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Successes and Challenges of Online Teaching: Evidence from Primary and Secondary Schools of Sindh

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Abstract

This study explores the key challenges and successes experienced by teachers and students in primary and secondary schools during this transition. Utilising a mixed-methods approach, quantitative data were collected from 160 teachers, while qualitative insights were derived from nine semi-structured interviews and three focus group discussions with teachers across public, private, and partnership schools. Major challenges included digital illiteracy, unstable internet access, and limited infrastructure. However, increased teacher adaptability, digital content delivery, and professional development in private schools emerged as key successes. The findings highlight the need for improved infrastructure, equitable digital access, and sustained teacher training. Policy recommendations emphasise the integration of blended learning and strong institutional support to enhance online education outcomes in Sindh.

Keywords

COVID-19

Digital readiness

ICT infrastructure

Online blended learning

Teacher professional development

INTRODUCTION

The COVID-19 pandemic marked an unprecedented global crisis, disrupting socio-political, economic, and educational systems across the world. It compelled a rapid shift from conventional classroom instruction to digital and blended learning, testing the resilience and adaptability of education sectors worldwide (UNESCO, 2020). In developed regions, this transition accelerated the integration of educational technologies. However, in low- and middle-income contexts like Sindh, Pakistan, it exposed long-standing structural deficiencies, particularly in digital infrastructure, teacher preparedness, and equitable access to learning resources (Gul et al., 2023). In the post-pandemic educational landscape, an effective education system is expected to ensure inclusive access to internet-enabled devices, equip teachers with digital pedagogy skills, and provide the technological infrastructure necessary for delivering hybrid and online instruction (Ossiannilsson, 2022). Unfortunately, the ground realities in Sindh remain far from this ideal. While national-level education reforms support digital learning, most schools in the province lack stable ICT infrastructure, and many teachers are inadequately trained in using educational technology (Qadir et al., 2021). Students, especially those in remote and economically marginalized areas, face significant hurdles in accessing digital tools and reliable internet connectivity (Zhang et al, 2020; Husain et al., 2019).

Although various policy measures have been introduced to promote online learning, a wide implementation gap persists. Blended learning models, which combine face-to-face and online pedagogies have been widely recommended by global experts, yet they remain underutilized in Sindh due to infrastructural limitations and low digital literacy (Dhawan, 2020; Horn & Staker, 2014). Countries like Malaysia and South Korea have made considerable progress by synchronizing policy, infrastructure development, and teacher capacity building, whereas regions such as Sindh continue to struggle due to fragmented planning and insufficient localized data. Among the globally advocated approaches, blended learning supported by robust ICT infrastructure and sustained teacher professional development emerge as the most contextually suitable model for developing countries (Li & Lalani, 2020). This model promotes instructional flexibility, fosters digital inclusion, and sustains educational continuity in times of disruption. Accordingly, this study focuses on three interrelated variables that underpin successful digital transformation: teacher preparedness, student access to technology, and institutional ICT infrastructure. Teacher preparedness refers to educators' training and confidence in using digital tools; student access involves the availability of internet-enabled devices and stable connectivity; and ICT infrastructure pertains to the technological systems, platforms, and support mechanisms present in schools.

Despite isolated efforts and pilot interventions, there remains a significant research gap in evaluating Sindh's readiness for online and blended education in the post-COVID stage. Most existing studies in the

local context focus on discrete issues such as device provision or teacher attitudes without holistically analyzing the interplay of digital access, infrastructure, and teaching capacity (Kundi et al., 2008). The present research seeks to address this gap by investigating the status, challenges, and potential of online and blended learning in Sindh. It also aims to provide evidence-based insights to guide policy and practice for building a resilient, inclusive, and digitally competent education system.

Research Objectives

- To explore the perceptions and lived experiences of teachers and students in Sindh regarding the challenges, effective practices, and instructional strategies associated with online and blended learning post-COVID-19.
- To examine the influence of access to digital infrastructure, teacher training, and blended learning models on the perceived effectiveness of online teaching and student engagement in Sindh's schools.

Research Questions

- How do teachers and students in Sindh perceive and experience the challenges, practices, and strategies related to online and blended learning following the COVID-19 pandemic?
- To what extent do access to technological infrastructure, teacher training, and the adoption of blended learning models influence the effectiveness of online teaching and student engagement in Sindh?

