



## Original Article



# Digital Leadership Competencies, Technology Integration, and Teaching Effectiveness: A Mixed-Methods Study in Schools

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**Background & Objective:** Digital transformation has reshaped educational systems worldwide, increasing the importance of digital leadership in promoting effective technology integration and improving teaching practices. However, the relationships among digital leadership, technology integration, and teaching effectiveness remain insufficiently understood, particularly within an integrated educational leadership framework. This study examined the influence of digital leadership competencies on technology integration and teaching effectiveness in schools and explored how these factors interact to support educational digital transformation.

**Methodology:** A mixed-methods cross-sectional design was employed. Quantitative data were collected from school leaders and teachers using validated questionnaires, while qualitative data were obtained through semi-structured interviews with school leaders. Descriptive statistics, exploratory factor analysis, and linear regression analyses were used to examine the quantitative data, whereas thematic analysis was conducted to analyse the interview findings.

**Results:** The findings demonstrated that school leaders exhibited high levels of digital leadership competencies. Digital leadership showed a strong positive association with technology integration, while technology integration was positively associated with teaching effectiveness. The combined regression model explained a substantial proportion of the variance in teaching effectiveness, indicating that leadership and technology integration jointly contribute to improved instructional outcomes. Qualitative findings complemented the quantitative results by highlighting that strategic vision, professional development, teacher support, organisational readiness, and adequate infrastructure are essential for successful technology integration and effective teaching.

**Conclusion:** These findings contribute to the growing body of knowledge in educational leadership by providing integrated evidence on the relationships among digital leadership, technology integration, and teaching effectiveness, offering practical insights for school leaders and policymakers seeking to advance sustainable digital transformation in schools.

**Keywords:** Digital Leadership, Educational Leadership, Mixed-Methods Research, School Management, Teaching Effectiveness, Technology Integration, Teacher Professional Development

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## BACKGROUND & OBJECTIVE

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The rapid digital transformation of education has fundamentally changed the way schools deliver teaching, learning, assessment, and organisational management. Digital technologies have created new opportunities to enhance instructional practices, improve communication, and support more flexible learning environments. However, simply providing access to technology does not guarantee meaningful improvements in educational outcomes.<sup>1</sup> The successful integration of digital technologies depends largely on organisational readiness, effective leadership, and teachers' ability to use technology in ways that support pedagogically sound teaching practices.<sup>2</sup> As a result, the role of school leaders has evolved from traditional administrative responsibilities to leading strategic digital transformation initiatives that foster innovation and sustainable technology adoption within schools.<sup>3</sup>

Digital leadership has consequently emerged as an essential component of educational improvement. Rather than being limited to technological competence, digital leadership encompasses the ability to develop a shared vision for digital transformation, promote innovation, strengthen communication, and support teachers through continuous professional development.<sup>4,5</sup> Effective digital leaders create organisational conditions that encourage collaboration, reduce resistance to change, and facilitate the meaningful adoption of digital technologies in educational settings.<sup>6,7</sup> Through these leadership practices, school leaders play a critical role in guiding institutional change and establishing a culture that supports continuous learning and instructional improvement.

The present study is conceptually informed by Transformational Leadership Theory, which emphasises the ability of leaders to inspire organisational change, establish a shared vision, motivate individuals, and foster continuous professional growth. In educational settings, transformational leaders create supportive environments that encourage innovation, collaboration, and the adoption of new practices. These leadership behaviours are particularly relevant to digital transformation, where successful technology integration depends not only on the availability of digital resources but also on leaders' ability to guide change, build teachers' confidence, and promote a culture of continuous learning. Consequently, Transformational Leadership Theory provides a useful conceptual lens for understanding how digital leadership competencies may influence technology integration and ultimately contribute to improved teaching effectiveness.<sup>8</sup>

