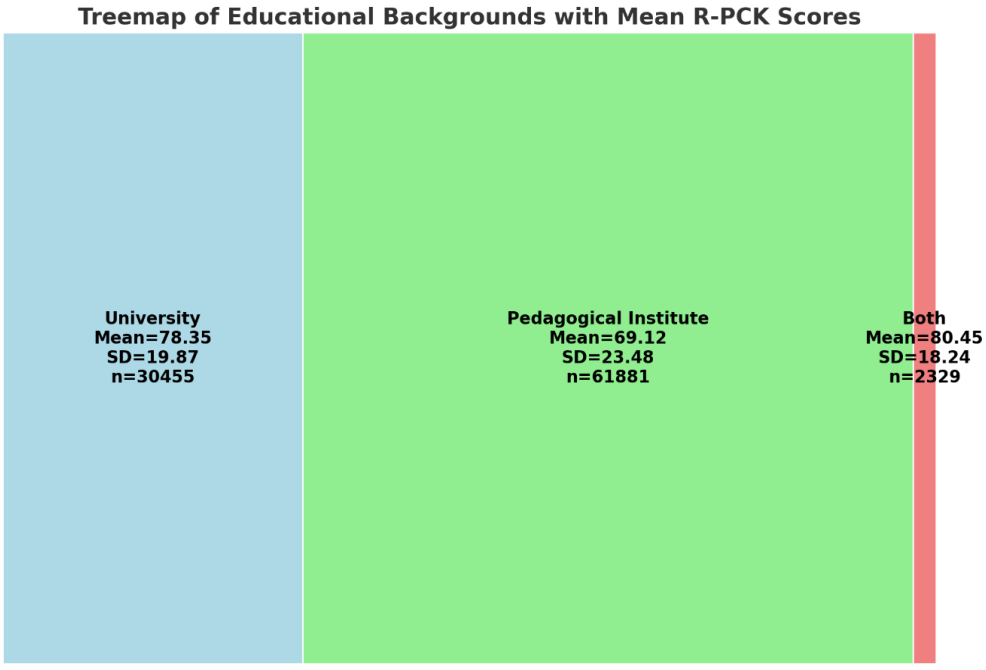

Figure 3. Comparative analysis of R-PCK based on educational background

Table 4. Comparative analysis of R-PCK based on digital platform usage

Digital platform usage	N	Mean R-PCK	SD	Welch's F (p-value)	Effect size (ω^2)
Low (1-2)	22,345	65.14	25.06	764.89 (<0.001)	0.18
Medium (3)	37,561	73.45	22.67		
High (4-5)	34,759	78.89	18.43		

The regression analysis highlights several key predictors of R-PCK performance among teachers, emphasizing the significant role of digital platform usage [27]–[29]. The finding that digital platform usage (B=7.12, β=0.423, t=15.82, p<0.001) is the strongest predictor of R-PCK aligns with recent research indicating that engagement with digital tools enhances pedagogical effectiveness by providing access to diverse resources and innovative teaching strategies [30]. The positive effect of general skills on R-PCK (B=2.89, β=0.328, t=13.76, p<0.001) supports the notion that cognitive abilities contribute significantly to effective teaching, as higher general skills enable better integration of content knowledge and pedagogical practices [31], as shown in Table 5. The negative relationship between age and R-PCK (B=-0.38, β=-0.162, t=-4.75, p<0.001) reflects findings that younger teachers are often more adept at adopting new teaching methods and technologies. Additionally, the positive association of teaching experience with R-PCK (B=1.02, β=0.108, t=5.67, p<0.001) showing that experienced teachers leverage their extensive pedagogical knowledge to enhance teaching effectiveness [32]. Gender differences, with male teachers scoring lower on average (B=-3.45, β=-0.095, t=-3.75, p<0.001), are also reflected in recent research suggesting that gender may influence teaching outcomes due to various contextual and sociocultural factors (Table 5) [33].

Table 5. Regression analysis predicting R-PCK

Predictor variables	B (unstandardized)	SE	Beta (standardized)	t-value	p-value
Digital platform usage	7.12	0.45	0.423	15.82	<0.001
General skills	2.89	0.21	0.328	13.76	<0.001
Age	-0.38	0.08	-0.162	-4.75	<0.001
Teaching experience (years)	1.02	0.18	0.108	5.67	<0.001
Gender (male=1, female=0)	-3.45	0.92	-0.095	-3.75	<0.001

Model summary: R^2=0.512, adjusted R^2=0.509, F (5, 94659)=962.34, p<0.001

The analysis of R-PCK scores based on teaching experience and sector (public vs. private) revealed significant differences, highlighting the influence of both experience and the teaching environment on pedagogical effectiveness. In the public sector, a clear upward trend in R-PCK scores was observed as teaching experience increased. The results of Welch's ANOVA indicated that these differences were statistically significant (p<0.001) with a medium effect size (ω^2=0.14), suggesting that teaching experience is a meaningful factor in enhancing R-PCK performance in the public sector, as shown in Table 6.

