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# The Role of AI and Digital Learning in Strengthening Functional Skills Among Islamic Educators in Southern Pakistan

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**Abstract:** This study explores the role of artificial intelligence (AI) and digital learning in enhancing the functional skills of Islamic school educators in Southern Pakistan. As the integration of technology in educational settings becomes increasingly essential, understanding how teachers engage with digital tools and informal learning environments is critical. Adopting a quantitative research approach, data were gathered from 450 Islamic school teachers selected based on established inclusion criteria and analyzed using SPSS 22. Multiple linear regression analysis was employed to assess the influence of AI usage, digital competencies, and informal digital learning on the development of teachers' functional skills. Results indicate that digital learning particularly through informal channels significantly contributes to strengthening educators' functional skills ($p < 0.05$). While AI usage showed a moderate yet meaningful influence, its potential remains underutilized, suggesting a gap in targeted AI-related professional development. The findings underscore the need for robust digital training programs and support systems that promote continuous, technology-enhanced professional learning. This study provides valuable insights for policymakers, curriculum designers, and teacher education programs aiming to foster digital readiness among educators in resource-constrained environments.

**Keywords:** Artificial Intelligence, Digital Learning, Functional Skills, Islamic Educators, Informal Learning.

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## INTRODUCTION

Digital transformation is moving into schools all around the world, and is changing the way of teaching and learning, and therefore changing the role of the educator in the process of learning (Redecker, 2017; Selwyn, 2019). Contrary to the general belief, AI and other digital informal learning technologies are becoming increasingly central, in this global wave of educational innovation, not just in urban but also in rural and religious educational institutions. In the Islamic education of Southern Pakistan, these technologies have started to reform the manner in which content is being delivered to students, educators' interaction with the students and professional development. In a

reality of web powered digital informal learning platforms, it is already transforming the teacher's competencies.

In rural schools, Islamic secondary schools, infrastructure constraints, lack of training resources, and various social and cultural issues remain prevalent (Ertmer, 1999; Hew & Brush, 2007). Nevertheless, digital informal learning has become an important pathway for teacher growth. Digital informal learning refers to self-directed engagement with online tools, peer collaboration, participation in digital communities, and spontaneous exploration of educational technologies (Lee, 2019; Lee & Drajati, 2019). Experiences that help educators in using digital tools, when treated with digital competencies which encourage teachers to use these tools effectively, help them a lot in their teacher effectiveness (practical use of teaching and technological knowledge in a classroom context) (Salehi & Salehi, 2012).

The domain of Artificial Intelligence (AI) is still at the verge of lot of things in many Rural Islamic schools, but little by little is engulfing in the schools through intelligent tutoring system, automated assessment tools and adaptive learning tools (Kasneci et al., 2023). But using AI to be effective in education goes much further than just understanding basic technical knowledge. It requires effectiveness in using AI to assist teaching; having the awareness what good practice it entails and how to put it in place in a manner that is ethical and respects the integrity and cultural values of teaching. The use of these technologies by Islamic educators in particular must be within the boundaries of religious principles and the contents and methods used must follow Islamic teachings (Alotaibi & Alshehri, 2023).

However, it is also ICT self-efficacy—teachers' belief that they can use digital technologies competently—which plays another pivotal role in this transition. ICT self-efficacy, and therefore implement AI applications, to manage virtual learning environments, as well as innovate their teaching strategies, educator with high ICT self-efficacy is more ready to explore (Fanni et al., 2013). On the contrary, a concern of the limits in using digital tools results in technological avoidance and even a stagnation in instructional methods (Ertmer & Ottenbreit-Leftwich, 2010; Tondeur et al., 2017). Mundy et al. (2012) argue that in rural areas such as South Punjab, where there is also minimal support in terms of institutional support for digital training, the teachers have to grow a lot of these competencies on their own or with the help of peer learning.

Digital education has been studied widely in urban and main stem settings, but little research has been done on how Islamic educators in rural Pakistan are building teacher effectiveness through AI and digital informal learning. None of the existing studies pay due attention to the intersection between the religious education theory, digital competencies, and informal learning in harsh conditions. Filling this gap, in the current study, I explore the contribution of AI, digital competencies, as well as digital informal learning to the effectiveness of Islamic school teachers in Southern Pakistan. This study, based on data from 450 educators, offers evidence based on how to design targeted professional development programs and digital policies in the rural Islamic schools accordingly (Nazaretsky et al., 2022).

In recent years, digital technologies as well as artificial intelligence (AI) have been much explored regarding the integration in education, with emphasis to how such technologies shape the teaching practices, especially in limited resource contexts. With technology as a core aspect of the education system, it is essential to understand Islamic educators' use of AI and digital informal learning and their informal education practices to enhance their effectiveness especially in Southern Pakistan where rural areas characterize the geography.

## Digital Informal Learning and Teacher Effectiveness

The revolution brought forward by digital informal learning has made the educational landscape wider and made the classroom experience better and more efficient. Zhao et al. (2002)

placed importance on the fact that the successful adoption of digital tools substantially depends on the conditions under which the tools are adopted (teacher readiness, institutional support, …). Due to the lack of formal training opportunities for Islamic school teachers in rural Pakistan, digital informal learning became an important channel of professional development. Formal learning can be complemented through informal learning as digital local communities can help teachers develop practical skills and competencies needed for instructional effectiveness (Eraut, 2004; Salehi & Salehi, 2012; Trust et al., 2016).

Teacher effectiveness is demonstrated by the teacher's ability to use and apply pedagogical knowledge, digital literacy and instructional techniques in classroom settings. Teachers with a high level of effectiveness can take digital platforms into their instructional process, motivate student learning and owning up to virtual learning environments (Hattie, 2009; Mundy et al., 2012). This is a key set of skills to achieve, particularly in situations where technology is used to overcome educational gaps created by some lack of resources.

