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Empowering female teachers through digital competence and AI integration to improve teaching effectiveness in Islamic Schools in Southern Pakistan

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Abstract

Female teachers in Islamic schools in Southern Punjab, Pakistan face unequal digital access, minimal Artificial Intelligence (AI) integration, and stark variations in digital competence. These conditions undermine teaching effectiveness and professional empowerment, with extreme regional disparities that cannot be ignored. This study analyzes regional differences in digital technology utilization, AI adoption, and informal digital learning, as well as how variations in access, digital competency, and institutional support influence teaching effectiveness among female teachers in Islamic secondary schools. Using a quantitative approach, the study examined the effects of digital competency, AI use, and informal digital learning on teaching effectiveness with 450 valid and reliable respondents, employing multiple regression analysis. The findings indicate that the empowerment of female teachers in Southern Pakistan varies across districts. First, female teachers' contributions to instructional tasks differ regionally. Second, workload distribution and technology adoption also vary. Third, female teachers demonstrate strong digital competence and actively engage in informal learning; however, technology adoption is influenced by regional contexts. The study concludes that the empowerment of female teachers through digital competence and AI in Southern Pakistan is shaped by regional contexts. Variations in contributions across districts indicate a dependence on local ecosystems and adaptive capacity, rather than merely access to technology. This study contributes to highlighting the importance of institutional support, revealing structural inequalities, and emphasizing the role of informal learning over AI adoption in empowering female teachers.

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INTRODUCTION

The accelerated integration of digital technology and artificial intelligence (AI) in education presents significant challenges for female teachers in Islamic secondary schools in Southern Pakistan, particularly in rural areas that continue to experience limited digital infrastructure and restricted access to formal professional training (Aruleba & Jere, 2022; Mustafa et al., 2024). Many female teachers are still developing foundational digital competencies, while the quality of learning is increasingly determined by teachers' ability to employ adaptive learning systems, automated assessment, and AI-based tools in ethical and contextually appropriate ways (Divanji et al., 2023; Katona & Gyonyoru, 2025). This mismatch between technology-driven pedagogical demands and teachers' actual readiness constitutes a structural issue with direct implications for the quality of Islamic education in the region (Zakharova et al., 2024; Tan et al., 2025).

Previous studies have extensively examined digital competence as a key determinant of technology-enhanced teaching effectiveness. The use of digital technology is associated with perceived usefulness and adaptive teaching profiles, and contributes to ICT integration and teachers' digital pedagogical competence (Guillén-Gámez et al., 2023; Cattaneo et al., 2025; Dringo-Horvath et al., 2025; Rosyidah et al., 2025). In rural contexts, limited resources encourage informal digital learning, while AI has the potential to enhance instructional quality, although its adoption remains limited (Guan et al., 2024; Galindo-Domínguez et al., 2024; Metwally & Bin-Hady, 2025). Although no significant gender differences in ICT knowledge have been identified, female teachers' technological capacity tends to develop through informal strategies, and empirical evidence in Southern Punjab remains scarce (Sánchez-Prieto et al., 2020; Alieto et al., 2024; Rehman et al., 2025). Therefore, this study addresses the research gap by examining variations in contributions, workload distribution, and the empowerment of female teachers through digital competence, AI, and regional, institutional, and gender-related factors.

This study aims to analyze variations in female teachers' contributions, workload distribution, and empowerment through digital competence, AI, and informal learning within regional and institutional contexts in Southern Pakistan. Accordingly, three research questions are proposed: (1) how variations in female teachers' contributions across districts are influenced by digital access, competence, and institutional support; (2) how patterns of workload distribution and digital self-efficacy are shaped by gender, and why female teachers outperform males in some regions while male dominance persists in others; and (3) to what extent digital competence, AI, and informal learning empower female teachers, and why independent content adaptation and AI personalization remain limited. Therefore, this study seeks to uncover regional and gender disparities, reinforce the role of informal learning, and emphasize the importance of institutional support and contextual readiness in enhancing female teachers' effectiveness and empowerment.

