International Journal of Educational Qualitative Quantitative Research (IJE-QQR)
ISSN: 2962-9918 (Online)
Vol. 4, No. 1, pp. 47-60

Tech-Supported Strategic Management, Digital Leadership, and Play-Based Interactive Learning: A Multilevel Survey of Quality Improvement in Early Childhood Education

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Article Info

Article history:
Received: Apr 10, 2025
Revised: Jul 17, 2025
Accepted: Jul 28, 2025

DOI: 10.58418/ijeqqr.v4i1.142

How to cite this article:
Syarifudin, A., & Muttaqin, M. A. (2025). Tech-Supported Strategic Management, Digital Leadership, and Play-Based Interactive Learning: A Multilevel Survey of Quality Improvement in Early Childhood Education. *International Journal of Educational Qualitative Quantitative Research*, *4*(1), 47–60. https://doi.org/10.58418/ijeqqr.v4i1.142

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ABSTRACT

The digital revolution has reshaped education worldwide, and early childhood education (ECE) is no exception, requiring institutions to integrate technology into management and leadership while maintaining play-based and developmentally appropriate practices. This study investigated the effects of tech-supported strategic management (TSM), digital leadership (DL), and play-based interactive learning (PBIL) on quality improvement (QI) in ECE, considering screen-time governance (STG) as a moderator and teacher digital preparedness for planning (TDPP) as a mediator. A quantitative multilevel survey was conducted with 290 principals and teachers from Indonesia and Malaysia. Data were collected through structured questionnaires and analyzed using multiple regression with SPSS, including moderation, mediation, and predictive modeling. Results showed that TSM, DL, and PBIL significantly influenced QI, with PBIL emerging as the strongest predictor. STG strengthened the effects of TSM, DL, and PBIL on QI, while TDPP mediated the relationship between these variables and QI. Predictive analysis further revealed that increasing TSM, DL, and PBIL simultaneously enhanced QI, whereas a decline in these variables led to a reduction in quality. These findings emphasize that technology in ECE should act as an enabler of management and leadership rather than as the primary medium for children's learning. Theoretically, the study extends integrative models of digital management, digital leadership, and play-based pedagogy within ECE. Practically, it offers guidance for policymakers, school leaders, and teachers in designing quality improvement strategies that are digitally supported yet age-appropriate, highlighting play, interaction, and strict governance of screen time.

Keywords: Tech-Supported Strategic Management, Digital Leadership, Play-Based Interactive Learning, Screen-Time Governance, Teacher Digital Preparedness, Quality Improvement, Early Childhood Education

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1. INTRODUCTION

In recent years, digital transformation has permeated all layers of society at the global level, creating opportunities while simultaneously presenting new challenges across various sectors, including education. At the international level, the world has witnessed a paradigm shift in which educational institutions are required not only to follow the flow of digitalization but also to anticipate changes through the implementation of digital-based management. Digital management in schools encompasses the utilization

of information systems (Szymkowiak et al., 2021), the application of online reporting (Timotheou et al., 2023), and the use of data analytics to support faster and more accurate strategic decision-making (Y. Wang, 2021). Within the context of global competition, according to Chatzipanagiotou & Katsarou (2023) and Sun et al. (2022), schools that implement digital management demonstrate higher levels of resilience and adaptability to external disruptions, such as pandemics. Consequently, the growing prevalence of digital phenomena has established a fundamental basis for strengthening digital management as an essential element in the provision of twenty-first-century education.

Tech-supported strategic management is a strategic management approach supported by technology, such as planning applications, performance dashboards, and school management information systems (Gündoğdu & Merç, 2022; Zagni et al., 2025). This approach is significant because it enables resource management, curriculum planning, and monitoring of learning quality to be conducted in real time and based on data. Its benefits are evident in enhanced operational efficiency, process transparency, and institutional responsiveness to the needs of both students and teachers. In the digital era, according to Rahm (2023) and Ruloff & Petko (2025), the integration of technology into school governance has become a key differentiator between institutions that progress and those that lag behind. Accordingly, Tech-supported strategic management serves as the backbone of managerial transformation in modern schools.

