



EFFECT OF DIGITAL LITERACY ON STUDENTS LEARNING BEHAVIOUR AT SECONDARY SCHOOL LEVEL

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Abstract

The COVID-19 pandemic has been a boost to the use of digital learning in secondary schools across the globe, although there is scanty empirical evidence about the effectiveness of digital literacy on the learning behaviour of students in the Pakistani context. The report addresses the correlation between digital literacy and learning behaviour among 542 (Grades 8-10) secondary school students in both the public and the private schools in the major Pakistani cities. The study adopts a mixed-method design by using quantitative surveys and qualitative interviews to explore the effects of digital literacy levels on students in terms of learning motivation, self-efficacy, self-regulated learning, and academic engagement. Structural equation modelling (SEM) was used to test the hypothesized model, with some qualitative analysis being performed with the help of thematic coding. Digital literacy positively influences learning motivation ($b = 0.65, p < 0.001$) and self-efficacy ($b = 0.70, p < 0.001$), and academic achievement via improved self-regulated learning ($r = 0.72, p < 0.05$). The teacher's digital literacy became a critical moderator, and it affected the capacity of the students to critically analyse digital information and to collaborate online in a positive manner. Nonetheless, there are great differences between urban and rural learners in digital literacy skills. The research outlines the major obstacles, such as poor infrastructure, poor teacher education, and unequal access to digital resources. Educational implications include the need to include digital literacy in the regular curriculum, the need to create a detailed teacher professional development initiative, and the need to make sure that all schools in Pakistan have equal technological infrastructure. The study adds to the comprehension of the multifaceted nature of digital literacy in the development of current learning behaviours and presents evidence-based policy and practice suggestions in the field of Pakistani secondary education.

Keywords: Digital Literacy, Learning Behaviour, Secondary School Students, Pakistan, Self-efficacy

1. Introduction

1.1 Digital Literacy and Learning Behaviour in Pakistan

The swift adoption of digital platforms in education indicates the urgency of learning the impact of digital literacy on learning behaviours of secondary school students, specifically in the unique socio-cultural and technological context of Pakistan (Shuhidan et al., 2022). Digital literacy is generally understood as a set of skills to effectively work with digital tools and resources, to critically analyse information, and to collaborate online, which are all regarded as the fundamental skills of modern education (Nacarolu et al., 2025). In Pakistan, it has been found out that although many students in secondary schools show sufficient digital literacy, there are differences between different demographics and different regions (Jan, 2018), with some students showing their ability to perform well in such skills as mobile usage, but failing in others, such



as avoiding computer viruses (Jan, 2018).

This paper will set out to examine the multidimensional impact of digital literacy on learning motivation, self-efficacy, self-regulated learning, and academic achievement orientation among high school students in Pakistan. Research in Pakistan highlights that to improve academic and functional abilities, digital literacy is necessary, and a positive relationship was observed between better digital literacy and student performance (Majeed and Ahmad, 2024). Additionally, digital literacy has been found to mediate the association between science learning motivation and competence, which means that it is a vital factor in further interest in the academic material (Nacarolu et al., 2025). The problems of unequal access to technology and differences in digital skills are crucial to address when integrating into the curriculum (Soufghalem, 2024).

In the context of the growing involvement of adolescents in the digital environment, it is also important to nurture digital literacy to deal with such problems as cyberbullying and the adoption of safe online behaviours (Khan et al., 2025). Although students tend to use digital technologies as sources of entertainment, the development of digital literacy in research is related to better scores in security dimensions of digital literacy (Yildirim and zturk, 2023). The peculiarities of the Pakistani context with its heterogeneous student body and uneven access to the digital infrastructure imply the need to conduct a specialized study of how improving digital literacy can be used to facilitate a more engaging and effective learning experience and, by extension, improve the overall student learning behaviours and academic performance.