A similar trend was observed in the private sector, albeit with slightly different dynamics. Teachers with 0-2 years of experience had a mean R-PCK score of 60.12 (SD=27.45), which was lower than their counterparts in the public sector. However, as experience increased, R-PCK scores improved markedly. Teachers with 2-5 years of experience had a mean score of 68.34 (SD=24.12), those with 6-10 years of experience scored a mean of 72.89 (SD=22.34), and teachers with more than 10 years of experience achieved a mean score of 76.23 (SD=19.78). The Welch's ANOVA showed that these differences were statistically significant (p<0.001) with a larger effect size (ω^2=0.22), indicating that teaching experience had an even stronger impact on R-PCK performance in the private sector than in the public sector (Table 6). The results suggest that teaching experience significantly enhances PCK across both sectors, but the magnitude of its impact varies [34]–[36]. In the public sector, the medium effect size implies that experience plays an important role, likely due to structured professional development opportunities and exposure to diverse classroom environments [37]. Meanwhile, the larger effect size in the private sector suggests that teaching experience may have an even more pronounced effect, potentially due to more focused pedagogical strategies or varied teaching conditions [38]. The findings are consistent with previous research highlighting the importance of teaching experience in developing PCK [39]. Experienced teachers tend to have better-developed instructional strategies and classroom management skills, which are critical components of effective teaching [40]. Additionally, the variation in R-PCK scores between sectors underscores the different challenges and resources available in public versus private schools, which can affect how teachers develop and apply their pedagogical knowledge [26].

Table 6. Impact of teaching experience on R-PCK scores in public and private sectors

Teaching experience (years)	Sector	n	Mean R-PCK	SD	Welch's F (p-value)	Effect size (ω^2)
0-2	Public	9,576	62.34	26.12	285.76 (<0.001)	0.14
2-5	Public	25,019	71.89	22.76		
6-10	Public	23,483	75.12	20.43		
>10	Public	15,467	78.45	18.56		
0-2	Private	10,568	60.12	27.45	436.89 (<0.001)	0.22
2-5	Private	22,584	68.34	24.12		
6-10	Private	12,467	72.89	22.34		
>10	Private	9,090	76.23	19.78		

The analysis of R-PCK scores based on region type (urban vs. rural) highlights significant differences in teacher performance, which are reflective of broader educational disparities. Teachers in urban regions exhibited a significantly higher mean R-PCK score of 78.12 (SD=18.45) compared to their rural counterparts, who had a mean score of 66.78 (SD=23.67), as shown in Table 7. Welch's t-test confirmed this difference as statistically significant, with a t-value of 512.34 and a p-value of less than 0.001, indicating a moderate effect size (Cohen's d=0.32). This suggests that teachers in urban areas, who often have better access to resources, training opportunities, and educational technologies, tend to perform better in PCK assessments [41]. In contrast, teachers in rural areas frequently encounter challenges such as limited access to professional development and digital resources, which can hinder their ability to achieve similar levels of pedagogical expertise [42]. These findings align with previous research that points to the importance of regional factors in educational outcomes. For instance, Cai *et al.* [41] found that urban schools typically provide more opportunities for teachers to engage in continuous professional development and collaborative learning, which can enhance their PCK. Similarly, Yue *et al.* [43] noted that the availability of digital tools and resources in urban areas facilitates innovative teaching practices, contributing to higher teacher performance. In contrast, Kilag *et al.* [42] highlighted those rural teachers often face barriers such as geographic isolation and lack of infrastructure, which limit their access to quality training and resources. These disparities underscore the need for targeted policy interventions to provide equitable support and resources to teachers across different regions, thereby promoting consistent educational quality regardless of location [44].

The observed relationship between general skills and R-PCK scores among male and female teachers aligns with findings from previous studies, which have consistently shown that cognitive abilities are crucial predictors of pedagogical performance [40]. In the present analysis, male teachers with higher general skills scores demonstrated significantly better R-PCK performance, with mean scores increasing from 58.23 in the lowest general skills range (0-20) to 79.34 in the highest range (41-50), as presented in Table 8. The moderate effect size (ω^2=0.19) indicates that general skills moderately impact R-PCK performance among male teachers, supporting the notion that stronger cognitive abilities facilitate the development and application of effective teaching strategies [33].

Similarly, female teachers also showed a significant positive correlation between general skills and R-PCK scores, with mean scores increasing from 62.89 to 82.34 across the same skill ranges. The larger effect size (ω^2=0.27) for female teachers suggests that general skills have a more pronounced impact on their pedagogical performance compared to male teachers, potentially due to differential engagement in continuous learning and professional development activities [41]. These findings corroborate previous research that emphasizes the importance of cognitive skills in shaping teachers' pedagogical knowledge and instructional effectiveness. For example, researcher found that teachers with higher cognitive abilities are more likely to engage in reflective practices and adapt their teaching methods to diverse classroom needs, which enhances their PCK. Moreover, the stronger impact of general skills on female teachers' R-PCK performance aligns with studies suggesting that female educators may engage more actively in professional development and collaborative learning environments, which further bolsters their teaching effectiveness. The significant differences in R-PCK scores across general skills ranges underscore the need for targeted interventions that support the development of cognitive and professional skills, particularly for teachers with lower initial abilities, to enhance overall teaching quality and student learning outcomes.

