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## **Digital Intelligence, Educational Leadership Practices and School Management Effectiveness: A Correlational Perspective at Secondary School Level**

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### **Abstract**

The rapid adoption of digital technologies and artificial intelligence has significantly transformed school administration practices. Modern educational organizations are increasingly compelled to operate within digital environments, requiring school leaders to develop robust digital intelligence to address contemporary institutional challenges. Using a quantitative, cross-sectional research design, this study collected data from 100 principals employed in secondary schools in South Punjab, Pakistan. Standardized instruments were used to measure digital intelligence, educational leadership practices, and school management effectiveness. Descriptive statistics and Pearson correlation analysis were used to analyze the data. Findings indicated that principals perceived digital intelligence at a high level ( $M = 4.12$ ,  $SD = 0.52$ ), educational leadership practices were also rated high ( $M = 4.05$ ,  $SD = 0.56$ ), and school management effectiveness demonstrated a high overall level ( $M = 3.95$ ,  $SD = 0.57$ ). Correlation analysis revealed strong and statistically significant positive associations among all three constructs ( $r = 0.61-0.74$ ,  $p < .01$ ). These findings suggest that enhancing principals' digital intelligence may be associated with improved educational leadership and school management outcomes. Educational authorities are encouraged to prioritize professional development programs focused on digital competency and leadership capacity-building.

### **Keywords**

Digital intelligence, Educational leadership, School management effectiveness, Digital transformation, School principals, Pakistan

### **Article History**

Received: 12 January 2026

Accepted: 20 April 2026

Revised: 25 March 2026

Available Online: 28 October 2026

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## 1. Introduction

The rapid development of digital technologies has significantly influenced nearly all sectors of society, including education. Schools are no longer confined to traditional administrative and instructional approaches but are increasingly integrating digital systems to optimize teaching, learning, and administration [1]. In recent years, digital intelligence has emerged as a critical construct in educational institutions, encompassing the effective use of digital tools, data-driven decision-making, artificial intelligence (AI) applications, and technology-based management practices [2]. These developments have compelled educational leaders to reconceptualize their roles in governing schools within the digital era.

Educational leadership occupies a central position in shaping the vision, culture, and effectiveness of schools. While leadership traditionally emphasized administrative control and supervision, the infusion of digital intelligence into school systems has expanded leadership responsibilities to include technological competence, innovation management, and strategic decision-making through digital data [3]. School leaders are now expected to guide teachers, manage digital resources, and ensure that technology meaningfully supports both instructional and administrative functions.

Globally, research has recognized that digitally competent leadership is essential for enhancing school performance and organizational effectiveness [4]. In developing nations such as Pakistan, digital learning platforms, digital assessments, and automated record systems are gradually being introduced; however, their successful implementation remains heavily dependent on the quality of school leadership [5]. Many Pakistani schools continue to struggle with issues of traditional management training, insufficient technological infrastructure, and limited digital competency development among leaders [6], while empirical evidence connecting digital intelligence to educational leadership and school management remains sparse [7].

Despite growing interest in digital transformation, a critical research gap persists: it remains unclear how principals' levels of digital intelligence relate to their specific leadership practices and, in turn, to overall school management effectiveness, particularly in resource-constrained South Asian contexts. This study addresses that gap by examining the associations among digital intelligence, educational leadership practices, and school management effectiveness among secondary school principals in South Punjab, Pakistan.

## 2. Problem Statement

Many schools continue to operate within conventional leadership and management paradigms that fail to leverage the potential of digital intelligence. School administrators frequently lack the digital competencies, strategic vision, and targeted training required to integrate technology effectively into administrative and management functions, resulting in the underutilization of digital tools and their associated benefits.

In Pakistan, the gap between available digital technologies and their effective application in school management is especially pronounced. Despite increasing exposure to digital systems, numerous educational leaders encounter difficulties with data-based decision-making, digital communication, and technology-supported management [5]. This deficit can impede institutional stability, transparency, and innovation. Furthermore, existing research has disproportionately focused on technology use in instructional settings, leaving the relationship between digital intelligence, educational leadership, and school management effectiveness substantially underexplored.

The key constructs underlying this investigation are operationalized as follows: digital intelligence refers to the integrated capacity of school leaders to use digital tools strategically, make ethically informed data-driven decisions, and apply technological skills effectively; educational leadership practices encompass transformational, distributed, and digital leadership behaviors adopted by principals; and school management effectiveness denotes the quality and efficiency of administrative functions, teacher performance management, and student outcome facilitation. This study seeks to fill the identified empirical gap by investigating the correlational relationships among these constructs at the secondary school level.