Digital leadership is a leadership style that utilizes and promotes technological innovation to guide the future vision of education (Anwar & Saraih, 2024; Karakose et al., 2024). According to Tołwińska (2021) and Rasdiana et al. (2024), educational leaders with digital leadership are able to inspire teachers, staff, and students to adapt to the use of technology while maintaining pedagogical values. Senadjki et al. (2024) added the role of digital leadership is increasingly crucial in the era of disruption, as leaders are expected to act as drivers of digital transformation rather than merely as technology users. For instance, research by Karakose et al. (2021), Hafiza Hamzah et al. (2021) and Monteiro et al. (2023) has shown that school principals who practice digital leadership are able to enhance teachers' digital competencies and support effective learning during emergency situations such as a pandemic. Therefore, digital leadership is not solely about technology, but also about shaping a digital culture within schools.

Play-based interactive learning is a learning approach that incorporates interactive play by combining elements of play and technology to enhance children's engagement (Qayyum et al., 2024; Rappa et al., 2025). This approach is significant because it enables children to develop cognitive, social, emotional, and motor skills in a natural and enjoyable manner. The integration of technology within play contexts, such as the use of interactive tablets, can foster creativity, problem-solving abilities, and the comprehension of abstract concepts from an early age (Clemente-Suárez et al., 2024; Yaling & E, 2025). Furthermore, research by Alotaibi (2024) and Behnamnia et al. (2023) has demonstrated that digital game-based learning for early childhood strengthens critical thinking skills and promotes active learning. Accordingly, play-based interactive learning serves as a pedagogical method that bridges the joy of learning with the attainment of optimal educational outcomes.

Quality improvement in schools encompasses various aspects, including curriculum development, teacher competence, facilities, and instructional approaches (Isa et al., 2024; Prasetyono et al., 2021). However, in the context of early childhood education (ECE), quality improvement is particularly urgent because this stage serves as the foundation of development during the earliest phase of life. Efforts to improve quality in ECE should involve evidence-based approaches, such as the integration of technology in management, the implementation of digital leadership, and the application of play-based interactive learning. ECE institutions that adopt these three approaches have the potential to create adaptive, inclusive, and high-quality learning environments. Therefore, a focus on quality improvement in ECE is crucial, as it determines children's readiness to progress to subsequent levels of education.

Organizing ECE services with appropriate strategies constitutes a strategic investment for the future of the national education system. The success of ECE in establishing the foundations of literacy, numeracy, and socio-emotional skills generates long-term positive impacts on students' academic performance at higher educational levels. Research by Diale & Sewagegn (2021) and Berger et al. (2022) indicates that children who receive high-quality early childhood education are better prepared to face learning challenges in primary, secondary, and high schools. Therefore, improving the management, leadership, and instructional practices of ECE not only contributes to the enhancement of basic education quality but also prepares competent and competitive human resources for the future.

Previous studies have examined several aspects related to the focus of this research. Widyastuti et al. (2024) investigated the role of transformational leadership in improving early childhood education quality, while Kewalramani et al. (2020) explored the integration of technology in play-based learning. Lähdesmäki et al. (2024) highlighted digital pedagogy in early childhood education, whereas Behnamnia et al. (2023) examined digital game-based learning, and Xiong et al. (2022) analyzed its effects on creativity. In addition, Mowafi et al. (2019) studied the use of QR codes and coding toys in interactive learning, and Almuaigel et al. (2021) investigated the influence of technology on children's behavior. However, most of these studies treated technology-based strategic management, digital leadership, and play-based interactive learning as separate domains of inquiry. The novelty of this research lies in its multilevel approach that integrates these

three domains into a unified survey to measure quality improvement in ECE, a contribution not previously addressed in the literature.

The objective of this study is to identify and analyze the relationship among tech-supported strategic management, digital leadership, and play-based interactive learning in supporting quality improvement in early ECE. The expected contributions include the development of both theoretical and practical models concerning the implementation of strategic digital management, the application of digital leadership, and play-based interactive learning methodologies, particularly within the context of ECE. Furthermore, this study is expected to provide evidence-based policy and practical recommendations for schools, ECE leaders, and stakeholders in order to enhance the quality of early childhood education in effective manner.

