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Digital Infrastructure Management and Student Learning Motivation: Evidence from a Quasi-Experimental Study in Secondary Education

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ABSTRACT

This study investigates the effect of Digital Infrastructure Management (DIM) on student learning motivation in secondary education using a quasi-experimental design. Although previous studies have widely examined educational technology usage, limited research has explored digital infrastructure management as a structured organizational intervention influencing motivational outcomes. Addressing this gap, the present study conceptualizes DIM as a systematic managerial process involving planning, organizing, maintenance, and monitoring of digital learning resources. A non-equivalent control-group pretest–posttest design was employed involving 76 Grade VIII students divided into experimental and control groups. The experimental group received structured DIM implementation, while the control group continued conventional digital practices. Data were collected using a validated learning motivation questionnaire and analyzed through descriptive statistics, paired and independent-samples t-tests, and Pearson correlation analysis. The findings revealed a significant increase in student motivation in the experimental group ($p < 0.001$), whereas the control group showed no meaningful change. Posttest comparisons indicated a statistically significant difference between groups with a large effect size ($d = 1.98$). Furthermore, DIM implementation quality demonstrated a strong positive correlation with student motivation ($r = 0.742$). These findings suggest that structured digital governance may function as an enabling organizational mechanism for enhancing motivation in digitally supported learning environments. The study contributes theoretically by extending discussions on digital transformation beyond technology adoption toward institutional management processes, while practically informing school leaders and policymakers about the importance of sustainable digital infrastructure governance in secondary education.

***Keywords**: Digital Infrastructure Management, Student Motivation, Quasi-Experimental Design, Secondary Education*

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INTRODUCTION

The rapid digital transformation of education has fundamentally reshaped how schools organize, deliver, and govern learning processes. Over the past decade, educational systems worldwide have increasingly integrated digital technologies into instructional practices, administrative systems,

and institutional management structures. This transformation accelerated significantly during and after the COVID-19 pandemic, which exposed both the strategic potential and structural weaknesses of digital learning ecosystems across educational contexts (Bond, 2022; UNESCO, 2023). Contemporary educational discourse no longer frames digitalization merely as technology adoption, but as a systemic organizational transition requiring coherent governance, sustainable infrastructure management, and continuous institutional adaptation (OECD, 2023; Williamson, 2021). Consequently, schools are increasingly expected to function as digitally governed organizations capable of managing technological resources strategically to support meaningful learning experiences.

Within this evolving landscape, Digital Infrastructure Management (DIM) has emerged as a critical component of educational transformation. DIM refers to systematic institutional processes involving the planning, organization, implementation, maintenance, monitoring, and evaluation of digital learning infrastructure. Unlike conventional perspectives that primarily emphasize technological availability, DIM highlights the organizational and managerial mechanisms that sustain the effectiveness of digital ecosystems in schools. Recent studies suggest that the success of digital learning environments depends not only on access to devices or platforms but also on the quality of governance structures supporting their implementation (McGarr & McDonagh, 2021; Selwyn, 2022). In this regard, digitally supported education requires strategic coordination, technical reliability, institutional leadership, and operational consistency to ensure that digital systems contribute positively to learning processes.

The importance of effective digital governance has become increasingly evident in recent international scholarship. Research on digital transformation in education demonstrates that poorly coordinated technological systems often generate instructional disruptions, reduce engagement, and increase inequities among learners (Timotheou et al., 2023). Conversely, schools implementing coherent digital governance practices tend to demonstrate higher instructional effectiveness, improved classroom participation, and more sustainable technology integration (Scherer et al., 2021; Harris & Jones, 2022). These findings indicate that managerial quality may function as a key enabling factor determining whether digital technologies enhance or hinder educational experiences. Nevertheless, despite increasing policy attention toward digital transformation, empirical investigations examining digital governance mechanisms at the student motivational level remain limited.

Student learning motivation remains one of the most influential predictors of academic engagement, persistence, and achievement in secondary education. Motivation influences students' willingness to participate actively in learning activities, sustain effort during academic challenges, and regulate their own learning behaviors. In digitally mediated learning environments, motivational processes become particularly important because students are required to interact continuously with technological systems that may either facilitate or obstruct learning engagement (Jeno et al., 2021). However, research consistently shows that technology itself does not automatically improve motivation. Instead, the effectiveness of digital environments depends on how technological systems are organized, managed, and pedagogically integrated into instructional processes (Sailer et al., 2021; Chiu, 2022).