## 3. Objectives of the Study

The main objectives of this study are to:

- (1) Assess principals' perceptions of their digital intelligence at secondary school level.
- (2) Assess principals' perceptions of educational leadership practices at secondary school level.
- (3) Assess principals' perceptions of school management effectiveness at secondary school level.
- (4) Investigate the relationship between digital intelligence and educational leadership practices at secondary school level.
- (5) Investigate the relationship between digital intelligence and school management effectiveness at secondary school level.

(6) Investigate the relationship between educational leadership practices and school management effectiveness at secondary school level.

#### **4. Research Questions**

The study is guided by the following research questions:

- (1) What is the perception of principals regarding digital intelligence at secondary school level?
- (2) What is the perception of principals regarding educational leadership practices at secondary school level?
- (3) What is the perception of principals regarding school management effectiveness at secondary school level?
- (4) Is there a significant relationship between digital intelligence and educational leadership practices at secondary school level?
- (5) Is there a significant relationship between digital intelligence and school management effectiveness at secondary school level?
- (6) Is there a significant relationship between educational leadership practices and school management effectiveness at secondary school level?

#### **5. Significance of the Study**

This study contributes to the growing body of literature by providing empirical evidence on the role of digital intelligence as a constituent of educational leadership and school management. The findings are intended to fill an existing knowledge gap by clarifying the role of digital competencies in school-level leadership practices. Practically, the results offer detailed insights useful to school heads, administrators, and policymakers in understanding the importance of digital intelligence to efficient school management and in designing leadership training and professional development programs. Additionally, the research may assist policymakers in formulating strategies to nurture digitally capable leadership at schools, thereby improving institutional effectiveness and broader learning outcomes.

#### **6. Literature Review**

##### **6.1 Conceptual Foundations and Theoretical Perspectives**

The digitization of organizational systems has prompted a revision of leadership theory to incorporate competencies directly related to digital technologies. Digital leadership is conceptualized as a paradigm for guiding institutions in the digital age, encompassing strategic use of digital tools to optimize organizational performance, innovation, and institutional goal achievement [8]. It extends classical leadership by introducing digital-competence dimensions, including digital culture development, technology governance, and digital strategy formation [9]. In the educational sector, digital leadership transcends mere adoption of devices and platforms; it entails cultivating a healthy digital learning culture and aligning policy, pedagogy, and technological innovation sustainably [10].

##### **6.2 Transformational Leadership Theory**

Transformational Leadership Theory, initially advanced by Burns (1978) and empirically developed by Bass (1985), posits that leaders inspire followers to transcend personal self-interest and engage in change-oriented practices through vision, intellectual stimulation, and individualized consideration [11,12]. In digitally mediated learning environments, empirical research consistently demonstrates strong associations between transformational leadership and effective technology integration [13]. Studies in secondary school contexts reveal that transformational leaders equip teachers with instructional and emotional resources that enhance digital skills and instructional quality [14-16]. Transformational leadership thus provides a solid theoretical basis for explaining how digital intelligence enables education administrators to adopt digital programs and foster innovation-oriented school cultures [17].

##### **6.3 Distributed Leadership Theory**

Distributed Leadership Theory challenges hierarchical conceptions by viewing leadership as a collective activity shared across multiple organizational actors [18-20]. It emphasizes teamwork, empowerment, and the strategic use of diverse expertise to achieve shared goals. In education, distributed leadership has been associated with increased teacher engagement, professional collaboration, and adoption of innovative practices [21,22]. This model aligns well with digital ecosystems, where technology integration requires multiple stakeholders including IT coordinators, teachers, and students [23-26].

##### **6.4 Technology Integration Frameworks: TPACK and TAM/UTAUT**

The Technological Pedagogical Content Knowledge (TPACK) framework defines the integration of technological,

pedagogical, and content knowledge necessary for effective technology use in education [27-29]. Although originally developed as a teacher competency instrument, TPACK has been extended to leadership research, explaining how educational leaders mediate technology integration through understanding both pedagogical and technological dimensions [30]. The Technology Acceptance Model (TAM) and its extension, the Unified Theory of Acceptance and Use of Technology (UTAUT), identify factors affecting technology adoption, including perceived usefulness, ease of use, social influence, and facilitating conditions [31-33].

In the current era of generative AI (GenAI), the acceptance, intention to use, and underlying psychological mechanisms of teachers and educational leaders have become increasingly critical variables. Recent work on GenAI literacy among educators—including scale development studies [34] and investigations using the UTAUT model with Self-Determination Theory [35]—highlights that digital intelligence must now account for leaders' and teachers' capacity to critically evaluate and responsibly adopt AI-powered tools.

## **6.5 AI in Educational Leadership**

AI represents an emerging dimension of digital intelligence in educational leadership. Studies indicate that AI can enhance strategic thinking, predictive analytics, and performance monitoring, enabling leaders to engage in data-driven decision-making and tailored management [36-38]. The implementation of AI in leadership practice is reshaping traditional administrative functions, requiring leaders to balance technological advantages with ethical obligations related to data privacy and equitable access [39].