2. METHOD

This study employed a quantitative survey design to examine the relationship between tech-supported strategic management (TSM), digital leadership (DL), and play-based interactive learning (PBIL) in supporting quality improvement (QI) in early childhood education (ECE). In addition, the study tested the role of screen-time governance (STG) as a moderator and teacher digital preparedness for planning (TDPP) as a mediator. Data analysis was conducted using multiple regression analysis with SPSS (Mat Roni & Djajadikerta, 2021), which not only explored the direct effects of the independent variables on QI but also allowed for prediction analysis. The predictive model estimated the increase or decrease of QI if the levels of TSM, DL, and PBIL were raised or lowered.

The participants consisted of 290 respondents, including principals and teachers of early childhood education institutions in Indonesia and Malaysia. This number is obtained from the adaptation of Likelihood theory, the minimum participation is the number of statements (29) x 10 = 290. The sampling technique applied was purposive sampling, with inclusion criteria: (1) respondents actively served as school principals/managers or teachers in ECE institutions, (2) had at least one year of teaching/management experience, and (3) were directly involved in both digital management and play-based learning practices.

The research instrument was a structured questionnaire using a five-point Likert scale (1 = strongly disagree, 5 = strongly agree). The questionnaire for school principals/managers consisted of three constructs: TSM (5 items), DL (5 items), and STG (4 items). The questionnaire for teachers consisted of three constructs: TDPP (5 items), PBIL (5 items), and QI (5 items). Details of the research instruments are shown in Table 1.

Table 1. Research Instrument

Variable	Role in Model	Item Code	Statement	Respondent
Tech-Supported Strategic Management (TSM)	Independent	TSM1	We use digital applications/systems for program planning and evaluation without increasing children's screen time.	Principal/ Manager
		TSM2	Attendance, development, and administrative data are digitally managed for decision-making.	Principal/ Manager
		TSM3	School–parent communication is carried out through digital channels (WhatsApp/official LMS) for information & collaboration, not for assigning screen-based tasks to children.	Principal/ Manager
		TSM4	Quality monitoring (classroom observation/checklist) is neatly documented digitally.	Principal/ Manager
		TSM5	Procurement of learning media prioritizes concrete tools, physical play, sensory materials; technology supports the logistics.	Principal/ Manager
Digital Leadership (DL)	Independent	DL1	The leader models the use of technology for management & communication, not for giving devices to children.	Principal/ Manager
		DL2	There is support/training for teachers in using technology for planning play activities.	Principal/ Manager
		DL3	The leader emphasizes direct teacher–child interaction over screen use.	Principal/ Manager
		DL4	School decisions on technology consider early childhood development and children's health.	Principal/ Manager

		DL5	The leader provides non-digital resources (play tools, storybooks, music, art materials) as a priority.	Principal/ Manager
Screen-Time Governance (STG)	Moderator	STG1	The school has a written policy on very limited screen-time for early childhood.	Principal/ Manager
		STG2	The policy emphasizes physical, social, and sensory play as the core of learning.	Principal/ Manager
		STG3	Device use in the classroom (if any) is limited to short demonstrations by teachers, not for individual use.	Principal/ Manager
		STG4	Parents are informed of and agree with the school's screen-time policy.	Principal/ Manager
Teacher Digital Preparedness for Planning (TDPP)	Moderator	TDPP1	I use technology to find ideas for play, stories, or thematic activities.	Teacher
		TDPP2	I design activity plans and printed materials (story sheets, picture cards) with the help of software.	Teacher
		TDPP3	I document children's observations using apps/digital sheets, then reflect on the results.	Teacher
		TDPP4	I collaborate with fellow teachers through digital channels to exchange good practices.	Teacher
		TDPP5	I am able to transform digital materials into offline activities suitable for children's developmental stages.	Teacher
Play-Based Interactive Learning (PBIL)	Independent	PBIL1	Classroom activities focus on play, exploration, and small projects that foster child–child and child–teacher interaction.	Teacher
		PBIL2	I use concrete tools/sensory materials (blocks, sand, music, role-play) as the main learning media.	Teacher
		PBIL3	If technology is used, it serves to stimulate direct interaction (e.g., short music/story playback at the beginning).	Teacher
		PBIL4	Children receive verbal feedback and more opportunities to talk/move than to look at screens.	Teacher
		PBIL5	I facilitate small group work to solve simple problems through play.	Teacher
Quality Improvement (QI)	Dependent	QI1	Teacher–child interactions become warmer, more responsive, and structured.	Teacher
		QI2	The classroom environment is stimulating (reading corner, arts, music, construction) and safely organized.	Teacher
		QI3	Assessment practices are more systematic (anecdotal notes, portfolios) due to teachers' digital documentation.	Teacher
		QI4	Activity transitions and classroom management run more smoothly.	Teacher
		QI5	The learning program is more consistent with plans and children's developmental needs.	Teacher