This study is grounded in the argument that the fundamental issue faced by female teachers in Islamic secondary schools in Southern Pakistan is not a lack of basic digital competence which is relatively strong but rather structural and contextual inequalities. In Kot Addu and Muzaffargarh, supportive environments enable female teachers to outperform their male counterparts, whereas in Jatoi and Shah Sultan, male dominance reflects persistent normative barriers. Paradoxically, in Mailsi, female teachers carry the highest workload yet demonstrate the lowest participation and task completion, indicating that increased effort is not matched by digital confidence. Although AI training has been well received, understanding of AI personalization and independent content adaptation remains limited. Addressing these challenges requires more than technical training; it necessitates gender-sensitive policy

interventions grounded in local wisdom, including strengthening sustained informal learning, ensuring distributive workload equity, and providing contextualized AI adaptation support, particularly in regions with significant structural constraints.

METHOD

Research Approach

This study aims to analyze regional differences in digital technology use, artificial intelligence (AI) adoption, and the role of informal digital learning in enhancing the professional effectiveness of female teachers in Islamic secondary schools. The study also explores how variations in technology access, digital competency readiness, and institutional support across tehsils influence technology adoption and teaching performance among female teachers. To achieve these objectives, a quantitative research design was employed, which White (2023) identifies as suitable for examining measurable cause-and-effect relationships between variables. This approach allows the evaluation of the effects of digital competence, AI use, and informal digital learning on female teachers' teaching effectiveness. Bazen et al. (2021) emphasize that quantitative analysis provides a robust foundation for systematic and objective hypothesis testing.

Population and Sampling Procedure

The study population consisted of approximately 620 female teachers teaching in Islamic secondary schools in rural South Punjab, Pakistan, based on school administrative data. Purposive sampling was used to select respondents relevant to the study's objectives. According to Ahmed (2024), this method is appropriate when researchers require participants with specific characteristics, while Morea (2022) asserts that it allows the selection of respondents with direct experience of the phenomenon under study. Consequently, only female teachers exposed to digital platforms, AI applications, and informal digital learning were included. From a population of 620 teachers, Krejcie and Morgan tables suggested a minimum of 240 respondents (Asare, 2025). The study collected 450 valid responses to enhance data reliability and stability of findings.

Research Instruments

Data were collected using a structured questionnaire distributed via Google Forms to ensure accessibility for teachers in rural areas with diverse teaching schedules. The instrument comprised five sections: demographic data, digital competence scale, AI usage in teaching, informal digital learning, and teaching effectiveness. According to Heo et al. (2022), a five-point Likert scale is effective for capturing respondents' perceptions in a measurable way. Additionally, Mårtensson et al. (2016) assert that a structured instrument with clear indicators enables systematic assessment of technology use and teaching effectiveness.

Validity and Reliability

To ensure methodological rigor, several procedures were conducted. Content validity was assessed through expert review by three specialists in educational technology and Islamic education to evaluate the clarity, relevance, and appropriateness of items for the measured constructs. Construct validity was further analyzed using exploratory factor analysis (EFA) in SPSS to confirm factor structure and eliminate items with low factor loadings. Reliability tests calculated Cronbach's alpha for each scale: digital competence (0.87), AI use (0.89), informal digital learning (0.85), and teaching effectiveness (0.91), all exceeding the 0.70 threshold, indicating high internal consistency.

Data Analysis

Data were analyzed using SPSS through systematic statistical procedures. Descriptive statistics described respondents' demographic characteristics. Reliability and validity were verified via Cronbach's alpha and factor analysis. Multicollinearity was examined using variance inflation factor (VIF) and tolerance values (Li, 2021). Normality and heteroskedasticity tests were conducted to assess regression model assumptions (Cardoso et al., 2023). Once assumptions were satisfied, multiple regression analysis tested the effects of digital competence, AI use, and informal digital learning on teaching effectiveness, with t-tests determining the significance of each predictor's contribution (Ratnasari et al., 2023).

Conceptual Framework

This study examines the relationships among three main independent variables: digital competence, AI use, and informal digital learning as predictors of female teachers' teaching effectiveness in Islamic secondary schools in South Punjab, Pakistan, including their combined effects. The framework reflects the reality that modern educational effectiveness increasingly requires digital technology integration, particularly in resource-limited areas such as the Kot Addu District. The model aligns with educational technology research emphasizing female teachers' readiness and ethical use of digital resources to support classroom innovation and performance.