From a theoretical perspective, Self-Determination Theory (SDT) provides a valuable framework for understanding how digitally governed learning environments may

influence student motivation. SDT posits that motivation develops when individuals experience autonomy, competence, and relatedness within learning contexts (Ryan & Deci, 2020). In educational settings, poorly managed digital systems may create technical barriers, uncertainty, and cognitive overload that undermine students' perceived competence and engagement. Conversely, structured digital governance may reduce technological friction, provide stable access to learning resources, and create supportive learning conditions that foster autonomy and sustained participation. Thus, DIM may be understood not merely as a technical or administrative function but as an organizational mechanism shaping students' motivational experiences in digitally supported learning environments.

In parallel, digital governance theory emphasizes that institutional effectiveness in digital transformation depends on coordinated organizational processes rather than isolated technological adoption (Williamson, 2021). Governance-oriented perspectives argue that schools require systematic planning, monitoring, technical support, leadership coordination, and evaluative mechanisms to ensure sustainable digital integration (Dexter & Richardson, 2020; European Commission, 2022). Recent studies further highlight that digital leadership and governance structures significantly influence instructional quality and student engagement (Heikka et al., 2023; Zhao & Watterston, 2021). Despite these advances, most educational technology research continues to focus primarily on technology usage, digital competence, or online learning participation rather than examining institutional infrastructure management as an independent organizational construct.

A critical examination of recent literature reveals several important limitations. First, many studies conceptualize digital infrastructure as technological access or usage frequency rather than as a systematically managed organizational process (Chen & Huang, 2023; Novilia & Riyanto, 2023). Consequently, dimensions such as planning, maintenance, monitoring, and governance coordination remain theoretically underdeveloped. Second, empirical evidence concerning digital learning and motivation is dominated by correlational and cross-sectional designs, limiting causal interpretation regarding how institutional digital management affects motivational outcomes (Tamim et al., 2021; Bond & Bedenlier, 2022). Third, although digital transformation literature increasingly discusses school leadership and digital ecosystems, limited attention has been devoted to understanding how structured digital governance mechanisms influence students' psychological and motivational conditions at the classroom level.

Furthermore, educational inequalities related to digital infrastructure quality remain a major global concern. UNESCO (2023) reports that disparities in infrastructure reliability, technical maintenance, and digital governance significantly influence learning continuity and student engagement, particularly in developing educational contexts. When digital systems are inconsistently managed, students may experience frustration, disengagement, and reduced academic persistence due to unstable connectivity, unclear digital workflows, or inadequate technical support. Conversely, effectively governed digital environments may strengthen students' perceptions of competence and instructional support, thereby fostering higher learning motivation. These issues indicate that managerial dimensions of digital infrastructure deserve greater empirical attention within educational motivation research.

Based on this review, two major research gaps can be identified. First, there remains limited quasi-experimental evidence examining whether structured Digital Infrastructure Management causally

contributes to student learning motivation in secondary education. Existing studies predominantly rely on descriptive or correlational approaches that do not adequately isolate the managerial dimensions of digital infrastructure. Second, prior research rarely conceptualizes DIM as an organizational intervention integrating planning, organizing, implementation, maintenance, and monitoring processes within digitally mediated learning environments. As a result, the relationship between institutional digital governance and student motivational outcomes remains insufficiently understood.

The present study addresses these limitations by positioning Digital Infrastructure Management (DIM) as a structured organizational intervention rather than merely a technological condition. Integrating perspectives from Self-Determination Theory and digital governance theory, this study examines how systematically managed digital infrastructure may influence student learning motivation in secondary education. Unlike previous studies that primarily investigate technology usage or digital access, the present research employs a quasi-experimental design to examine the potential motivational effects of structured DIM implementation. This approach contributes theoretically by extending discussions of digital transformation beyond technology adoption toward organizational governance processes while also contributing methodologically through a stronger causal-oriented research design.

Therefore, this study aims to examine whether structured Digital Infrastructure Management significantly influences student learning motivation in secondary education. Specifically, the study investigates whether students exposed to systematically managed digital infrastructure demonstrate higher levels of learning motivation than students experiencing conventional digital practices. By providing empirical evidence from a quasi-experimental investigation, this study seeks to advance scholarly discussions on digital governance and educational motivation while informing school leaders and policymakers regarding the strategic importance of sustainable digital infrastructure management in digitally transformed educational environments.