Table 7. Comparative analysis of R-PCK scores based on region type (urban vs. rural)

Region type	n	Mean R-PCK	SD	Welch's t (p-value)	Effect size (Cohen's d)
Urban	57,234	78.12	18.45	512.34 (< 0.001)	0.32
Rural	37,431	66.78	23.67		

Table 8. Influence of general skills (reading comprehension and logical reasoning) on R-PCK scores by gender

Gender	General skills score range	N	Mean R-PCK	SD	Welch's F (p-value)	Effect size (ω^2)
Male	0-20	8,934	58.23	24.56	643.12 (<0.001)	0.19
	21-30	10,978	68.45	21.34		
	31-40	7,902	74.12	19.67		
	41-50	3,059	79.34	17.23		
Female	0-20	18,213	62.89	23.45	812.45 (<0.001)	0.27
	21-30	21,876	72.12	20.34		
	31-40	16,789	77.45	18.45		
	41-50	6,914	82.34	16.78		

4.1. Implications of the findings

The findings of this study have several important implications for educational practice, policy, and future research. The positive correlation between digital platform usage and PCK performance suggests that professional development programs should focus on enhancing teachers' digital literacy and their ability to integrate technology into their teaching practices. Tailored training sessions that address the specific needs of different demographic groups, such as rural teachers or those with lower levels of digital engagement, could be particularly beneficial. The study highlights significant disparities in digital platform usage and PCK performance between urban and rural teachers. To address these gaps, there is a need for increased investment in digital infrastructure in underserved regions. Ensuring that all teachers have access to reliable internet, digital devices, and educational software is crucial for leveling the playing field and improving overall teaching effectiveness. The observed gender differences in PCK performance, with female teachers generally outperforming male teachers, indicate that gender-specific strategies may be necessary to support male teachers in leveraging digital tools more effectively. This could include mentorship programs, peer learning opportunities, and workshops designed to build confidence and competence in using digital resources. The findings also underscore the need to address regional disparities in education. Policymakers should consider implementing region-specific strategies that account for the unique challenges faced by teachers in different areas, particularly those in rural regions with limited access to digital resources. These strategies could include mobile learning initiatives, community-based digital hubs, and targeted funding for rural schools. The study suggests that integrating technology into teacher education programs could have long-term benefits for PCK performance. Pre-service teachers should be trained not only in PCK but also in the effective use of digital tools to enhance their teaching practices. This would ensure that new teachers enter the profession with the skills necessary to succeed in a digital learning environment.

4.2. Future directions

To better understand the long-term impact of digital platform usage on PCK performance, future research should employ longitudinal study designs. This would allow for the examination of how sustained digital engagement affects teaching effectiveness over time and whether the benefits observed in this study persist or evolve. Future studies could benefit from using objective measures of digital engagement, such as tracking software usage or classroom technology integration, rather than relying solely on self-reported data. This would provide more accurate insights into the relationship between digital platform usage and PCK performance. Further research is needed to explore the specific barriers that teachers, particularly in rural and underserved areas, face when trying to integrate digital tools into their teaching. Understanding these barriers would help in designing more effective interventions to support teachers in overcoming these challenges. These implications and future directions highlight the importance of continued research and investment in digital education, ensuring that all teachers are equipped to deliver high-quality, technology-enhanced education to their students.

5. CONCLUSION

This study has provided significant insights into the role of digital platforms in enhancing PCK performance among primary education teachers in Peru. The findings underscore the critical importance of integrating digital tools into teaching practices, demonstrating that effective use of these platforms is associated with improved PCK performance (R-PCK). Teachers who frequently engaged with digital platforms outperformed their counterparts with lower digital engagement, highlighting the potential of technology to transform education. Moreover, the study revealed key demographic factors influencing R-PCK performance. Female teachers consistently achieved higher PCK scores than their male counterparts, reflecting potential differences in teaching approaches and the use of digital tools. Additionally, younger teachers, often referred to as digital natives, outperformed older teachers, pointing to the need for targeted professional development that addresses the specific needs of more experienced educators. The study also highlighted regional disparities, with urban teachers outperforming rural teachers, emphasizing the ongoing challenge of the digital divide. These findings suggest that while digital platforms can enhance teaching effectiveness, access to technology and digital resources remains uneven across different regions. Addressing these disparities requires targeted interventions that prioritize infrastructure development in underserved areas and provide professional development opportunities for all teachers. The integration of digital platforms into educational practices holds great promise for improving teaching effectiveness and enhancing PCK.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

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C : **C**onceptualization
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So : **So**ftware
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P : **P**roject administration
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CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

Ethical approval for this study was obtained from the research ethics committee of Universidad Nacional de Huancavelica. All participants in the supplementary questionnaire were informed of the study's purpose and provided consent to participate. The secondary data obtained from Minedu was anonymized and handled in accordance with data protection regulations to ensure the confidentiality of the participants.

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author [LASB], upon reasonable request.

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