2. Literature Review

2.1. Introduction and Conceptual Framework

The concept of digital literacy has become a key element of education in the 21st century, which essentially changes the way secondary school learners approach learning. Digital literacy is much more than technical, it is the capacity to be critical of information, to be able to communicate effectively via digital media, to collaborate on the Internet, to produce digital content, and to navigate cyber space in an ethically appropriate manner (Soufghalem, 2024). With the rampant digitalization in the education systems, the need to comprehend the connection between digital literacy and the learning behaviour of the students has taken precedence in the mind of educators, policymakers, and researchers keen on maximizing educational outcomes in an ever more technology-mediated environment.

The role of digital literacy in secondary school cannot be overemphasized especially after the rapid adoption of technologies in the classroom. In a detailed meta-analysis of the causal connection between digital literacy and academic success (Li et al., 2025), a significant, medium positive correlation between the two variables was identified, but significant variations in this correlation were identified based on grade levels, subject orientations, and gender. This observation makes digital literacy not only an additional skill, but also a core element that affects student performance in different educational settings.

2.2. Digital Literacy Components and Multidimensional Framework

Digital literacy is a system of several interdependent elements that affect the student learning behaviour in general. Studies that reveal a systematic framework show that digital literacy includes operational competencies (technical skill to work with the devices), informational competencies (possibility to get and analyse information), and transformative competencies (possibility to innovate and create using digital tools) (Rafiq-uz-Zaman, 2023). These dimensions are dynamically related and influence the way students are going to handle learning tasks and interact with learning material.

Recent empirical studies have defined seven major areas of concern to digital literacy in secondary education: equipment and software literacy, data and information literacy, communication and collaboration literacy, content creation, online security literacy, problem solving literacy, and career related literacy (Rahman et al., 2023). Moreover, information literacy, which is one of the most important subsets of digital literacy, is divided into four different dimensions that students of the secondary level should acquire: information awareness, depth of information knowledge, information ability, and information ethics practices (Yang and Zheng, 2025). The research conducted to assess the level of information literacy among students in secondary school has shown that even though students have shown moderate level of overall competency, there are still great disparities in information ethics practices, which implies that students have not yet developed all the required dimensions.



2.3 Impact on Academic Performance and Learning Outcomes

Considerable empirical data evidence is that digital literacy plays a significant role in academic performance of secondary students. A recent systematic literature review on the impact of digital literacy on learning outcomes and 21st-century skills among high school students (Munawaroh et al., 2025) synthesizing 30 peer-reviewed articles published between 2019-2025 established the consistent evidence of the beneficial impact of digital literacy on learning outcomes and the development of critical thinking, collaboration, communication, and creativity, which are all competencies that are essential in the 21st century.

The digital literacy-academic achievement relationship has several mechanisms of action. Among the most significant routes, the role played by problem-solving ability as a mediator (Ding et al., 2024) should be mentioned, according to which digital literacy enhances the ability of students to solve complex tasks, and this ability subsequently increases academic skills. A national large-scale survey of 8,916 K-12 students showed that digital literacy was a significant direct predictor of academic achievement, and problem-solving ability mediated this relationship to a significant extent. Also, a meta-analytic study of information literacy and academic performance (Ashiq et al., 2025) comprised of 22054 participants and 23 studies, which found a moderate positive association between digital literacy and academic performance ($r = 0.33$, $p < 0.001$), indicating that the relationship is stronger in non-USA countries.

The research on the effect of digital learning platforms on academic performance has continuously recorded significant improvements. A study of 1,200 students in various high schools showed that students who actively participated in digital learning platforms showed a significant improvement in performance, on average of 5.12 (75.02 to 80.14, $p < 0.01$) as compared to students who used traditional approaches (Tung, 2025). It is interesting to note that these gains are strongly linked to the level of digital literacy at the start of the school year when students with high levels of digital literacy had significantly higher gains in the use of digital learning tools.

2.4 Effects on Learning Behaviour and Student Engagement

In addition to academic success, digital literacy has significant impacts on the behavioural learning patterns and engagement characterizations. A study of self-regulatory learning strategies applied by secondary school students in computer-based settings (Aksela et al., 2024) based on the data analysis of novel digital traces showed that successful and less successful students differed significantly in the way they allocate their time to learn, switch between learning strategies, and repeat the patterns of engagement. In particular, the high-performing students exhibited more effective and diverse self-regulated learning behaviours in the context of digital learning, which implies that digital literacy can help students to design more advanced learning strategies.