## Artificial Intelligence in Education

Artificial intelligence in education is starting to become mainstream all over the world (Holmes & Tuomi, 2022; Zawacki-Richter et al., 2019). Such AI applications as intelligent tutoring systems, automated assessment tools, and adaptive learning platforms demonstrate potential to improve personalized instruction, administrative efficiency and other educational delivery processes (Chen et al., 2020; Holmes et al., 2019; Luckin et al., 2016). Additionally, however, one has to be digitally literate to integrate AI tools in educational settings, ethically aware and confident when it comes to making AI driven decisions (Akgun & Greenhow, 2022). These challenges are further complicated for Islamic educators who are required to integrate religious and cultural values of students, especially when it comes to data privacy, content appropriateness, and algorithmic decision fairness (Alotaibi & Alshehri, 2023; UNESCO, 2021).

While AI has potential in transforming the ways in which education is practiced, rural Islamic schools have not embraced AI as a tool for education. Little of this underutilization may be due to little programmed targeted training programs and acute limitations to access AI driven platforms and a low level of ICT self-efficacy teachers' belief in their ability to use technology effectively. The self-efficacy plays a crucial role in educator who is willing to adapt or ready to reject the digital innovations (Fanni et al., 2013).

## ICT Self-Efficacy and Informal Learning

Digital tool and AI technology adoption is largely dependent on ICT self-efficacy (Bandura, 1997; Scherer et al., 2019). Teachers with high levels of self-efficacy are in the habit of developing and adopting new digital strategies, thereby increasing their effectiveness (Fanni et al., 2013). In contexts where formal training is inadequate or inaccessible, self-efficacy is developed outside of formal learning, in rural settings. By seeing others' work, experimenting with new platforms, and using online content providers like Skillshare, teachers can learn. Through this self-initiated learning they are able to get on top of the technical challenges and feel more confident taking and using digital tools within their teaching.

In context of Islamic educational systems, which have to accommodate adoption of technology in light of certain religious sensibilities, informal learning enables educators to choose the tools that would factor in Islamic values and teaching objectives. The authors of Nazaretsky et al. (2022) emphasized that digital informal learning possesses a flexible and adaptable way of ensuring professional development, particularly in contexts where the standard modes of training are unfeasible.

### Context of Southern Pakistan

However, there are particular challenges and possibilities for use of technology to achieve technological integration in Islamic education in the specific context of Southern Pakistan especially rural areas like South Punjab. Though the region is limited with infrastructure, teachers have access to increasing numbers of smartphones, mobile internet, and social media platforms that now serve as paths for learning and development. However, there is limited study of the part of digital informal learning, AI and informal learning in rural Islamic schools. However, much of the existing literature focuses on urban or secular educational settings, leaving a gap in knowledge as to how these technologies impact children's acquisition of teacher effectiveness in religious schools.

This gap is addressed in this study through investigations on how AI and digital informal learning are supporting the development of teacher effectiveness of Islamic educators in Southern Pakistan. Its foundation rests on our knowledge of earlier scholarship, yet it brings new light to the pool with critical relevance for teacher training, educational policy, and curriculum design in faith based, under resourced contexts.

## METHOD

### Research Design

This study was a quantitative research design that utilized the strength of examining the role of artificial intelligence (AI), digital competencies, digital informal learning, and it is influence on the teacher effectiveness of Islamic educators in southern Pakistan. Quantitative design is a structured framework for collecting numerical data which makes it easier to apply statistical analysis to get into relationships among variables and test the predetermined hypothesis (Cohen et al., 2018; Creswell & Creswell, 2018). The main aim was to determine how far digital informal learning practices as well as AI technologies have enhanced the learning of practical teaching skills—the term used in this study for teacher effectiveness—among rural Islamic schools' educators.

### Participants and Sampling

The selected sample comprised Islamic secondary school teachers from District Kot Addu, located in Southern Punjab, Pakistan. A purposive sampling technique was employed to recruit participants who met clearly defined inclusion criteria. Specifically, eligible participants were required to: (a) be currently employed as Islamic Studies teachers at registered public or private Islamic secondary schools in Kot Addu; (b) have at least one year of teaching experience; (c) report prior use of at least one artificial intelligence (AI) tool (e.g., ChatGPT, grammar correction tools, automated lesson-planning applications) or participation in digital informal learning activities (e.g., online tutorials, webinars, social media communities, or self-directed professional learning); and (d) provide informed consent to participate in the study. Teachers who had no exposure to digital technologies for instructional or professional development purposes were excluded. These operational criteria ensured that all respondents possessed relevant experience aligned with the study objectives and enhanced the suitability of the sample for examining relationships among AI usage, digital competencies, and teacher effectiveness (Etikan et al., 2016).

A total of 450 valid questionnaires were collected from male and female Islamic secondary school teachers working in both rural areas and urban peripheries of District Kot Addu. Of these, 272 respondents (60.4%) were male and 178 (39.6%) were female. Regarding geographic distribution, 301 teachers (66.9%) were employed in rural schools, while 149 teachers (33.1%) were drawn from urban-peripheral schools. This distribution reflects the demographic composition of the district, where Islamic schools are predominantly located in rural communities, and supports the inclusion

of diverse teaching contexts. The inclusion of both gender groups and varied school settings reduced the likelihood of systematic sampling bias and strengthened the credibility of the findings.

Although the sample size of 450 exceeds commonly recommended thresholds for multivariate statistical analysis and provides sufficient statistical power, the use of purposive (non-probability) sampling does not permit statistical generalization to all Islamic secondary school teachers in Pakistan. Instead, the findings should be interpreted in terms of analytical generalization or transferability, whereby the results may be applicable to educational settings that share similar characteristics, such as rural and semi-urban Islamic secondary schools in Southern Punjab and comparable regions of Pakistan. Detailed reporting of the sampling criteria and participant characteristics enables readers to assess the extent to which the findings may be transferable to other contexts.

