Technology Integration in Secondary STEM Classrooms: The Role of Teacher Demographics

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ABSTRACT: The research aimed to investigate the role of teachers' demographics in technology integration among mathematics and science secondary teachers in Lahore. A quantitative research design within the positivist paradigm was employed. One research objective and four null hypotheses were developed. Data were collected through convenience sampling from 451 secondary mathematics and science teachers in public and private schools of Lahore using a survey questionnaire. Reliability and validity of the instrument were ensured through pilot testing and expert opinions. Data were analyzed using t-tests and ANOVA to examine how demographic factors influence technology integration. Female participants constituted 50.3% of the sample, while teachers represented Chemistry (32.6%), Computer Science (23.7%), Physics (14.4%), Biology (12.0%), Science (9.1%), and Mathematics (8.2%). The findings revealed that the influence of female teachers was stronger than that of male teachers. Teachers aged more than 30 years demonstrated better performance (M = 322.49) compared to those aged less than 30 years (M = 316.42). Differences were also observed across teaching experience categories, including less than one year, 1–5 years, and 6–10 years, indicating variation in technology application. Similarly, educators from Science, Mathematics, Physics, Computer Science, Chemistry, and Biology showed unequal levels of knowledge and competence in technology use. Based on the findings, the study recommends strengthening TPACK-based professional development, enhancing support for teachers, improving technological facilities, and providing quality technical support to promote the efficiency and sustainability of technology integration across subject areas.

KEYWORDS: Technology Integration, Secondary Schools, Mathematics and Science Teachers, Quantitative Research, Undergraduate Students, Lahore

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Introduction

In the 21st century, advancements in digital technology have facilitated learning objectives throughout the world that have affected almost every aspect of human life (Ghayyur & Mirza, 2021). This paradigm shift is particularly evident in mathematics education, where the integration of technology introduced innovative strategies to enhance students' engagement, promote comprehensive learning, and improve pedagogical approaches (Loong & Herbert, 2018; Rakes et al., 2022). Developing countries like Pakistan face significant challenges in education. Integration of Technology (IT) is crucial in developing a skilled and talented workforce to compete with the digital economy of the world.

Considering this, the Government of Punjab has initiated various reforms, including the Punjab Education Sector Reform Program (PESRP) and the "Digital Punjab" vision. These programs include the establishment of ICT labs in schools, the distribution of laptops among students, and organizing teachers' training and workshops to modernize and innovate learning styles in schools (Government of Punjab, 2024). Hennessy et al. (2010) evaluated that the execution of Integration of Technology (IT) and pedagogical implications for teachers' professional development facilitates the integration of schooling within a developmental framework, promoting education into the technological era. There has been a debate about employing IT for educational purposes in Pakistan, especially from the primary level in Punjab (Ali et al.,2015).

National Professional Standards for Teachers in Pakistan were established by the Pakistan Ministry of Education in collaboration with UNESCO and USAID. It is a framework of instructions for teacher educators. Standard 7 emphasizes ICT and recommends that teacher educators train tutors with hands-on practice to use hardware and software technologies. Recent studies highlighted the importance of incorporating digital technology in teacher training programs through Technological Pedagogical and Content Knowledge (TPACK) (Byker et al., 2018; Joo et al., 2018).

However, developing TPACK is essential for prospective teachers and educators because it allows them to apply digital technologies meaningfully in disciplines where technology is not the central focus. Mishra and Koehler (2006) came up with the Technological Pedagogical and Content Knowledge (TPACK) framework. It says that a teacher's ability to balance and use knowledge of content, pedagogy, and technology is what makes technology integration work. Research in Pakistan has found that a lot of secondary school teachers have trouble with one or more parts of the TPACK framework, which makes it harder for them to use technology for more than just basic tasks (Ghaffar et al., 2024).

Hew and Brush (2007) say that two of the main things that keep technology from being used effectively in schools are that teachers don't have enough chances to get professional development and that they cannot get technical support easily. Their research showed that teachers often do not know how to use technology well, even when it is available, unless they get the right training. This is a big problem in developing countries like Pakistan, where access to technology and infrastructure is often limited. These problems are even worse in Pakistan because there are not enough teacher training programs that teach how to use technology in the classroom.

Aslam et al. (2021) found that teachers who have a lot of Technological Pedagogical and Content Knowledge (TPACK) are more likely to use technology confidently and effectively in their classrooms. But a lot of teachers in Pakistan do not know enough about one or more of the TPACK components, so they only use technology for simple tasks like showing videos or PowerPoint presentations instead of doing things that could change the way they teach. Because of this, it is harder to use technology effectively.

Acknowledging the importance of technology integration in education in Pakistan has led to strategic initiatives by national and provincial governments in Pakistan. Educational development policies in Punjab include notable programs such as the Punjab Education Sector Reform Program (PESRP) and the *Digital Punjab* initiative, leading the vision to execute IT labs, provision of IT resource centers, teachers' training, and instructional modernization.