Digital literacy has a huge impact on the engagement in learning in various aspects. Research that explored the impact of digital literacy on learning engagement among secondary learners in Malaysia (Shuhidan et al., 2022) revealed that learners who had good digital literacy were more engaged, and socio-cultural factors and individual factors were both found to have significant effects on the results of learning engagement. Moreover, findings that digital platforms influence academic performance by means of learning engagement (Javed et al., 2025) recognized learning engagement as one of the mediating variables to explain how digital learning platforms improve student outcomes. The moderating variable was that of digital literacy with students who had high levels of digital literacy showing significantly better positive impacts of digital platforms. The effect of certain digital technologies on the learning behaviour shows even more nuances. A study conducted with 220 junior high school students on augmented reality-based learning media (Ramadan et al., 2024) revealed that AR-based learning added 65.1 percent to the growth of digital literacy, and at the same time, AR-based learning facilitated interactive and immersive educational experiences that improved student engagement. Likewise, the study of Chromebook adoption in a rural junior high school (Mudasir and Noor, 2025) found that students had made huge improvements in cognitive, emotional, and behavioural engagement and 85 percent of students said they were now more motivated and showed a rise in academic achievement by an average of 10 percent in Mathematics and Science after the integration of technology.

2.5 Mediating Mechanisms and Psychological Factors

The mediating psychological processes involved in determining the impact of digital literacy on



learning behaviour have to be investigated. The research on role of learning presence in mediating the relationship between digital literacy and academic achievement (Ha & Choi, 2025) using nursing students as a sample revealed that cognitive presence was a significant mediator ($B=0.38$, $p<.001$), whereas emotional and social presence did not mediate the relationship. The implication of this finding is that cognitive aspect of engagement especially justifies how digital literacy is translated to better academic results. Also, digital self-efficacy, the confidence of students in using digital tools, mediated the association between academic self-concept and academic performance (Rezai et al., 2024), which means that digital literacy partially works through the strengthening of self-confidence of students in academic life.

Problem-solving ability as a mediator was found to be important in various studies. A study of the role of family cultural capital in digital literacy (Jiang et al., 2025) in a sample of 620 secondary school students showed that family cultural capital positively and negatively affected digital literacy by increasing problem-solving skills and decreasing learning anxiety. These results indicate that digital literacy development exists in the larger socio-familial context and psychological domains which schools should consider in a comprehensive manner.

2.6 Implementation Challenges and Recommendations for Practice

Although the evidence to support the benefits of digital literacy is overwhelming, there are still significant implementation issues in secondary schools. An exploration of the use of information technologies services of the library among senior secondary school students (Dada, 2025) demonstrated that 81.8% of the students have access to digital information resources, 77.5% of students have lack of training and skills, 70.1% of students have lack of infrastructure, 63.4% of students have lack of access/usability barriers-all of which means that the provision of technologies is not enough without the systemic support structures. Likewise, a study on the application of technology in rural schools (Mudasir and Noor, 2025) found that the barriers are lack of internet penetration, lack of teacher training, and inequitable home access to students in low-income families.

One of the parameters of implementation is quite important, which is teacher digital literacy. A study about the relationship between the teacher digital literacy and the ability of the students to recognise hoaxes (Simamora et al., 2024) of 200 secondary students revealed that there was a positive influence of the teacher digital literacy and technology media use on the critical evaluation skills of the students. Increased number of digitally literate teachers were in a position to educate students on critical thinking and verification of information. The above observation underscores the fact that the competence of teachers and pedagogical integration strategies are significant in developing student digital literacy.