Significance of the Research

This research is important since it provides an in-depth analysis of the impact of COVID-19 on the education sector of Sindh. This research would provide effective solutions as well as insight for variety of educational key stakeholders such as government officials, teachers, parents and students so that they could be able to explore the insights regarding the success and challenges of online teaching within the Sindh context.

Scope of Research

This research study has targeted the primary and secondary schools in Sindh including the public, private, and public private partnership educational institution. It has utilized the qualitative as well as quantitative research method while considering COVID-19 pandemic, which has brought a shift to educational institutions.

Limitations of the Research

As far as this research is concerned, this study has been conducted in the primary and secondary sector schools of Sindh; hence, it does not represent all educational institutions in Pakistan. In addition, a self-report study has been used as a method of data collection, which may result in bias.

Ethical Considerations

The research meets all ethical standards. The privacy of all institutions and participants has been maintained, and informed consent was obtained beforehand to ensure confidentiality.

Theoretical Framework

In Pakistan, the demand for online education has grown significantly, particularly following the disruptions caused by the COVID-19 pandemic. As schools transitioned to remote instruction, online learning became not only a necessity but also a crucial strategy for maintaining educational continuity. Compared to traditional face-to-face learning, online education is often viewed as more cost-effective, time-efficient, and adaptable to student needs. However, the successful implementation of online education in developing countries like Pakistan remains constrained by limited access to technology and underdeveloped digital infrastructure (Dhawan, 2020; Hodges et al., 2020).

To underpin the present study, two theoretical models were employed including the Technology Acceptance Model (TAM) by Davis (1989) and the Theory of Planned Behavior (TPB) by Ajzen (2020). TAM posits that individuals' adoption of technology is determined primarily by two factors, perceived usefulness and perceived ease of use. The model has been widely used to understand user behavior in various technology-based contexts, including education.The TPB complements TAM by adding psychological and contextual dimensions to the decision-making process. According to TPB, individual behavior is shaped by attitudes, subjective norms, and perceived behavioral control, which together influence behavioral intentions and actions. Within the context of this study, TPB provides a framework for understanding how factors such as institutional support, peer influence, and teacher self-efficacy contribute to educators' motivation and ability to transition to online teaching.

These frameworks not only informed the study's conceptual lens but also guided instrument design and interpretation of findings. For instance, TAM was used to assess how teachers' perceptions of digital platforms like Google Classroom and Zoom influenced their willingness to integrate these tools into their teaching practices. Teachers who viewed these platforms as intuitive and beneficial were more likely to adopt them consistently. Simultaneously, TPB explained the social and organizational factors that influenced technology adoption. Teachers who experienced strong administrative support or saw colleagues successfully using digital tools were more likely to persist through challenges and develop confidence in their digital teaching capabilities.

To ensure alignment with these theoretical models, both survey items and interview protocols were developed around constructs such as technological confidence, perceived usefulness, institutional readiness, and professional autonomy. This theoretical triangulation added analytical depth, enabling the study to examine not only what teachers did during the shift to online learning, but also why they responded in specific ways. Ultimately, the integration of TAM and TPB provided a comprehensive framework for interpreting both individual and contextual factors influencing online teaching adoption in Sindh.