However, the disparities between policy and practice are extensively documented; research states that teachers in Pakistan have a positive attitude towards technology integration, but its implementation in real practice is still questioned. Determinants include limited availability of technology integration resources, inadequate technical assistance, and poorly structured advanced training (Chaudhary & Ahmad, 2025). To get rid of these barriers, we need a comprehensive plan that includes better training for teachers, more access to digital resources, and a more supportive environment in schools.

Policymakers and school leaders need to focus on making professional development programs that are specifically meant to improve teachers' Technological Pedagogical and Content Knowledge skills (TPACK). Also, steps should be taken to close the digital divide between urban and rural schools by improving infrastructure and making sure that all schools in the country have equal access to technology. To fully realize the potential of technology integration in Pakistani secondary schools, these systemic problems must be fixed. The main research objective of the study was to explore differences in teachers' technology integration practices based on demographic variables such as gender, age, area of specialization, and teaching experience.

Research Hypothesis

There were four null hypotheses of the study:

H_{01}: There is no significant difference in the mean score of teachers' gender and their Technology Integration.

H_{02}: There is no significant difference in the mean score of teachers' age and their technology integration.

$H_{03:}$ There is no significant difference in the mean score of teachers' experiences and their Technology Integration.

H_{04}: There is no significant difference in the mean score of teachers' area of specialization and their Technology Integration

Literature Review

Technology Integration in the teaching and learning process

TITP (Technology integration during teaching practice) refers to the integration of technology in teaching activities. Aslan and Zhu (2017) assert that the use of technology in teaching practices is an indicator of the willingness and preparedness of pre-service teachers (PSTs) to use technology in their classrooms in the future. According to Bayaga et al. (2021), the performance of PSTs concerning the incorporation of technology in teaching practices can be explained by their experiences and the knowledge they gained during the teacher preparation programs. When PSTs prepare sufficiently to face challenges in the classroom, they come up with theories and methods of teaching that either directly or indirectly affect their future teaching environments. Furthermore, the Quality of Technology Integration (QTI) assesses the quality of the integration of technology in real teaching settings by pre-service teachers. Scholars assume that the degree of technology integration in the context of preparation and teaching practice significantly influences the quality of its further implementation in the classroom. In the present work, the technology integration quality tools designed by Cheng et al. (2020) and the Triple-E evaluation rubric by Kolb (2017, 2020) are used to measure QTI.

The effective use of technology by preservice teachers in their practice can improve the overall quality of their use of the technology in the instructional setting. Song and Zhou (2021) established that the quality and implementation of STEM education in schools depend on the teaching competence and that the latter depends on the learning experiences of teachers in their training programs. Tucker et al. (2024) research findings showed that, despite teachers indicating that they were confident about using integrated STEM lessons, several barriers, such as a lack of administrative support, cooperation with peers, and follow-up professional development opportunities, hindered their application.

Manasia et al. (2019) assessed the principal components of teacher preparation to teach STEM, with the target of promoting sustainable development goals in the education sector. They found the skill of didactic transposition to be the most centrally dependent in teacher readiness. To facilitate this, educational professionals should also be able to develop effective assessment instruments and should be able to interpret learning outcomes. As it turned out, the capacity to handle disruptive students, the personalization of learning, and the self-regulation of teaching emotions were identified as the most crucial weaknesses in teacher training.

Teacher Preparation (TP) and Technology Integration (TI)

Technology education in teacher education is strongly correlated with pre-service teachers' STEM preparedness, as they receive training in content, pedagogy, and technology over the four-year teacher preparation period. Most U.S. Colleges of Education use a one-technology-course approach, so that post-service educators will have sufficient technology knowledge and skills. The content coverage of these courses depends on the instructor's knowledge, how technology is used in the educational context, and their teaching philosophy. Pre-service teachers may receive poor technology education due to outdated information, weak course breadth, or the instructor's delivery style, which can be conceptual, lecture-based, or hands-on. The adequacy of the one-technology-course approach is questioned given rapid technological changes, such as AI. Additionally, the timing of the technology course is critical, as what is taught when the pre-service teacher is a freshman may be outdated by graduation and may not remain realistic or applicable (Wu & Zhou, 2025).

In Pakistan, teacher training has gained a lot of attention, but the issue is that this sphere is doing very little for the teachers of government-funded schools and colleges. The arguments that teacher training programs are inconsistent with the school educational programs, common affirmation principles, and problematic access to resources have been presented. Furthermore, these programs are often characterized by the absence of any quality control mechanism. In the last thirty years, Pakistan has undergone a silent revolution in the development of teachers by introducing reforms to the teacher preparation programmes, performance-based licensing and accreditation, and by creating the National Accreditation Council for Teacher Education (NACTE). Research conducted on public sector university teachers has indicated that teacher training centers do not have enough infrastructure, human, and knowledge resources as per the needs of the newly proposed standard-based teacher education programmes. These results also show that the reforms' delay in sustainability and effectiveness has been due to insufficient support mechanisms and resource investments (Hero, 2020).

