



Teachers' Adoption of Emerging Educational Technologies: Opportunities, Challenges, and Pedagogical Readiness in Private Schools of Karachi

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ABSTRACT

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The rapid advancement of emerging educational technologies has transformed teaching practices and created new opportunities for improving learning experiences. The present study investigated how teachers use emerging educational technologies in private schools of Karachi with respect to the teachers' familiarity, adoption of the technology, pedagogical readiness, barriers, and professional development requirements. The research design adopted was quantitative research design with cross-sectional design, and the data collection technique used was a structured questionnaire, the subjects of the study were 34 teachers. The data collected were analyzed using SPSS, descriptive statistics, reliability analysis, Pearson correlation and regression analysis. The results showed that teachers' knowledge of emerging technologies was positive, and they were also ready to use and ready to teach technologies. Pedagogical readiness, professional development needs, teacher familiarity were among the factors that significantly predicted technology adoption while barriers negatively predicted technology adoption. The study highlights the importance of strengthening teachers' digital competencies, providing continuous professional development, and ensuring institutional support for sustainable technology integration in school education.

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Introduction

The rapid digital transformation of education has significantly reshaped teaching and learning practices worldwide. Digital technologies have transformed teaching and learning practices from teacher-centered to more student-centered and interactive, promoting collaboration, creativity, and critical thinking. The COVID-19 pandemic has also contributed to the increased use of digital learning technologies, underscoring the importance of teachers building their digital competencies and pedagogical skills to effectively integrate technologies into learning (Chiu, 2024; UNESCO, 2023). Such technological advancements as Augmented Reality (AR), Virtual Reality (VR), educational simulations, gamification, and Artificial Intelligence (AI) have become pivotal tools for enhancing learning experiences by offering immersive, engaging, and personalized teaching (Lampropoulos & Kinshuk, 2024). Technology-enhanced learning has emerged as a global educational priority as schools look for innovative solutions to enhance the quality of teaching and learning.

Emerging Educational Technologies in School Education

The development of new education technologies has revolutionized the way teachers teach and students learn in the classroom. AR and VR enable students to visualise complex concepts in an immersive way and educational simulations give a

hands-on opportunity to learn skills through firsthand experience. Gamification incorporates game-based elements, such as rewards and challenges, to increase learners' motivation and engagement. Moreover, AI-powered instructional technologies enable adaptive learning, intelligent tutoring, automated assessment, and personalised feedback, which allows teachers to better cater to individual learning needs (Wang & Li, 2024; Lampropoulos & Kinshuk, 2024; Chiu, 2024). In their use within the classroom, these technologies have shown great promise to improve student achievement and to facilitate innovative teaching methods.

Technology Adoption among Teachers

The teachers are one of the essential factors that affect the successful implementation of emerging educational technologies, as teachers decide how to use digital tools in the education process. They are an important factor in the acceptance, technological proficiency, pedagogical preparedness and attitudes towards new developments of technology integration and classroom effectiveness. It is noted that teachers who consider the use of educational technologies as beneficial and get appropriate support from the institution and professional development opportunities are more inclined to use innovative teaching methods and digital pedagogy (Bakhadirov et al., 2024). Thus, teachers are also important agents of change to support technology-based learning and innovation in classrooms.

Problem Statement

Although in recent years, educational technology has been a major priority in the education sector globally, there remains a lack of empirical study about the implementation of new educational technologies in private schools of Karachi (Akram et al., 2022; Zaman & Anwar, 2023). While digital infrastructure in many private schools has been renovated, pedagogical readiness, the use of new technologies, and teachers' professional development have not been studied thoroughly (Ghaffar et al., 2024; Hidayati et al., 2023). Furthermore, institutional obstacles such as the lack of training, technical support, and organizational issues can also impede the successful adoption of technology in teaching practices (Berry, 2024; Bashir, 2025).

Research Objectives

1. To examine teachers' familiarity with and frequency of using emerging educational technologies (AR, VR, simulations, and gamification).
2. To identify the pedagogical benefits and barriers influencing teachers' technology adoption.
3. To investigate teachers' professional development needs for effective technology integration.