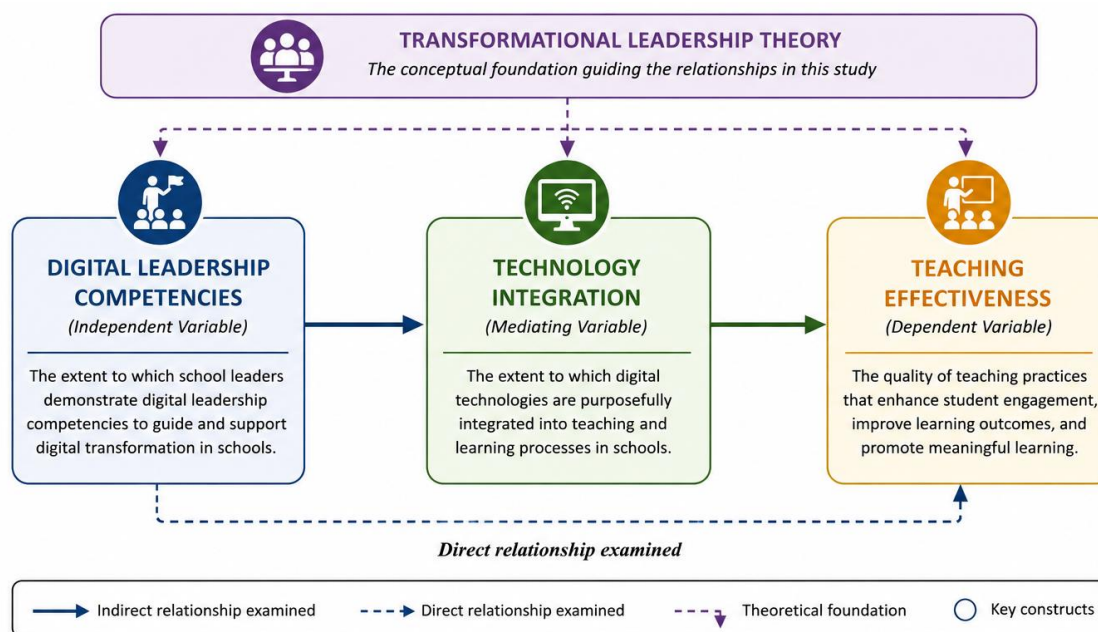
Technology integration has similarly shifted from being viewed as the simple adoption of digital tools to becoming an important pedagogical process. Educational technologies contribute to teaching and learning only when they are purposefully aligned with curriculum objectives and effective instructional strategies.<sup>8</sup> Previous studies have shown that technology integration can improve student engagement, collaboration, and personalised learning experiences. However, these benefits depend on several organisational and instructional factors, including teachers' digital competence, access to professional development, institutional support, and adequate technological infrastructure.<sup>9</sup> Consequently, challenges associated with technology integration often reflect organisational and leadership issues rather than technological limitations alone.

Teaching effectiveness within digitally enabled learning environments is likewise influenced by multiple interacting factors. While technology-supported instruction has been associated with improved student engagement, classroom interaction, and learning outcomes,<sup>10,11</sup> technology itself does not automatically improve the quality of teaching. Its educational value depends on teachers' pedagogical competence, continuous professional support, and the organisational environment in which technology is implemented.<sup>12</sup> Effective teaching in digital contexts therefore emerges from the interaction between leadership practices, teacher capability, and meaningful technology integration rather than from the use of technology alone.<sup>13</sup>

Despite the growing interest in digital transformation within education, important gaps remain in the existing literature. Previous research has frequently examined digital leadership, technology integration, and teaching effectiveness as separate areas of investigation, resulting in a fragmented understanding of how these constructs interact.<sup>14</sup> Furthermore, much of the available evidence has focused primarily on technological infrastructure and teachers' digital competencies, while comparatively limited attention has been given to the strategic role of school leadership in facilitating technology adoption and supporting instructional improvement.<sup>15</sup> This limitation is particularly important because ineffective leadership has been associated with lower levels of technology use, reduced teacher confidence, and limited innovation within classroom practice.<sup>16,17</sup> Moreover, relatively few studies have adopted a mixed-methods approach to examine these relationships within a single conceptual framework, limiting understanding of how leadership practices shape technology integration and teaching effectiveness simultaneously. Therefore, a more integrated investigation is needed to provide both empirical and contextual evidence that can inform educational leadership and school improvement initiatives.