## **6.6 Empirical Evidence on Digital Intelligence, Leadership, and School Management**

A qualitative case study of smart schools in Pakistan highlighted that vision-based leadership, professional growth, and stakeholder involvement are essential for digital preparedness, although systemic barriers remain [40,41]. Semi-structured interviews with 43 school leaders in Cyprus found that despite improvements in communication and administrative efficiency, insufficient training and infrastructure constitute critical barriers [42]. A quantitative study in Greece found positive associations between teachers' digital literacy and perceptions of digital leadership [14]. A bibliometric review of 350 articles confirmed the rapidly growing interdisciplinary field of digital leadership research in education [43], while systematic reviews and a meta-analysis affirmed strong positive associations between digital leadership practices and school performance outcomes [44-46].

## **6.7 Synthesis and Research Gap**

The reviewed literature consistently demonstrates that digital intelligence and leadership practices are associated with improved school management outcomes. However, most empirical studies have been conducted in high-income or middle-income countries, with limited research from the Pakistani secondary school context. The specific mechanisms by which digital intelligence translates into management effectiveness—potentially mediated by educational leadership practices—remain poorly understood. The present study addresses these gaps by empirically investigating the associations among digital intelligence, educational leadership practices, and school management effectiveness among secondary school principals in South Punjab, Pakistan.

# **7. Method**

## **7.1 Research Design**

The study adopted a quantitative, cross-sectional survey design, permitting standardized data collection from multiple participants to test the proposed conceptual framework. A descriptive-correlational approach was used to assess the levels of digital intelligence, leadership practices, and school management effectiveness, while inferential statistics examined relationships among these variables.

## **7.2 Ethical Considerations**

Ethical approval was obtained from the relevant institutional authorities prior to data collection. All participants provided informed consent before completing the questionnaire, and participation was voluntary. Confidentiality and anonymity of respondents were maintained throughout the study. The research was conducted in compliance with the Declaration of Helsinki principles governing research involving human participants, including obligations to protect participant welfare and ensure voluntary participation without undue pressure.

## **7.3 Population and Sample**

The study population comprised all principals working in public sector secondary schools in Punjab, Pakistan. Due to budgetary and time constraints, the study was delimited to South Punjab. A multistage random sampling technique was employed. In the first stage, four districts were selected: Multan, Muzaffargarh, Kot Addu, and Dera Ghazi Khan. In the second stage, 25 schools were randomly selected from each district (equal allocation), yielding a total sample of 100 schools, with one principal selected from each.

While a sample of 100 is a recognized constraint, Cohen's power analysis for detecting a medium correlation ( $r = 0.30$ ) at  $\alpha = .05$  (two-tailed) indicates that approximately 85 participants are required for power of 0.80 [47]; the current sample of 100 meets this criterion. Data were collected via online surveys (Google Forms, 70%) and personal school visits (30%); cross-checking of demographic profiles between collection modes revealed no significant differences in gender, age, or experience distributions.

#### 7.4 Data Collection Instruments

Data were collected using a structured questionnaire comprising four sections: (1) Demographics; (2) Digital Intelligence Scale (DIS) with three subscales—Strategic Awareness (5 items), Ethical Judgment (5 items), Technological Skills (5 items); (3) Educational Leadership Practices (ELP) with three subscales—Transformational Leadership (6 items), Distributed Leadership (6 items), Digital Leadership (6 items); and (4) School Management Effectiveness (SME) with three subscales—Administrative Efficiency (5 items), Teacher Performance (5 items), Student Outcomes (5 items). All items were measured on a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). Subscale scores were computed by averaging item scores within each subscale. Interpretation thresholds: 1.00-2.49 = low; 2.50-3.49 = moderate; 3.50-5.00 = high [47].

#### 7.5 Validity and Reliability

Content validity was verified through a panel of five subject-matter experts in educational leadership and technology. Pilot testing was conducted with 30 participants not included in the main study. Internal consistency reliability was assessed using Cronbach's alpha at both the total scale level and the subscale level. As presented in Table 1, all values exceeded the acceptable threshold of 0.70.

**Table 1.** Reliability coefficients for scale and subscales.

| Construct/Subscale                              | Items | $\alpha$ |
|-------------------------------------------------|-------|----------|
| <b>Digital Intelligence (Total)</b>             | 15    | 0.92     |
| Strategic Awareness                             | 5     | 0.87     |
| Ethical Judgment                                | 5     | 0.84     |
| Technological Skills                            | 5     | 0.88     |
| <b>Educational Leadership Practices (Total)</b> | 18    | 0.89     |
| Transformational Leadership                     | 6     | 0.85     |
| Distributed Leadership                          | 6     | 0.81     |
| Digital Leadership                              | 6     | 0.83     |
| <b>School Management Effectiveness (Total)</b>  | 15    | 0.83     |
| Administrative Efficiency                       | 5     | 0.79     |
| Teacher Performance                             | 5     | 0.76     |
| Student Outcomes                                | 5     | 0.74     |

Note: All alpha coefficients exceed the 0.70 threshold, indicating acceptable to excellent internal consistency. Confirmatory factor analysis (CFA) is recommended in future studies with larger samples to provide further evidence of construct validity.