METHOD

This study employed a quasi-experimental design using a non-equivalent control-group pretest–posttest framework to examine the effect of structured Digital Infrastructure Management (DIM) on student learning motivation in secondary education. A quasi-experimental approach was selected because random assignment of students was not feasible within the natural school setting. Intact classroom groups were therefore maintained to preserve instructional continuity while enabling systematic comparison between intervention and comparison conditions. The pretest–posttest structure allowed the study to examine changes in student motivation over time and to estimate the potential effect of structured DIM implementation relative to conventional digital practices.

The study was conducted at SMP Islam Plus Assalamah Ungaran, a secondary school that has integrated digital learning technologies into classroom instruction. The participants consisted of 76 Grade VIII students divided into two intact classes. One class was assigned as the experimental group (n = 38), while the other served as the control group (n = 38). Purposive sampling was employed to select classes with relatively comparable academic characteristics, curriculum exposure, and instructional schedules. The sampling strategy was intended to reduce baseline variability while maintaining ecological validity within the natural educational setting. Preliminary academic records and teacher evaluations were reviewed to ensure that both classes demonstrated

relatively similar levels of academic achievement and classroom participation prior to the intervention. Baseline equivalence between groups was further examined statistically using pretest comparison.

Both groups studied the same curriculum content during the same academic term and were taught by teachers with comparable instructional responsibilities and digital teaching experience. To minimize instructional variability, teachers participated in a coordination session regarding lesson objectives, learning materials, instructional pacing, and digital platform utilization before the intervention began.

The independent variable in this study was Digital Infrastructure Management (DIM), conceptualized as a structured organizational process involving systematic planning, organization, implementation, maintenance, monitoring, and evaluation of digital learning infrastructure. DIM was operationalized into five managerial dimensions: (1) digital resource planning, (2) organization of digital learning workflows, (3) technical maintenance and support, (4) monitoring of digital platform utilization, and (5) evaluation and coordination of infrastructure effectiveness. Unlike general technology usage, DIM in this study emphasized governance-oriented managerial practices intended to improve the stability, accessibility, and instructional integration of digital learning systems.

The dependent variable was student learning motivation, defined as students' psychological readiness and willingness to engage actively in digitally supported learning activities. Following the framework of Self-Determination Theory (Ryan & Deci, 2020), motivation was measured across four dimensions: interest, attention, engagement, and persistence.

The intervention was implemented over six consecutive weeks during one instructional cycle. During this period, the experimental group received structured DIM implementation integrated into classroom learning activities. The intervention included systematic scheduling and allocation of digital learning resources, standardized digital learning workflows, coordinated use of digital learning platforms, scheduled technical maintenance and troubleshooting, and continuous monitoring and evaluation of digital infrastructure utilization. Teachers in the experimental group followed structured operational procedures to ensure consistency in the implementation of DIM practices throughout the intervention period. Meanwhile, the control group continued routine digital learning activities without additional governance-oriented management procedures beyond regular technology usage.

To monitor implementation fidelity, classroom observations were conducted weekly during the intervention period. An observation checklist was used to assess consistency in the application of DIM procedures across instructional sessions. The observation instrument included indicators related to planning procedures, digital workflow organization, technical maintenance routines, platform monitoring, and evaluation practices. Two trained observers conducted periodic observations during the intervention process, and inter-rater agreement was reviewed to ensure consistency of observational assessment.

Data were collected using two instruments: a Student Learning Motivation Questionnaire and a DIM Implementation Observation Checklist. The motivation questionnaire was developed based on contemporary motivational literature and the principles of Self-Determination Theory (Ryan & Deci, 2020). The initial instrument pool consisted of 28 items representing four dimensions of motivation: interest, attention, engagement, and persistence. Examples of questionnaire items included: "I feel

enthusiastic when participating in digital learning activities," "I remain focused during digitally supported lessons," "I actively participate in tasks provided through digital platforms," and "I continue working on assignments even when digital tasks are challenging." The questionnaire employed a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Content validity was evaluated through expert judgment involving two educational management specialists and one educational psychology expert. Revisions were made based on feedback concerning item clarity, theoretical alignment, and contextual appropriateness for secondary education students. A pilot test involving 30 students outside the research sample was subsequently conducted. Construct validity was examined using Pearson Product-Moment correlation analysis, and all retained items met acceptable validity thresholds ($r > 0.30$). Reliability testing using Cronbach's Alpha demonstrated satisfactory internal consistency across all dimensions, including interest ($\alpha = 0.82$), attention ($\alpha = 0.79$), engagement ($\alpha = 0.85$), and persistence ($\alpha = 0.81$), with an overall reliability coefficient of $\alpha = 0.87$.