In response to these gaps, the present study examines the relationships among digital leadership competencies, technology integration, and teaching effectiveness in school settings using a mixed-methods approach. Specifically, the study investigates the digital leadership competencies demonstrated by school leaders, examines the influence of digital leadership on technology integration, explores the relationship between technology integration and teaching effectiveness, and evaluates the combined contribution of digital leadership and technology integration to teaching effectiveness. By integrating quantitative findings with qualitative insights, this study provides a more comprehensive understanding of how digital leadership supports educational digital transformation. The findings contribute to the growing body of knowledge in educational management and leadership by offering integrated evidence on the relationships among digital leadership, technology integration, and teaching effectiveness, while providing practical implications for school leaders, educational managers, and policymakers seeking to strengthen sustainable technology-enabled teaching and learning.

**Figure 1. Conceptual Framework of the Study**



*Note.* The framework presents the proposed relationships among the key constructs examined in this study. Digital leadership competencies are proposed to influence teaching effectiveness both indirectly through technology integration and directly.

*Source:* Developed by the authors based on Transformational Leadership Theory and the reviewed literature.

## METHODOLOGY

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This study employed a mixed-methods cross-sectional research design to investigate the relationships among digital leadership competencies, technology integration, and teaching effectiveness in schools. The mixed-methods approach was selected to provide a comprehensive understanding of the research problem by integrating quantitative and qualitative evidence. The quantitative component enabled the measurement of associations among the study variables through statistical analysis. In contrast, the qualitative component provided contextual insights into school leaders' experiences, leadership practices, and challenges associated with technology integration. Collecting both forms of data within the same study allowed the researchers to complement numerical findings with participants' perspectives, thereby enhancing the overall interpretation of the results.

The study included a total of 58 participants, comprising 50 respondents who participated in the quantitative survey and eight school leaders who participated in qualitative interviews. Participants consisted of school leaders, administrators, and teachers working in technology-enabled school environments. A purposive sampling technique was employed to recruit participants who possessed relevant knowledge and experience regarding digital leadership and technology integration within schools. This sampling strategy enabled the inclusion of individuals directly involved in leadership, instructional practices, and technology implementation, thereby providing information that was considered appropriate for addressing the study objectives.

Data were collected using two complementary instruments. The quantitative component utilized a structured questionnaire consisting of statements related to digital leadership competencies, technology integration, and teaching effectiveness. Responses were recorded using a five-point Likert scale, allowing participants to indicate their level of agreement with each statement. The questionnaire generated quantitative data that were subsequently analyzed to examine the relationships among the study variables. The qualitative component employed semi-structured interviews with eight school leaders. The interview format enabled participants to discuss their experiences, perceptions, and leadership practices related to digital transformation in schools while allowing sufficient flexibility to explore issues emerging during the interviews. The qualitative findings were used to supplement and explain the quantitative results by providing contextual evidence regarding leadership practices, technology adoption, and challenges encountered during implementation.

Data collection involved the administration of the questionnaire to the selected participants, followed by semi-structured interviews with school leaders. Participants were informed about the purpose of the study before participating, and participation was entirely voluntary. The survey responses provided quantitative information regarding leadership competencies, technology integration, and teaching effectiveness, while the interviews generated qualitative data describing leadership experiences, institutional practices, and perceived barriers to effective technology integration. The combination of both datasets enabled a broader understanding of the phenomenon under investigation.