RESULTS AND DISCUSSION

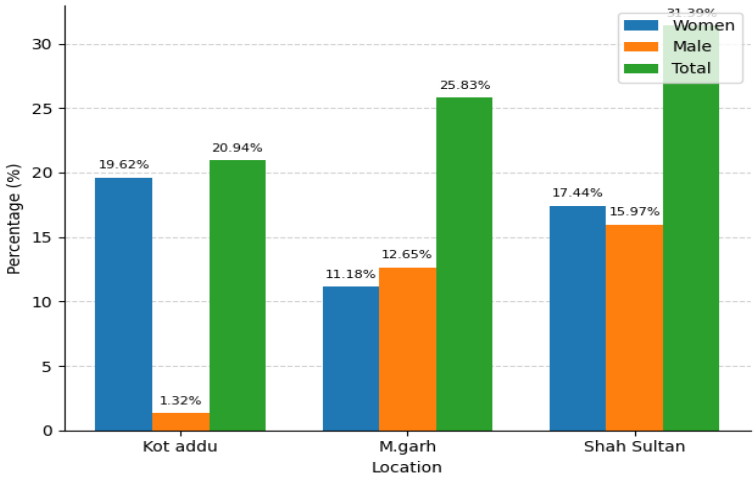
Results

Regional differences in digital technology use and female teacher performance

Based on questionnaire data, the use of digital technology and AI among female teachers in Kot Addu, Muzaffargarh, and Shah Sultan shows regional variation. Social environment, infrastructure, and organizational support influence technology adoption in Islamic secondary schools. Access to digital technology functions as an instrument of professional empowerment. This study examines how differences in access, digital readiness, and institutional support contribute to variations in technology utilization among female teachers.

Figure 1

Use of digital tools and AI usage among Female Teachers



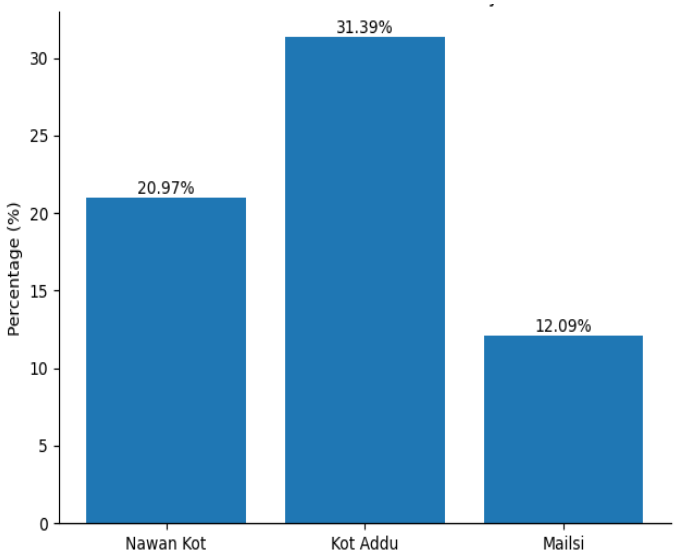
Source: Compiled by the researcher, 2025

Figure 1 shows that female teachers' contributions to instructional tasks vary across districts. In Kot Addu, they account for 19.62% of workload and complete 20.94% of tasks.

Khan Garh records the highest contribution (25.83%), comprising 11.18% implementation and 12.65% completion. In Mailsi, implementation reaches 14.09%, but completion is only 8.76% (total 20.84%). Nawan Kot reports 17.44% implementation and 15.9% completion. These variations indicate that female teachers' participation and effectiveness are influenced by digital access, competency readiness, and institutional support across districts.

Figure 2

Performance of Women Teachers



Source: Compiled by the researcher, 2025

Figure 2 shows that female teachers contribute 31.39% to the overall educational performance in the study area. Their performance is most prominent in Tehsil Nawan Kot, reaching 20.97% higher than other regions, while in Tehsil Mailsi it is only 12.09%. These findings highlight that better access to digital resources and educational technologies plays a crucial role in enhancing productivity, work effectiveness, and strengthening the professional competence and empowerment of female teachers within the education system.