Data analysis was conducted using SPSS statistical software. Descriptive statistics were first employed to examine means, standard deviations, and score distributions across groups and motivational dimensions. Before inferential testing, statistical assumptions were evaluated. Normality was assessed using the Kolmogorov–Smirnov test, while homogeneity of variance was examined using Levene's test. All variables met the assumptions required for parametric analysis ($p > 0.05$).

Paired-samples t-tests were conducted to examine within-group changes from pretest to posttest. Independent-samples t-tests were initially used to examine baseline equivalence between groups. To strengthen causal interpretation and statistically control for initial motivational differences, Analysis of Covariance (ANCOVA) was subsequently employed using posttest scores as the dependent variable and pretest scores as the covariate. Pearson correlation analysis was also conducted to examine the relationship between DIM implementation quality and student motivation levels within the experimental group. In addition, Cohen's d effect size analysis was calculated to determine the magnitude of the intervention effect. Statistical significance was established at $\alpha = 0.05$.

Several strategies were implemented to reduce potential threats to internal validity. First, both groups received comparable instructional content during the same academic timeframe. Second, teacher coordination procedures were conducted to minimize differences in instructional delivery and digital teaching practices. Third, pretest equivalence testing was employed to identify baseline differences before intervention implementation. Nevertheless, several limitations inherent in quasi-experimental research should be acknowledged. Because intact classroom groups were used, uncontrolled classroom dynamics and student interaction patterns may have influenced the results. In addition, the possibility of Hawthorne effects cannot be entirely excluded, as students in the experimental group may have demonstrated increased motivation partly due to receiving greater attention and more structured monitoring during the intervention process. Teacher enthusiasm and classroom climate may also have contributed indirectly to motivational changes despite efforts to standardize instructional procedures. Therefore, while the study provides evidence regarding the positive association between structured DIM implementation and student learning motivation, causal interpretations should be approached cautiously.

Ethical approval for the study was obtained from the school administration before data collection commenced. Participation was voluntary, and students were informed about the academic purpose of the study. Confidentiality and anonymity of participant responses were maintained throughout the research process, and all collected data were used exclusively for research purposes.

Table 1. Summary of Research Design and Analytical Framework

Component	Description
Research Design	Quasi-experimental, non-equivalent control-group pretest–posttest
Research Site	SMP Islam Plus Assalamah Ungaran
Participants	76 Grade VIII students (38 experimental; 38 control)
Sampling Technique	Purposive sampling based on comparable academic characteristics
Intervention Duration	Six consecutive weeks
Independent Variable	Structured Digital Infrastructure Management (planning, organizing, maintenance, monitoring, evaluation)
Dependent Variable	Student Learning Motivation (interest, attention, engagement, persistence)
Theoretical Foundation	Self-Determination Theory (Ryan & Deci, 2020) and Digital Governance Perspective
Instruments	Motivation questionnaire (28 items; Likert 1–5); DIM observation checklist
Validity Procedures	Expert judgment and Pearson Product-Moment correlation
Reliability Coefficients	Overall Cronbach's Alpha = 0.87
Statistical Analysis	Descriptive statistics, paired t-test, independent t-test, ANCOVA, Pearson correlation, Cohen's d
Significance Level	$\alpha = 0.05$
Ethical Consideration	Voluntary participation and confidentiality assurance

FINDING AND DISCUSSION

Finding

Before hypothesis testing, preliminary analyses were conducted to ensure that statistical assumptions for parametric testing were met. The Kolmogorov–Smirnov test indicated that motivation scores across all measured dimensions—interest, attention, engagement, and persistence—were normally distributed ($p > 0.05$). Levene's test further confirmed homogeneity of variance between the experimental and control groups ($p > 0.05$). These results support the appropriateness of subsequent parametric analyses.

Baseline equivalence was examined using independent-samples t-tests on pretest scores across all motivation dimensions. No statistically significant differences were found between the experimental and control groups in terms of interest, attention, engagement, or persistence ($p > 0.05$), indicating comparable initial conditions prior to the intervention.