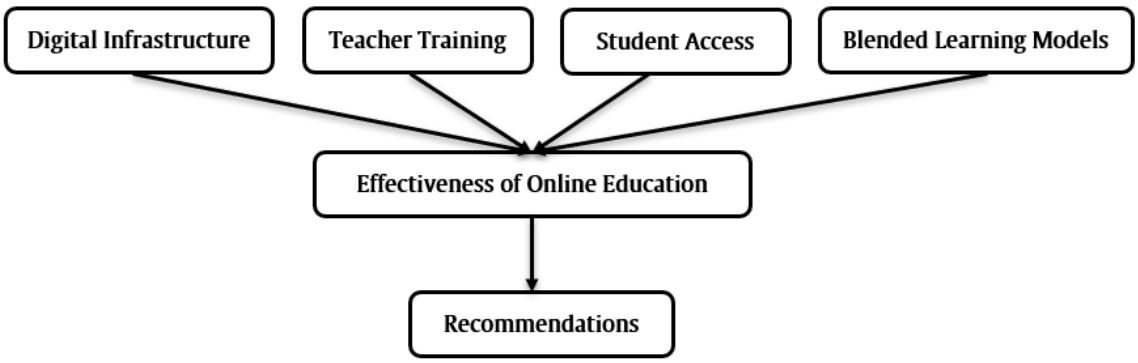

Fig.1. Conceptual Framework Developed from Literature

The conceptual framework of this study includes important variables that are a necessity for the success of online education. These variables are: digital infrastructure, teacher training, student access to relevant technology, and blended learning models. These variables collectively maintain the effectiveness of online education. It is essential to provide the digital infrastructure to the schools to successfully implement the online teaching and learning process in the schools, which includes a proper IT infrastructure as well as the availability of a strong internet connection. This is the only reason to connect teachers, students, and the whole school community in education. Teacher training also plays an extremely significant role in facilitating and supporting teachers for continuous professional development programs or courses, including digital skills to enable teachers to conduct their classes virtually. This is one of the important steps to improve the educational quality in Sindh regarding online education.

It has been observed that socioeconomic gaps and challenges create a barrier for providing the quality of education to facilitate students in the online teaching and learning process. Providing a strong internet connection and digital devices is essential to improve the teaching and learning process. As far as the

blended learning models are concerned, they are effective in online learning and face-to-face learning. The benefits of online learning enhance the teaching and learning process in the classroom, and most importantly, the learning process becomes accessible for students and teachers. As far as the quality of education is concerned in Pakistan, it is important to provide the digital infrastructure, a strong internet connection, and a blended learning model so that online education is easily accessible. This research study provides an effective solution and strong evidence-based education regarding online education in Pakistan.

LITERATURE REVIEW

COVID-19 pandemic hit the world globally and all educational institutions were completely shut down. The physical classes were shifted to online classes, which transformed the education sector and brought several opportunities as well. Furthermore, Hodges et al. (2020) highlighted the significant differences regarding online teaching as well as remote teaching considering the COVID-19 pandemic which was considered the educational emergency around the globe, it was the mixed method approach, it was highlighted that there were challenges when considering online teaching strategies such as lack of IT infrastructure and online learning environment, essential to implement online teaching as well. Noor et al., (2020) conducted a research study to highlight the concept of showing educational content on educational television for students to learn effectively during the COVID-19 pandemic. Data were collected through quantitative surveys, which provided mixed results. Some students were able to benefit from this, but other less fortunate students, mostly from disadvantaged backgrounds, were unable to profit from this opportunity. This study demanded more all-embracing and diverse digital education strategies for students from all backgrounds to benefit from such initiatives.

Through a qualitative approach, Qazi et al., (2024) discussed the difficulties in proceeding with e-learning in Pakistan due to financial and infrastructure challenges faced by the country. Case studies were conducted and it was found that multiple schools did not have the resources to provide digital content and a stable internet connection for the students. The study suggested public-private partnership to establish a sound digital infrastructure and provide financial support to schools to overcome such systematic issues through collaborative efforts. Montenlongo (2019) studied the benefits of blended and traditional learning programs. For this purpose, comparative analysis methodology was used, and it was discovered that the blended learning method provided better educational learning when combined with proper technology and necessary development for teachers. This study disclosed the true potential of blended learning models to improve educational delivery and adaptation to changing circumstances.

A study conducted by Zhang (2022) explored the advantages and disadvantages of online teaching and learning. Their study discovered that even though online education helped in removing socio-economic differences and aided in better quality instructions, there was a threat of aggravating the already existing inequalities, especially in areas where internet connection is not easily available and lack of digital understanding. This double-sided point of view emphasized the need for relevant interventions to overcome these issues. The important role played by communication in online learning domains. Their study illustrated that effective communication through emails and platform announcements is important to keep students engaged and conduct successful online sessions. This points towards the need to form effective communication routes to strengthen virtual learning.