Based on the findings, it can be concluded that female teachers' contributions to instructional tasks vary across districts. Khan Garh records the highest performance, with a strong balance between task implementation and completion. Kot Addu shows nearly equal levels of participation and completion. In Nawan Kot, implementation is relatively high, but completion is lower. In contrast, Mailsi exhibits low implementation and the lowest completion rates, resulting in less optimal contribution. Overall, female teachers make a significant contribution to total educational performance, with the most prominent achievement in Nawan Kot, surpassing other regions, while Mailsi ranks the lowest. This pattern of variation indicates that access to digital technology, competency readiness, and institutional support across districts significantly influence participation, work effectiveness, and the professional empowerment of female teachers within the education system.

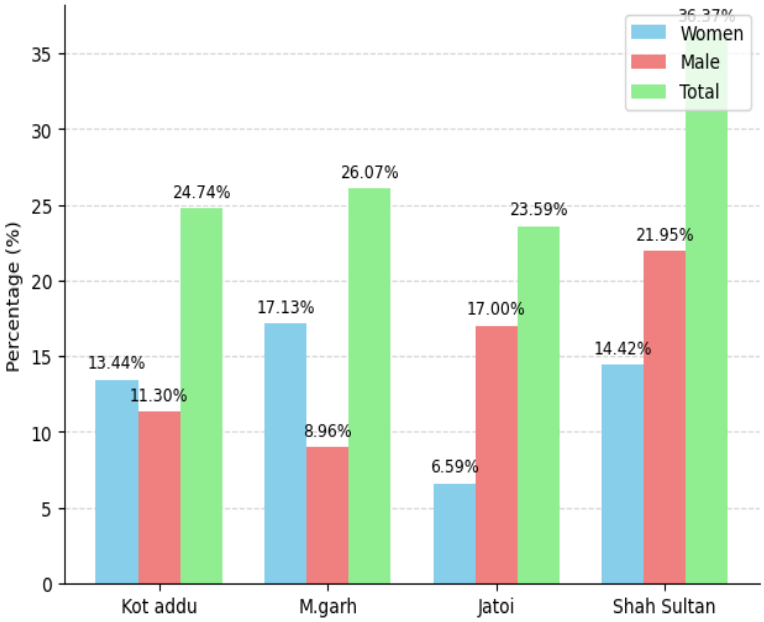
Distribution of digital competencies and gender-based learning in Tehsils

Based on questionnaire data, the distribution of gender-based digital competence utilization across different tehsils shows significant variation in the implementation of educational technology. These differences reflect the division of teaching roles as well as disparities in access, self-confidence, and institutional support in each region. Digital competence emerges as a key factor in enhancing professional capacity and empowering

female teachers in the teaching and learning process. The subsequent findings are presented in Figure 3 below.

Figure 3

Uses of Digital competencies in Technology for Educational Purposes

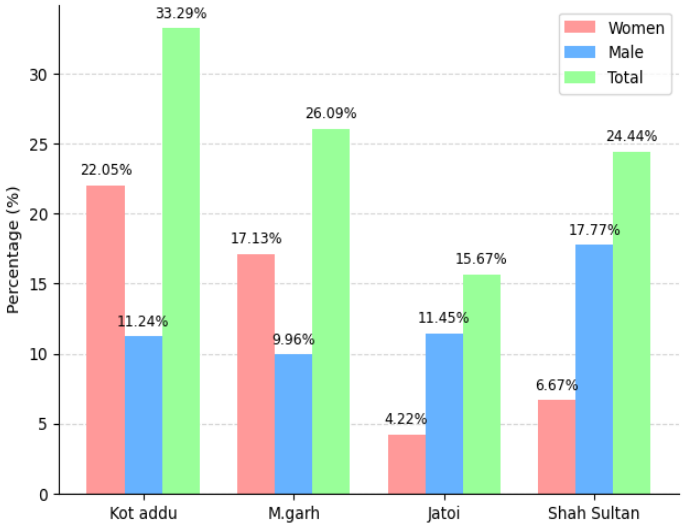


Source: Compiled by the researcher, 2025

Figure 3 shows that the distribution of teaching workload across tehsils varies, with the combined contribution of female teachers and other groups highest in Khan Garh (26.07%), followed by Kot Addu (24.74%), Mailsi (23.59%), and Nawan Kot (21.95%). Overall, female teachers account for 36.37% of the total educational workload. Notably, female teachers in Mailsi handle a workload 23.95% higher than other regions, despite receiving only 6.59% additional tasks. In contrast, female teachers in Nawan Kot demonstrate higher digital self-confidence in using educational technology. These variations reflect differences in professional capacity, access to digital competence, and institutional support that influence participation and the empowerment of female teachers.