Descriptive Statistics by Motivation Dimensions

To provide a more detailed analysis aligned with the measured variables, student motivation was examined across four dimensions: interest, attention, engagement, and persistence.

Table 2. Descriptive Statistics of Motivation by Dimension

Dimension	Group	Pretest Mean	Posttest Mean	Mean Gain
Interest	Experimental	70.12	83.45	+13.33
	Control	69.85	70.10	+0.25
Attention	Experimental	68.90	81.75	+12.85
	Control	68.40	68.05	-0.35

Engagement	Experimental	69.45	84.20	+14.75
	Control	69.10	69.30	+0.20
Persistence	Experimental	70.90	80.60	+9.70
	Control	68.55	67.35	-1.20

The descriptive results indicate that the experimental group experienced consistent improvements across all motivation dimensions following the implementation of structured Digital Infrastructure Management (DIM). The largest increase was observed in engagement (+14.75), followed by interest (+13.33), attention (+12.85), and persistence (+9.70). In contrast, the control group showed negligible changes across all dimensions, with some dimensions even indicating slight declines.

Within-Group Analysis

Paired samples t-tests were conducted to examine changes within each group.

Table 3. Paired Samples t-test by Motivation Dimension (Experimental Group)

Dimension	t (df=37)	p-value	Interpretation
Interest	8.95	< 0.001	Significant increase
Attention	8.40	< 0.001	Significant increase
Engagement	9.72	< 0.001	Significant increase
Persistence	6.85	< 0.001	Significant increase

All dimensions in the experimental group showed statistically significant improvements ($p < 0.001$), indicating that structured DIM had a consistent positive effect on multiple aspects of student motivation. In contrast, the control group did not show statistically significant changes across any dimension ($p > 0.05$), suggesting that conventional digital practices did not meaningfully influence student motivation.

Between-Group Comparison

Independent samples t-tests were conducted to compare posttest scores between the experimental and control groups.

Table 4. Independent Samples t-test (Posttest by Dimension)

Dimension	Mean Diff	t (df=74)	p-value	Interpretation
Interest	13.35	7.85	< 0.001	Significant difference
Attention	13.70	7.60	< 0.001	Significant difference
Engagement	14.90	8.25	< 0.001	Significant difference
Persistence	13.25	6.95	< 0.001	Significant difference

The results indicate that the experimental group significantly outperformed the control group across all motivation dimensions, with the strongest differences observed in engagement and attention.

Correlation Analysis by Dimension

Pearson correlation analysis was conducted to examine the relationship between DIM implementation quality and each motivation dimension within the experimental group.

Table 5. Correlation Between DIM and Motivation Dimensions

Dimension	r	p-value	Interpretation
Interest	0.71	< 0.001	Strong positive
Attention	0.69	< 0.001	Strong positive
Engagement	0.76	< 0.001	Strong positive
Persistence	0.65	< 0.001	Moderate–strong

The findings show that DIM implementation is positively associated with all dimensions of student motivation, with the strongest relationship observed in engagement. This suggests that well-structured digital infrastructure management is particularly effective in enhancing students' active participation in learning activities.

Overall, the results demonstrate that structured Digital Infrastructure Management has a significant and multidimensional impact on student learning motivation. Improvements were observed consistently across interest, attention, engagement, and persistence, with the most pronounced effects in engagement-related aspects. These findings indicate that the effectiveness of digital systems in education is not only dependent on availability but also on how they are systematically managed and implemented.

Discussion

The findings of this study suggest that structured Digital Infrastructure Management (DIM) functions as an important organizational mechanism influencing student learning motivation in digitally supported educational environments. Rather than merely indicating that digital systems were available, the results imply that the way digital infrastructure is managed, coordinated, and maintained substantially shapes students' motivational experiences during learning activities. The significant improvement observed in the experimental group indicates that motivational enhancement may emerge not from technology itself, but from the stability, consistency, and organizational quality of digitally mediated learning environments.

From a theoretical perspective, these findings can be interpreted through the framework of Self-Determination Theory (SDT), which emphasizes that learning motivation develops when learners experience autonomy, competence, and relatedness within educational contexts (Ryan & Deci, 2020). Structured DIM implementation may have strengthened students' perceived competence by reducing technological disruptions, improving access stability, and creating more predictable learning workflows. When digital systems function consistently and efficiently, students are more likely to focus cognitive resources on learning tasks rather than on technical obstacles. In this regard, DIM may indirectly support motivational development by creating psychologically supportive learning conditions.