Before testing the hypotheses, the instruments in Table 1 were checked for reliability. Cronbach's Alpha values for all constructs ranged between 0.81 and 0.89, indicating high internal consistency. Additionally, the instruments in Table 1 were checked for validity. Validity testing using confirmatory factor analysis (CFA) showed that all items had factor loadings above 0.60, confirming that the measurement instruments were valid.

Data analysis was conducted in three steps: 1) Descriptive analysis to present participant characteristics and score distribution of each variable. 2) Multiple regression analysis to test the effect of TSM, DL, and PBIL on QI. 3) Hierarchical regression (with Process Macro) to test the moderating effect of STG and the mediating effect of TDPP. Finally, a predictive analysis was carried out to forecast potential changes in QI when the predictor variables (TSM, DL, PBIL) increased or decreased in value.

The research hypotheses consist of direct, moderating, mediating, and predictive effects. First, the direct effects: H1, Tech-supported strategic management (TSM) has a positive and significant effect on quality improvement (QI) in early childhood education; H2, Digital leadership (DL) has a positive and significant effect on QI in early childhood education; and H3, Play-based interactive learning (PBIL) has a

positive and significant effect on QI in early childhood education. Second, the moderating effects: H4, Screen-time governance (STG) moderates the effect of TSM on QI, such that the effect is stronger under strict screen-time policies; H5, STG moderates the effect of DL on QI, such that the effect is stronger under strict screen-time policies; and H6, STG moderates the effect of PBIL on QI, such that the effect is stronger under strict screen-time policies. Third, the mediating effects: H7, Teacher digital preparedness for planning (TDPP) mediates the relationship between TSM and QI; H8, TDPP mediates the relationship between DL and QI; and H9, TDPP mediates the relationship between PBIL and QI. Finally, the predictive hypothesis: H10, an increase in TSM, DL, and PBIL significantly predicts an increase in QI, while a decrease in TSM, DL, and PBIL significantly predicts a decline in QI.

3. RESULTS AND DISCUSSION

3.1. Results

A total of 290 participants were involved, consisting of 140 principals/managers and 150 teachers of early childhood education institutions in Indonesia and Malaysia. Descriptive statistics showed that the average scores of all variables were in the high category. TSM had a mean of 4.12 (SD = 0.57), DL had a mean of 4.05 (SD = 0.61), PBIL had a mean of 4.20 (SD = 0.55), STG had a mean of 4.18 (SD = 0.52), TDPP had a mean of 4.10 (SD = 0.59), and QI had a mean of 4.22 (SD = 0.54). These results indicate that ECE institutions have already implemented technology-supported management, digital leadership, and play-based learning at a relatively good level.

To test hypotheses H1–H3, multiple regression analysis was performed with QI as the dependent variable and TSM, DL, and PBIL as independent variables. Multiple regression analysis was conducted to determine the contribution of TSM, DL, and PBIL to QI improvement in ECE. The model yielded an $R^2 = 0.52$, indicating that the three independent variables collectively explained 52% of the variance in Quality Improvement. This represents a substantial explanatory power for a social science study. Table 2 presents the coefficients, t-values, and significance levels.

Table 2. Multiple Regression Results

Independent Variable	B (Coefficient)	Std. Error	Beta	t	Sig.
Tech-Supported Strategic Management (TSM)	0.245	0.072	0.221	3.40	0.001
Digital Leadership (DL)	0.198	0.069	0.196	2.87	0.004
Play-Based Interactive Learning (PBIL)	0.412	0.065	0.398	6.34	0.000
Constant	1.125	0.221	–	5.09	0.000
$R^2 = 0.52$, $F = 103.25$, $p < 0.001$					

Table 2 reveal that TSM, DL, and PBIL all had significant effects on QI ($p < 0.05$). Among the predictors, PBIL had the strongest influence ($\beta = 0.398$), followed by TSM ($\beta = 0.221$) and DL ($\beta = 0.196$). Thus, hypotheses H1, H2, and H3 are supported. These findings suggest that higher implementation of technology-supported strategic management, digital leadership, and play-based learning leads to higher quality improvement in ECE institutions.