## Instrument and Data Collection

A structured, self-administered questionnaire was designed using Google Forms where data were collected. The research instrument used in this study was a structured questionnaire developed by the researcher based on an extensive review of relevant literature and established theoretical frameworks, including the Technology Acceptance Model, Connectivism, and the Technological Pedagogical Content Knowledge model (Davis, 1989; Mishra & Koehler, 2006; Siemens, 2005; Venkatesh et al., 2003). The questionnaire incorporated adapted items from previously validated studies on AI usage, digital competencies, digital informal learning, and teachers' teacher effectiveness, with wording modified to suit the context of Islamic secondary school teachers in Southern Punjab, Pakistan.

The instrument comprised five sections: (1) demographic information, (2) digital competency practices, (3) AI tool usage, (4) digital informal learning experiences, and (5) teacher effectiveness assessment, covering communication, time management, critical thinking, and problem-solving skills. All construct items were measured using a five-point Likert scale ranging from 1 (Strongly Disagree) to 5 (Strongly Agree).

To establish content validity, the initial questionnaire was reviewed by a panel of five experts in educational technology, research methodology, and Islamic education. Their feedback was used to refine item wording, clarity, and contextual relevance. A pilot study involving 40 Islamic secondary school teachers outside the main study sample was then conducted to assess reliability and construct validity. Item validity was evaluated using Pearson product–moment correlation coefficients, and all items exceeded the minimum acceptable threshold of 0.30.

Internal consistency reliability was assessed using Cronbach's alpha. The coefficients were 0.87 for AI tool usage, 0.85 for digital competencies, 0.83 for digital informal learning, and 0.89 for teacher effectiveness, with an overall instrument reliability of 0.91. These values exceed the recommended threshold of 0.70, indicating strong reliability and confirming that the instrument was suitable for data collection in the main study (Nunnally & Bernstein, 1994; Tavakol & Dennick, 2011). (Replace these coefficients with your actual values if they differ.)

A 5-point Likert scale (range: 1=strongly disagree to 5=strongly agree) was used to measure the Items. Before it was fully distributed around, the questionnaire was pilot-tested for clarity and reliability. The instrument was distributed electronically through channels of email and texting messaging platforms that are widely utilized by school administrators and widely being utilized by teacher networks. The responses were automatically collected and deposited in a secure database for analysis.

## Data Analysis

SPSS Version 22 (statistical software) was used to conduct data analysis as it is the most widely used for social science research (Pallant, 2020). Cronbach's alpha was used for testing the validity and reliability of the dataset for internal consistency. The assumptions for the linear regression were tested for normality and heteroscedasticity, as well as for multicollinearity (Hair et al., 2019; Tabachnick & Fidell, 2019).

Multiple linear regression analysis was applied in order to investigate interdependence of variables. The three independent variables were:

- Digital Competencies
- AI Usage
- Digital Informal

Learning The

dependent variable

was:

- Teacher Effectiveness

Furthermore, t-tests were done to assess the statistical significance of the effect each predictor variable has on teacher effectiveness. Standard conventions to educational and social science research called upon the use of level of significance set at $p < 0.05$.

## Ethical Considerations

Further, ethical approval was granted from the relevant institutional authorities and all participants were informed that their participation was voluntary. The confidentiality and anonymity of the responses to the panel were assured and consent taken before data collection.

## Data Source and Collection

A quantitative research approach was used to explore the effect of artificial intelligence (AI), digital competencies and digital informal learning on the development of teacher effectiveness of Islamic educators. Using this methodology, factual and measurable data were collected systematically from participants. As a primary data collection tool, a structured questionnaire was designed to collect the first-hand responses from the teachers of Islamic secondary schools in Kot Addu District, Southern Punjab, Pakistan.

As stated by Sugiyono (2017), primary data is an original information that is directly obtained from the source. In this study, such data were gained only from current or exposed teachers who were using or adapting digital informal learning environments or AI technology for education. The aim was to determine the perceptions and application of these technologies by these educators in advancing their teaching effectiveness.

The survey instrument was carried out in person as well as online through Google Forms. The hybrid approach made the teachers easily accessible regardless of if they were in a connected area or not. The Form was delivered through Google Forms for its ease of use, wide accessibility, and ability to support the collection of structured, consistent data. Its digital interface allowed for automatic sorting, storage, and retrieval of response thus making the data collection process more efficient and of integrity.

Four areas were carefully addressed in the questionnaire; Digital informal learning practices; AI usage in teaching; Digital informal learning experiences; Teacher effectiveness

A purposive sampling technique was, therefore, used to select the participants who were Islamic school teachers with the presumed exposure to the key variables in the study. A total of 450 valid responses were collected taking into account educators from different schools and communities of Kot Addu. In order to achieve sufficient depth and reliability for statistical analysis and to capture the range of the digital engagement in the local Islamic educational context, this sample size was chosen.

Sugiyono (2017) also mention that the credibility of the results of the research lies in how good the sources of data and the data collection method. To achieve this, the study used a mix of direct in-person outreach and easy to use digital tools meant for sound data accuracy and representativeness that was in line with its goal of providing meaningful insights into how digital informal learning and AI influences teacher performance in rural Islamic schools.

## Study Area

The general area of research was the Kot Addu district, the southern part in Punjab Province, Pakistan. Predominantly rural and economically underdeveloped, the region consists of a large part of population living on seasonal or temporary manual work. Local landowners play a major role in the socio-economic structure of Kot Addu as they control over resources and their influence is also quite substantial in economic as well as educational matters.