The situation is impaired by the absence of an institutional support system, the inconsistencies of the teaching-related policies, and the practices in the classroom. Institutional barriers may include leadership, school time-tabling structure, and school planning. (Hew & Brush, 2007). Several infrastructural and institutional issues hinder the adoption of technology in teaching and learning by teachers. The results reiterate the need for universities to design policies and provide adequate resources to facilitate comprehensive technology training and effective technology integration (Bugti et al., 2024). The best way a person can address these gaps is by putting through professional development programs that involve more than basic digital literacy and extend to more specific integration.

A research study conducted by Indris et al. (2021) looked at the induction training program introduced by the government of Khyber Pakhtunkhwa in the light of National Professional Standards for Elementary Teachers (NPSET) in Pakistan; it was found that the induction program was not based on national professional standards, as the focus of induction was not on professional development of teachers; rather its focus was on content teaching. It was recommended that induction should bring some changes within its practice, as this program needs to focus more on professionalism rather than content teaching.

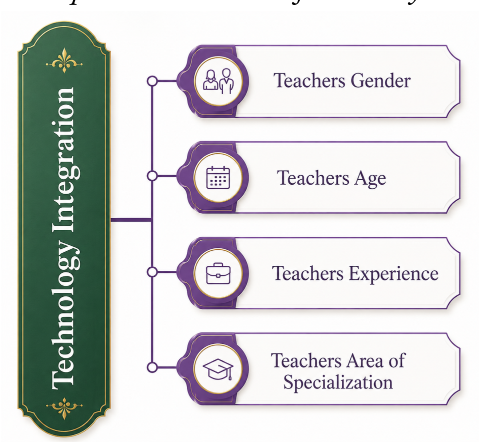
The literature review examined previous research on the topic of technology integration in the teaching and learning of mathematics, emphasizing how digital tools may serve to better conceptual learning, problem-solving, and student engagement. The research on teacher preparation was also included in this review, and it is important to recognize how technological, pedagogical, and content knowledge are critical elements that allow effective implementation of technology in classrooms. Besides, the review has covered research that has been done in the Pakistani context to clarify the current practices, challenges, and institutional support related to the use of technology in mathematics education. It is based on this literature that the proposed research will specifically focus on how the demographic aspects of teachers determine the use of technology in teaching mathematics.

Conceptual Framework

The figure below shows one dependent variable, Technology Integration (TI), and other independent variables or demographics that influence the integration of technology in secondary mathematics and science classrooms of Lahore, Pakistan. The demographic factors included: gender of teachers, experience in teaching, age, and area of specialization of the teacher, which can determine the readiness and ability of teachers to adopt technological tools in teaching practices. The theoretical framework outlined in this research outlines the possible influence of these background factors on the interest of teachers in using digital resources and on their effectiveness in integrating technology in the teaching and learning processes. Such a subtle understanding of these interrelations makes it easier to pinpoint the factors that are considered salient, which make or hinder the effective use of technology in the classroom of a secondary school.

Figure 1

Conceptual Framework of the Study



Methodology

Research Design

The nature of the study is quantitative, and a descriptive research design was adopted to explore the teachers' demographic variables that influence technology integration in secondary schools of Lahore. Creswell and Creswell (2022) stated that a quantitative research design focuses on discovering correlations and causal relationships among variables, with the findings being generalizable to larger populations. It is deductive in nature and uses statistical and mathematical tools to measure, compare, and draw conclusions. The positivist paradigm has been followed in this research to ensure the study's objectivity, generalizability, and reliability using numeric results rather than descriptive or personal findings (Creswell & Creswell, 2018).

Population and Sample

A convenience sample method was used for the sample selection. This is a non-probability sampling method wherein the subjects are chosen based on their convenience and ease of accessibility compared to the researcher (Creswell & Creswell, 2018). The sample used was 451 secondary school teachers (SSTs). Such an approach was suitable due to the lack of a detailed sampling frame. The secondary schools were contacted through easily available means, and the teachers were invited to join in. Further, both genders, male and female, were included in the sample with a specialization in mathematics and science subjects.

Instrumentation

The structured questionnaire was used to collect the data in closed-ended responses from the participants. The instrument was adapted from Anwar et al. (2025), as their study is related to pre-service teacher technology integration during teaching practice: Trends, frameworks, practices, and recommendations for future research. The Cronbach's alpha value of the adapted questionnaire is >0.70. The overall reliability of the instrument was 0.951

Data Collection

The researcher used a questionnaire to get quantitative responses from the participants. In this regard, she distributed tools in the form of soft as well as hard copies to the participants. The data collection took 1.5 months. The researcher also visited those schools that were accessible and near her residence. Further, the majority of the responses were received through Google Form. During this process, she maintained the research ethical guidelines and took proper permission and consent from the respondents, and ensured that the recorded comments were kept anonymous. After the completion of data collection, proper coding was provided to each response, and then transferred to an SPSS file.