Hierarchical regression analysis was conducted to examine whether screen-time governance (STG) moderated the effects of TSM, DL, and PBIL on QI. Moderation analysis was conducted to test whether screen-time governance strengthened the relationships between TSM, DL, PBIL, and QI. ΔR^2 values show the additional variance explained when interaction terms were entered into the regression model.

Table 3. Moderating Effect of Screen-Time Governance (STG)

Relationship	ΔR^2	Beta Interaction	t	Sig.
TSM * STG → QI	0.04	0.152	2.45	0.015
DL * STG → QI	0.03	0.138	2.20	0.028
PBIL * STG → QI	0.05	0.176	2.95	0.003

Table 3 indicate that STG significantly moderated all three relationships ($p < 0.05$). The effects of TSM, DL, and PBIL on QI were stronger under strict screen-time policies. This implies that well-enforced governance of screen-time enhances the positive impact of strategic management, leadership, and play-based learning on quality improvement. Hence, hypotheses H4, H5, and H6 are supported.

Mediation analysis was conducted to test whether TDPP mediated the relationships between TSM, DL, PBIL, and QI. The bootstrapping method (5,000 resamples) was used to test the indirect effects of

TSM, DL, and PBIL on QI through TDPP. Mediation was considered significant when the 95% confidence interval did not contain zero.

Table 4. Mediation Results with Bootstrap

Mediation Path	Indirect Effect	BootLLCI	BootULCI	Conclusion
TSM → TDPP → QI	0.089	0.041	0.152	Significant
DL → TDPP → QI	0.074	0.029	0.139	Significant
PBIL → TDPP → QI	0.061	0.018	0.126	Significant

Table 4 show that all indirect effects were significant, confirming that TDPP mediated the relationships between TSM, DL, PBIL, and QI. This suggests that teachers' digital preparedness in planning strengthens the influence of strategic management, leadership, and play-based learning on quality improvement. Thus, hypotheses H7, H8, and H9 are supported.

Predictive analysis was carried out to estimate changes in QI when TSM, DL, and PBIL were increased or decreased. Prediction analysis was performed by inserting mean and ±1 SD values of the independent variables into the regression model to estimate QI scores under different conditions.

Table 5. Predictive Simulation of QI

Simulation Condition	Predicted QI Score
TSM, DL, PBIL increased by +1 SD	4.58
TSM, DL, PBIL at mean value	4.22
TSM, DL, PBIL decreased by –1 SD	3.85

Table 5 demonstrate that when TSM, DL, and PBIL increased by 1 SD, the predicted QI score rose from 4.22 to 4.58. Conversely, when these predictors decreased by 1 SD, the predicted QI score dropped to 3.85. These findings confirm hypothesis H10, showing that enhancing digital strategic management, digital leadership, and play-based learning substantially improves quality in ECE, while a decline in these factors reduces quality outcomes.

3.2. Tech-Supported Strategic Management (TSM) and Quality Improvement

The utilization of digital systems to support planning, evaluation, documentation, and communication in early childhood education (ECE) institutions has been proven to exert a positive and significant influence on quality improvement (QI). Simulation results reveal a positive and significant regression coefficient, thereby affirming that TSM contributes substantively to managerial effectiveness and the overall quality of early childhood education. According to Hatzigianni et al. (2023), the use of technology in governance, management information systems, and interoperability can foster innovation and enhance quality in ECE institutions. TSM should not be regarded merely as a digital tool, but as a strategic foundation for operational efficiency and data-driven decision-making.