Research Questions

1. What is the level of teachers' familiarity with and frequency of using emerging educational technologies (AR, VR, simulations, and gamification)?
2. What pedagogical benefits and barriers influence teachers' adoption of emerging educational technologies?
3. What are teachers' professional development needs for the effective integration of emerging educational technologies?

Research Gap

Previous studies have primarily focused on students' learning outcomes and technology acceptance, while comparatively little attention has been given to teachers' perspectives regarding emerging educational technologies. Furthermore, empirical studies that adopt the same theoretical lens in examining teachers' familiarity, pedagogical readiness, perceived barriers and professional development are limited, especially in the context of Pakistan (Akram et al., 2022; Ghaffar et al., 2024). Existing research suggests that various factors, including technological competence, institutional support, and professional training, affect teachers' technology integration practices, pointing to a need for further research to better understand the readiness of teachers in private schools in Karachi to integrate emerging educational technologies (Zaman & Anwar, 2023; Jawed et al., 2025; Bahadur & Sharjeel, 2026).

Significance of the Study

This study is a contribution to the literature because it analyzes the use of emerging educational technologies in private schools of Karachi from the perspective of teachers. The results would benefit the teachers in enhancing their digital pedagogical skills, the school administration in shaping digital technology integration initiatives, the educational policymakers in formulating evidence-based digital technology integration policies, the teacher education institutions in

updating their curricula in light of the newly emerged competency characteristics, and the future researchers in the empirical evidence for further research and investigation on the adoption of digital technology in Pakistan (Aslam et al., 2020; Jamil et al., 2024). Moreover, recognizing the preparedness and the hurdles faced by teachers in the integration of technology can help in the sustainable use of technology by addressing the challenges of infrastructure, digital literacy and pedagogical preparedness (Hidayati et al., 2023; Bashir, 2025; Rehman et al., 2025).

Literature Review

Emerging Educational Technologies

Emerging educational technologies have transformed teaching and learning by promoting interactive, personalized, and student-centered instructional practices. The technology used in the field of education has come a long way since the introduction of computers and multimedia resources; it has advanced to include Artificial Intelligence (AI), Augmented Reality (AR), Virtual Reality (VR), learning analytics, educational simulations, and gamification. These developments reflect the principles of Education 4.0 – digital transformation, collaboration, creativity and lifelong learning. Since the outbreak of COVID-19, schools globally have hurried to integrate digital tools in order to maintain educational continuity, and technology enhanced learning has become an integral part of education in the modern era (Bond et al., 2021; Chiu, 2024). Recent studies have shown that teachers' perceptions, technological awareness, and institutional conditions play a significant role in successful technology integration (Akram et al., 2022).

Digital classrooms improve teaching quality and enhance students' participation by providing interactive learning, prompt feedback, collaborative activities and differentiated teaching. Smart learning environments with digital devices, AI and data-driven learning strategies enhance cognitive and learning outcomes for students through adaptive learning experiences (Chiu, 2024). Moreover, the well-executed use of AR, VR and gamification can lead to better motivation, engagement, and conceptual understanding (Lampropoulos & Kinshuk, 2024; Javed et al., 2025). However, the use of technology in private schools in Pakistan has improved the engagement levels and effectiveness of instruction, though resource limitations and teacher readiness pose challenges (Javed et al., 2025; Zaman & Anwar, 2023).

Teacher Familiarity with Emerging Technologies

Teachers' experiences with developing technologies are important to the success of their technology integration. It involves digital literacy, technological knowledge, confidence, and previous experience of educational technologies. The purpose of digital literacy is to help educators to access, assess, produce and share information effectively and responsibly (UNESCO, 2023). The study found a strong connection between teachers' confidence and their familiarity with digital tools and their willingness to adopt technology in the classroom (Hidayati et al., 2023; Krismiyati, 2025).

The Technological Pedagogical Content Knowledge (TPACK) framework states that for technology to be integrated effectively, the knowledge of technology, pedagogy, and content should be integrated (Mishra, 2019). Recent research still confirms the significance of TPACK in understanding teachers' digital competencies and teaching practices (Wang & Li, 2024). Teachers' technological pedagogical knowledge has been identified as a significant factor in the implementation of technology in the classroom in Pakistan (Ghaffar et al., 2024). Moreover, teachers' preparedness and confidence to use educational technologies are shaped by their professional experience, training opportunities, and exposure to digital platforms (Aslam et al., 2020; Jamil et al., 2024).