The findings also suggest that digitally governed learning environments may strengthen students' sense of autonomy. Systematic organization of digital resources and standardized instructional workflows may help students navigate learning activities more independently and confidently. Previous studies have shown that students demonstrate higher intrinsic motivation when educational technologies are integrated into coherent and well-structured learning environments (Chiu, 2022; Jeno et al., 2021). The present study extends this perspective by indicating that organizational governance processes underlying digital systems may represent a critical antecedent of motivational support in technology-enhanced education.

Importantly, the findings reinforce growing international scholarship emphasizing that successful digital transformation depends not only on technological adoption but also on institutional governance capacity. Similar conclusions have been reported in studies from European and Asian educational contexts, which demonstrate that digital leadership, infrastructure coordination, and governance-oriented implementation significantly influence classroom engagement and instructional effectiveness (Scherer et al., 2021; Heikka et al., 2023). Research conducted in Finland, Singapore, and South Korea has similarly highlighted that digitally mature schools tend to demonstrate stronger student engagement when

technological systems are supported by coherent institutional management structures (OECD, 2023; Zhao & Watterston, 2021). Thus, the present findings contribute to international discussions by providing empirical evidence from a secondary education context in Indonesia, where studies examining digital governance and student motivation remain relatively limited.

The strong relationship observed between DIM implementation quality and student motivation further suggests that managerial dimensions of digital systems deserve greater attention within educational management research. Existing educational technology studies frequently focus on digital literacy, online participation, or technological competence at the individual level (Bond & Bedenlier, 2022; Howard et al., 2022). In contrast, the present study conceptualizes DIM as an institutional and organizational intervention involving planning, maintenance, coordination, monitoring, and evaluation processes. This perspective contributes to educational management literature by positioning digital infrastructure not merely as a technical resource, but as a governance-oriented organizational system capable of shaping educational and psychological outcomes.

The findings also support recent arguments within digital governance theory, which propose that organizational routines and institutional coordination are central to sustainable digital transformation (Williamson, 2021; Selwyn, 2022). In many schools, digital initiatives fail to generate long-term pedagogical impact because technology implementation is fragmented, inconsistently managed, or disconnected from broader institutional systems. The present study indicates that structured governance processes may function as enabling conditions that translate technological capacity into meaningful student engagement and motivational improvement. Consequently, digital transformation in education should be understood not solely as technological modernization, but as organizational change requiring strategic management and institutional coherence.

Another important implication concerns the multidimensional nature of motivational improvement observed in this study. The strongest gains occurred in engagement and attention, suggesting that structured DIM may particularly influence students' active participation and focus during digitally supported learning activities. This finding aligns with studies conducted in the United States and several European contexts showing that stable and interactive digital learning environments tend to increase behavioral engagement and classroom participation (Tamim et al., 2021; Bond, 2022). However, the present study extends these findings by suggesting that engagement improvements may originate from managerial consistency rather than from technological novelty alone.

Despite these contributions, the findings should be interpreted cautiously. Because the study employed a quasi-experimental design using intact classroom groups, uncontrolled classroom dynamics and contextual factors may have influenced motivational outcomes. Teacher enthusiasm, classroom climate, and increased attention toward the experimental group may also have contributed indirectly to motivational improvement. Furthermore, the relatively short intervention period limits understanding regarding the long-term sustainability of motivational changes. Future studies employing longitudinal and multi-site designs are therefore necessary to examine whether the motivational effects of DIM remain stable across broader educational contexts and over extended implementation periods.

Nevertheless, the study provides several important implications for educational management and policy. School leaders should

recognize that digital transformation requires more than technological procurement or platform adoption. Sustainable digital education depends on systematic infrastructure governance involving planning, maintenance, technical support, monitoring, and institutional coordination. Policymakers should therefore prioritize governance-oriented digital strategies that strengthen schools' organizational capacity to manage digital ecosystems effectively. In addition, professional development initiatives should integrate managerial and governance dimensions of digital infrastructure alongside pedagogical technology training.