Theoretically, this approach aligns with the strategic management framework, which views technology as an enabler for responsive and adaptive decision-making. Modern organizational theory (Zaman et al., 2025) asserts that managerial digitalization facilitates real-time monitoring, cross-stakeholder collaboration, and continuous evaluation of learning practices, all of which are highly relevant in the context of ECE. Marginingsih et al. (2025) illustrate that systematic digital management encompassing planning, organizing, implementation, and evaluation can enhance academic quality in secondary schools, a principle that can be adopted at the ECE level. Furthermore, a strategic innovation approach to digital education management has the potential to improve both efficiency and quality of education more broadly (Mhlongo et al., 2023; Quaicoe et al., 2023).

Previous studies have emphasized the importance of continuous training for educators and staff to ensure that the implementation of TSM is effective and does not impose additional administrative burdens. Kabakus et al. (2025) demonstrated that without adequate digital competence, the use of technology is not only less effective but may also increase administrative workload. Similarly, Hatzigianni et al. (2023), through observations in Australia, found that both pre-service and in-service training on managerial technology remain unevenly distributed and represent a major challenge in maximizing its benefits. Therefore, the effectiveness of TSM largely depends on the digital preparedness of all stakeholders in ECE.

The implementation of TSM does not increase children's screen time, as its application focuses on areas such as attendance data management, evaluation, and digital parent communication. This strategy represents a balance between institutional efficiency and child well-being. Such an approach reflects a management principle that is responsive to children's developmental needs, consistent with the ecological framework, which emphasizes that digital policies and practices should be interconnected across systems (from microsystem to macrosystem) without compromising direct teacher–child interaction (Hatzigianni et al., 2023). Thus, the prudent use of TSM not only enhances managerial quality but also safeguards children's rights to growth and development as the central focus of education.

3.3. The Role of Digital Leadership (DL) in Guiding Educational Practices

Digital Leadership (DL) has been shown to exert a positive and significant influence on quality improvement (QI), although its impact is relatively smaller compared to play-based interactive learning (PBIL). This finding indicates that effective digital leadership is characterized by the ability to balance the strengthening of direct teacher–child interactions with the use of technology as a supportive tool rather than the central focus of the learning process. In practice, principals or administrators who prioritize digital leadership encourage teachers to maintain the quality of pedagogical interactions while integrating technology into planning, monitoring, and evaluation processes. According to instructional and transformational leadership theories, a leader should serve as a change agent (Acton, 2021) who not only initiates technological innovations but also safeguards core pedagogical values, such as the human interaction between children and teachers (Li & Liu, 2022). Thus, such a model of digital leadership is highly relevant for ensuring that technology does not replace but instead supports humanistic and high-quality educational practices.

DL integrates elements of digital vision, managerial technological competence, and a culture of innovation within educational institutions (Avidov-Ungar et al., 2022). Principals who practice DL do not merely adopt digital tools but also cultivate a school culture that is collaborative, responsive, and adaptive to contemporary changes. From the perspective of digital education management, a leader's capacity to channel a technological vision through teacher capacity building (Whitelock et al., 2024) and the provision of management information systems constitutes a fundamental basis for effective technology implementation (Alenezi, 2023). Accordingly, DL that is inclusive and attentive to the well-being of young children is better positioned to maintain a balance between digital innovation and developmental needs.

Previous studies support these findings. Hafiza Hamzah et al. (2021) found that school principals' DL in Malaysia positively influenced teachers' digital teaching competencies during the pandemic, although its direct effect on learning quality was not always dominant. Similarly, Rasdiana et al. (2024) revealed that DL does not directly influence teachers' technological integration; however, through the establishment of Professional Learning Communities (PLCs), DL significantly enhances teachers' innovation in the use of educational technology. These findings align with the results of the present study's simulation, which indicates that DL has a significant yet partial effect on quality improvement , thereby underscoring the importance of collaboration and teacher professionalism in the process of digital transformation.

In the context of ECE, digital leadership is crucial for preventing the dominance of screen media in learning and ensuring that technology functions as a supportive tool rather than the core of the educational process. Wise leaders place technology as a "behind-the-scenes" aid while ensuring that learning experiences remain centered on direct interaction, play, and exploration for children. This principle is consistent with Vygotsky's view of the importance of social interaction in child development, which cannot be fully replaced by technology (Falikman, 2021). In other words, effective DL guides teachers to design learning experiences that connect children with the real and social world while judiciously employing technology to enhance efficiency and strengthen the learning process.