#### 7.6 Data Collection Procedure

Formal approval was obtained from relevant educational district authorities. Questionnaires were distributed via Google Forms (70%) and personal school visits (30%). Reminder messages were sent to non-responders to maximize response rates. Missing data checks revealed less than 1% of individual item responses were missing; these were handled using mean substitution at the item level within the respective subscale. Only questionnaires with complete demographic data and fewer than 10% missing item-level responses were retained, resulting in the final analytic sample of  $N = 100$ .

#### 7.7 Data Analysis Techniques

Data were analyzed using SPSS (version 26). Descriptive statistics (frequencies, percentages, means, and standard deviations) were used to profile participants and describe the levels of study variables. Reliability analysis was conducted using Cronbach's alpha. Pearson correlation coefficients were computed to examine associations among the three composite variables. A multiple regression analysis was additionally conducted to examine the relative contributions of digital intelligence and educational leadership practices in predicting school management effectiveness.

### 8. Results

#### 8.1 Demographic Profile of Respondents

A total of 100 principals participated in the study. Table 2 presents their demographic characteristics.

**Table 2.** Demographic profile of respondents.

| Demographic Variable | Category | Frequency | Percentage (%) |
|----------------------|----------|-----------|----------------|
| <b>Gender</b>        | Male     | 50        | 50             |
|                      | Female   | 50        | 50             |
| <b>Age</b>           | 25-35    | 30        | 30             |
|                      | 36-45    | 45        | 45             |
|                      | 46-55    | 20        | 20             |
|                      | 56+      | 5         | 5              |
|                      |          |           |                |
| <b>Location</b>      | Urban    | 62        | 62             |
|                      | Rural    | 38        | 38             |

Note. N = 100.

## 8.2 Descriptive Statistics of Study Variables

Table 3 presents mean scores and standard deviations for all three constructs and their subdimensions. Scores are interpreted using the adopted thresholds: high (3.50-5.00), moderate (2.50-3.49), and low (1.00-2.49).

**Table 3.** Descriptive statistics of study variables.

| Variable                                         | Mean | SD   | Interpretation |
|--------------------------------------------------|------|------|----------------|
| <b>Digital Intelligence (Composite)</b>          | 4.12 | 0.52 | High           |
| Strategic Awareness                              | 4.18 | 0.55 | High           |
| Ethical Judgment                                 | 4.09 | 0.58 | High           |
| Technological Skills                             | 4.10 | 0.54 | High           |
| <b>Educational Leadership (Composite)</b>        | 4.05 | 0.56 | High           |
| Transformational Leadership                      | 4.11 | 0.60 | High           |
| Distributed Leadership                           | 3.98 | 0.59 | High           |
| Digital Leadership                               | 4.06 | 0.57 | High           |
| <b>Sch. Management Effectiveness (Composite)</b> | 3.95 | 0.57 | High           |
| Administrative Efficiency                        | 3.72 | 0.61 | High           |
| Teacher Performance                              | 4.02 | 0.58 | High           |
| Student Outcomes                                 | 3.88 | 0.63 | High           |

Note. N = 100. SD = Standard Deviation. Subscale rows are in italics. Interpretation based on adopted Likert-scale thresholds.

Principals reported high levels across all three constructs and their subdimensions. Among the SME subdimensions, Administrative Efficiency recorded the lowest mean ( $M = 3.72$ ), suggesting that while overall school management is perceived as effective, administrative processes represent a relative area for improvement.

## 8.3 Correlation Analysis

Pearson correlation coefficients were computed to examine associations among the three composite variables. The correlation matrix is presented in Table 4.

**Table 4.** Pearson correlation matrix.

| Variable                       | DI     | EL   | SME  |
|--------------------------------|--------|------|------|
| Digital Intelligence (DI)      | 1      | 0.68 | 0.61 |
| Educational Leadership (EL)    | 0.68   | 1    | 0.74 |
| Sch. Mgmt. Effectiveness (SME) | 0.61Ss | 0.74 | 1    |

Note. N = 100. \*\*  $p < .01$  (two-tailed). DI = Digital Intelligence; EL = Educational Leadership; SME = School Management Effectiveness.

All pairwise correlations were statistically significant ( $p < .01$ ). The association between DI and EL ( $r = 0.68$ ) and between EL and SME ( $r = 0.74$ ) were strong, while the association between DI and SME ( $r = 0.61$ ) was moderate-to-strong. These findings indicate that higher levels of digital intelligence are associated with higher levels of educational leadership practices and school management effectiveness.