Quantitative data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 23.0. Descriptive statistics were computed to summarize participants' demographic characteristics and responses to the study variables. Exploratory factor analysis was conducted to examine the underlying structure of digital leadership competencies. Sampling adequacy was assessed using the Kaiser-Meyer-Olkin (KMO) measure, while Bartlett's Test of Sphericity was used to determine the suitability of the data for factor analysis. Regression analyses were subsequently performed to examine (i) the influence of digital leadership on technology integration, (ii) the relationship between technology integration and teaching effectiveness, and (iii) the combined influence of digital leadership and technology integration on teaching effectiveness. Statistical significance was interpreted using a significance level of  $p < 0.05$ . Qualitative interview data were analyzed using thematic analysis. Interview responses were reviewed and organized into recurring patterns

and themes reflecting participants’ perceptions of digital leadership competencies, technology integration practices, and teaching effectiveness. The identified themes were subsequently compared with the quantitative findings to provide a more comprehensive interpretation of the study results.

Ethical principles were observed throughout the research process. Participants were informed about the objectives and purpose of the study before participation, and informed consent was obtained before data collection. Participation was voluntary, and respondents were informed of their right to decline participation or withdraw from the study at any stage without consequence. Confidentiality and anonymity were maintained throughout the research process by ensuring that participants’ identities were not disclosed during data analysis or reporting. The collected data were used solely for research purposes and handled in accordance with accepted principles of research ethics.

RESULTS

Quantitative Findings

The quantitative phase included 50 respondents comprising school leaders, administrators, and teachers working in technology-enabled schools. Table 1 summarizes the demographic characteristics of the participants, including age, professional position, frequency of technology use, and gender. The sample was predominantly composed of participants aged 41–50 years (78%), while 22% were aged 51 years and above. School leaders and administrators represented the majority of respondents (70%), with teachers accounting for 30% of the sample. Most participants (72%) reported using digital technology on a daily basis, indicating regular engagement with technology in their professional practice. The gender distribution comprised 60% male and 40% female respondents. Overall, the participant profile indicates that the study was informed primarily by experienced educational professionals, particularly those in leadership positions, with most respondents reporting frequent use of digital technologies. This provides an appropriate context for examining digital leadership competencies, technology integration, and teaching effectiveness.

Table 1. Demographic Characteristics of Participants

| Variable                       | Category             | Frequency<br>(n) | Percentage<br>(%) |
|--------------------------------|----------------------|------------------|-------------------|
| Age                            | 41–50 years          | 39               | 78                |
|                                | 51 years and above   | 11               | 22                |
| Professional<br>Position       | Teacher              | 15               | 30                |
|                                | Leader/Administrator | 35               | 70                |
| Frequency of<br>Technology Use | Daily                | 36               | 72                |
|                                | Weekly               | 7                | 14                |
|                                | Occasionally         | 7                | 14                |
| Gender                         | Male                 | 30               | 60                |
|                                | Female               | 20               | 40                |
| Total                          |                      | 50               | 100               |

Digital leadership competencies were examined using descriptive statistics and exploratory factor analysis to assess participants’ perceptions of leadership practices related to technology integration in schools, as shown in Table 2. Descriptive statistics provided an overview of leadership competency levels, while factor analysis identified the underlying dimensions of digital leadership represented by the survey items. The descriptive analysis showed that participants generally perceived digital leadership competencies positively, with mean scores ranging from 3.98 to 4.70, indicating favourable perceptions of school leaders’ ability to promote



technology use, encourage innovation, and provide support for digital initiatives. Exploratory factor analysis supported a two-factor structure of digital leadership competencies. The first factor, Strategic Leadership and Innovation, comprised items related to developing a digital vision, encouraging innovation, supporting teachers, and promoting technology use. The second factor, Training and Communication, included competencies associated with organizing professional development, communicating through digital platforms, and facilitating technology-related support. The Kaiser-Meyer-Olkin (KMO) value of 0.716 indicated acceptable sampling adequacy, while Bartlett's Test of Sphericity was statistically significant ( $p < 0.001$ ), confirming that the data were suitable for factor analysis. Overall, the findings suggest that digital leadership competencies are represented by two complementary dimensions: strategic leadership and innovation, and training and communication. Participants generally perceived school leaders as demonstrating strong digital leadership practices across both dimensions, providing a foundation for examining their influence on technology integration and teaching effectiveness.