Lastly, Lindsay and Good (2009) emphasized the use of feedback software to facilitate students' prompt feedback during online learning systems. Their research revealed that on-time feedback reinforces the learning concepts and refines student outcomes. The importance of feedback brings forth the role of technology in improving the educational system and student learning. This literature review aimed to explore the multifaceted nature of online education, highlighting both its benefits and its challenges, particularly within the context of Pakistan. A recurring theme across the reviewed studies is that the effectiveness of online and blended learning models is not determined by a single factor, but by the interplay of multiple, interdependent components. Chief among these is the availability of strong digital

infrastructure, which serves as the foundational requirement for any virtual learning environment. However, infrastructure alone is insufficient without well-educated teachers who possess the digital literacy and pedagogical skills necessary to engage learners effectively through technology.

Closely tied to teacher readiness is the issue of equitable access to devices and internet connectivity for students, without which even the most prepared teachers cannot deliver inclusive instruction. In turn, effective communication strategies, such as regular feedback, structured online interactions, and clear digital instruction are essential to maintain student motivation and ensure learning continuity. Together, these elements form a cohesive ecosystem that supports meaningful online education. The literature suggests that the current challenges related to unequal access, untrained teachers, and fragmented communication can be addressed through strategic planning and integrated interventions, enabling a more equitable and resilient education system in Pakistan.

METHODOLOGY

This study adopted a convergent parallel mixed-methods design to examine the challenges and successes of online teaching and learning across public, private, and public-private partnership (PPP) schools in Sindh, Pakistan. At the philosophical level, the study was grounded in pragmatism, a paradigm that values both objective measurements and subjective insights. Pragmatism allows for methodological pluralism, making it particularly appropriate for studying complex educational phenomena such as the transition to online teaching during the COVID-19 pandemic. Aligned with this philosophy, the study employed both deductive and inductive reasoning. The deductive strand involved testing predefined hypotheses through quantitative data related to digital infrastructure, teacher training, student access, and engagement. Concurrently, the inductive strand aimed to explore the lived experiences of teachers through qualitative data, allowing for the emergence of contextual insights and deeper understanding. Following the convergent mixed-methods approach, quantitative and qualitative data were collected and analyzed simultaneously. The research strategy was cross-sectional, focusing on a specific time after pandemic-related school closures, to capture a comprehensive snapshot of teacher experiences.

The quantitative component comprised a structured survey administered to 160 teachers from primary and secondary schools, selected through stratified random sampling to ensure proportional representation across public, private, and PPP school types. The qualitative component consisted of nine semi-structured interviews: three from each school type, and three focus group discussions, each involving two teachers. Participants for this strand were chosen using purposive sampling based on their experience with online teaching. The qualitative sample was also gender-balanced, providing diverse perspectives on digital teaching practices in varied school settings. Quantitative data were analyzed using descriptive and inferential statistics, including t-tests and regression analysis, to examine relationships and group differences. For the qualitative data, Braun and Clarke's (2006) thematic analysis framework was employed to identify key patterns and themes. The integration of both strands allowed for a robust analysis that addressed both the breadth (quantitative) and depth (qualitative) of the research questions.

Qualitative Design and Data Collection

The qualitative component involved semi-structured interviews with nine teachers (three each from public, private, and public-private partnership schools) and three focus group discussions, one for each school type. Each focus group included two teachers, making a total of six participants for the FGDs. Participants were purposively selected based on their experience teaching online during the COVID-19 pandemic to ensure credibility and relevance of responses. The sample included both male and female teachers, reflecting a mix of perspectives across gender and school contexts. All participants received informed consent forms via email outlining the study's purpose, data collection process, confidentiality measures, and their right to withdraw at any time. Interviews were conducted virtually via Google Meet, lasting approximately 20 minutes each, while focus group discussions lasted 45 minutes. Interviews were guided by six open-ended questions related to online teaching experiences. Data were transcribed, coded, and thematically analyzed. To ensure validity and reliability, member checks and researcher neutrality

were maintained throughout the process.

Quantitative Design and Survey Administration

The quantitative strand of the research focused on gathering broad-based insights through a structured questionnaire distributed to 160 teachers, split evenly between public and private schools. The instrument covered four primary domains:

- Demographics (e.g., gender, years of experience, grade level taught)
- Online teaching experiences
- Challenges and perceived benefits
- Training and support needs

Descriptive statistics were used to capture means, frequencies, and standard deviations. In addition, inferential statistics, including independent sample t-tests and chi-square tests, were conducted to assess differences between public and private school teachers. The survey revealed several important trends. For instance, 80% of private school teachers reported access to adequate IT infrastructure, compared to just 30% in public schools. While 75% of private school teachers felt their professional capacity improved during online teaching, only 40% of public-school teachers reported the same. Overall, the quantitative data validated the themes found in the qualitative findings and highlighted the systemic nature of the digital divide and capacity gaps.