Technology Adoption

Technology adoption means that teachers accept and integrate technology into their classroom practice. Teachers' perception, attitude, motivation, institutional support and resources are critical for successful adoption. According to the Technology Acceptance Model (TAM), the key factors that affect technology acceptance decision are perceived usefulness and perceived ease of use (Davis, 1989). In line with the above, recent studies keep on supporting TAM as an explanation for teachers' use of emerging technologies in education (Ateş & Şahin Kölemen, 2025).

The more teachers feel that technology will be helpful in enhancing student engagement, learning, and the efficiency of instruction, the more often they will use it in their teaching. But adoption is different in each context because leadership support, professional development opportunities, digital competencies and infrastructure differ. Research conducted in the private education sector has highlighted the importance of training, administrative support, and technological resources on teaching practices (Zaman & Anwar, 2023; Ali et al., 2024). In addition, findings from schools in Karachi suggest that digital literacy efforts and teacher training enhance teachers' capacity to effectively leverage new technologies (Aurangzeb et al., 2026; Bahadur & Sharjeel, 2026).

Pedagogical Readiness

Pedagogical readiness is teachers' readiness to incorporate technology while maintaining effective instructional design, curriculum alignment, classroom management and student engagement. It is teacher knowledge and skills, as well as their beliefs and confidence on using a suitable technology to facilitate learning objectives (Ali et al., 2025).

Teachers must go beyond technology skills and adopt pedagogically sound strategies to effectively integrate technology. Students' teachers who are better prepared in teaching are more likely to embrace the use of AI-supported tools, AR, VR and digital assessment platforms to boost active learning and critical thinking (Chiu, 2024; Wang & Li, 2024). But lack of training and inadequate instructional assistance are still obstacles to teacher readiness. Therefore, enhanced professional development and institutional support are crucial to sustainable technology uptake (Bashir, 2025; Rehman et al., 2025).

Barriers to Technology Integration

While emerging educational technologies offer a number of advantages there are a number of barriers that limit the effective use of those technologies in the classroom. Lack of infrastructure, access to limited digital equipment, obsolete equipment, and unreliable internet connections are still significant problems, especially in developing settings (UNESCO, 2023). Access to digital facilities and technological resources is a factor that impacts teachers' effectiveness in using technology (Berry, 2024).

Moreover, teachers' resistance to new technologies is due to technical support, lack of professional training, and concerns about unfamiliar technologies (Bakhadirov et al., 2024; Wang & Li, 2024; Meccawy, 2023). Limits of time, budget issues and poor administrative support continue to impact technology implementation. The findings from the private school setting show that institutional support and professional learning opportunities are strong factors in technology supported teaching practices (Mustapa & Miskon, 2023).

Professional Development Needs

Teacher development is a continuous process that enables teachers to use educational technologies effectively. Technical preparation is not the only thing that should be emphasized in training; instructional design, digital evaluation, technology use strategies, and classroom management should also be included (Chiu, 2024). Technological competency, pedagogical application, ethics, communication, collaboration, and lifelong learning are highlighted as elements of digital competence by UNESCO (2023).

Teachers share their experiences through mentoring, collaborative learning communities, and school-based workshops to address technology related issues and challenges. Continuous professional development (CPD) leads to increased CPD teachers' confidence, acceptance of technology, and pedagogical readiness (Lampropoulos & Kinshuk, 2024; Berry, 2024).

Relevant Theory: Technological Pedagogical Content Knowledge (TPACK)

The TPACK is a theoretical model for the understanding of teachers' incorporation of emerging educational technologies. It believes that Content Knowledge (CK), Pedagogical Knowledge (PK), and Technology Knowledge (TK) are needed for effective Integration. These domains facilitate teachers to plan for meaningful learning experiences using technologies (Schmidt et al., 2009).

Recent studies have validated that the higher the level of TPACK, the more confident, prepared, and effective teachers become in using emerging technologies in their classrooms (Wang & Li, 2024). Likewise, technological pedagogical competencies also help the preparedness of teachers in using innovative digital tools (Ghaffar et al., 2024).