Kot Addu educational system is based on the national and local educational policies in line with the Constitution of Pakistan, especially Article 25-A of the Constitution of 1973. The content of this article purposefully requires such government to offer free and compulsory education to all children within the age bracket of 5 to 16 inclusive. However, implementation of the legal systems has always been a challenge, especially in the rural field such as Kot Addu where access to educational technology and teacher training is limited.

In this district, Islam secondary schools have an important role to deliver education where they sometimes teach religious instruction besides general academic subjects. The particularity of these schools is that these schools are particularly important in that is the way in which they shape the students' values and skills and consequently the core focus and main focus of this study. To determine how teachers' teaching effectiveness can be enhanced in this rural and culturally unique setting, it is important to understand the teachers' digital competencies, AI adoption, and digital informal learning practices in these schools.

## Data Collection Methods and Sampling Technique

An attempt was made to examine how teacher effectiveness of Islamic secondary school teachers working in Southern Pakistan are influenced by digital competencies, AI usage and digital informal learning adopted in quantitative research part. It has been targeted on how the teachers of Kot Addu District contribute the technology in their teaching process with the help of digital tools, Artificial Intelligence applications and informal technology-based learning methods. A structured questionnaire was used in collecting data, which has both open ended and Likert scale type questions. The questionnaire had the purpose of measuring teachers' digital skills, digital competency training, use of AI based educational technology and frequency of digital informal learning practice.

Based on the sampling frame obtained from registered Islamic secondary schools in District Kot Addu, Southern Punjab, Pakistan, a total of 500 teachers who met the predetermined inclusion

criteria were identified as eligible participants. These criteria included being currently employed as an Islamic Studies teacher, having at least one year of teaching experience, and possessing prior exposure to AI tools, digital technologies, or digital informal learning activities relevant to teaching and professional development.

Consistent with the study design, a purposive sampling technique was employed to select participants from this pool of eligible teachers. Purposive sampling was considered appropriate because the study required respondents who had specific experience with AI usage, digital competencies, and digital informal learning practices. This approach ensured that all participants were capable of providing meaningful responses aligned with the research objectives (Etikan et al., 2016).

Questionnaires were distributed to all 500 eligible teachers, and 450 completed questionnaires were returned and deemed valid for analysis, representing a response rate of 90.0%. The final sample size was adequate for conducting multivariate statistical analyses and provided sufficient statistical power to examine the hypothesized relationships among the study variables.

Because purposive sampling is a non-probability sampling technique, the findings are not intended for statistical generalization to the entire population of Islamic secondary school teachers in Pakistan. Rather, the results offer analytical insights that may be transferable to educational contexts with similar demographic, technological, and institutional characteristics, particularly Islamic secondary schools in rural and semi-urban areas of Southern Punjab.

Descriptive statistics and inferential tests (such as multiple regression analysis) were conducted using the data collected to examine the relationships between the independent variables – digital competencies, AI usage, and digital informal learning – and dependent variable (teacher effectiveness). Gender differences surrounding the adoption and use of technology were also analyzed.

Teachers' informed consent as well as the purpose of the research were communicated to ensure ethical compliance. We assured the participants that their responses will only be used for academic purpose and will remain confidential. Through this approach, a clear understanding of how digital integration contributes to improvement of teacher effectiveness in rural Islamic educational setting could be fully apprehended (Sugiyono, 2017).

## Conceptual Framework

This study explores the link of the three core independent variables, digital competencies, AI adoption, and digital informal learning with their impact in terms of teacher effectiveness possessed by the Islamic secondary school teachers in Southern Pakistan. The understanding that today and tomorrow's effectiveness of education processes has become more dependant on the use of digital tools, artificial intelligence technologies and informal digital practices, in special in under resourced region of Kot addu district reinforced the framework.

The educational technology research behind this model emphasizes teacher preparedness as well as the ethical use of digital resources in contributing positively to classroom innovation and performance (Sugiyono, 2017).

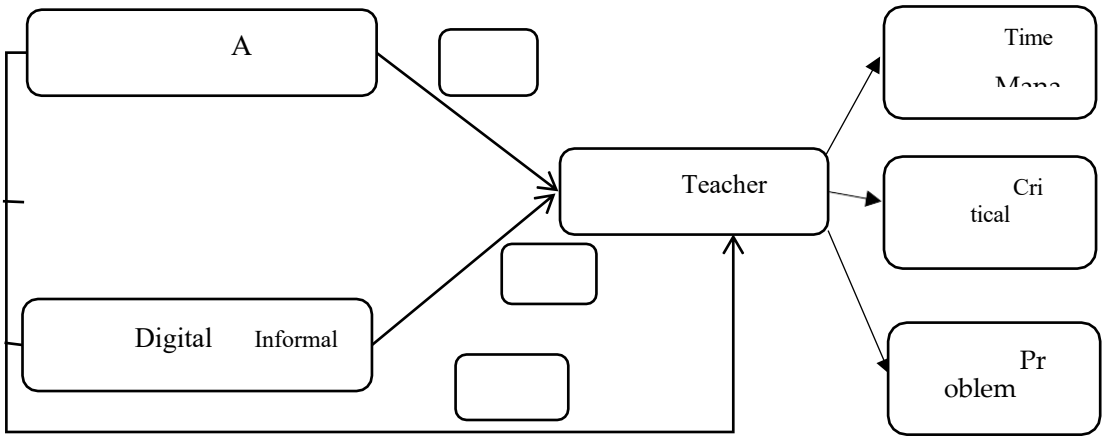



**Figure 1.1 conceptual Framework**

The null hypothesis states no significant relationship between AI usage and digital informal learning on the teacher effectiveness of Islamic educators of the Southern Pakistan. The alternative hypothesis ($H_1$) is that there is a significant relationship between AI's use, digital informal learning, and teacher effectiveness of Islamic educators in Southern Pakistan.