**Table 2. Factor Structure of Digital Leadership Competencies**

| Digital Leadership Competency                                                    | Strategic Leadership & Innovation | Training & Communication |
|----------------------------------------------------------------------------------|-----------------------------------|--------------------------|
| School leaders promote a clear vision for technology use in education.           | .780                              | .471                     |
| School leaders encourage teachers to use digital technologies in teaching.       | .861                              | .208                     |
| School leaders provide adequate ICT resources for teaching and learning.         | .735                              | .616                     |
| School leaders organize digital skills training for teachers.                    | .202                              | .946                     |
| School leaders effectively communicate through digital platforms.                | .297                              | .928                     |
| School leaders provide support when teachers face technology-related challenges. | .754                              | .602                     |
| School leaders encourage innovation and creativity through technology.           | .881                              | .133                     |

*Sampling adequacy: KMO = 0.716; Bartlett's Test of Sphericity,  $p < 0.001$ .*

To examine the influence of digital leadership competencies and technology integration in schools, a simple linear regression analysis was performed. The model assessed the extent to which digital leadership predicts technology integration among school leaders and teachers. The regression results are presented in Table 3. The regression analysis demonstrated a statistically significant relationship between digital leadership and technology integration ( $F = 153.098$ ,  $p < 0.001$ ). The model explained 76.1% of the variance in technology integration ( $R^2 = 0.761$ ), indicating that digital leadership accounted for a substantial proportion of differences in technology integration among the participating schools. The adjusted  $R^2$  value (0.756) further suggests that the model retained strong explanatory power after adjusting for sample size.

The standardized regression coefficient ( $\beta = 0.873$ ,  $p < 0.001$ ) indicated a strong positive association between digital leadership and technology integration. This finding suggests that higher levels of digital leadership competency were associated with greater levels of technology integration within schools. The regression analysis indicates that digital leadership is a significant predictor of technology integration. Schools demonstrating stronger digital leadership competencies were likely to report higher levels of technology integration, highlighting the important role of leadership in digital practices within educational settings.

**Table 3. Linear Regression Analysis Examining the Influence of Digital Leadership on Technology Integration**

| Model Statistics               | Value   |
|--------------------------------|---------|
| R                              | 0.873   |
| R <sup>2</sup>                 | 0.761   |
| Adjusted R <sup>2</sup>        | 0.756   |
| Standard Error of the Estimate | 0.303   |
| F                              | 153.098 |
| p-value                        | <0.001  |

To examine the relationship between technology integration and teaching effectiveness, a simple linear regression analysis was conducted. The analysis evaluated whether the level of technology integration significantly predicted teaching effectiveness among the study participants. The results are presented in Table 4. The regression model was statistically significant ( $F = 14.382$ ,  $p < 0.001$ ), indicating that technology integration significantly predicted teaching effectiveness. The model explained 23.1% of the variance in teaching effectiveness ( $R^2 = 0.231$ ), suggesting that technology integration contributed meaningfully to differences in teaching effectiveness among the participants. The adjusted  $R^2$  value (0.215) indicates that the explanatory power of the model remained relatively stable after adjustment.

The standardized regression coefficient ( $\beta = 0.480$ ,  $p < 0.001$ ) demonstrated a positive association between technology integration and teaching effectiveness. This finding indicates that higher levels of technology integration were associated with improved teaching effectiveness within the participating schools. The findings indicate that technology integration is a significant predictor of teaching effectiveness. Although the model explains a moderate proportion of the variance, the positive relationship suggests that greater integration of digital technologies into educational practice is associated with improved teaching effectiveness.