Development of the Research Framework

This study outline a conceptual framework that comprises the teacher's familiarity, technology adoption, pedagogical readiness, barriers, and teacher needs for professional development based on the literature and TPACK framework (Schmidt et al., 2009). The increase in teachers' familiarity is anticipated to have a positive impact on the adoption of technology because teachers who are more familiar and confident with technology are more likely to use digital technology in teaching (Akram et al., 2022; Meccawy, 2023).

The technology adoption is expected to have a positive effect on pedagogical readiness which increases teachers' readiness to implement technology-supported instructional strategies (Mustapa & Miskon, 2023; Shuhaimi et al., 2025). However, factors such as weak infrastructure, lack of technical assistance, training and financial resources, and weak administrative support can impede adoption. Professional development is suggested as a facilitating factor to improve digital competencies, readiness and sustainable technology integration in private schools of Karachi.

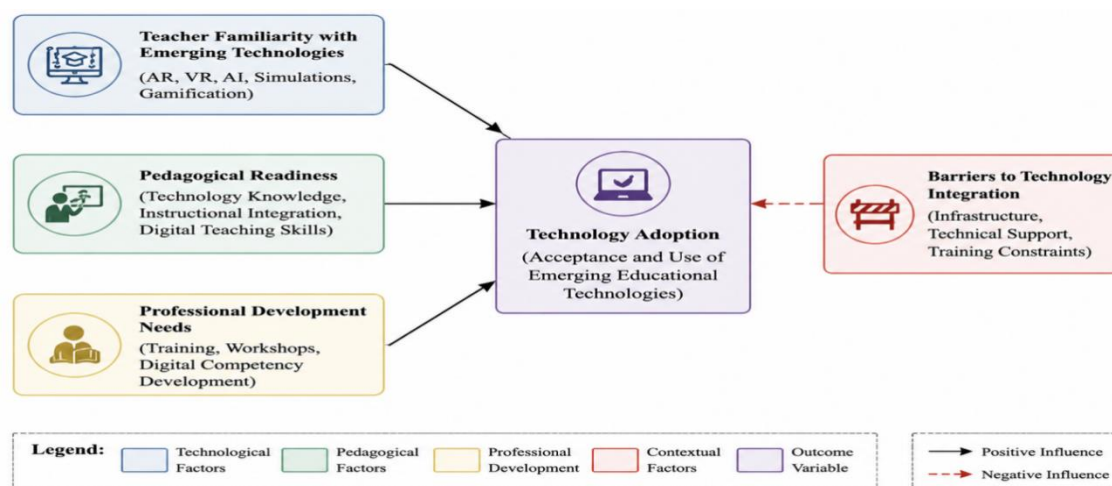


Figure 1. Conceptual Framework Illustrating Factors Influencing Teachers' Adoption of Emerging Educational Technologies

Methodology

This study has adopted quantitative research design with cross sectional survey approach to explore the teachers' willingness to implement emerging application in education and educational opportunities, challenges and pedagogical readiness in private schools of Karachi. A quantitative approach was chosen since numerical data could be obtained and statistical analysis could be used to study the relationship between the variables in the study. The cross-sectional survey design was suitable for the researcher to assess teachers' perceptions and practices as it was concerned with a moment in time (Creswell & Creswell, 2017).

The study was carried out based on the philosophy of Positivist research which believes that knowledge can be gained from objective observation and empirical measurement. The deductive research method was used due to the study being theory-driven and based on previous empirical studies. Quantitative data obtained from the respondents were used to test the proposed relationships between the study variables (Saunders et al., 2009).

The study was conducted on teachers of private schools of Karachi, Pakistan. A total of 34 teachers participated in the study. The participants were from various age groups and educational qualifications, teaching experience and subject specialization groups. The participants were easily accessible and had agreed to take part in the study, hence the use of a convenience sampling technique (Saunders et al., 2009).

A structured questionnaire was used to obtain the data. The questionnaire had six sections. The first section focused on demographic data such as sex, age, qualification, years of teaching experience and subject taught. The remaining sections assessed teacher familiarity with emerging educational technologies, adoption of technologies, pedagogical readiness, barriers to the integration of educational technologies, and teacher professional development needs. Each item was rated on a 5-point scale ranging from Strongly Disagree (1) to Strongly Agree (5).