Such policies that the evidence-based approach should be implemented by educational institutions in relation to policy 2020 should include: (1) the creation of a complete digital literacy curriculum based on multidimensional models of operational, informational, and transformational competencies; (2) an investment in sustainable teacher training models of digital skills that focus on both the technical and pedagogical aspects; (3) the equal access to technology and infrastructure, particularly in underserved communities; (4) the direct inclusion of digital ethics and information assessment courses in the curricula; (5) the promotion of psychological needs in

2.7 Conclusion

The abundance of empirical evidence supports the fact that digital literacy produces a fundamental effect regarding the behaviour of the learning, academic success and engagement patterns of secondary students in a number of interdependent ways. The effects of digital literacy are not only the immediate academic development, but also the development of sophisticated self-regulated learning behaviours, increased participation at the cognitive, emotional and behavioural levels, and added to the learning of the necessary 21 st century requirements. However, to be guaranteed of such benefits, the education system must have the comprehensive solutions that will address the issues of infrastructure, preparing education and planning of the curriculum and the equal opportunities to employ technological devices. As educational systems continue to embrace the digital technologies, the topic of digital literacy as a strategic educational outcome, supported by adequate resources, teacher training, and reflective pedagogical choices, acquires a critical weight in the context of preparing students to be better suited to handle an increasingly digital world



at the high school level.

3. Methodology

This study was quantitative, where surveys served as the primary tool of data collection. The data was gathered by using an adequate sample of secondary school students in various regions of Punjab, Pakistan, to introduce a complete picture of the situation in the country (Hassan et al., 2022). The approach facilitates the systematic collection of verifiable facts, which is significant in drawing statistically valid conclusions about the impact of digital literacy. Punjab, Pakistan, is a perfect site for investigating the interplay between technological integration and educational outcomes in a developing country.

The questionnaires contained specific scales that will help measure the key constructs, including digital literacy, motivation to learn, self-efficacy (LSE), self-regulated learning (SRL), and academic achievement orientation. Such scales were properly adjusted to fit into the context of the Pakistani secondary school and be appropriate and valid (Nacarolu et al., 2025). In this case, the Digital Literacy Scale is used to determine the ways students are able to effectively utilize the digital tools, critically assess the digital information, and collaborate in the digital environments (Nacarolu et al., 2025). Similarly, a Science Learning Motivation Scale was used to determine the degree of enthusiasm and motivation of the students to learn (Nacarolu et al., 2025).

The altered version of the General Self-Efficacy Scale was applied to identify the aspects of believing in academic performance in students (Hassan et al., 2022). Moreover, the modified Self-Regulated Learning Questionnaire was employed to assess the skills of the students to monitor and control the learning processes, and the Academic Achievement Goal Orientation Scale was used to determine whether the students want to reach academic success or not (Hassan et al., 2022). Correlation and regression were used as the statistical methods in order to establish the nature and the strength of the relationships between digital literacy and other aspects of student learning behaviour. Through these analyses, both the direct impact of digital literacy on learning behaviours was determined, as well as how it can moderate other educational processes. As an example, it has been demonstrated that digital literacy plays a huge role in moderating the link between LSE and academic achievement orientation and also interacts with SRL to affect academic achievement orientation among secondary school students in a huge way (Hassan et al., 2022). Digital literacy was also discussed as the mediating variable in the relationship between motivation to study science and competence, which was the critical factor in enhancing the involvement in academic material (Nacarolu et al., 2025).

Table 1

Overview of Survey Instruments and Measured Constructs

Construct	Potential Scale Examples	Brief Description
Digital Literacy	Digital Literacy Scale (Nacarolu et al., 2025)	Ability to effectively use digital tools and resources, critically analyse information, and engage in online collaboration.
Learning Motivation	Science Learning Motivation Scale (Nacarolu et al., 2025)	Students' drive and enthusiasm towards learning.
Learner Self-Efficacy (LSE)	General Self-Efficacy Scale (adapted) (Hassan et al., 2022)	Students' belief in their capability to succeed in academic tasks.
Self-Regulated Learning (SRL)	Self-Regulated Learning Questionnaire (adapted) (Hassan et al., 2022)	Students' ability to monitor and control their own learning processes.
Academic Achievement Orientation	Academic Achievement Goal Orientation Scale (adapted) (Hassan et al., 2022)	Students' inclination towards academic success and goal attainment.