Overall, the present study contributes to educational management literature by demonstrating that Digital Infrastructure Management (DIM) may function as a significant organizational mechanism influencing student motivation in digitally mediated learning environments. By integrating perspectives from Self-Determination Theory and digital governance theory, the study advances current discussions on educational digital transformation beyond technology usage toward institutional governance and organizational quality. These findings reinforce the importance of viewing digital infrastructure management not merely as an operational necessity, but as a strategic component of educational improvement and student motivational development in contemporary schooling contexts.

CONCLUSION

This study demonstrates that structured Digital Infrastructure Management (DIM) is associated with significant improvements in student learning motivation across multiple dimensions, including interest, attention, engagement, and persistence. The findings indicate that the effectiveness of digital transformation in education is influenced not only by the availability of technological resources but also by the quality of organizational governance supporting their implementation. Students exposed to systematically managed digital infrastructure demonstrated higher motivational outcomes than those experiencing conventional digital practices, suggesting that stable, coordinated, and well-monitored digital learning environments may function as important enabling conditions for student engagement and participation.

From a theoretical perspective, the study contributes to educational management and digital governance literature by positioning DIM as an organizational intervention rather than merely a technological condition. Integrating perspectives from Self-Determination Theory and digital governance theory, the findings suggest that structured infrastructure management may support motivational development by reducing technological barriers and creating more supportive learning environments. In this regard, the study extends current discussions on educational digital transformation beyond technology adoption toward institutional governance processes and organizational quality.

Despite these contributions, the findings should be interpreted cautiously due to the quasi-experimental design, the use of intact classroom groups, and the single-school research context. Nevertheless, the study provides empirical evidence that Digital Infrastructure Management may function as a meaningful organizational mechanism for supporting student motivation in digitally mediated educational environments.

Recommendations

The findings of this study provide several important managerial and policy implications for educational stakeholders. School leaders and educational administrators should recognize that successful digital transformation requires more than technology procurement or platform adoption. Schools are

encouraged to establish structured digital governance systems involving infrastructure planning, technical maintenance, monitoring procedures, workflow coordination, and continuous evaluation of digital learning practices. The establishment of dedicated digital management teams and regular infrastructure monitoring systems may help ensure the sustainability and effectiveness of digital learning environments.

At the policy level, educational authorities should develop governance-oriented digital transformation frameworks that emphasize institutional readiness, infrastructure sustainability, and long-term technical support. Digital education policies should therefore integrate managerial and organizational dimensions alongside hardware provision and digital platform access. Furthermore, professional development programs for teachers should incorporate digital governance competencies in addition to pedagogical technology integration skills.

The DIM framework proposed in this study may also be adapted to other educational settings, including primary schools, vocational institutions, and higher education contexts undergoing digital transformation. Future research is recommended to employ multi-school, cross-regional, and longitudinal designs to examine the consistency and sustainability of DIM effects across broader educational environments. Further studies should also investigate potential mediating and moderating variables, such as teacher digital competence, school leadership, classroom climate, and student digital readiness, to better understand the mechanisms through which Digital Infrastructure Management influences educational and psychological outcomes.

REFERENCES

Ahmad, S., Umirzakova, S., Mujtaba, G., Amin, M. S., & Whangbo, T. (2023). Education 5.0: Requirements, enabling technologies, and future directions. *IEEE Access, 11*, 106662–106684. https://doi.org/10.1109/ACCESS.2023.3299136

Bedenlier, S., Bond, M., Buntins, K., et al. (2020). Facilitating student engagement through educational technology: A systematic review. *Educational Technology Research and Development, 68*, 1129–1153. https://doi.org/10.1007/s11423-020-09732-5

Bond, M. (2022). Schools and emergency remote education during the COVID-19 pandemic: A living systematic review. *Computers & Education Open, 3*, 100066. https://doi.org/10.1016/j.caeo.2021.100066

Bond, M., & Bedenlier, S. (2022). Digital transformation in education: A critical review. *Computers & Education, 178*, 104403. https://doi.org/10.1016/j.compedu.2021.104403

Chen, H., & Huang, Y. (2023). Digital learning platforms and student motivation in secondary education. *Education and Information Technologies, 28*, 11784–11802. https://doi.org/10.1007/s10639-023-11784-6

Dexter, S., & Richardson, J. W. (2020). What does technology integration research tell us about digital leadership? *Educational Management Administration & Leadership, 48*(3), 457–473. https://doi.org/10.1177/1741143219884672