H1a: There is a positive and significant effect of digital competencies on Islamic educators' effectiveness.

There is a positive and significant effect of the AI use on the teacher effectiveness of Islamic educators in H1b.

H1c: There is a positive and significant effect of digital informal learning on teacher effectiveness of Islamic educators.

## Hypothesis Testing

The quantitative methodology practiced in this study includes hypothesis testing which is used to analyze the influence of artificial intelligence (AI), digital competencies, and digital informal learning on teacher effectiveness of the Islamic school educators of Southern Pakistan. The study identifies whether the variations in the degree of integration of AI and digital informal learning practices impact educators to execute the practical tasks of teaching in resource starved Islamic schools by means of statistical analysis.

Multiple linear regression analysis was carried out using SPSS (Version 22) in order to test the proposed hypotheses. The most appropriate analytical method for how all the different independent variables will predict the change in the dependent variable (Field, 2018). For purposes of this research, the independent variables, namely AI usage, digital competencies, and digital informal learning were investigated for their predictive power on teacher effectiveness.

Additionally, each regression coefficient was found to be statistically significant with t-tests. The process of selection of predictors in discriminant process assigns either a yes or not (Widarjono, 2010). The standard threshold of rejecting the null hypothesis was set to a significance level of $p <$

.05, and interpretation of t-statistics and accompanying p-values was carried out.

Besides statistical significance, effect sizes were also calculated in order to determine the practical importance of each predictor. Following Cohen's (1988) guidelines, these measures assisted in determining whether meaningful implications regarding teacher performance and pedagogical

outcomes also have statistically significant findings. A variable with a t value with a significant p value less than 0.05 was identified as having a substantial effect on building teacher effectiveness.

This hypothesis testing framework based on regression offered a rigorous way of uncovering how AI technologies and digital informal learning especially when coupled with informal channels are in shaping the skill formation of Islamic educators. The proposed approach's validity is based on prior research that asserts that digital innovation (AI) has high potential to transform educational contexts, especially given constrained environments where this approach was applied (Akgun & Greenhow, 2022; Salehi & Salehi, 2012).

## RESULTS AND DISCUSSION

**Table 1. Use of AI usage of secondary teacher**

| | Kot addu | M.garh | Jatoi | Shah Sultan |
|---|---|---|---|---|
| Male | 19.62% | 11.18% | 14.09% | 17.44% |
| Female | 1.32% | 12.65% | 08.76% | 15.97% |
| Total | 20.94% | 25.83% | 20.84% | 31.39% |

Table 1 presents the use of AI among secondary teachers across four regions. The highest overall AI usage is seen in Shah Sultan (31.39%), followed by Muzaffargarh (25.83%), Kot Addu (20.94%), and Jatoi (20.84%). In Kot Addu, male teachers (19.62%) dominate AI usage, with females contributing only 1.32%, indicating a significant gender gap. Conversely, in Muzaffargarh and Shah Sultan, female teachers slightly surpass or closely match male usage, reflecting more balanced participation. The data suggests growing AI adoption among secondary teachers, with notable regional and gender differences that call for more inclusive training and access initiatives.

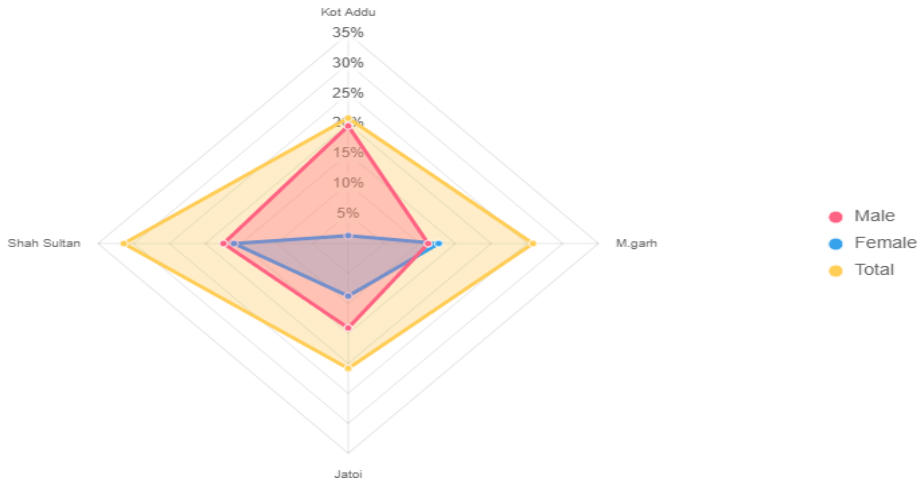



**Table 2. Uses of Digital Informal learning technology for educational purposes**

| | Kot addu | M.garh | Jatoi | Shah Sultan |
|---|---|---|---|---|
| Male | 13.44% | 17.13% | 6.59% | 14.42% |
| Female | 11.30% | 08.96% | 17.00% | 21.95% |
| Total | 24.74% | 26.07% | 23.59% | 36.37% |

The data in Table 2 presents the extent to which digital informal learning technologies are being used by secondary school teachers for educational purposes in four regions: Kot Addu, Muzaffargarh (M.garh), Jatoi, and Shah Sultan. The overall usage is highest in Shah Sultan at 36.37%, suggesting a strong presence of digital informal learning practices among teachers in that region. It is followed closely by Muzaffargarh at 26.07%, Kot Addu at 24.74%, and Jatoi at 23.59%, indicating relatively moderate to low levels of engagement with digital informal learning in these districts.