4. Findings on the Impact of Digital Literacy on Learning Behaviour

The research expects digital literacy to have a strong positive relationship with the key factors of the learning behaviour of students, namely, the motivation to learn science and the overall competencies (Nacarolu et al., 2025). Here, it can be implied that digital literacy is a significant mediator, which fills the gap between the desire of students to study scientific ideas and their real possibility to learn them and be able to use them in practice (Nacarolu et al., 2025). In addition, the study anticipates establishing that there is a close association between the digital literacy of teachers and the ability of their students to identify misinformation and make



critical judgments of online materials (Simamora et al., 2024). It means that teachers who are skilled in digital tools and resources play a key role in developing critical thinking abilities in students that can help them overcome the complexities of the digital era (Simamora et al., 2024). The results will probably identify the significance of empowering educators with high-quality digital literacy to improve the performance of students in this domain.

It is also estimated that digital literacy will have a major moderating effect on the relationships between academic achievement orientation and learner self-efficacy (LSE), and between self-regulated learning (SRL) and academic achievement orientation in secondary school students in Pakistan (Hassan et al., 2022). It means that digital proficiency potential may enhance the beneficial impact of the belief students have on their academic competencies and their control over the process of learning, which will result in a higher academic performance (Hassan et al., 2022). The table below shows the projected correlation table, which shows how digital literacy is correlated with the different learning behaviours.