## 8.4 Multiple Regression Analysis

To examine the unique and combined associations of digital intelligence and educational leadership practices with school management effectiveness, a simultaneous multiple regression was conducted with SME as the dependent variable and DI and EL as predictors. Results are presented in Table 5.

**Table 5.** Multiple regression analysis: Predictors of school management effectiveness.

| Predictor                   | B    | SE B | $\beta$ | t    | p     |
|-----------------------------|------|------|---------|------|-------|
| Constant                    | 0.72 | 0.31 | —       | 2.32 | .022  |
| Digital Intelligence (DI)   | 0.21 | 0.08 | 0.19    | 2.63 | .010  |
| Educational Leadership (EL) | 0.54 | 0.07 | 0.53    | 7.71 | <.001 |

Note. N = 100.  $R^2 = .59$ ; Adjusted  $R^2 = .58$ ;  $F(2, 97) = 69.82$ ,  $p < .001$ . DI = Digital Intelligence; EL = Educational Leadership; SME = School Management Effectiveness.

The model was statistically significant,  $F(2, 97) = 69.82$ ,  $p < .001$ , and accounted for approximately 59% of the variance in school management effectiveness ( $R^2 = .59$ ). Educational leadership practices emerged as a stronger predictor ( $\beta = 0.53$ ,  $p < .001$ ) than digital intelligence ( $\beta = 0.19$ ,  $p = .010$ ).

## 9. Discussion

### 9.1 Levels of Digital Intelligence

School leaders reported high levels of digital intelligence ( $M = 4.12$ ), reflecting strong perceived performance in strategic awareness, technological skills, and ethical judgment. These findings align with a growing body of evidence highlighting digital intelligence as a central competency for educational leaders [8,48]. Given the reliance on self-reported data, these perceptions should be interpreted as reflecting principals' subjective assessments rather than objective performance indicators. The somewhat lower mean on Administrative Efficiency ( $M = 3.72$ ) within the SME composite suggests that contextual and infrastructural factors likely play important moderating roles.

### 9.2 Educational Leadership Practices

Educational leadership practices were reported at high levels ( $M = 4.05$ ), suggesting the prevalence of transformational, distributed, and digital leadership dispositions. These findings are broadly consistent with Transformational Leadership Theory [11,12] and are consistent with empirical evidence from other contexts showing that digital leadership competencies are associated with improved instructional quality and organizational performance [8,14,45].

### 9.3 School Management Effectiveness

The composite measure of school management effectiveness was rated high ( $M = 3.95$ ). The relatively lower Administrative Efficiency subdimension ( $M = 3.72$ ) compared to Teacher Performance ( $M = 4.02$ ) suggests that while digital leadership is associated with improvements in instructional management, administrative streamlining may require more targeted intervention. This is consistent with literature indicating that technology-mediated management improvements are contingent on systemic infrastructure support [49,50].

### 9.4 Relationships among Constructs

Correlational and regression analyses revealed statistically significant positive associations among digital intelligence, educational leadership practices, and school management effectiveness. These results are consistent with TPACK [27,29] and TAM/UTAUT frameworks [31,32]. The regression analysis further indicated that educational leadership practices were a stronger predictor of school management effectiveness ( $\beta = 0.53$ ) than digital intelligence alone ( $\beta = 0.19$ ), suggesting that digital intelligence may operate, in part, through leadership practices. The correlational, cross-sectional nature of this study precludes causal inference. The potential mediating role of educational leadership—whereby educational leadership might mediate the relationship between digital intelligence and school management effectiveness—represents a theoretically important mechanism, but formal mediation analysis was not conducted due to sample size constraints. This is acknowledged as a significant limitation and is recommended as a priority for future research.

### 9.5 Alternative Explanations

Several alternative explanations merit consideration. The strong associations may partly reflect social desirability bias inherent in self-reported data. Additionally, unmeasured variables such as school resources, parental engagement, regional infrastructure quality, and broader educational policy environment may account for a portion of the observed variance in school management effectiveness.

## 10. Limitations

This study has several important limitations. First, the study relied exclusively on self-reported data from principals, introducing the risk of social desirability bias. Second, the sample was restricted to 100 principals in South Punjab, limiting generalizability. Third, the sample size is insufficient to support robust CFA or structural equation modeling (SEM); a sample of at least 200-300 participants is recommended for such analyses [47]. Fourth, the predominance of online data collection (70%) may have introduced selection bias toward more digitally active principals. Fifth, the cross-sectional design precludes causal or temporal inference. Sixth, formal mediation analysis was not conducted due to sample constraints, leaving the potential mediating role of educational leadership empirically untested. Seventh, the study did not include construct validity testing through CFA, which is a fundamental limitation for a quantitative correlational study; future research should perform and report CFA results. These limitations should be kept in mind when applying the findings to policy or practice.