**Table 4. Linear Regression Analysis Examining the Relationship Between Technology Integration and Teaching Effectiveness**

| Model Statistics               | Value  |
|--------------------------------|--------|
| R                              | 0.480  |
| R <sup>2</sup>                 | 0.231  |
| Adjusted R <sup>2</sup>        | 0.215  |
| Standard Error of the Estimate | 0.422  |
| F                              | 14.382 |
| p-value                        | <0.001 |

To examine the combined contribution of digital leadership and technology integration to teaching effectiveness, a multiple linear regression analysis was performed. The model assessed the extent to which both variables jointly explained variations in teaching effectiveness. The results are presented in Table 5. The multiple regression model was statistically significant ( $F = 19.506$ ,  $p < 0.001$ ), indicating that digital leadership and technology integration collectively explained a significant proportion of the variation in teaching effectiveness. The model accounted for 45.4% of the variance in teaching effectiveness ( $R^2 = 0.454$ ), while the adjusted  $R^2$  (0.430) suggests that the explanatory power of the model remained stable after adjustment.

Although the overall model was statistically significant, the individual regression coefficients did not reach statistical significance after controlling for the other predictor. Digital leadership demonstrated a standardized coefficient of  $\beta = 0.378$  ( $p = 0.093$ ), while technology integration showed a standardized coefficient of  $\beta = 0.317$

( $p = 0.157$ ). These findings indicate that neither variable independently explained a statistically significant proportion of teaching effectiveness within the combined model. The multiple regression analysis demonstrates that digital leadership and technology integration jointly contribute to explaining teaching effectiveness. However, when both predictors were entered simultaneously into the model, neither variable independently remained statistically significant. This suggests that their contribution to teaching effectiveness may be interrelated rather than acting as separate independent influences.

**Table 5. Multiple Regression Analysis Examining the Combined Influence of Digital Leadership and Technology Integration on Teaching Effectiveness**

| Model Statistics               | Value  |
|--------------------------------|--------|
| R                              | 0.673  |
| R <sup>2</sup>                 | 0.454  |
| Adjusted R <sup>2</sup>        | 0.430  |
| Standard Error of the Estimate | 0.394  |
| F                              | 19.506 |
| p-value                        | <0.001 |

Qualitative Findings

To complement the quantitative findings, semi-structured interviews were conducted with eight school leaders to explore their perspectives on digital leadership, technology integration, and teaching effectiveness. The interview data were analysed using thematic analysis, resulting in four major themes that aligned with the study objectives.

**Theme 1: Digital Leadership Competencies of School Leaders**

Participants viewed digital leadership as a strategic and dynamic process that extends beyond the use of technology. They emphasised the importance of leadership vision, innovation, effective communication, and continuous support for teachers in creating a digitally responsive school environment. At the same time, some participants acknowledged that organisational capacity and available resources influenced the successful implementation of digital leadership initiatives. A participant described digital leadership as: *“Digital leadership is an active, practical and dynamic process.”* (Interview 6). Overall, the findings indicate that participants perceived digital leadership as a key element in driving educational innovation and supporting organisational change within schools.

**Theme 2: Influence of Digital Leadership on Technology Integration**

Participants consistently highlighted the central role of school leaders in promoting technology integration. They explained that effective leaders encourage teachers to adopt digital tools by providing professional development opportunities, recognising innovative practices, facilitating access to digital resources, and creating a supportive learning environment. However, participants also noted that limitations in resources and institutional support could restrict the implementation of technology initiatives. One participant stated: *“Regular professional training, motivating innovation, and timely teacher recognition”* (Interview 3). These findings suggest that leadership support is viewed as an important facilitator of successful technology integration in schools.