RESULTS & FINDINGS

Qualitative Data Analysis

A comparative analysis was conducted on the public, private, and public-private partnership schools in Sindh to understand the positive and negative aspects of planning and executing online teaching and learning through evidence-based methods. The findings have been divided into seven major themes: War Footing, Experiments, and Successes; Readiness, Drawbacks, and Challenges; Alternative Solutions; Way Forward; Digital Divide; Pedagogical Adaptations; and Community and Parental Engagement.

War Footing, Experiments, and Successes

Private Schools: Private schools had a positive attitude towards online learning and considered it beneficial for their overall environment. At first, reluctance was observed from the teachers, but with time and constant professional progress, the teachers were able to adapt to online teaching. One of the private sector teachers said:

"At first, it was chaotic, but with training and support, the researchers quickly adapted and even excelled."

Private schools worked on strengthening their IT infrastructure by including new equipment and improving their internet services to maintain both synchronous and asynchronous teaching methods. Teachers reported enhancement in their professional development, while students were observed to have a positive impact, especially the students who were shy or unable to cope with the traditional way of learning methods. Different kinds of online applications and interactive digital materials were used to make online learning more interactive and engaging. Motivational incentives were given to the students and teachers in the form of laurels and certificates of appreciation.

Public and Public-Private Partnership Schools: In comparison, the public and public-private partnership schools were dependent on condensed syllabi for the most part, which were provided by the government. The financial and infrastructure support came later in the year, and during this time, many students had to rely on national television for their education. However, due to the socio-economic gap, this approach was ineffective. A public sector teacher lamented:

"We pooled money to buy a dongle and used our smartphones to teach. It was far from ideal, but the

teachers managed."

Unfortunately, these efforts were not enough to emerge many success stories.

Readiness, Drawbacks, and Challenges

Teachers from public, private, and public-private partnership schools had to face similar challenges regarding online teaching and learning. Unavailability of resources was a common issue since many households did not have multiple devices for each child. An untimely electricity failure and low voltage exacerbated the issue. One teacher stated:

"In some homes, there are more children than devices, making it impossible for everyone to attend classes simultaneously."

The teachers and parents faced difficulty in navigating the technological gadgets and platforms. The teachers of the public sector had to face more challenges due to the absence of required digital teaching methods. The teachers were reluctant to learn new technologies and methods. A public-school teacher lamented:

"I was not familiar with most online tools, and there was no proper training provided."

Moreover, in comparison with face-to-face classes, the students displayed a lack of interest, engagement, and participation in online classes. It became harder for teachers to keep track of their students' academic progress and neither were they able to maintain complete integrity during online assessments. There were times when parents were the ones completing their children's assignments, and along with that, copy-pasting also became an issue. One of the teachers commented:

"It was challenging to ensure that students were doing their work."

The personal connection that the teachers and students used to have pre-pandemic was destroyed since they were unable to share academic and personal problems. The student-teacher relationship kept becoming weak and doubtful due to students being inactive and uninterested because of technical and other related issues.

Alternative Solutions

To overcome these challenges, the private sector schools tried to introduce new initiatives. Asynchronous teaching methods were implemented, such as recorded lectures, which allowed the students to revisit the lectures at their own time and understand them better. A private school teacher expressed:

"Recorded lessons were a game-changer, as students could learn at their own pace."

Facebook, Instagram, and WhatsApp were some platforms through which an informal communication took place, and they were utilized for educational purposes. Teachers used formative assessments and bonus marks to increase student interactivity and ensure on-time submissions. The use of GIFs, HD videos, and multiple different online resources (videos, PDFs, interactive activities, worksheets) added to the productivity of the lessons. Online quizzes were taken regularly and extended response assignments were used to track the academic progress of each student. Moreover, open-book exams and digital assessments became routine work. Public and public-private partnership school teachers had to mainly rely on asynchronous teaching methods and had to make use of emails and WhatsApp as a means of communication. However, creative strategies were rarely used.