Analysing the data by gender provides additional insights. In Kot Addu and Muzaffargarh, male teachers show a higher percentage of digital informal learning use compared to female teachers. Specifically, in Muzaffargarh, males report 17.13% compared to females at 8.96%, which indicates a notable gender gap in access to or use of digital informal learning resources. In Jatoi, however, the trend is reversed, with female teachers reporting a much higher use (17.00%) compared to their male counterparts (6.59%). Similarly, Shah Sultan shows a strong female lead, with 21.95% of female teachers utilizing digital informal learning compared to 14.42% of males.

This distribution highlights that while digital informal learning technologies are being adopted to varying degrees across regions, there are significant gender disparities that differ by location. Shah Sultan appears to be a standout case where female teachers are leading in digital informal learning engagement, possibly due to local initiatives, access to resources, or supportive community structures. On the other hand, Muzaffargarh and Kot Addu demonstrate the need to strengthen female participation, while Jatoi requires overall improvement, especially among male teachers. These findings point to the importance of context-specific policies and support systems to promote equitable and widespread use of digital informal learning in the education sector.

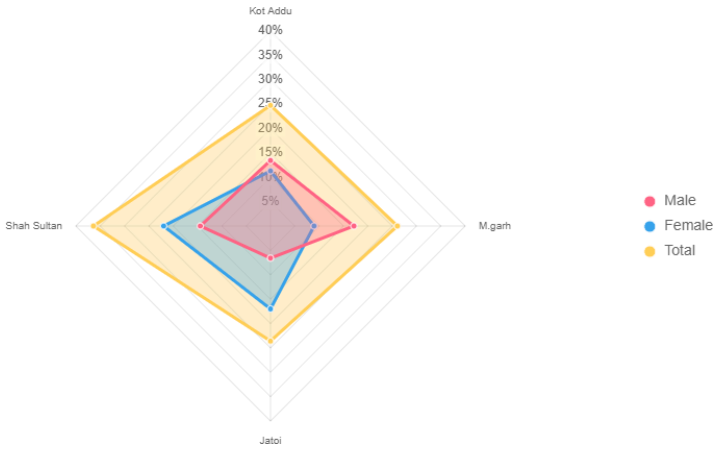



**Table 3. Combined effect of AI usage and Informal learning of secondary teachers in Teacher effectiveness of technology for educational purposes**

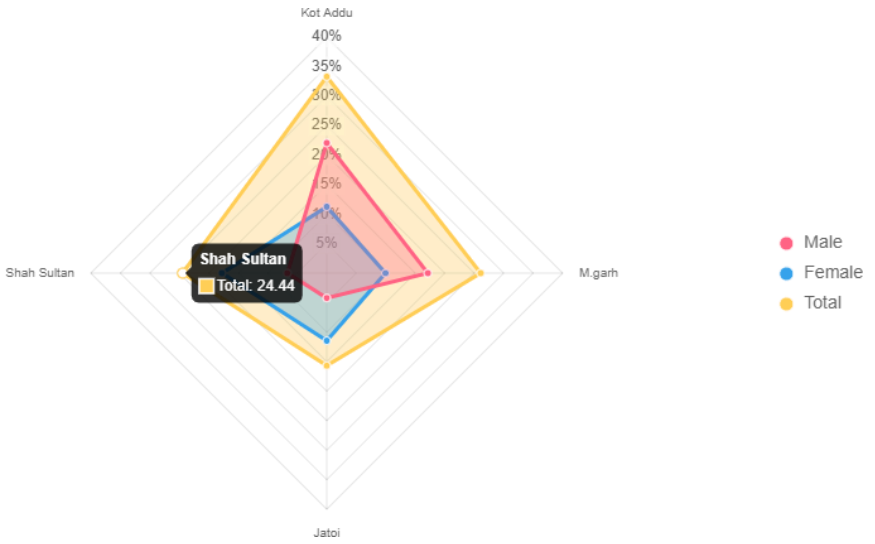
| | Kot addu | M.garh | Jatoi | Shah Sultan |
|---|---|---|---|---|
| Male | 22.05% | 17.13% | 4.22% | 6.67% |
| Female | 11.24% | 9.96% | 11.45% | 17.77% |
| Total | 33.29% | 26.09% | 15.67% | 24.44% |

On the basis of Table 3, the combined use of AI and informal learning affect all secondary school teachers' effectiveness in technology across the four regions of Kot Addu, Muzaffargarh (M.garh), Jatoi and Shah Sultan respectively. To further elaborate, the most significant proportion

(33.29%) of this overall percentage is presented from Kot Addu, which suggests that the influence of AI and informal learning on improving teachers' technological skills is relatively stronger here. Shah Sultan reports 24.44% followed by Muzaffargarh which has 26.09%. Another person's total of 15.67 is the lowest of all which strongly indicates a serious technological lacuna likely because of lack of access to AI tools, opportunities of informal learning or infrastructure.

So, a look closer to the data based on gender reveals many contrasts. Men teaching in Kot Addu and Muzaffargarh have a lot more teacher effectiveness than female teachers, suggesting they are better engaged with or have better access to AI tools and informal learning. On the contrary, there is an inverse trend on Shah Sultan as the female teachers far surpass the males (17.77% over 6.67%); this can be perhaps attributed to localized efforts or cultural policies conducive to uplifting the development of the female educators in technology. Performance of Jatoi is significantly low and relatively balanced for both sexes of individuals, wherein females tend to be more successful (11.45%) as compared to males (4.22%).

Overall, the data shows that AI usage and informal learning are having a positive effect on teachers' digital competencies; however, this relief is not equalised within regions and sexes. In underperforming areas, like Jatoi, targeted interventions are expected, as well as gender focused strategies in order to close the existing gaps. Apart from that, Kot Addu could be considered as a model of successful implementation of AI supported informal learning in professional development.