The questionnaire was reviewed by experts in educational Technology and research methodology to ensure the validity of the instrument. They provided their comments and suggestions to make the questionnaire clearer, relevant, and with content. In this way, the instrument's content validity was established (Taherdoost, 2016).

Cronbach's alpha was used to test the reliability of the questionnaire. Hair et al. (2022) states that any Cronbach's Alpha index of 0.70 or above is considered acceptable internal consistency. All constructs were thus tested for reliability prior to further statistical analyses.

The management of the selected private schools gave permission before data collection. All participants were informed of the purpose of the study and questionnaires were given to them both in person and electronically. There was no coercion in any way in either participation or the confidentiality of the responses, and the respondents were assured that their answers would only be used for academic research.

All the data collected was compiled into the Statistical Package for the Social Sciences (SPSS) for analysis. Demographic characteristics and responses of the participants were summarized by descriptive statistics: frequencies, percentages, means

and standard deviations. For the reliability of the questionnaire, Cronbach's Alpha was used. Pearson correlation and regression analysis were used to explore relationships between the study variables, as appropriate.

Ethical principles were adhered during the process of research. All participants gave informed consent prior to data collection. No one was forced to participate and there was no penalty for leaving the study at any time. All participants were kept confidential and anonymous, and the data collected were kept safely and given only for academic purposes.

Results

Data collected were analyzed using SPSS (Statistical Package for Social Sciences). The present study employed descriptive statistics, reliability analysis, Pearson correlation analysis, regression analysis to analyze teachers' utilization of emerging educational technologies, pedagogical readiness, perceived obstacles and professional development needs. The results are summarized in the ensuing sections.

Demographic Profile of Respondents

Demographic characteristics of the respondents were analyzed in terms of frequency and percentage. The demographic variables taken into consideration were: gender, age, qualification, teaching experience and subject specialization.

Table 1: Gender Distribution of Respondents

Gender	Frequency	Percentage (%)
Male	18	52.9
Female	16	47.1
Total	34	100

Table 1 show that there was a participation of both male and female teachers in the study. The male teachers constituted 52.9 % of the total sample while the female teachers constituted 47.1 % indicating relatively balanced gender distribution among the teachers.

Table 2: Age Distribution of Respondents

Age Group	Frequency	Percentage (%)
Below 25 years	5	14.7
25-35 years	16	47.1
36-45 years	9	26.5
Above 45 years	4	11.8
Total	34	100

Table 2 presents the age distribution of teachers who participated in the study. The majority of respondents were aged 25 to 35 years (47.1%) followed by age group 36 to 45 years teachers (26.5%). The results revealed that most of the participants were professionally active teachers who have had a potential exposure to digital teaching.

Table 3: Qualification of Respondents

Qualification	Frequency	Percentage (%)
Bachelor	7	20.6
Master	21	61.8
MPhil/Other	6	17.6
Total	34	100

The findings show that most of the respondents had master's degree level qualifications (61.8%) followed by bachelor's level qualifications (20.6%) and MPhil/other qualifications (17.6%). This shows that most participants possessed the academic background to grasp and utilize Technology-supported Teaching Practices.

Table 4: Teaching Experience of Respondents

Experience	Frequency	Percentage (%)
Less than 5 years	8	23.5
5–10 years	15	44.1
Above 10 years	11	32.4
Total	34	100

Table 4 shows that majority of teachers (44.1%) had five to ten years of teaching experience while 32.4% of teachers had over ten years of teaching experience. This means that the sample had teachers with different years of experience.

Descriptive Statistics of Study Variables

Descriptive statistics were conducted to explore teachers' perceptions of the familiarity, adoption of emerging educational technologies, readiness to teach with these technologies, barriers and professional development needs. The results of the mean score and standard deviation are shown in Table 5.