Data Analysis and Results

The data were analysed through SPSS and applied both descriptive and inferential statistics to answer the research objectives and scope of the study, and these tests were applied to explore the true picture of the exploration of the teachers' demographic factors influencing technology integration by mathematics and science teachers in secondary education in Lahore, Pakistan. The independent sample T-test and ANOVA were used to analyse the differences in teachers' technology integration practices based on demographic variables such as age, gender, experience, and the area of specialization.

Table 1

Frequency and Percentages of the Demographic Variables of Participants

Variables	Frequency	Percent
Gender		
Male	224	49.7
Female	227	50.3
Age		
Below 30	219	48.6
Above 30	232	51.4
Major Subjects		
Science	41	9.1
Mathematics	37	8.2
Physics	65	14.4
Computer	107	23.7
Chemistry	147	32.6
Biology	54	12.0

Variables	Frequency	Percent
Area of Specialization		
Science	37	8.2
Mathematics	48	10.6
Physics	56	12.4
Computer	111	24.6
Chemistry	146	32.4
Biology	53	11.8
Attended ICT related courses		
1	80	17.7
2-3	155	34.4
>4	216	47.9
Taught Classes		
9th	221	49.0
10th	230	51.0
Years of experience		
Less than 1 year	78	17.3
1-5 years	171	37.9
6-10 years	202	44.8
Total	451	100.0

Table 1 shows the demographic information of the secondary mathematics and science teachers. The subsequent section provides a comprehensive analysis of each research question's hypothesis formulated in the research.
An independent-samples t-test was applied to the teachers' gender and age, and an ANOVA was conducted on the teachers' experiences and area of specialization variables. As the T-test is more suitable to compare the means of two groups to determine a significant difference, and ANOVA is the statistical technique to use to compare the means of more than three groups. Thus, the details of each demographic with respect to their hypotheses are explained below.

H_{01}: There is no significant difference in the mean score of teachers' gender and their Technology Integration

To test this hypothesis, an independent samples t-test was conducted. Table 2 presents the results of the analysis, showing the comparison of mean scores between male and female teachers in relation to their technology integration. The test determines whether a statistically significant difference exists between the two groups.

Table 2

Independent Sample T-test on Demographic-Gender

Variable	N	Mean	df	t-value	sig
Male	224	314.08	442.765	-3.579	.000
Female	227	324.84			

It is evident from Table 2 that the t-value (-3.579) is significant at p=0.000 ($p \leq 0.05$) level of significance, so the null hypothesis is rejected, and it is concluded that "there is a significant difference in the mean score of teacher gender and their technology integration. It is further explained by Table 2 that the mean score of female mathematics and science teachers (324.84) is better than that of male mathematics and science teachers (314.08). Thus, this suggests that teachers' gender significantly influences the technology integration by mathematics and science teachers in secondary classrooms of Lahore. Therefore, the null hypothesis was rejected.

H_{02}: There is no significant difference in the mean score of teachers' age and their technology integration

An independent samples t-test was applied to determine the existence of a statistically significant change in technology integration of teachers based on their respective age brackets. The scores on technology integration between the two groups of teachers were compared in terms of their means. The use of this test was aimed at establishing the role of age as a determinant of the degree of technology integration in classroom practices.

Table 3

Independent Sample T-test on Demographic-Age

Variable	N	M	df	t-value	p
Below 30	219	316.42	448.978	-1.973	.049
Above 30	232	322.40			

*p≤ .05

An independent sample t-test was applied to discover the significant difference between teachers' age and the technology integration. The results revealed no significant difference, as the p-value was 1.973, and the sign is .049. The p-value is greater than 0.05, so we fail to reject the null hypothesis. So, it is concluded that there is a significant difference in the mean score of teacher age and their technology integration. It is further explained by Table 3 that scores above 30 teachers (322.49) are better than those below 30 (316.42) in the secondary schools of Lahore. This suggests that age significantly influences technology integration by mathematics and science teachers in secondary classrooms of Lahore.

H_{03}: There is no significant difference in the mean score of teachers' experiences and their Technology Integration.

One-way ANOVA was applied to assess whether the differences in technology integration (TI) between teachers with different teaching experience levels are statistically significant. The comparison made in the analysis is based on the mean scores of technology integration by various groups of experience. This helps in establishing the role of teaching experience on the degree to which teachers adopt technology in classroom activities.