Figure 4

Informal Digital Learning for Educational Technology Use



Source: Compiled by the researcher, 2025

Figure 4 shows a clear gender-based pattern across different tehsils. In Tehsil Kot Addu, female teachers make the highest contribution at 22.05%, compared to male teachers at 11.24%, with a combined teaching performance of 33.29%. A similar pattern is observed in Tehsil Khan Garh, where female teachers' contribution (17.13%) also exceeds that of male teachers (9.96%), resulting in a total performance of 26.09%. In contrast, Tehsil Mailsi records the lowest participation of female teachers, at only 4.22%. Meanwhile, Tehsil Nawan Kot shows female teacher participation at 17.77%, making it the second highest after Kot Addu. Additionally, Kot Addu stands out in educational outcomes, with female students demonstrating better performance in using digital tools and higher levels of trust in female teachers.

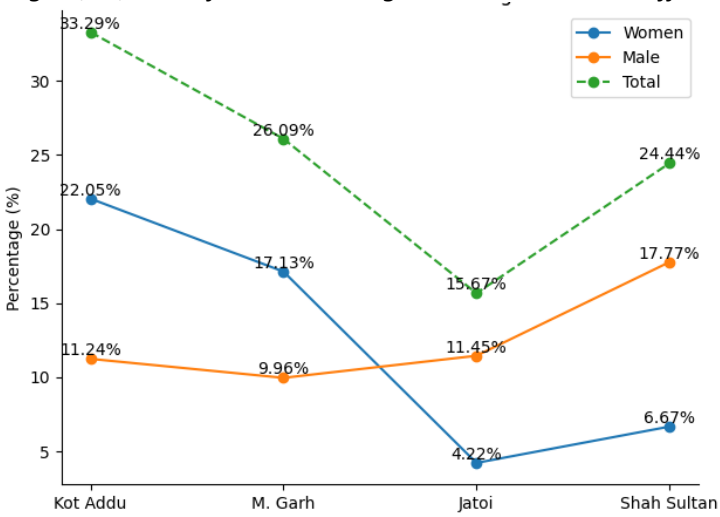
Based on the findings, it can be concluded that workload distribution shows the highest combined contribution in Khan Garh, followed by Kot Addu, Mailsi, and Nawan Kot. Overall, female teachers contribute more than one-third of the total educational workload, with Mailsi recording a significantly higher workload compared to other regions despite receiving only a small increase in additional tasks. In contrast, Nawan Kot demonstrates higher digital self-confidence. From a gender-based perspective, Kot Addu records female teachers' contributions surpassing those of males, with female students also performing better and showing higher trust in female teachers. Khan Garh exhibits a similar pattern, while Mailsi has the lowest level of participation. In conclusion, a higher workload does not necessarily correspond to greater digital confidence, as institutional support and access to technology play a crucial role in shaping the effectiveness of female teacher empowerment.

Digital technology, AI, and informal learning empowering female teachers

Furthermore, the combined influence of digital device use, artificial intelligence (AI), and informal learning on the effectiveness of female secondary school teachers in utilizing technology for educational purposes was also analyzed. This analysis was conducted based on gender differences and tehsil-level variations, allowing for a more comprehensive understanding of differences in contributions, technology adoption patterns, and contextual support affecting female teachers' performance in using educational technology.