## 11. Implications

### 11.1 Theoretical Implications

This study extends classical transformational and distributed leadership theories by integrating digital intelligence as a construct associated with leadership effectiveness. The regression findings offer preliminary empirical support for a mediation pathway consistent with TPACK and TAM/UTAUT frameworks. The incorporation of GenAI literacy perspectives [34,35] broadens the conceptualization of digital intelligence beyond technical skills to include adaptive, ethical, and metacognitive dimensions.

### 11.2 Practical Implications

Professional development programs for school principals should explicitly target digital intelligence competencies, including strategic awareness, ethical data governance, and technological skill development. Policymakers in Pakistan's education sector should consider investing in digital infrastructure, particularly in rural school districts. Administrators are encouraged to explore AI-based management systems to support evidence-based decision-making, subject to appropriate ethical safeguards. These recommendations should be acted upon with appropriate caution given the limitations of the present study's design and analytical approach.

## 12. Recommendations for Future Research

- (1) Conduct longitudinal studies to assess changes in digital intelligence and leadership effectiveness over time.
- (2) Expand research to primary and higher education institutions and to cross-country comparative designs.
- (3) Investigate the mediating role of educational leadership practices in the relationship between digital intelligence and school management effectiveness using formal mediation analysis.
- (4) Conduct CFA and SEM with larger samples to test and refine the proposed measurement and structural models.
- (5) Integrate qualitative methods to understand contextual factors affecting digital leadership in resource-constrained settings.
- (6) Examine GenAI literacy as an emerging dimension of digital intelligence in educational leadership research.

## 13. Conclusion

This study examined the associations between digital intelligence, educational leadership practices, and school management effectiveness among 100 secondary school principals in South Punjab, Pakistan. Using a quantitative, cross-sectional correlational design, the findings indicated high perceived levels across all three constructs and revealed statistically significant positive associations among them. Multiple regression analysis further suggested that educational leadership practices are a stronger proximate predictor of school management effectiveness than digital intelligence alone.

These findings offer empirical support for the relevance of digital intelligence and leadership competencies in school management contexts, and align with transformational, distributed, and technology acceptance theoretical frameworks. At the same time, the correlational, cross-sectional design, reliance on self-reported data, regional sample, and modest sample size impose important constraints on causal inference and generalizability. Educational authorities are encouraged to consider digital intelligence and leadership capacity as interrelated investment priorities, while recognizing that infrastructural, systemic, and contextual factors must also be addressed for digital competencies to translate into meaningful improvements in school management and student outcomes.

## Acknowledgements

Not applicable

## Funding

Not applicable

## Ethics Statement

Not applicable

## Data Availability Statement

Not applicable

## Author Contributions

Daneval Farid: Conceptualization, methodology, formal analysis, investigation, data curation, writing – original draft, writing – review & editing, project administration.

Muhammad Aqeel: Resources, investigation, data collection, validation, writing – review & editing.

Noor Muhammad: Supervision, methodology, validation, writing – review & editing.

## Conflict of Interest

The authors declare no conflict of interest.

## Generative AI Statement

The authors declare that no GenAI was used in the creation of this manuscript.