Table 4

ANOVA test on Demographic-Teacher's experiences

Variables	Sum of Squares	df	Mean Square	F	Sig.
Teacher's experiences	9687.627	2	4843.814	4.704	.010
	461333.109	448	1029.761		
Total	471020.736	450			

*p≤ .05

Table 4 shows the results of a one-way ANOVA regarding the teachers' experiences and their use of technology. It was shown the p≤0.05 level of significance, there was a significant difference between teachers' use of technology in terms of their experiences. Therefore, it is concluded that teachers with different experiences (Less than 1 year, 1-5 years, and 6-10 years) have different experiences regarding the application of technology in the secondary schools of Lahore. Therefore, the null hypothesis was rejected.

Since the one-way ANOVA showed differences in technology integration (TI) among teaching experience of teachers, a post-hoc comparison was carried out to pinpoint the differences. The elements of the post-hoc test include the pairwise comparison of the means of TI scores between all the pairs of experience cohorts, hence clarifying which specific teaching experience strata have statistically different degrees of technology integration.

Table 5

Post HOC Tukey Test for Multiple Comparisons among Secondary Mathematics and Sciences Teachers based on Experience

(I) Experience	(J) Experience	Mean Difference	Std. Error	Sig.
Less than 1 year	1-5 years	-5.898	4.385	.538
	6-10 years	-12.427	4.278	.012
1-5 years	Less than 1 year	5.898	4.385	.538
	6-10 years	-6.528	3.335	.153
6-10 years	Less than 1 year	12.427	4.278	.012
	1-5 years	6.528	3.335	.153

*Bonferroni adjusted level of statistical significance 0.0167

A post hoc test was used to understand the mean difference in different experience groups of teachers. A Bonferroni-adjusted significance level of 0.0167 as per test (0.5/3) was applied to report for multiple comparisons. The result showed that the difference between teachers with 1 to 5 to 10 years' teaching experience group have only statistical significance, as p value is 0.153 and indicates a meaningful difference. However, no significant difference is found in other group pairs, as their p-values are 0.153 and 0.538. It was evident from the table that the score values of teachers having experience (Less than 1 year) were significantly in comparison to the mean score values of teachers in the experience group (6-10). It means that teachers who have experience (less than 1 year) were thinking differently about the use of technology as compared to teachers in the experience group (6-10 years), as their mean difference value is -12.427, which is high. Mean scores with the experienced group (1-5 years) were significantly different in comparison to the mean score values of teachers with experience group (6-10). It means that teachers who have experience (less than 1-5 years) were thinking differently about the use of technology as compared to the teachers with experience group (6-10 years), as their mean difference value is -6.528, which is high. Teachers with 6–10 years of experience scored significantly higher on technology use compared to those with less than 1 year of experience (M difference = 12.427, $p < .001$) and those with 1–5 years of experience (M difference = 6.528, $p = .015$).

H_{04}: There is no significant difference in the mean score of teachers' area of specialization and their Technology Integration

The analysis of variance (ANOVA) was conducted to find out whether there is a significant difference in technology integration (TI) with respect to the area of specialization of teachers. The comparison of mean scores of technology integration was completed in different subject-specialization groups. The results make it possible to determine whether disciplinary areas of teachers determine the degree to which they implement technology in their classroom activities.

Table 6

ANOVA test on Demographic-Teachers' areas of specialization

Variables	Sum of Squares	df	Mean Square	F	Sig.
Teachers' area of specialization	16363.707	5	3272.741	3.203	.007
	454657.030	445	1021.701		
Total	471020.736	450			

*$p \leq .05$

Table 6 shows the results of One-way ANOVA regarding the area of specialization and their use of technology. It was displayed that p≤0.05 level of significance, there was a significant difference between the teachers' use of technology in terms of their specialization. Therefore, it is concluded that teachers with different major specializations (Science, Mathematics, Physics, Computer, Chemistry, Biology) have different knowledge and expertise regarding the application of technology in the secondary schools of Lahore. Therefore, the researcher failed to accept the null hypothesis.

Table 7

Post HOC Tukey Test for Multiple Comparisons among Secondary Mathematics and Sciences Teachers based on Area of Specialization

(I) Area of Specialization	(J) Area of Specialization	Mean Difference	Std. Error	Sig.
Science	Mathematics	-8.637	6.993	1.000
	Physics	-11.000	6.772	1.000
	Computer	-3.541	6.068	1.000
	Chemistry	-11.794	5.883	.684
	Biology	-21.903	6.848	.022
Mathematics	Science	8.637	6.993	1.000
	Physics	-2.363	6.287	1.000
	Computer	5.097	5.522	1.000
	Chemistry	-3.156	5.318	1.000
	Biology	-13.266	6.369	.567
Physics	Science	11.000	6.772	1.000
	Mathematics	2.363	6.287	1.000
	Computer	7.460	5.239	1.000
	Chemistry	-.793	5.024	1.000
	Biology	-10.903	6.126	1.000
Computer	Science	3.541	6.068	1.000
	Mathematics	-5.097	5.522	1.000
	Physics	-7.460	5.239	1.000
	Chemistry	-8.253	4.025	.614
	Biology	-18.363	5.337	.010
Chemistry	Science	11.794	5.883	.684
	Mathematics	3.156	5.318	1.000
	Physics	.793	5.024	1.000
	Computer	8.253	4.025	.614
	Biology	-10.109	5.126	.738
Biology	Science	21.903	6.848	.022
	Mathematics	13.266	6.369	.567
	Physics	10.903	6.126	1.000
	Computer	18.363	5.337	.010
	Chemistry	10.109	5.126	.738