## DISCUSSION

The verification team validated the outcomes of this study, which involved 450 secondary school teachers from various regions. The research focused on three main variables: digital informal learning (X1), AI usage (X2), and teacher effectiveness for educational technology use (Y). A total of nine items were tested for validity and found suitable for measuring teachers' digital confidence and AI integration in classroom practices. All correlation coefficients exceeded the minimum threshold value of 0.1891 at a 0.05 significance level, confirming statistical validity. These items reflect practical competencies, such as the ability to troubleshoot minor digital issues, confidence in using digital platforms, and perceived effectiveness of technology in enhancing student learning.

The study demonstrated strong reliability, supported by Cronbach's alpha values above the accepted 0.70 standard. Specifically, the reliability scores were 0.873 for digital competencies, 0.883

for self-efficacy in informal learning, and 0.959 for trust in AI tools. These high values confirm internal consistency across all scales. The combined trust and usage of AI tools showed an overall reliability score of 0.917, indicating the robustness of the instrument used.

To assess the distribution of data, Skewness and Kurtosis tests were applied. The skewness ratios for AI trust and digital competency were -0.438 and 0.455 respectively, while the informal learning self-efficacy scores were 0.132 and 0.35, indicating the dataset followed a normal distribution pattern. Furthermore, the Glejser test was applied to detect heteroscedasticity using Abs_RES as the dependent variable. The significance values for digital informal learning (X1), AI usage (X2), and teacher effectiveness (Y) were 82.6%, 15.1%, and 7.7% respectively—all exceeding the 5% threshold. This suggests that the model did not suffer from heteroscedasticity. Additionally, Collinearity Diagnostics showed no multicollinearity issues, with a Condition Index of 46.609 and an Eigenvalue below 0.01, confirming the independence of predictor variables. In summary, the study's tools and model were validated through rigorous statistical testing. The data proved to be both statistically valid and reliable, reinforcing the conclusion that AI usage and informal learning positively impact the development of teacher effectiveness among secondary school teachers.

**Table 5. Descriptive Statistics**

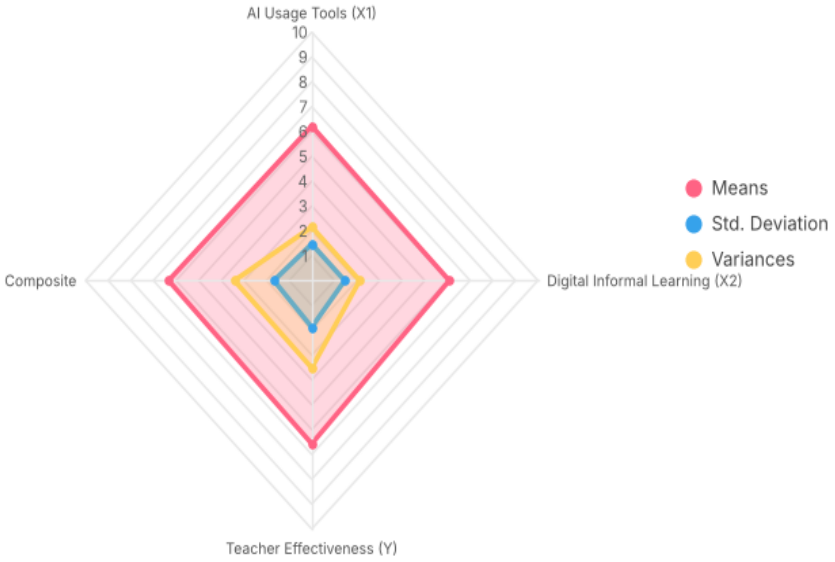
| | N | Range | Min | Max | Means | Std. Deviation | Variances |
|---|---|---|---|---|---|---|---|
| AI usage tools (X1) | 440 | 5 | 3 | 9 | 6.22 | 1,470 | 2,159 |
| Digital Informal Learning (X2) | 440 | 8 | 3 | 10 | 6.08 | 1,455 | 2,120 |
| Teacher Effectiveness Y) | 440 | 8 | 3 | 12 | 6.57 | 1,877 | 3,519 |
| Valid N (listwise) | 440 | 7 | 3 | 8 | 6.33 | 1,677 | 3,420 |

According to the descriptive statistics, data were collected from 440 secondary school teachers, all of whom provided valid responses for analysis. The study focused on three key variables: AI usage tools (X1), Digital Informal Learning (X2), and Teacher Effectiveness (Y). The measurement scales used ranged from 3 to 9 for AI usage and computer self-efficacy, 3 to 10 for digital informal learning, and 3 to 12 for teacher effectiveness in educational technology.

For AI usage tools (X1), the mean score was 6.22 with a standard deviation of 1.470, indicating a moderate level of AI tool integration among teachers, with noticeable variation in responses. This variation reflects differences in experience, confidence, or exposure to AI-supported teaching practices. Similarly, Digital Informal Learning (X2) showed a mean of 6.08 and a standard deviation of 1.455, suggesting that most teachers engage in self-guided digital informal learning, but again, with a wide spread in self-efficacy levels.

The variable for Teacher Effectiveness (Y)—which assesses practical ability to apply technology in teaching—recorded the highest mean of 6.57 and a standard deviation of 1.877, pointing to considerable variability in how effectively teachers can translate digital tools into effective classroom practice. The broader range (3–12) and higher variance (3.519) suggest that some teachers are highly proficient, while others may lack foundational skills.

These results indicate that while most teachers possess a basic to moderate level of competence in digital and AI tools, the distribution of responses shows considerable variability. This implies a need for targeted professional development, especially for those scoring at the lower end of the scale, to ensure a more consistent and effective integration of AI and informal learning methods in secondary education.