## References

- [1] Selwyn N. 'It's all about standardisation'-Exploring the digital (re)configuration of school management and administration. *Cambridge Journal of Education*, 2011, 41(4), 473-488. DOI: 10.1080/0305764X.2011.625003
- [2] Drigas A, Papanastasiou G, Skianis C. The school of the future: The role of digital technologies, metacognition and emotional intelligence. *International Journal of Emerging Technologies in Learning*, 2023, 18(9), 65-85. DOI: 10.3991/ijet.v18i09.38133
- [3] Anwar S, SaraihUN. Digital leadership in the digital era of education: Enhancing knowledge sharing and emotional intelligence. *International Journal of Educational Management*, 2024, 38(6), 1581-1611. DOI: 10.1108/IJEM-11-2023-0540
- [4] Guo RQ, Empirical study on enhancing fundamental education administration through digital intelligence integration. *Transactions on Comparative Education*, 2024, 6(4), 84-91. DOI: 10.23977/trance.2024.060411
- [5] Brohi KB, Memon S, Shaikh KH. Navigating barriers to successful implementation of digital record management system: A case study of Pakistani public sector universities. *Journal of Entrepreneurship, Management, and Innovation*, 2023, 5(3), 414-429. DOI: 10.52633/jemi.v5i3.346
- [6] Nasir F, Bhatti AH, Zubair M, Sarfaraz M, Miran G. Globalization impact on 21st century educational leadership: Challenges and adaptation in Pakistan. *The Critical Review of Social Sciences Studies*, 2025, 3(1), 830-844. DOI: 10.59075/pdnkez10
- [7] Kafa A. Exploring integration aspects of school leadership in the context of digitalization and artificial intelligence. *International Journal of Educational Management*, 2025, 39(8), 98-115. DOI: 10.1108/IJEM-11-2024-0703
- [8] Karakose T, Polat H, Tülübaş T, Demirkol M. A review of the conceptual structure and evolution of digital leadership research in education. *Education Sciences*, 2024, 14(11), 1166. DOI: 10.3390/educsci14111166
- [9] Rizki AM, Suwadi S. Digital leadership (theory and implementation in higher education). *Jurnal Ekonomi*, 2024, 13(02), 389-391.
- [10] Mustafa M. Building a digital learning culture: Strategic educational leadership in smart school ecosystems. *Journal of Research in Educational Management*, 2025, 4(1), 12-21. DOI: 10.71392/jrem.v4i1.88
- [11] Bass BM, Riggio RE. *Transformational Leadership*. New York: Psychology Press, 2006.
- [12] Sun JP, Chen XJ, Zhang SJ. A review of research evidence on the antecedents of transformational leadership. *Education Sciences*, 2017, 7(1), 15. DOI: 10.3390/educsci7010015
- [13] Mehmood S. Exploring digital leadership, technology integration, and teacher task performance in higher education institutions. *Journal of Digitization and Information System*, 2023, 3(1), 141-155. DOI: 10.54433/JDIIS.2023100026
- [14] Antonopoulou H, Matzavinou P, Giannoukou I, Halkiopoulos C. Teachers' digital leadership and competencies in primary education. *Education Sciences*, 2025, 15(2), 215. DOI: 10.3390/educsci15020215
- [15] Sliwka A, Klopsch B, Beigel J, Tung L. Transformational leadership for deeper learning. *Journal of Educational Administration*, 2024, 62(1), 103-121. DOI: 10.1108/JEA-03-2023-0049