Table 5: Descriptive Statistics of Research Variables

Variables	N	Minimum	Maximum	Mean	Std. Deviation
Teacher Familiarity	34	1.80	5.00	3.92	.71
Technology Adoption	34	2.00	5.00	4.01	.68
Pedagogical Readiness	34	2.20	5.00	3.95	.65
Barriers	34	1.60	4.80	3.41	.76
Professional Development Needs	34	2.00	5.00	4.18	.62

The descriptive results show that teachers' technology adoption and teachers' PD needs are relatively high ($M = 4.01$, $SD = .68$) and ($M = 4.18$, $SD = .62$), respectively. The teacher familiarity ($M = 3.92$, $SD = .71$) and pedagogical readiness ($M = 3.95$, $SD = .65$) also had positive responses, indicating that teachers had good readiness to implement new educational technologies. However, barriers achieved a relatively lower mean score ($M = 3.41$, $SD = .76$), representing technological and institutional problems of effective implementation.

Reliability Analysis

Cronbach's Alpha reliability test was used to determine the internal consistency of the research instrument. The reliability coefficients of all constructs are given in Table 6.

Table 6: Reliability Statistics of Study Constructs

Variables	No. of Items	Cronbach's Alpha
Teacher Familiarity	5	.82
Technology Adoption	6	.86
Pedagogical Readiness	5	.84
Barriers	5	.79

Professional Development Needs	5	.88
Overall Scale	26	.91

The measurement of the reliability is acceptable for all constructs (Table 2). Cronbach's alpha values ranged from .79 to .88 and the Cronbach's alpha for the overall scale was .91. The results of these findings indicated that the items of the questionnaire consistently measured the intended constructs. Hair et al (2022) state that Cronbach's Alpha's scores greater than .70 are considered acceptable.

Correlation Analysis

Pearson correlation analysis was used to explore the relationships between teacher familiarity, technology use, pedagogical readiness, barriers and professional development needs.

Table 7: Pearson Correlation Analysis among Study Variables

Variables	TF	TA	PR	B	PDN
Teacher Familiarity (TF)	1				
Technology Adoption (TA)	.62**	1			
Pedagogical Readiness (PR)	.58**	.71**	1		
Barriers (B)	-.31	-.42*	-.35*	1	
Professional Development Needs (PDN)	.55**	.67**	.63**	-.29	1

*Note: *p < .05, **p < .01

The correlation analysis showed that the major study variables were interrelated. The correlation between the teacher's familiarity and the technology adoption was significant and positive ($r = .62$, $p < .01$). Likewise, pedagogical readiness was found to have a strong positive correlation with technology adoption ($r = .71$, $p < .01$), which suggests that teachers who had a higher pedagogical readiness were more likely to use emerging educational technologies. Conversely, barriers showed negative relationships with technology adoption, suggesting that technological and institutional constraints may reduce teachers' adoption practices.

Regression Analysis

A multiple regression analysis was used to assess the predicting effect of the teacher familiarity, pedagogical readiness, barriers, and professional development needs on the adoption of technology.

Dependent Variable: Technology Adoption

Predictors: Teacher Familiarity, Pedagogical Readiness, Barriers, Professional Development Needs

Table 8: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error
1	.81	.66	.61	.38

According to the model summary, the predictor variables account for 66% of the variation in technology adoption ($R^2 = .66$). This shows that the collective effect of teachers' familiarity, pedagogical readiness, barriers, and teachers' needs for professional development explained a significant proportion of the variance in teachers' technology adoption.

Table 9: ANOVA Table

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	12.45	4	3.11	21.43	.000

Residual	6.20	29	.21
Total	18.65	33	

The results of the ANOVA test indicated that the regression model was statistically significant ($F = 21.43$, $p < .001$), and therefore the selected variables in this study (demographic, attitude, and knowledge factors) contributed significantly towards explaining the variations in the teachers' technology adoption.

Table 10: Regression Coefficients Predicting Technology Adoption

Predictor	Beta (β)	t-value	Sig.
Teacher Familiarity	.28	2.41	.022
Pedagogical Readiness	.41	3.52	.001
Barriers	-.19	-2.06	.048
Professional Development Needs	.32	2.87	.007

The regression coefficient for pedagogical readiness was the greatest positive predictor for technology adoption ($\beta = .41$, $p < .01$). Professional development needs and teacher familiarity also significantly influenced technology adoption, with β values of .32 ($p < .01$) and .28 ($p < .05$), respectively. However, barriers negatively predicted technology adoption ($\beta = -.19$, $p < .05$), indicating that technological limitations and institutional challenges may hinder teachers' willingness to integrate emerging educational technologies.