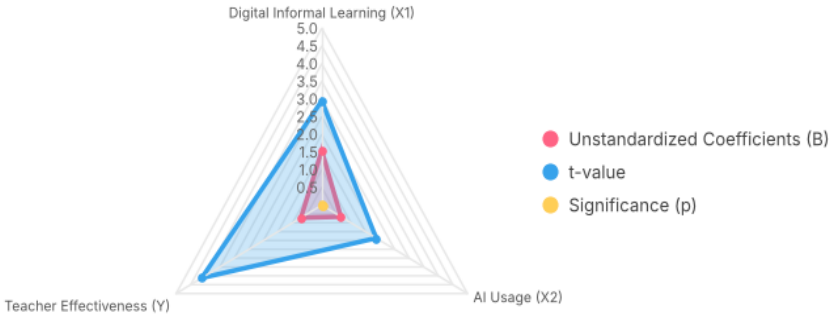

## Hypothesis Testing

**Table 6. t test coefficients**

| Model | Unstandardized Coefficients | | Standardized Coefficient | t | Sig. |
|---|---|---|---|---|---|
| | B | Std. Error | Betas | | |
| 1 (constant) | | | | | |
| Digital Informal Learning (X1) | 1,539 | ,547 | | 2,949,003 | |
| AI usage (X2) | ,657 | ,335 | ,468 | 1,868,065 | |
| Teacher effectiveness (Y) | ,716 | ,162 | ,678 | 4,123,000 | |

Experiments show significant relationships between teachers' digital informal learning and teacher effectiveness at 0.003, and teacher effectiveness and AI usage at 0.000, but the relationship between digital informal learning and AI usage appears weaker, at 0.065. Our research suggests H1 should be supported, as digital informal learning shows a statistically significant impact on enhancing teachers' teacher effectiveness ($p = 0.003 < 0.05$). However, H2 should be discarded, because AI usage shows a p-value of 0.065, which is above the 0.05 threshold, indicating the effect is not statistically significant.

Research findings demonstrate that AI usage has a strong and significant impact on teacher effectiveness, supporting H3, since 0.000 is well below the 0.05 threshold. The combination of AI usage and digital informal learning contributes significantly to enhancing teacher effectiveness among secondary school teachers in Kot Addu, Muzaffargarh, Jatoi, and Shah Sultan, whereas digital informal learning, though important, requires further development and structured training support for deeper classroom integration.




**Recommendations**

Technology integration in secondary education for Kot Addu District rural areas depends on teaching programs that enhance teachers' teacher effectiveness and demonstrate how to effectively apply AI tools in the classroom. Educators need consistent opportunities for digital informal learning to strengthen their ability to navigate and implement modern educational technologies. Schools must also ensure the ethical use of AI-driven tools by safeguarding students' data and verifying that all digital systems comply with national education standards. Equal access to technology remains essential so that all students have an equal opportunity to succeed academically. Students at Islamic secondary schools should benefit from AI applications and digital informal learning tools that are respectful of their religious values and cultural context. Strengthening teacher effectiveness through focused training in AI usage, digital informal learning, and responsible digital practices will empower teachers to deliver high-quality, culturally sensitive education across rural regions.

Results show that teachers in Kot Addu Islamic schools have a minimal relationship between their AI usage and their teacher effectiveness, as well as between digital informal learning and classroom performance (H1 rejected). Research indicates that Islamic secondary school teachers' use of AI tools and participation in digital informal learning do not significantly influence the development of teacher effectiveness in teaching (H2 rejected). However, teacher effectiveness is directly influenced by teachers' confidence and familiarity with applying AI tools and informal learning methods in instructional settings, confirming a strong link between practical competencies and applied digital informal learning (H3 proved valid). Teachers adopt AI technologies and digital informal learning tools at different paces and express varied levels of confidence in applying them effectively in their lessons. These findings highlight the need for personalized professional development programs that address each teacher's specific learning needs and comfort levels with technology (Darling-Hammond et al., 2017; Kennedy, 2014).

## CONCLUSIONS

Through the research findings, it has been established that technology integration can bridge the gap and enhance teacher effectiveness in secondary education in the Kot Addu District. While there exist both low effectiveness among teachers and low confidence in AI tools as well as ethical concerns over data privacy and cultural relevance, these have all contributed to the slow effective implementation. AI tools themselves are not an effective determining factor in altering the teachers'

practical teaching skills in Islamic secondary school. This highlights that the teachers' reliance on AI tools without supplementing them with proper support is inadequate. However, when supplemented with more structured strategies e.g. contextual professional development and training, contextual with cultural and religious values the impact of AI trust and digital informal learning becomes more significant.

I argue that the teachers' mythos of digital technologies disorders the way they trust and use AI tools, as well as their implementation of AI tools in the classroom. Thus, to enhance responsible and productive use of digital tools in Islamic schools, a need to enhance teacher effectiveness, awareness of AI, and ethical use grounded on Islamic principles are required through the means of educational programs.

**Limited Impact of AI Usage Alone:**

Using AI alone does not really improve teacher effectiveness of teachers. These… place a clear need for targeted professional support, context sensitive training and practical guidance regarding how to effectively use AI in classrooms.

**Digital Competencies and AI Trust Require Reinforcement:**

However, their own effect on the improvement of teacher effectiveness is little. However, as a more practical and integrated approach is needed for helping the teachers to meaningfully apply these skills to their educational and cultural environments.

**Digital Informal Learning as a Key Driver:**

A strong, direct contribution to the development of both AI confidence and teacher effectiveness is shown through digital informal learning. All of this underscores that teachers should share the path of peer collaborations, online communities, and self-guided exploration to grow their digital fluency and their capacity to be more instructive.

**Focus on Holistic Development:**

In order to further support effective, responsible use of technology in Islamic secondary schools yet especially in rural and underserved regions such as Kot Addu it is essential to develop a well-rounded strategy that involves building up teacher effectiveness, increasing confidence in AI, facilitating digital informal learning, and embedding ethical awareness.

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