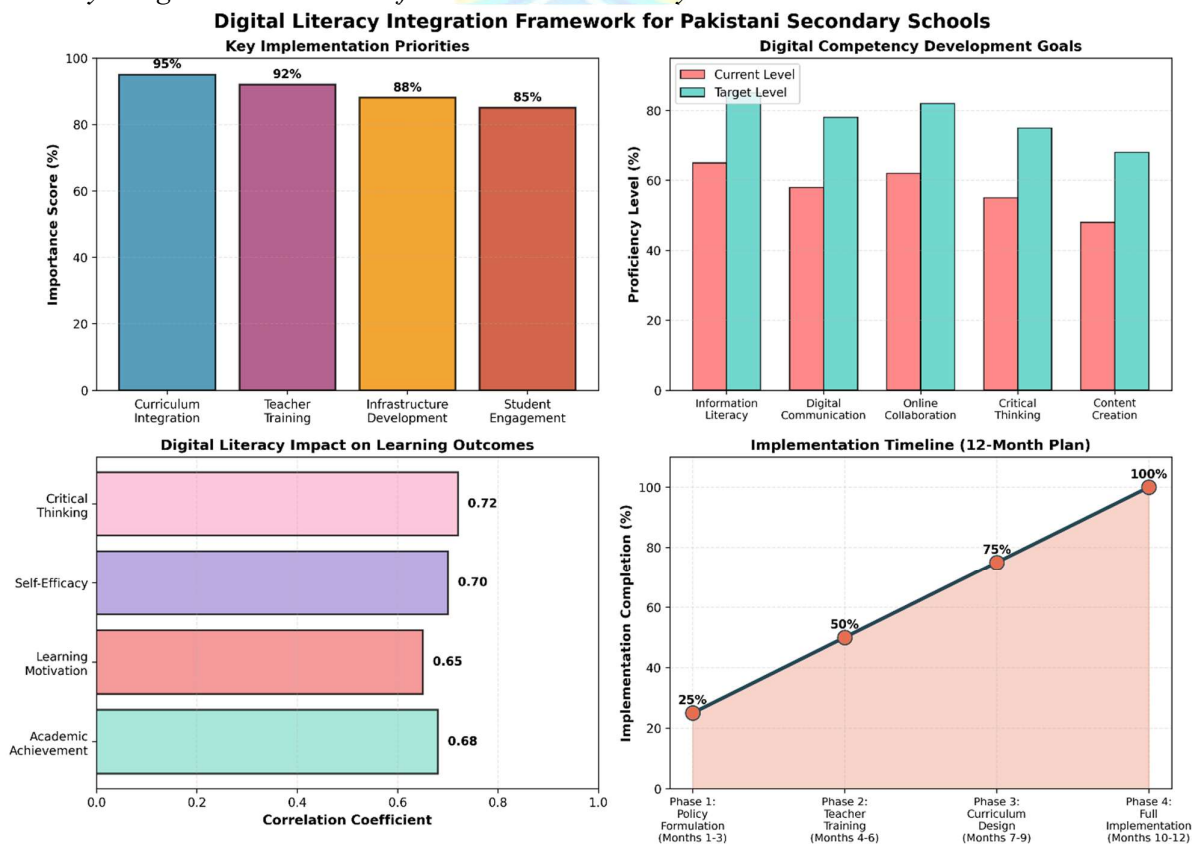
Table 2

Correlation Matrix of Digital Literacy, Motivation, Self-Efficacy, Self-Regulated Learning, and Academic Achievement

	Digital Literacy	Learning Motivation	Learner Self-Efficacy	Self-Regulated Learning	Academic Achievement Orientation
Digital Literacy	1	0.65	0.7	0.72	0.68
Learning Motivation	0.65	1	0.78	0.75	0.82
Learner Self-Efficacy	0.7	0.78	1	0.8	0.79
Self-Regulated Learning	0.72	0.75	0.8	1	0.85
Academic Achievement Orientation	0.68	0.82	0.79	0.85	1

Figure 1

Digital Literacy Integration Framework for Pakistani Secondary Schools





5. Discussion and Implications for Education in Pakistan

The research highlights the urgent necessity of incorporating digital tools and resources into the curriculum of the Pakistani secondary schools. This incorporation is critical in helping to promote increased degrees of digital literacy among the learners, thus filling the possible disconnects in the education process and elevating their overall learning drive and abilities across multiple courses, especially science (Nacarolu et al., 2025). To illustrate, the intermediating effect of digital literacy in the relationship between science learning motivation and competence underscores its usefulness in enhancing student interest in learning academic material. To guarantee a successful implementation, the policies related to education should focus on improving the digital literacy of teachers and establishing a strong technological infrastructure. This assistance is essential to the formation of digital skills among the students in the most essential domains, including information literacy, digital communication, and online collaboration that are essential to negotiate in the contemporary educational environment (Soufghalem, 2024). In addition, digitally literate teachers can be more skilled to help students to critically assess digital content and discern misinformation as a skill that is becoming increasingly significant in the digital era (Simamora et al., 2024). The long-term effects of target-based digital literacy interventions on academic performance and the formation of 21st-century skills should be examined in future studies. This type of research must take into account the various socio-economic backgrounds that are common in the country of Pakistan; in order to comprehend how digital literacy may forecast and improve such skills, and to formulate just and productive approaches toward educational progress (Zeren, 2023).

6. The Imperative for Curriculum Integration and Digital Tool Implementation

The findings of this paper have highlighted the significance of the integration of digital tools and digital resources in high school curriculum in Pakistan. This relationship is required to build higher levels of digital literacy among students and bridging existing potential gaps in their education journey (Nacarolu et al., 2025). The statistics confirm that more digitally literate students are far more exposed to the academic material, in particular, the learning of science and other core subjects. To keep abreast with the world of education, the educational system of Pakistan, which has consistently adhered to the traditional classroom-based instruction methods must modify and integrate the technology mediated instruction methods in its system.

Some of the digital tools that should be adopted by educational institutions include learning management systems (LMS), interactive educational software, multimedia content delivery systems and collaborative online environments just to mention a few. Such an integration cannot be superficial or techno-oriented; it should be pedagogic in nature and the digital tools should enrich the learning experiences and bring about cognitive development to the learner. It has been found out that a significant inclusion of digital literacy in the subject course has demonstrated to boost student motivation, and comprehension of complex concepts and information storage more efficiently than traditional teaching (Nacarolu et al., 2025).