*Bonferroni adjusted level of statistical significance 0.0033

A one-way analysis of variance (ANOVA) test was used to examine whether there are significant differences in the level of technology integration (TI) among teachers, which depends on their disciplinary specialization. The statistical test comparatively evaluated the mean score of TI measures between different subject-specialty samples, such as mathematics and science. This research methodology makes it easier to explain the degree to which the disciplinary orientations of teachers can affect their technological pedagogical use in the classroom.

Table 7 presents the calculations of post-hoc comparisons through the Tukey HSD test. The multiple comparisons among secondary Mathematics and Sciences teachers based on Area of Specialization were conducted using Bonferroni adjusted alpha levels of. 0.0033 per test (.05/3). The results showed that there was no significant difference regarding teachers' area of specialization and the integration of technology, and p-values below the adjusted threshold. All observed p-values (e.g., 0.010, 0.022, 0.567, 0.684, 1.000) exceeded 0.0033, indicating that there were no statistically significant differences between any of the groups.

The findings show that the female teachers had a substantially enormous impact on the integration of technology as compared to their male counterparts, with females being 50.3 percent of the sample. The more significant technology integration was found in teachers with an age above 30 years (Mʿ=322.49) in comparison to teachers with an age below 30 years (M¯ 316.42). Moreover, the disparity was also observed in terms of teaching experience and area of specialization, with the teachers with diversified experience and disciplinary background having different competencies in technological knowledge and application in the secondary schools of Lahore.

Discussion

The results of the current research validate the idea that incorporation of technology in mathematics and science teaching in secondary schools is a complex and interdependent process that depends on teacher preparation, intention, and acceptance to use technology, technology competence, and innovation level. This role played by teacher preparation in drawing about the importance of structured pre-service and in-service training as a way of enabling a teacher to effectively integrate the use of digital tools in classroom teaching. This result is not isolated and is in line with the TPACK framework, which highlights the interdependence of technological, pedagogical, and content knowledge in an effective integration of technology (Chai et al., 2013; Mishra & Koehler, 2006). Similar empirical data in Pakistan indicates that poor preparation is an essential obstacle to successful ICT implementation in high school learning (Aslam et al., 2021; Hero, 2020). In line with the prior research carried out in both developed and developing settings, the results show that educators who view technology as useful and easy to use have higher probabilities of implementing it in their instructional activities (Khong et al., 2023; Scherer et al., 2019). There have been comparative trends within the Pakistani setting as well, with positive attitudes towards ICT being related to increased classroom implementation. It has also been previously noted that the lack of ICT skills in Pakistan has become a limiting factor in teachers using innovative instructional methods, although technological tools are accessible (Jogezai et al., 2020; Ghayyur & Mirza, 2021).

Lastly, the results indicate that technology integration is successful not only based on the individual teacher characteristics but also based on the larger institutional and contextual environment. Even though personal preparedness is imperative, insufficient infrastructure, little technical assistance, and inconsistent application of policies may limit the work of teachers. This finding goes in line with prior studies that have provided relevance on the importance of organizational support and leadership in maintaining technology integration (Hew & Brush, 2007; Hsu & Kuan, 2013). Although the results do indicate that preparation, skills, acceptance, and innovation play a crucial role in technological integration, these results also suggest that these factors are embedded in larger structural factors. The teachers might have the necessary knowledge and positive attitudes, but the lack of institutional support, autonomy in curriculum use, and examination-based teaching cultures may limit the richness and sustainability of technology usage. This implies that the process of technology integration cannot be perceived as any linear process but as a dynamic and contextual practice, which is influenced by policy, leadership, and school culture. In consequence, there should be a match between individual capacity and system-level reforms to prevent surface or compliance with the use of technology. Moreover, the results of the research show that technology integration in secondary schools is moving out of the phase of access to a quality phase. With the increasing access to digital tools as a basic, the question now becomes one of how well the technology can be integrated into pedagogy to improve conceptual knowledge and higher-order cognition, especially in mathematics and science classrooms. This paper thus brings to light the need to re-conceptualize technology integration as an ongoing professional learning process and not an outcome of a single technology adoption. Taken altogether, these results support the conceptual framework suggested by the researchers and prove its applicability to the context of secondary education in Pakistan.