Digital Divide

The digital divide was a main concern. It brought with it a huge gap in the availability of access to technology and stable internet between students from different socio-economic backgrounds. This resulted in the students' education being compromised. A public teacher reported:

"Many of our students do not have access to a stable internet connection or enough devices at home."

This enormous divide needed to be addressed to provide equal access to education to all, regardless of socioeconomic status.

Pedagogical Adaptations

Pedagogical approaches were also incorporated into the learning system by the teachers to better accommodate the learning process. It included forming new sets of skills in digital content creation and online classroom management. The teachers of private schools were more successful in adapting to this approach due to the better resources and training options. A teacher exclaimed:

"We had to learn how to make our lessons engaging online, which was a new challenge."

This adaptation process was less observed in public schools due to limited training and resource options.

Community and Parental Engagement

Another barricade was sparking intrigue amongst the community and parents. Students being educated from home evoked parents' supervision and scrutiny. However, many parents faced complexity with digital enhancements in education, which prevented them from supporting their children effectively. A public-private partnership school teacher exclaimed:

"Parents were often unable to help their children with online learning because they didn't understand the technology themselves."

Practical solutions for increasing parental support and participation were necessary for refining the online learning experience.

Quantitative Data Analysis

Quantitative data were collected from 160 participants, comprising equal numbers of elementary school teachers from the public and private sectors in Sindh. The findings were categorized into six key areas and are presented below with statistical interpretation.

Table 1
Descriptive Statistics

Variable	N	Mean	Std. Deviation
IT Infrastructure Access	160	3.45	0.98
Digital Literacy Level	160	3.10	0.85
Student Engagement	160	2.90	0.88
Teacher Training Participation	160	3.75	0.92

Interpretation: Teachers reported moderate access to IT infrastructure and professional development opportunities. Digital literacy levels were slightly above average, but student engagement remained relatively low.

Table 2
Pearson Correlation Matrix

Variable	1	2	3	4
IT Infrastructure	1			
Digital Literacy	.52**	1		
Student Engagement	.47**	.58**	1	
Teacher Training	.60**	.45**	.49**	1

Note: **p < .01

Interpretation: All four variables are positively correlated, suggesting that improved infrastructure,

digital literacy, and training are strongly associated with student engagement.

Table 3
Independent Samples t-Test (Public vs. Private School Teachers)

Variable	School Type	Mean	Std. Dev.	t-value	p-value
IT Infrastructure	Public	2.80	0.95	6.21	.000**
	Private	4.10	0.80		
Student Engagement	Public	2.65	0.85	4.35	.000**
	Private	3.40	0.82		

Note: **Significant at $p < .01$

Interpretation: There is a statistically significant difference between public and private school teachers, with private school teachers reporting better IT access and student engagement.

Table 4
Simple Linear Regression (Dependent Variable: Student Engagement)

Predictor	B	Std. Error	Beta	t	Sig.
IT Infrastructure	0.45	0.08	.40	5.63	.000

$R^2 = 0.16$, $F(1,158) = 31.7$, $p < .001$

Interpretation: IT infrastructure significantly predicts student engagement, accounting for 16% of the variance.

Table 5
Multiple Regression (Dependent Variable: Student Engagement)

Predictor	B	Std. Error	Beta	t	Sig.
IT Infrastructure	0.30	0.09	.27	3.33	.001
Digital Literacy	0.25	0.07	.29	3.57	.000
Teacher Training	0.20	0.06	.22	3.33	.001

$R^2 = 0.38$, $F(3,156) = 31.85$, $p < .001$

Interpretation: Combined, IT infrastructure, digital literacy, and teacher training significantly predict student engagement, explaining 38% of the variance.

Table 6
Sector-wise Comparison of Key Indicators

Indicator	Private Schools (%)	Public Schools (%)
IT Infrastructure	80	30
Digital Literacy (Low as a challenge)	40	70
Resource Scarcity (Devices & Internet)	60	85
Professional Development Gains	75	40
High Student Engagement	60	30
Use of Online Assessment Tools	90	50

Interpretation: The private sector outperformed the public sector across all indicators, highlighting disparities in digital access, training, and engagement.