Discussion

The present study aimed to explore the teachers' awareness, adoption, pedagogy readiness, obstacles and professional development needs for the emerging educational technologies in private schools of Karachi. The results showed that teachers had a positive level of awareness of emerging technologies, meaning that they had a certain awareness and understanding of digital tools such as artificial intelligence, augmented reality, virtual reality, simulations, and gamification. This is in line with Akram et al. (2022), who emphasized that teachers' technological awareness, confidence and experiences with digital tools have a significant impact on their willingness to use technology in their teaching. Similarly, Hidayati et al. (2023) pointed out that digital literacy and technological competence are among the factors that contribute to teachers' readiness in using technology effectively. Thus, the present study indicates that teachers' basic technological knowledge has been acquired in the private schools of Karachi, but further practice and professional assistance are required to make them useful in the classrooms (Oad et al., 2024; Faheem, Gulab, & Ahmad, 2025).

The results of the study also showed that teachers' level of technology adoption was high, which indicated that the study's participants were aware of the value of the emerging education technologies to boost instructional effectiveness and increase student engagement. The results of this finding align with the Technology Acceptance Model (TAM) that proposed that PUE would be the most critical factors in the acceptance of a technology (Davis, 1989). The findings also align with the findings of Zaman and Anwar (2023), who concluded that having a positive perception of the benefits of digital tools and adequate institutional support had a positive effect on teachers' willingness to use them in private educational institutions (Dilshad, Shah, & Ahmad, 2023). Finally, the positive relationship between familiarity and adoption suggests that teachers' technology acceptance and implementation behaviors are influenced by their technology knowledge.

Furthermore, the results showed high teachers' pedagogical readiness in the use of technology in teaching, meaning that teachers could apply technology in their teaching practice, not for simple purposes only (Haider, Ahmad, & Ali, 2024). The result aligns with the Technological Pedagogical Content Knowledge (TPACK) model that states that technological knowledge, pedagogical knowledge, and content knowledge are needed to be integrated so that technology can be used effectively in the teaching and learning process (Mishra, 2019). Wang and Li (2024) also suggested that teachers holding higher technological pedagogical skills have higher confidence in the application of emerging technologies like AR, VR, and mixed reality for the purpose of meaningful learning. Therefore, pedagogical readiness seems to be the most important determinant of sustainability of technology adoption.

Although teachers were highly positive about technology integration, their answers showed that there are still some barriers to technology incorporation such as technological limitations, lack of help, and implementation challenges (Ali et al., 2023; Imran et al., 2023). Negative correlation between barriers and technology adoption suggests that institutional and personal

factors can negatively affect the teachers' capacity to effectively adopt emerging technologies. The results are consistent with UNESCO (2023), who highlighted that inadequate infrastructure, accessibility to digital materials, and teacher support are critical issues around technology integration globally. Likewise, Bashir (2025) noted that shortage of training, technical assistance and resources continue to be a major challenge for teachers especially in creating learning environments.

Teachers' demand for continuous training and capacity building opportunities was noted as the highest mean score, reflecting teachers' keen interest in professional development. This is a key observation that indicates the need for teacher structured PD in pedagogical approaches to the effective use of technology. Chiu (2024) emphasized the need for teacher professional development to empower educators to utilize the latest technologies in curriculum planning, evaluation, and student-centered learning. Similarly, Lampropoulos and Kinshuk (2024) proposed that mentoring, co-learning communities, and ongoing training increases teachers' confidence and preparedness in teaching with technology.

Overall, the findings align with the literature in showing that there are several interrelated factors that affect teachers' use of emerging educational technologies: technological familiarity, pedagogical readiness, perceived usefulness, institutional barriers, and professional learning opportunities. The results lend empirical support to both TAM and TPACK, since they showed that the adoption of technology is not only dependent on teachers' acceptance of technology, but also on the effective integration of technology in teaching. This research builds upon the existing research and offers evidence from PKS and emphasizes on the need of a holistic approach to create digital professional development programs to encourage sustainable technology integration in school education.