Graph 1

Digital, AI, and Informal Learning in Female Teachers' Effectiveness



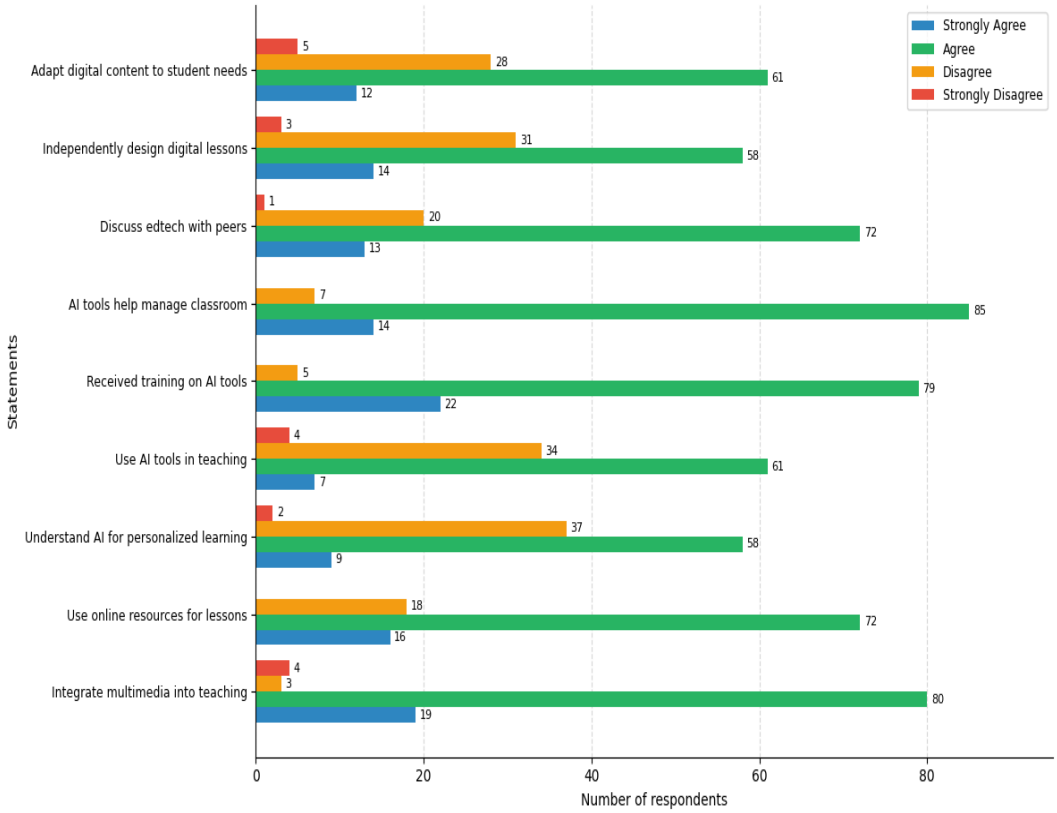
Source: Compiled by the researcher, 2025

Graph 1 shows that the contributions of female and male teachers in utilizing digital tools, artificial intelligence, and informal learning toward technological effectiveness vary

across regions. In Kot Addu, female teachers contribute 22.05%, significantly surpassing male teachers at 11.24%, with a combined performance of 33.29%. A similar pattern appears in Muzaffargarh, where female teachers contribute 17.13% compared to 9.96% for males, resulting in a total of 26.09%. In contrast, in Jatoi, female teachers contribute only 4.22%, far below male teachers at 11.45%, with a total of 15.67%. Meanwhile, in Shah Sultan, female teachers contribute 6.67%, while males dominate at 17.77%, producing a total performance of 24.44%. These data indicate that gender dominance in the adoption of educational technology is strongly influenced by regional context.

Figure 5

Teacher Digital Competency, AI Usage, and Informal Digital Learning



Source: Compiled by the researcher, 2025

Figure 5 shows that female teachers' basic digital competence is relatively high, with most expressing confidence in using digital tools and integrating multimedia into teaching. The use of online resources for lesson preparation is also widespread. However, understanding of AI-based personalized learning remains moderate, with only a small proportion strongly agreeing. The use of AI tools such as ChatGPT is still limited, although AI training has been well received and AI is considered helpful for classroom management. Informal digital learning through peer discussions is also quite active. The main challenges lie in teachers' ability to independently design learning using digital platforms and to adapt content based on students' needs, which still require improvement. Overall, female teachers have a solid foundation of digital competence, but AI adoption and independent digital content adaptation remain areas that need further development.