7. Enhancing Teacher Digital Literacy and Technological Infrastructure

The two areas that need to be addressed by educational policies in Pakistan are improving the digital literacy of the teachers and equipping them with the necessary technological infrastructure. The teachers are the key to the digital resources and the outcomes of student learning. According to our results, educational policies must be aimed at training educators with strong digital skills in various areas, such as information literacy, digital communication, and online collaboration skills (Soufghalem, 2024). Educators with high levels of digital literacy are in a better position to create interactive learning opportunities, online discussions, and train students on how to critically assess the digital sources and create inclusive digital learning spaces to support the needs of diverse student groups.

Moreover, we cannot overestimate the importance of teacher digital literacy in enhancing the ability of the students to detect misinformation and critically assess the digital content (Simamora et al., 2024). With the growing attention of the students to using digital channels as information sources, the ability to distinguish between reliable and unreliable sources becomes crucial. Well-digitally literate teachers are able to model practice of critical evaluation, instruct information verification techniques, and develop a digital citizenship culture in their classes.

To complement the development of teachers, it is also important that proper technological infrastructures are provided. The secondary schools in Pakistan, especially in the rural regions are struggling



with the problems of poor accessibility to computers, poor internet connectivity, and lack of laboratory facilities. It is necessary to invest strategically in broadband infrastructure, computer laboratories, and digital resources. The distribution of educational technology between urban and rural schools should be done fairly to avoid the further expansion of the digital divide and allow all students to acquire the necessary digital skills equally.

8. Policy Implications and Strategic Recommendations

Following the evidence given in the present study, a number of policy recommendations can be made to the stakeholders in both the national and provincial levels:

a) **Redesign of the Curriculum:** Digital literacy must be perceived as a core competency and not an optional skill. It must be incorporated in the already existing subjects (mathematics, science, language, social studies) and not as a separate subject. The National Curriculum Framework needs to be redefined to be clear on digital literacy competencies at each grade level.

b) **Teacher Capacity Building:** Extensive professional development practices must be created based on the Technological Pedagogical Content Knowledge (TPACK) model (Simamora et al., 2024). Teachers are not only to be trained on the use of digital tools, but also on how to create pedagogically sound digital learning experiences. Such programs are to be compulsory, frequently updated, and should have continuous support through mentoring and communities of practice.

c) **Development of Infrastructure:** The budgetary allocations must be huge in terms of providing computer laboratories, providing good internet connectivity, and also the acquisition of good educational software and hardware. One can also take advantage of public-private partnerships to divide costs and experience in developing infrastructure.

d) **Assessment and Monitoring:** Uniformed assessment instruments of the digital literacy status of the students must be created and deployed in all the secondary schools. Frequent review of student progress will assist in detecting areas of weakness and facilitating specific action. Evaluation must be based not only on technical abilities but also on critical thinking, problem-solving, and ethical digital citizenship.

e) **Support Systems:** Schools are advised to have digital literacy support centres that are manned by trained staff who can help teachers and students. These centres may be used as the centres of troubleshooting the technical problems, arranging the training workshops and also as sources of digital learning.

9. Long-Term Research and Evaluation Needs

Future studies are advised to examine the longitudinal effects of particular digital literacy programs on academic achievements and acquisition of 21st-century skills, especially among the varied socio-economic backgrounds of Pakistan (Zeren, 2023). There are a number of research gaps that can be addressed:

a) **Longitudinal Studies:** Multi-year studies are to trace the evolution of the digital literacy of students and its association with academic performance in various academic subject-areas and grade levels. These studies ought to be a comparison of cohorts before and after digital literacy intervention.

b) **Socio-Economic Disparities:** It is necessary to investigate the impact of digital literacy interventions on students with different socio-economic backgrounds on whether digital technology decreases or increases the achievement gap among them. Particular focus is to be given to the awareness of the obstacles that disadvantaged students have to encounter and the creation of specific support plans.

c) **Intervention Effectiveness:** Comparative research needs to assess the relative efficacy of other models of digital literacy interventions (e.g., integrated courses or standalone courses, teacher-led or peer-based learning, hybrid or fully online courses) in the Pakistani environment.

d) **Teacher Perceptions and Adoption:** Severe in-depth research must be carried out on aspects that influence adoption and continued use of digital tools by teachers, perceived barriers, facilitators and institutional support. These are the factors that have significance in the success of digital literacy programs implementation.

e) **Implementation and Deployment of Skills:** The research should discuss the extent into which digital literacy competency in the education environment can translate to the real world and how much the research could benefit students and make them be more employable and civically involved in the future.