**Theme 3: Relationship Between Technology Integration and Teaching Effectiveness**

Participants generally believed that technology integration enhances teaching effectiveness by promoting interactive learning, improving student engagement, and expanding instructional opportunities. Nevertheless, they emphasised that technology alone does not guarantee improved teaching outcomes. Factors such as



teachers' digital competence, adequate infrastructure, and continuous professional development were considered essential for the effective use of technology in classroom practice.

As one participant explained: *"Teachers find it difficult to design lessons, learn how to deal with new tools, and have a lack of technical problem-solving skills."* (Interview 5). Overall, participants viewed technology as a valuable instructional resource whose effectiveness depends on appropriate teacher preparation and institutional support.

#### **Theme 4: Influence of Digital Leadership on Teaching Effectiveness**

Participants perceived digital leadership as an important contributor to teaching effectiveness by influencing school culture, teacher motivation, and professional growth. They described school leaders as individuals who provide strategic direction, encourage continuous learning, and create opportunities for teachers to strengthen their digital competencies. Participants believed that such leadership practices contribute to a more supportive environment for effective teaching and learning.

One participant remarked: *"Leaders become strategic architects and provide comprehensive support."* (Interview 7). Overall, participants agreed that effective digital leadership promotes an organisational culture that encourages innovation, collaboration, and continuous improvement in teaching practices.

## **DISCUSSION**

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This study examined the influence of digital leadership competencies on technology integration and teaching effectiveness in schools using a mixed-methods approach. Overall, the findings suggest that digital leadership contributes positively to technology integration, while improvements in teaching effectiveness depend on a broader combination of leadership practices, teacher readiness, and organisational support.

Participants generally perceived school leaders as demonstrating strong digital leadership competencies, particularly in promoting innovation, supporting teachers, and encouraging the effective use of digital technologies. The qualitative findings reinforced this perception by describing digital leadership as a strategic and dynamic process characterised by vision, communication, and continuous professional support. These findings are consistent with previous studies, which emphasise that effective digital leadership extends beyond technology management to include developing a shared vision, promoting professional learning, and fostering an organisational culture that supports innovation and continuous improvement.<sup>18</sup> The positive perceptions of leadership competencies observed in this study further support earlier evidence that leaders who provide clear direction, adequate resources, and ongoing support are more successful in facilitating digital transformation within educational institutions.<sup>19</sup>

A key finding of this study is the strong positive association between digital leadership and technology integration. Rather than viewing technology adoption solely as the responsibility of individual teachers, the findings suggest that leadership creates the organisational conditions necessary for meaningful technology use. Participants consistently highlighted professional development opportunities, teacher recognition, access to digital resources, and continuous leadership support as important contributors to successful technology integration. These findings are in agreement with previous research demonstrating that school leaders facilitate technology integration by strengthening collaboration, building teachers' digital capacity, and encouraging instructional innovation.<sup>14</sup> Collectively, the quantitative and qualitative findings indicate that effective digital leadership strengthens organisational readiness and supports teachers throughout the process of integrating digital technologies into classroom practice.

The study also found a positive relationship between technology integration and teaching effectiveness, although the strength of this relationship was moderate. This finding indicates that technology has the potential to enhance teaching practices when it is implemented within a supportive educational environment.

Interview participants consistently emphasised that improvements in teaching effectiveness depend not only on access to technology but also on teachers' digital competence, professional development opportunities, adequate infrastructure, and sufficient time to adapt instructional practices. These findings support previous research suggesting that technology contributes to improved teaching only when combined with appropriate pedagogical strategies and institutional capacity.<sup>18</sup> The qualitative findings further demonstrate that barriers such as limited infrastructure, insufficient digital skills, and time constraints may reduce the educational benefits of technology despite the availability of digital tools. Consequently, technology should be viewed as an enabling resource that supports effective teaching rather than as a standalone solution for educational improvement.<sup>20</sup>