Based on the findings, it can be concluded that female teachers possess a strong foundation of basic digital competence, including confidence in using digital tools and multimedia, as well as active engagement in informal learning. However, the actual utilization of technology from a gender perspective is highly influenced by regional contexts. In areas

such as Kot Addu and Muzaffargarh, female teachers' contributions to the adoption of digital technology and AI surpass those of male teachers, reflecting supportive environments that enable their competencies to be fully realized. In contrast, in Jatoi and Shah Sultan, male dominance indicates the presence of structural and normative barriers that limit female participation. Furthermore, although AI training has been well received, in-depth understanding of AI personalization and the independent ability to design and adapt digital content remain limited. Therefore, the main conclusion is that improving technical competence alone is insufficient; contextual interventions addressing structural inequalities and strengthening female teachers' adaptive capacity in independently utilizing AI are essential.

Discussion

This study shows that the empowerment of female teachers through digital competence and AI integration in Southern Pakistan is shaped by regional contexts. First, female teachers' contributions vary: Khan Garh is the highest and most balanced, Kot Addu remains stable, Nawan Kot shows high implementation but lower completion, and Mailsi records the lowest outcomes. Second, workload distribution and technology adoption differ: Khan Garh ranks highest, Mailsi has high workload but low participation, Nawan Kot demonstrates strong digital confidence, and Kot Addu shows good performance and student trust. Third, female teachers possess strong digital competence and actively engage in informal learning, but technology adoption is context-dependent; female contributions surpass males in some regions, while male dominance persists in others.

This study reveals that the empowerment of female teachers through digital competence and AI integration in Southern Pakistan is influenced by regional contexts. Female teachers' contributions vary across districts: Khan Garh shows the highest and most balanced performance, Kot Addu remains stable, Nawan Kot demonstrates high implementation but lower completion, while Mailsi records the lowest outcomes. These variations reflect gender-based digital disparities, particularly in rural areas with limited infrastructure. In the accelerated post-pandemic digital transformation, unequal access to technology and institutional support reinforces structural inequalities. Luo and Liu (2025) emphasize that access and experience shape teachers' digital readiness. Workload distribution and technology adoption also vary: Khan Garh is highest, Mailsi shows high workload but low participation, Nawan Kot demonstrates strong digital confidence, and Kot Addu shows strong performance and student trust. This is consistent with Hennessy et al. (2022), Ragnedda et al. (2022), and Babirye et al. (2022) regarding the importance of gender-sensitive policy interventions.

Theoretically, this study reinforces that female teachers' adoption of digital technology is not merely a technical phenomenon, but the result of interactions among individual capacity, social context, and institutional support. The finding that strong digital competence and informal learning act as reinforcing factors supports Instefjord & Munthe (2017), who argue that digital competence develops through contextual practices rather than technical training alone. The low significance of AI in influencing teaching effectiveness aligns with Cattaneo et al. (2022), emphasizing the need for interaction between individual capacity and institutional support for meaningful technology integration. Furthermore, the mediation logic suggests that gender influences technology effectiveness indirectly through access and self-efficacy, while regional context acts as a moderating factor that strengthens or weakens these effects, consistent with Mayantao & Tantiado (2024) and Alieto et al. (2024). Thus, female

teacher empowerment through digital technology is highly dependent on regional context and the strengthening of adaptive capacity.

This study provides an understanding that women's digital empowerment is not merely dependent on hardware access or technical training. Female teachers' contributions are strongly shaped by local ecosystems, including social norms, gender role divisions, and sustained informal learning mechanisms. The findings from Nawan Kot (high implementation but low completion) and Mailsi (lowest performance) highlight the importance of distributive justice in workload allocation, rather than mere equality of access. Local wisdom such as mutual cooperation and deliberation should be revitalized to ensure that technology use aligns with local social values. Although AI training has been well received, understanding of personalization and independent content adaptation remains limited, requiring structured institutional approaches (Ning et al., 2024; Salih et al., 2025). In Islamic secondary schools, cultural sensitivity is crucial, as technological interventions must align with local norms to avoid counterproductive outcomes. Strengthening basic digital competence and informal learning represents the most realistic short-term strategy.