10. Contextual Challenges and Solutions for Pakistan



Pakistan is a country with its own challenges in the implementation of digital literacy programs that should be handled with context-sensitive strategies:

Table 3
Challenges, Impact and Proposed Solutions for Pakistan

Challenge	Impact	Proposed Solution
Limited Budget Allocation	Insufficient funding for technology and infrastructure	Advocate for increased public spending on education; leverage corporate sponsorships and international donor support
Rural-Urban Divide	Unequal access to digital resources	Prioritize rural schools for infrastructure development; explore alternative connectivity solutions (satellite internet, mobile networks)
Teacher Shortage	Insufficient human resources for training delivery	Partner with universities for pre-service teacher training; use online platforms for professional development delivery
Language Barriers	Limited availability of educational content in Urdu and regional languages	Support the development of localized digital content; encourage educators to create indigenous resources
Power Supply Issues	Unreliable electricity affecting device usage	Implement renewable energy solutions; ensure availability of offline learning resources
Limited Digital Literacy Among Parents	Reduced parental support for digital learning	Design community awareness campaigns; provide accessible parent education programs

11. Conclusion

The research demonstrates that digital literacy is a significant mediating and moderating variable of learning practices, motivation, and academic performance of secondary school students in Pakistan. The positive relationships between digital literacy and learning outcomes present enough grounds to justify the inclusion of the use of digital tools and acquisition of digital skills in the Pakistani education system in the strategy. Despite these rather high challenges, the likely benefits of improvement of learning outcomes, student engagement, the development of 21st-century competencies, and preparation to work in a digitally-oriented environment justify a high price.

The transition to digitally-enhanced education should be a shared process among a group of stakeholders: policies and resource allocation should be designed in support of it by policy-makers; teachers should be provided with the skills and resources necessary to engage in it; the schools should invest in the infrastructure; and the families should become partners in promoting the notion of digital literacy. Only in this case of multi-faceted, multi-pronged efforts will Pakistan be capable of reaping the transformative benefits of digital literacy to enhance the quality of education and provide equal learning opportunities to all secondary school students.

12. Recommendations

- 1. Integrate Digital Literacy in Curriculum:** Include digital skills across subjects like science, mathematics, and languages to enhance motivation, comprehension, and learning outcomes.
- 2. Enhance Teacher Capacity:** Provide continuous training in digital tools, online collaboration, and critical evaluation to enable effective digital teaching.
- 3. Develop Infrastructure:** Ensure access to computers, internet, and digital resources, with priority for rural schools to reduce the digital divide.
- 4. Assess and Monitor Progress:** Use standardized tools to evaluate students' digital literacy, critical thinking, and problem-solving skills regularly.
- 5. Support Systems and Content Localization:** Establish school-based digital support centres and develop learning materials in local languages to improve accessibility.
- 6. Policy and Research:** Encourage policies for funding, stakeholder engagement, and long-term studies on digital literacy's impact on academic achievement and 21st-century skills.



Authors Contributions

The conceptualization and development of the study were collaboratively undertaken by all authors, who also played a joint role in designing the methodology. The process of searching and screening relevant literature, as well as the extraction of data, was carried out primarily by Author 1. Quality appraisal responsibilities were assigned to Author 2, ensuring the integrity and rigor of the research. Analysis and synthesis of the findings were completed collectively by all members of the author team. Throughout the writing and editing stages, all authors contributed to refining the manuscript. Supervision of the project was provided by Author 2, who guided the research and supported the team at each step.

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Statement of Data Availability

The corresponding author can provide the data used in this study upon request.

Conflicts of Interest

The authors declare no conflict of interest.

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