Conclusion

To sum up, this research highlights the central role of teacher demographics in the adoption of technology in the classroom. The quantitative data indicate that the practices of technology integration were more vigorous among the female educators who represented 50.3 percent of the sample and mostly worked in STEM subjects, compared to the male participants. Further, teaching experience and subject disciplinary focus were also found to be influential factor to the abilities and readiness of teachers to utilize technological tools successfully. The results of the findings are indicative of the urgent necessity to respond to the professional development requirements of educators by means of specialized training programs, facilitating policy frameworks, and organized technical support to foster the introduction of technology into the diverse educational settings. With a careful arrangement of these dimensions, the educational institutions will be able to nurture a more balanced and effective application of technology and, thus, increase the overall results of teaching and learning.

Delimitation of the Study

This study is delimited to secondary mathematics and sciences teachers of Lahore. It focuses on the demographic factors that influence the integration of technology in secondary classrooms of Lahore. A quantitative research approach is used with questionnaires as the primary data collection method. The study specifically examines secondary schools, excluding other institutions.

Recommendations

Recommendations for the study are as follows:

1. All government and private secondary schools' leadership need to focus on the teachers' continuous professional development requirements, so their technological skills and confidence become strengthened.
2. Management of all secondary schools ensures reliable access to up-to-date devices, internet connectivity, and technical maintenance, reducing interruptions during lessons.
3. The government educational policies need to design and establish programmes that promote fair access to technology between the male and female teachers with built-in mentoring, flexible training module and peer support systems to counter the obstacles encountered by the male teachers.

References

Ali, M. Q., Nargis, N., Yasmeen, R., & Iqbal, Z. (2015). ICT use for effective teaching–learning process in secondary schools in Punjab Province. *Asian Journal of Social Sciences & Humanities, 4*(3), 138–147

Anwar, K., Musa, J., & Salleh, S. M. (2025). From learning to practice: The role of preparation, acceptance, skills, and innovativeness in affecting preservice teacher technology integration. *Education and Information Technologies, 30*, 9041–9067. https://doi.org/10.1007/s10639-024-13181-1

Aslam, R., Khan, N., Asad, M. M., & Ahmed, U. (2021). Impact of technological pedagogical content knowledge on teachers' digital proficiency at classroom in a higher education institution of Pakistan. *Interactive Technology and Smart Education, 18*(1), 119–130. https://doi.org/10.1108/ITSE-11-2020-0222

Aslan, A., & Zhu, C. (2017). Investigating variables predicting Turkish pre-service teachers' integration of ICT into teaching practices. *British Journal of Educational Technology, 48*(2), 552–570. https://doi.org/10.1111/bjet.12437

Bayaga, A., Bossé, M. J., Sevier, J., Fountain, C., Williams, D., Bosire, S., & Blignaut, S. (2021). University faculty opinions of preservice teachers' technological readiness. *Canadian Journal of Science, Mathematics and Technology Education, 21*(1), 44–64. https://doi.org/10.1007/s42330-021-00138-6

Bugti, F., Sarhandi, P. S. A., & Bugti, S. M. (2024). A qualitative study on challenges and opportunities for technology integration in pedagogy. *Journal of Development and Social Sciences, 5*(3), 100–109. https://doi.org/10.47205/jdss.2024(5-III)10

Byker, E. J., Putman, S. M., Polly, D., & Handler, L. (2018). Examining elementary education teachers and preservice teachers' self efficacy related to technological pedagogical and content knowledge (TPACK). In C. B. Hodges (Ed.), *Self efficacy in instructional technology contexts* (pp. 119–140). Springer. https://doi.org/10.1007/978-3-319-99858-9_8

Chai, C. S., Koh, J. H. L., & Tsai, C.-C. (2013). A review of technological pedagogical content knowledge. *Educational Technology & Society, 16*(2), 31–51. https://www.jstor.org/stable/jeductechsoci.16.2.31

Chaudhary, M. K. M., & Ahmad, T. B. B. T. (2025). The impact of digital literacy on ICT self-efficacy in Islamic secondary school teachers in District Kot Addu South, Pakistan. *LECTURES: Journal of Islamic and Education Studies, 4*(1), 51–61. https://doi.org/10.58355/lectures.v4i1.130

Cheng, S.-L., Lu, L., Xie, K., & Vongkulluksn, V. W. (2020). *Understanding teacher technology integration from expectancy-value perspectives. Teaching and Teacher Education, 91*, 103062. https://doi.org/10.1016/j.tate.2020.103062

Creswell, J. W., & Creswell, J. D. (2018). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications

Creswell, J. W., & Creswell, J. D. (2022). *Research design: Qualitative, quantitative, and mixed methods approaches* (5th ed.). SAGE Publications

Ghaffar, R., Khoso, F. J., & Sahito, Z. H. (2024). Assessing secondary school teachers' perceptions of their technological pedagogical and content knowledge in Karachi, Pakistan. *Spry Contemporary Educational Practices, 3*(1), 119–137. https://doi.org/10.62681/sprypublishers.scep/3/1/7

Ghayyur, T. S., & Mirza, N. A. (2021). Exploring TPACK skills of prospective teachers and challenges faced in digital technology integration in Pakistan. *Journal of Development and Social Sciences, 2*(4), 226–241. https://doi.org/10.47205/jdss.2021(2-IV)19

Hennessy, S., Harrison, D., & Wamakote, L. (2010). Teacher factors influencing classroom use of ICT in Sub-Saharan Africa. *Itupale Online Journal of African Studies, 2*, 39–54.