- [16] Vermeulen M, Kreijns K, van Buuren H, Van Acker F. The role of transformative leadership, ICT-infrastructure and learning climate. *British Journal of Educational Technology*, 2017, 48(6), 1427-1440. DOI: 10.1111/bjet.12478
- [17] Hou MY, Ahmad JB, Zhao Y. Integrating transformational leadership with artificial intelligence: Driving a new future for Chinese K-12 education. *International Journal of Educational Organization & Leadership*, 2024, 31(1), 123-144. DOI: 10.18848/2329-1656/CGP/v31i01/123-144
- [18] Bolden R. Distributed leadership in organizations: A review of theory and research. *International Journal of Management Reviews*, 2011, 13(3), 251-269. DOI: 10.1111/j.1468-2370.2011.00306.x
- [19] Gronn P. Distributed leadership. *Second International Handbook of Educational Leadership and Administration*, Dordrecht: Springer Netherlands, 2002, 8, 653-696. DOI: 10.1007/978-94-010-0375-9\_23
- [20] Harris A, Jones M, Ismail N. Distributed leadership: Taking a retrospective and contemporary view. *School Leadership & Management*, 2022, 42(5), 438-456. DOI: 10.1080/13632434.2022.2109620
- [21] N. Ghamrawi. Trust me: Your school can be better-A message from teachers to principals. *Educational Management Administration & Leadership*, 2011, 39(3), 333-348. DOI: 10.1177/1741143210393997
- [22] Spillane JP. Distributed Leadership. *The Educational Forum*, 2005, 69(2), 143-150. DOI: 10.1080/00131720508984678
- [23] Yassin MK. Technology integration in learning ecosystems. *Revitalizing the Learning Ecosystem for Modern Students*, 2024, 73-86. DOI: 10.4018/979-8-3693-4103-2.ch004
- [24] Nadeem M. Distributed leadership in educational contexts: A catalyst for school improvement. *Social Sciences & Humanities Open*, 2024, 9, 100835. DOI: 10.1016/j.ssaho.2024.100835
- [25] Baštea AR, Catalano H, Dohotaru AI. An overview of distributed leadership and its shortcomings in educational settings. *Educatia* 21, 2023, 25, 116-126. DOI: 10.24193/ed21.2023.25.12
- [26] Jones S. Distributed leadership: A critical analysis. *Leadership*, 2014, 10(2), 129-141. DOI: 10.1177/1742715011433525
- [27] Archambault LM, Barnett JH. Revisiting technological pedagogical content knowledge. *Computers & Education*, 2010, 55(4), 1656-1662. DOI: 10.1016/j.compedu.2010.07.009
- [28] Koehler MJ, Mishra P, Cain W. What is technological pedagogical content knowledge (TPACK)? *Journal of Education*, 2013, 193(3), 13-19. DOI: 10.1177/00220574131930030
- [29] Mishra P, Koehler MJ. Technological pedagogical content knowledge. *Teachers College Record*, 2006, 108(6), 1017-1054. DOI: 10.1111/j.1467-9620.2006.00684.x
- [30] Makri A, Vlachopoulos D. Professional development for school leaders: A focus on soft and digital skills. *Edulearn19 Proceedings*, 2019, 6200-6209. DOI: 10.21125/edulearn.2019.1492
- [31] Ursavaş ÖF. Unified Theory of Acceptance and Use of Technology Model (UTAUT). *Conducting Technology Acceptance Research in Education*, 2022, 111-133. DOI: 10.1007/978-3-031-10846-4\_6
- [32] Dwivedi YK, Rana NP, Jeyaraj A, Clement M, Williams MD. Re-examining the UTAUT: Towards a revised theoretical model. *Information Systems Frontiers*, 2019, 21(3), 719-734. DOI: 10.1007/s10796-017-9774-y
- [33] Martin F, Gezer T, Ceviker E. Exploring multidimensional factors influencing teachers' technology integration in K-12 education. *Journal of Research on Technology in Education*, 2025, 1-35. DOI: 10.1080/15391523.2025.2534951
- [34] Wang YL, Derakhshan A, Ghiasvand F. EFL teachers' generative artificial intelligence (GenAI) literacy: A scale development and validation study. *System*, 2025, 133, 103791. DOI: 10.1016/j.system.2025.103791
- [35] Jin HY, Rui YP. Gen AI literacy and acceptance among EFL teachers: An exploration through the UTAUT model and Self-Determination Theory. *European Journal of Education*, 2025, 61(1), e70364. DOI: 10.1111/ejed.70364
- [36] Qayyum A, Sadiqi T, Abbas MA. Integrating artificial intelligence into early childhood education policy in Pakistan. *Journal of Development and Social Sciences*, 2024, 5(4), 416-431. DOI: 10.47205/jdss.2024(5-IV)36
- [37] Qureshi H. AI for predictive analytics: Transforming business strategies with intelligent systems. *Journal of AI Range*, 2025, 2(1), 23-32.
- [38] Wang XB, Zhao SL, Xu XS, Zhang HH, Lei VNL. AI adoption in Chinese universities. *Acta Psychologica*, 2025, 258, 105160. DOI: 10.1016/j.actpsy.2025.105160
- [39] Roberts H, Cowls J, Morley J, Taddeo M, Wang V, Floridi L. The Chinese approach to artificial intelligence: An analysis of policy, ethics, and regulation. *AI & Society*, 2021, 36, 59-77. DOI: 10.1007/s00146-020-00992-2
- [40] Ansari AN, Asad MM. Role of school leaders in cultivating professional learning communities in Pakistani schools. *Journal of Professional Capital and Community*, 2024, 9(2), 135-153. DOI: 10.1108/JPC-03-2023-0022
- [41] Khan RAG. Impact of strategic leadership on growth in the universities of Pakistan: Moderating role of strategic alignment. *Eskişehir: Anadolu University*, 2023.
- [42] Kafa A. Exploring integration aspects of school leadership in the context of digitalization and artificial intelligence. *International Journal of Educational Management*, 2024, 39(8), 98-115. DOI: 10.1108/IJEM-11-2024-0703
- [43] Liu YL, Li XL, Chen JJ, Lee JCK. A bibliometric review of research on digital leadership, 1991-2025: Implications for digital leadership in education. *Educational Management Administration & Leadership*, 2025. DOI: 10.1177/17411432251349806
- [44] Jing MY, Guo Z, Wu X, Yang Z, Wang XQ. Higher education digital academic leadership. *Education Sciences*, 2025, 15(5), 606. DOI: 10.3390/educsci15050606
- [45] Li WZ, Liu KC, Belitski M, Ghobadian A, O'Regan N. e-Leadership through strategic alignment. *Journal of Information Technology*, 2016, 31(2), 185-206. DOI: 10.1057/jit.2016.10
- [46] Okunlola JO. Digital leadership and employee performance: A meta-analysis. *Social Sciences and Education Research Review*, 2025, 12(1), 226-236. DOI: 10.5281/zenodo.15804548
- [47] Cohen J. *Statistical Power Analysis for the Behavioral Sciences*. New York: Routledge, 1988. DOI: 10.4324/9780203771587
- [48] Zhu JQ, Liu XN, Gao P. Digital intelligence technology: New quality productivity for precision traditional Chinese medicine. *Frontiers in Pharmacology*, 2025, 16, 1526187. DOI: 10.3389/fphar.2025.1526187
- [49] Marks HM, Printy SM. Principal leadership and school performance. *Educational Administration Quarterly*, 2003, 39(3), 370-397. DOI: 10.1177/0013161X03253412
- [50] Robinson VMJ, Lloyd CA, Rowe KJ. The impact of leadership on student outcomes. *Educational Administration Quarterly*, 2008, 44(5), 635-674. DOI: 10.1177/0013161X08321509