Practical Implications

The results of this study have implications in practice for various stakeholders associated with educational technology integration. School administrators need to create enabling digital school contexts, which involves ensuring sufficient technological facilities, technical support and ongoing professional development for teachers. Teachers need to take an active role in improving their digital skills and engagement by creating pedagogical approaches that allow for meaningful use of new technologies instead of limiting technology to a supplemental role (Aslam, Iqbal & Ahmed, 2022). Educational policymakers should develop a comprehensive policy on technology integration that covers issues such as institutional support, teacher training, and digital access, especially in the private schools. Professional development programs for teachers in teacher training institutions need to be re-designed to include the concepts of emerging technologies, digital pedagogy and Technological Pedagogical Content Knowledge (TPACK). It is important that curriculum developers ensure that technology and technology supported learning activities are aligned with the curriculum goals and are student based. Educational technology vendors should create user-friendly, accessible digital products that are contextually relevant and meet teachers' in-class needs and challenges.

Conclusion

This study investigated teachers' familiarity, adoption, pedagogical readiness, barriers and professional development needs of emerging educational technologies in private school system of Karachi. The results showed that the teachers had a positive familiarity level, meaning they were aware of and had a basic understanding of new technologies like artificial intelligence, augmented reality, virtual reality, simulations, gamification, etc. This finding also revealed a high level of technology adoption by teachers indicating that they were aware of the benefits of new technologies to improve teaching effectiveness and student engagement.

The study also concluded that pedagogical readiness was one of the significant factors that affect technology integration. Teachers with high technological pedagogical competencies were more ready to support the use of digital tools in teaching. The results confirmed the assumptions of the model of technology adoption known as the Technology Acceptance Model (TAM) and Technological Pedagogical Content Knowledge (TPACK) framework, indicating that the adoption of technology is not only influenced by the acceptance of digital innovations by teachers, but also on the skills teachers need to combine effective teaching methods with technology.

In addition, while teachers displayed positive attitudes towards the integration of technology, some barriers still had an impact on the effective use of technology, which were found to include insufficient resources, limited training opportunities, and inadequate technical support. The findings of the study indicate the critical need for ongoing professional development efforts, emphasizing technical skill and pedagogical uses of new technologies.

The study's goals were met by examining teachers' familiarity with emerging technologies, barriers to technology adoption, and the professional development needs. Overall, this research has added to the body of knowledge by offering empirical evidence from private schools in Karachi, while highlighting the importance of teacher readiness for effective technology

integration. The implementation of sustainable educational technology should be a balanced approach that takes into account teacher competence development, institutional support, policy development, and professional learning opportunities. Improving teachers' capacities will help schools fully leverage the learning opportunities of new technologies and provide innovative, engaging, and future-focused learning spaces.

Limitations

The limitations of this study must be taken into account when interpreting the results of this study. First, the number of teachers in the sample was limited to 34 which could limit the generalizability of the results to a larger sample of teachers. Secondly, the study was conducted on private schools of Karachi so the results are limited to the experiences and challenges of the teachers in the private sector in this area and the experiences and challenges in the public sector or in other geographical regions may vary. Third, cross section research design only measured teachers' perceptions at one point in time, and did not assess technology adoption and readiness over time. Last, the study was based on self-reported questionnaire information which can encounter response bias, as participants may have interpreted the questions differently than the way they actually implemented technology. However, the study offers some insights into the preparedness and challenges of teachers dealing with the adoption of new educational technologies in the private school setting.

Recommendations for Future Research

Future research should consider the following directions:

1. Future research should involve educators from both public and private schools to gain a broader picture of technology integration in various areas of education.
2. The researchers need to expand the sample size by recruiting more teachers from different schools and regions to ensure the findings are generalizable.
3. Longitudinal studies need to be conducted to investigate the growth of teachers' technology adoption, digital competencies and pedagogical readiness over time.
4. Comparative studies should investigate the differences among urban and rural schools in technological resources, teacher preparedness and obstacles to the integration of technology.
5. Future studies should use mixed research methods and include quantitative survey data and qualitative interview data or classroom observations to better understand teachers' experiences and practices.
6. Future research might explore the effects of school leadership, institutional support, and the role of policy as intervening or moderating variables between teachers' use of emerging educational technologies.
7. Students' viewpoints and outcomes of learning can also be studied by researchers to measure the effectiveness of technology integration from various stakeholder perspectives.

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