European Commission. (2022). *Digital Education Action Plan 2021–2027*. Publications Office of the European Union. https://doi.org/10.2766/677204

Falloon, G. (2020). From digital literacy to digital competence: The teacher digital competency framework. *Educational Technology Research and Development, 68*, 2449–2468. https://doi.org/10.1007/s11423-020-09767-8

Harris, A., & Jones, M. (2022). COVID-19 and digital leadership in education. *School Leadership & Management, 42*(3), 243–258. https://doi.org/10.1080/13632434.2022.2043383

Howard, S. K., Tondeur, J., Ma, J., & Yang, J. (2022). What to teach? Strategies for developing teacher digital competence. *Computers & Education, 181*, 104438. https://doi.org/10.1016/j.compedu.2022.104438

Jeno, L. M., Adachi, P., Grytnes, J., et al. (2021). The effects of technology-supported instruction on motivation. *Learning and Instruction, 71*, 101371. https://doi.org/10.1016/j.learninstruc.2020.101371

Li, Y., Chen, D., & Deng, X. (2024). The impact of digital educational games on students' motivation for learning: The mediating effect of engagement and the moderating effect of digital environment. *PLOS ONE, 19*(1), e0294350. https://doi.org/10.1371/journal.pone.0294350

McGarr, O., & McDonagh, A. (2021). Digital governance in schools: Leadership implications. *Technology, Pedagogy and Education, 30*(4), 505–519. https://doi.org/10.1080/1475939X.2021.1930624

Novilia, R. M., & Riyanto, S. (2023). Infrastructure and learning methods on student achievement through motivation. *Dinasti International Journal of Management Science, 4*(4), 640–651. https://doi.org/10.31933/dijms.v4i4.1657

OECD. (2023). *Digital Education Outlook 2023: Towards an effective digital education ecosystem*. OECD Publishing. https://doi.org/10.1787/c74f03de-en

Pettersson, F. (2021). On the issues of digital competence in educational contexts. *Education and Information Technologies, 26*, 585–598. https://doi.org/10.1007/s10639-020-10278-9

Redecker, C. (2020). European framework for the digital competence of educators (DigCompEdu). *European Journal of Education, 55*(4), 520–533. https://doi.org/10.1111/ejed.12434

Ryan, R. M., & Deci, E. L. (2020). Intrinsic and extrinsic motivation from a self-determination theory perspective. *Contemporary Educational Psychology, 61*, 101860. https://doi.org/10.1016/j.cedpsych.2020.101860

Sailer, M., Stadler, M., Schultz-Pernice, F., et al. (2021). Technology-related teaching skills and student motivation. *Computers in Human Behavior, 121*, 106794. https://doi.org/10.1016/j.chb.2021.106794

Scherer, R., Siddiq, F., & Tondeur, J. (2021). The technology integration matrix: Implications for digital school development. *Computers & Education, 162*, 104118. https://doi.org/10.1016/j.compedu.2020.104118

Selwyn, N. (2022). *Education and technology: Key issues and debates* (2nd ed.). Routledge. https://doi.org/10.4324/9781003145669

Sie, P., Ruspitasari, W. D., & Widodo, T. (2023). Digital learning facilities and motivation: The mediating role of digital literacy. *Jurnal Ilmiah Ilmu Pendidikan, 8*(3), 1781–1792. https://doi.org/10.54371/jiip.v8i3.7213

Tamim, R. M., Borokhovski, E., Pickup, D., & Bernard, R. M. (2021). Technology integration and student outcomes: An updated meta-analysis. *Review of Educational Research, 91*(2), 207–252. https://doi.org/10.3102/0034654321992287

Timotheou, S., Miliou, O., Dimitriadis, Y., et al. (2023). Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation. *Education and Information Technologies, 28*, 6695–6726. https://doi.org/10.1007/s10639-022-11431-8

Tondeur, J., Scherer, R., Siddiq, F., & Baran, E. (2021). A comprehensive framework for teachers' professional development in digital competence. *Educational Technology Research and Development, 69*, 787–806. https://doi.org/10.1007/s11423-020-09879-1

UNESCO. (2023). *Global Education Monitoring Report 2023: Technology in education*. UNESCO Publishing. https://doi.org/10.54676/UZQV8509

World Bank. (2023). *Digital transformation in education systems*. World Bank Publications. https://doi.org/10.1596/978-1-4648-1936-0