Hero, J. L. (2020). Teachers' preparedness and acceptance of information and communications technology (ICT) integration and its effect on their ICT integration practices. *Puissant*, *1*, 59-76.

Hew, K. F., & Brush, T. (2007). Integrating technology into K–12 teaching and learning: Current knowledge gaps and recommendations for future research. *Educational Technology Research and Development, 55*(3), 223–252. https://doi.org/10.1007/s11423-006-9022-5

Hsu, S., & Kuan, P.-Y. (2013). The impact of multilevel factors on technology integration: The case of Taiwanese grade 1–9 teachers and schools. *Educational Technology Research and Development, 61*(1), 25–50. https://doi.org/10.1007/s11423-012-9269-y

Idris, M., Khan, I., & Khan, A. (2021). *Induction program of teacher training of Khyber Pakhtunkhwa in the light of standards for elementary teachers in Pakistan. Journal of Arts & Social Sciences, 8*(1), 109–117. https://doi.org/10.46662/jass-vol8-iss1-2021(109-117)

Jogezai, N. A., Ismail, S. A. M., & Baloch, F. A. (2020). Hindering and enabling factors towards ICT integration in schools: A developing country perspective. Elementary Education Online, 19(3), 1537–1547. https://doi.org/10.17051/ilkonline.2020.733176

Joo, Y. J., Park, S., & Lim, E. (2018). Factors influencing preservice teachers' intention to use technology: TPACK, teacher self-efficacy, and technology acceptance model. *Journal of Educational Technology & Society, 21*(3), 48–59. https://www.jstor.org/stable/26458506

Khong, H., Celik, I., Le, T. T. T., Lai, V. T. T., Nguyen, A., & Bui, H. (2023). Examining teachers' behavioural intention for online teaching after COVID-19 pandemic: A large-scale survey. *Education and Information Technologies, 28*(5), 5999–6026. https://doi.org/10.1007/s10639-022-11417-6

Kolb, L. (2017). *Learning first, technology second: The educator's guide to designing authentic lessons*. ASCD.

Kolb, L. (2020). *Learning first, technology second in practice: New strategies, research, and tools for student success*. International Society for Technology in Education.

Loong, E. Y.-K., & Herbert, S. (2018). Primary school teachers' use of digital technology in mathematics: The complexities. *Mathematics Education Research Journal, 30*(4), 475–498. https://doi.org/10.1007/s13394-018-0235-9

Manasia, L., Ianos, M. G., & Chicioreanu, T. D. (2020). Pre-service teacher preparedness for fostering education for sustainable development: An empirical analysis of central dimensions of teaching readiness. *Sustainability, 12*(1), 166. https://doi.org/10.3390/su12010166

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017–1054. https://doi.org/10.1111/j.1467-9620.2006.00684.x

Rakes, C. R., Stites, M. L., Ronau, R. N., Bush, S. B., Fisher, M. H., Safi, F., Desai, S., Schmidt, A., Andreasen, J. B., Saderholm, J., Amick, L., Mohr-Schroeder, M. J., & Viera, J. (2022). Teaching mathematics with technology: TPACK and effective teaching practices. *Education Sciences, 12*(2), 133. https://doi.org/10.3390/educsci12020133

Scherer, R., Siddiq, F., & Tondeur, J. (2019). The technology acceptance model (TAM): A meta-analytic structural equation modeling approach to explaining teachers' adoption of digital technology in education. *Computers & Education, 128*, 13–35. https://doi.org/10.1016/j.compedu.2018.09.009

Song, H., & Zhou, M. (2021). STEM teachers' preparation, teaching beliefs, and perceived teaching competence: A multigroup structural equation approach. *Journal of Science Education and Technology, 30*(3), 394–407. https://doi.org/10.1007/s10956-020-09881-1

Tucker, C. B., Byrd, K. O., Gossen, D., & Morrison, K. (2024). *Teacher self-efficacy and preparedness for integrating STEM education using a project-based learning approach. Journal of Research in Science, Mathematics and Technology Education, 7*(Special Issue), 43–59. https://doi.org/10.31756/jrsmte.313SI

Wu, M. L., & Zhou, Y. (2025). Strengthening teachers' STEM preparedness through a technology integration online course. *Education and Information Technologies, 30*, 17191–17206. https://doi.org/10.1007/s10639-025-13479-8