An important finding of this study is that the combined regression model significantly explained variation in teaching effectiveness, whereas digital leadership and technology integration did not remain individually significant after controlling for one another. This suggests that their contribution to teaching effectiveness is interconnected rather than independent. In practice, digital leadership appears to influence teaching effectiveness by establishing organisational conditions that enable teachers to integrate technology more effectively, while technology integration contributes to improved teaching when supported by effective leadership, teacher preparedness, and institutional capacity. This interpretation is consistent with previous studies highlighting the interaction between leadership practices, organisational support, and instructional innovation in achieving meaningful educational improvement.<sup>8,20</sup> Together, these findings indicate that improving teaching effectiveness requires a comprehensive approach that combines effective digital leadership with sustained investment in teacher development, infrastructure, and supportive organisational practices.

### **Practical Implications**

The findings have important implications for educational leaders and policymakers seeking to strengthen digital transformation within schools. Developing digital leadership competencies should extend beyond the adoption of digital technologies to include strategic planning, continuous professional development, teacher empowerment, and the creation of a supportive organisational culture. Investment in digital infrastructure alone is unlikely to produce meaningful improvements in teaching effectiveness unless accompanied by leadership practices that encourage innovation, collaboration, and continuous learning. Educational institutions should therefore prioritise leadership development programmes that strengthen school leaders' capacity to guide technology integration while simultaneously supporting teachers through ongoing training, mentoring, and access to appropriate digital resources.

### **Study Strengths and Limitations**

A major strength of this study is the use of a mixed-methods design, which enabled the integration of quantitative and qualitative evidence to provide a more comprehensive understanding of the relationship between digital leadership, technology integration, and teaching effectiveness. Combining survey findings with interview data enhanced the depth of the analysis by explaining not only the statistical relationships but also the practical experiences of school leaders.

Despite these strengths, several limitations should be acknowledged. The study employed purposive sampling with a relatively small sample size, which may limit the generalisability of the findings beyond the participating schools. The cross-sectional design also captures participants' perceptions at a single point in time and therefore does not allow conclusions regarding changes over time or causal relationships. In addition, the findings relied primarily on participants' self-reported perceptions, which may be influenced by individual experiences or response bias. Future research should consider larger and more diverse samples, longitudinal research designs, and additional organisational variables to further examine how digital leadership influences technology integration and teaching effectiveness across different educational contexts.

## CONCLUSION

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This study demonstrates that digital leadership plays an important role in promoting technology integration within schools and contributes to improved teaching effectiveness when supported by appropriate organisational conditions. The findings suggest that effective digital leadership extends beyond the adoption of technology by fostering strategic vision, continuous professional development, teacher support, and an organisational culture that encourages innovation. While technology integration was positively associated with teaching effectiveness, its impact depended on teacher readiness, digital competence, adequate infrastructure, and sustained institutional support. The combined findings highlight that meaningful educational improvement requires the interaction of effective leadership, well-prepared teachers, and purposeful technology use rather than reliance on digital tools alone. These findings provide valuable insights for school leaders, educational managers, and policymakers seeking to strengthen digital transformation initiatives. Future research should validate these findings across different educational systems using longitudinal and multi-level research designs to better understand how leadership practices influence sustainable digital transformation over time.

## DECLARATIONS

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**Ethics Approval and Consent to Participate:** All participants were informed about the purpose and objectives of the study before participation. Written informed consent was obtained from all participants. Participation was voluntary, and all procedures were conducted in accordance with relevant ethical guidelines and regulations.

**Consent for Publication:** Not applicable.

**Availability of Data and Materials:** The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

**Competing Interests:** The authors declare that they have no competing interests.

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## AUTHOR CONTRIBUTIONS

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**VL:** Conceptualization, Methodology, Investigation, Project Administration, Writing – Review & Editing.

**TH:** Formal Analysis, Data Curation, Validation, Writing – Review & Editing.

**IN:** Investigation, Visualization, Writing – Original Draft, Writing – Review & Editing.

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