This study reinforces Luo & Liu (2025) and Li & Xu (2024) regarding the importance of access and institutional support in shaping teachers' digital readiness. However, it extends the arguments of Gandara & Laesecke (2022) and Charania et al. (2024) by providing evidence that female teachers' contributions vary significantly across regions: Khan Garh shows the highest performance, Kot Addu remains stable, Nawan Kot demonstrates high implementation but low completion, and Mailsi records the lowest outcomes. In contrast to Roorda & Jak (2024), who emphasize gender alignment in teaching roles, this study identifies pronounced structural inequalities, where male dominance persists in Jatoi and Shah Sultan, while female teachers outperform males in Kot Addu and Muzaffargarh. Compared with Koehorst et al. (2021) and Inayati et al. (2025), which focus on training policies, this study explicitly distinguishes that informal learning is more influential than AI adoption an important new finding. The key distinction of this study lies in showing that spatial variation and distributive inequality, rather than merely access or policy, are the main determinants of female teachers' digital empowerment.

Based on the research findings, this study proposes policy recommendations for empowering female teachers through digital competence and AI integration in Southern Pakistan that require context-sensitive interventions. Resource prioritization should be directed toward low-performing regions such as Mailsi and Jatoi. Strengthening informal digital learning ecosystems through best-practice sharing forums and peer mentoring is essential, given that female teachers already possess strong competencies but require continuous support. Basic digital training with a focus on pedagogical reflection should be enhanced, as understanding of AI personalization and independent content adaptation remains weak. Gender- and region-based workload adjustment, for instance through teaching assistants, is necessary in Nawan Kot (high implementation but low completion) and Mailsi (high workload but low participation). AI integration should be implemented gradually, starting from more prepared regions such as Kot Addu and Muzaffargarh, while capacity building is strengthened in Jatoi and Shah Sultan. Local affirmative policies, such as women-focused digital scholarships and community leader mentoring, are also urgently needed.

CONCLUSION

This study concludes that the empowerment of female teachers through digital competence and AI integration in Southern Pakistan is strongly shaped by regional contexts. Findings reveal uneven contributions across districts: Khan Garh shows the most balanced

performance, Kot Addu remains relatively stable, Nawan Kot demonstrates high implementation but lower completion, while Mailsi records the lowest outcomes. Workload distribution also varies, with Khan Garh performing strongly, Mailsi experiencing high workload but low participation, Nawan Kot showing strong digital confidence, and Kot Addu reflecting consistent performance and student trust. Female teachers generally possess solid digital competence and actively engage in informal learning. However, technology adoption is mediated by local social norms, with female contributions exceeding males in some districts, while male dominance persists in others. Although AI training is positively received, understanding of AI personalization and adaptive content design remains limited. Overall, empowerment depends on local ecosystems and adaptive capacity.

This study contributes by reinforcing previous findings on the importance of access and institutional support, while extending the understanding of spatial variations in female teachers' contributions. In contrast to studies emphasizing gender alignment, this research identifies the dominance of structural inequalities. A key novelty is that informal learning is found to be more influential than AI adoption, a finding rarely reported in prior studies. From a practical perspective, the study emphasizes that policy interventions must be gender-sensitive and grounded in local wisdom, as distributive justice in workload is more critical than mere equality of access. Strengthening basic digital competence and informal learning represents the most realistic short-term strategy, while AI integration requires structured institutional approaches aligned with local social norms, particularly in Islamic secondary schools.

This study is limited to Southern Pakistan (Khan Garh, Kot Addu, Nawan Kot, Mailsi, Jatoi, Shah Sultan, and Muzaffargarh), so its generalizability should be tested in other contexts. Its focus on Islamic secondary schools also restricts applicability to other educational levels and school types. In addition, the study does not measure the long-term impact of AI interventions on student learning outcomes. Future research should develop comparative studies across regions and cultures to identify universal versus context-specific factors. Experimental research with structured AI training interventions is needed to examine causal effects more rigorously. Ethnographic approaches are also recommended to explore in depth how social norms and local wisdom dynamically moderate female teachers' adoption of digital technologies.

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AUTHOR CONTRIBUTION STATEMENT

Muhammad Kashif Majeed: Conceptualization; Formal Analysis; Investigation; Methodology; Writing Original Draft; Writing Review & Editing. **Tunku Badariah Ahmad**: Conceptualization; Methodology; Project Administration; Resources. **Aizat Bin Shamsuddin**: Conceptualization; Visualization and Writing Review & Editing.

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