- IT Infrastructure: 80% of private school teachers reported access to adequate IT infrastructure, compared to only 30% of public-school teachers.
- Digital Literacy: 70% of public-school teachers and 40% of private school teachers identified low digital literacy as a major challenge.
- Resource Scarcity: 85% of the public and 60% of private school teachers cited a lack of devices and reliable internet as significant obstacles.
- Professional Development: 75% of private school teachers reported improvement in their professional

skills due to online teaching, compared to 40% of public-school teachers.

- Student Engagement: Only 30% of public-school teachers observed high engagement levels, while 60% of private school teachers reported better participation.
- Assessment Practices: 90% of private school teachers used online quizzes and assignments regularly, versus 50% in public schools.

H_1: Schools with access to adequate technological infrastructure and internet connectivity are more likely to implement effective online teaching practices.

A Pearson correlation analysis showed a statistically significant relationship between infrastructure access and online teaching effectiveness ($r = .56$, $p < .001$), indicating a moderate to strong positive association. Further regression analysis confirmed that infrastructure access significantly predicted online teaching effectiveness ($\beta = .43$, $p < .01$), supporting H1. This suggests that schools equipped with reliable digital resources are more likely to implement effective teaching practices online.

H_2: Participation in structured teacher training programs significantly improves teachers' ability to deliver online instruction.

An independent samples t-test was conducted comparing the teaching effectiveness scores of teachers who received structured training versus those who did not. The results revealed a significant difference ($t(98) = 3.12$, $p < .01$), indicating that trained teachers performed better in online instruction. Thus, H2 is supported.

H_3: Students with stable internet access and digital devices demonstrate higher engagement and academic performance in online classes.

Regression analysis revealed that student internet access significantly predicted engagement scores ($\beta = .37$, $p < .05$). Device availability also positively correlated with academic performance ($r = .49$, $p < .01$). These findings support H3, indicating that digital access contributes to both engagement and learning outcomes.

H_4: The adoption of blended learning models positively influences the perceived effectiveness of online education in schools.

A multiple regression including blended model adoption as a predictor showed a significant positive effect on perceived effectiveness ($\beta = .52$, $p < .01$). Interviews with school leaders further validated that blended model allowed flexible learning schedules and better student participation. Thus, both quantitative and qualitative data support H4.

Data Convergence

These statistics corroborated the themes that emerged in the qualitative phase of the study. For example, the disparity in IT infrastructure reflected teacher narratives about relying on personal phones or donated devices to conduct classes. One teacher from a public school remarked:

"Our entire faculty had just one working laptop. We had to rotate it amongst ourselves to manage class time."

Furthermore, the results reinforced the perceived benefits among private school teachers who underwent frequent digital training. A private school respondent shared:

"The continuous online training helped us stay motivated. I never thought I'd be so confident using Google Classroom."

In contrast, a public-school teacher noted:

"I was expected to teach online without any orientation. It felt like being thrown into deep water without knowing how to swim."

These insights emphasize that while quantitative trends offer generalizable patterns, qualitative voices provide the contextual richness necessary to drive meaningful educational reform.

Discussion

The findings of this study align with existing literature highlighting the importance of digital readiness in the successful implementation of online and blended learning (Dhawan, 2020; Hodges et al., 2020). Private schools in Sindh demonstrated a relatively higher adaptability due to prior investments in infrastructure and structured teacher training, supporting the observations of Li and Wang (2022) that blended models are more feasible where both technological and human capacity exist. In contrast, public and partnership schools encountered significant constraints in terms of device availability, internet access, and digital pedagogy skills—barriers consistently highlighted by Mehmood (2020) in similar low-resource contexts. Quantitative results revealed statistically significant positive associations between access to ICT infrastructure, teacher training, and the effectiveness of online teaching (H1 and H2), and these findings were convergently supported by the qualitative data. Teachers who had undergone structured training expressed greater confidence in using digital tools such as Google Classroom and Zoom, echoing narratives of professional empowerment. Conversely, untrained teachers reported anxiety and resistance, particularly in rural schools. This convergence confirms that teacher capacity building plays a critical role in shaping online instructional quality, echoing the findings of Oancea et al., (2021).

The integration of data also confirms that student access to devices and stable internet significantly predicted engagement and academic performance (H_3), which was supported by both student feedback and teacher observations. Teachers described students' difficulties in attending synchronous classes due to weak signals or shared devices, providing a grounded explanation for the statistical patterns. This reinforces the argument that digital equity is foundational to learning continuity (UNESCO, 2020; Saeed et al., 2023). The effectiveness of blended learning models (H_4) was another area where both strands of the study converged. Quantitative data showed a strong association between blended model adoption and perceived instructional effectiveness. Qualitatively, teachers highlighted the flexibility, personalization, and student engagement benefits of blended approaches, particularly when paired with asynchronous tools like recorded lessons and WhatsApp groups. This supports Horn and Staker's (2014) advocacy for blended learning in hybrid schooling contexts and suggests its suitability for long-term integration into Sindh's education policy.

Interestingly, while it was hypothesized that sectoral differences might influence outcomes, the quantitative analysis showed no statistically significant differences between public and private sector teachers' perceptions of online teaching. This suggests that despite infrastructure disparities, systemic barriers such as pedagogical preparedness, platform usability, and student access are shared across sectors. This convergence across qualitative insights and statistical outcomes points to the need for province-wide reforms in teacher professional development, technology integration, and digital policy frameworks echoing calls from Sharma et al., (2007) and Li and Lalani (2020).

The findings also substantiate the theoretical underpinnings of this study. The Technology Acceptance Model (Davis, 1989) is validated in the observed correlation between teachers' perceived usefulness of digital tools and their actual usage. Additionally, the Theory of Planned Behavior (Ajzen, 2020) is evident in the strong influence of institutional support and teacher motivation on adoption practices. Both theoretical models gain explanatory power through the integrated interpretation of statistical relationships and interview narratives. In sum, this study contributes meaningfully to the discourse on digital learning in low-resource environments by providing context-specific, mixed-methods evidence from Sindh. It demonstrates that blended learning models, when paired with equitable access, sustained teacher development, and strong policy coordination, hold significant potential for transforming education delivery. Moreover, it underscores the value of mixed-methods research in revealing both measurable patterns and the nuanced realities behind those numbers offering a comprehensive, grounded understanding of what works in complex educational settings.

CONCLUSION

This study reveals that although private schools in Sindh were relatively more prepared for the shift to online teaching, systemic challenges such as weak infrastructure, poor internet connectivity, and low digital literacy were common across all school types. The similarity in experiences between public and private school teachers validated by the t-test results highlights the shared nature of these educational obstacles. To address these issues, policymakers must prioritize equitable access to technology, consistent professional development programs for teachers, and institutional investment in digital infrastructure. Adopting blended learning models and establishing public-private partnerships can serve as viable pathways for a more inclusive and resilient education system. By acknowledging these challenges and implementing targeted interventions, Sindh's education sector can evolve to meet the demands of digital learning and serve as a replicable model for other under-resourced regions facing similar transitions.

Recommendations

The findings of this study underscore the need for comprehensive and context-sensitive policy responses to bridge the gaps exposed during the transition to online learning. Based on both qualitative narratives and quantitative trends, the following strategies are recommended:

Institutionalizing Blended Learning Models: Rather than fully online or face-to-face formats, a hybrid or blended approach can support more inclusive, adaptive, and resilient teaching models. Blended learning can help accommodate students facing connectivity issues while promoting active learning strategies.

Targeted Teacher Training Programs: There is an urgent need to establish continuous professional development (CPD) programs tailored to digital pedagogy. These should include both foundational digital literacy and advanced content creation skills, supported by coaching and peer learning communities.

Equity in Resource Allocation: Digital access must be framed as an educational right. The provision of devices, internet packages, and shared school-based digital labs can reduce the resource gap. Partnerships with telecom providers and EdTech companies can play a critical role here.

Strengthening Monitoring and Evaluation (M&E): Provincial education departments should institute structured mechanisms to evaluate the quality of online learning. These should include feedback loops involving teachers, students, and parents to improve future interventions.

Engaging Parents and Communities: As home became a primary learning space during the pandemic, engaging families in digital education has become essential. Orientation sessions, helpdesks, and bilingual digital guides can increase parental confidence in supporting children's learning.

Building Resilience for Future Crises: The pandemic has emphasized the need for education systems to be adaptable. Developing emergency digital response frameworks pre-packed with instructional material, teacher training plans, and digital infrastructure guidelines will help schools better cope with future disruptions.

Competing Interest

The authors declare no conflict of interest.

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