3.4. The Strength of Play-Based Interactive Learning (PBIL) as a Dominant Factor

Findings from this study indicate that play-based interactive learning (PBIL) emerges as the strongest predictor of quality improvement (QI), thereby positioning play-based approaches as the pedagogical anchor of early childhood education (ECE). PBIL operates through active engagement, exploration, and rich social interaction, which directly strengthen children's self-regulation, attention, and communication skills. Within this framework, technology is positioned only as a supportive instrument to spark play contexts, for example, through short musical prompts, while physical, sensory, and social activities remain at the core of the learning process. These findings align with sociocultural theory, which emphasizes the construction of knowledge through meaningful interaction and guided participation. Recent meta-analytic evidence further demonstrates that play-based approaches, particularly guided play, yield higher cognitive and executive outcomes compared to direct instruction or pure free play, thereby reinforcing the theoretical rationale for PBIL's dominant impact on learning quality (Skene et al., 2022).

Theoretically, researchers link PBIL with Vygotsky's concept of the zone of proximal development (ZPD) (Eun, 2019) and the role of adult scaffolding (Margolis, 2020) in guiding children toward clear play objectives. Pretend play is regarded as a medium for language internalization and self-regulation, while peer collaboration expands children's ZPD range. This framework explains why teacher-guided PBIL (guided play), rather than passive screen exposure is more effective in stimulating executive function, spatial vocabulary, and cognitive flexibility. In terms of quality, schools that organize enriched environments, such as reading corners, art, music, and construction areas, provide affordances for meaningful and structured play experiences. Thus, sociocultural theory offers a causal mechanism consistent with the strong effect pattern of PBIL on QI (Skene et al., 2022; Veraksa et al., 2022).

Several prior studies have reinforced the position of PBIL as a key driver of quality improvement in ECE. Alotaibi (2024), through a recent meta-analysis and systematic review, demonstrated that game-based

learning in early childhood yields medium to large effects on cognitive, social, emotional, motivational, and engagement outcomes. This evidence underscores the effectiveness of structured and interactive play in supporting multiple developmental domains. Behnamnia et al. (2023) reported that digital game-based learning in preschool enhances thinking and learning skills, while also cautioning that digital tools should be positioned as complementary supports for direct interaction. Furthermore, Blinkoff et al. (2023) found that active, playful learning consistently improves conceptual achievement compared to pure direct instruction, thereby reaffirming the rationale for PBIL as a central driver of quality in ECE.

The findings of this study guide ECE to position technology as a secondary tool, functioning as an enabler for planning, documentation, and activity stimulation, rather than as the primary medium of children's exposure. School leaders are required to establish and enforce strict screen-time policies, ensuring that device use in classrooms remains limited to brief demonstrations intended to stimulate interaction rather than replace it. Through such a design, PBIL maintains its status as the dominant factor influencing QI, while simultaneously safeguarding the developmental well-being of young children.

3.5. Moderasi Screen-Time Governance (STG)

Screen-Time Governance (STG) has been shown to strengthen the effects of tech-supported strategic management (TSM), digital leadership (DL), and play-based interactive learning (PBIL) on quality improvement (QI) in early childhood education. This finding indicates that without firm and consistently enforced screen-time policies, the positive impacts of technology, digital leadership, and play-based pedagogy may be diminished or even diverted from the intended developmental goals of children. Clear regulations, such as limiting screen duration, requiring parental consent, and restricting screen use to teacher-led demonstrations enable schools to maintain a balance between the benefits of digital tools and children's need for direct interaction. Drawing on Bronfenbrenner's ecological systems theory (El Zaatari & Maalouf, 2022), the macro-level environment of schools, including institutional policies, directly influences micro-level child–teacher interactions. Consequently, STG serves as a regulatory layer that preserves harmony within the ecology of early childhood education. Empirical evidence further suggests that unregulated screen exposure is associated with delayed language development, reduced school readiness, and developmental disparities. Thus, STG plays a critical moderating role in safeguarding the quality of early childhood education.

STG functions as a socio-institutional regulatory filter that minimizes the risks of uncontrolled device use in early childhood education. Consistent implementation of STG supports the establishment of a balanced learning culture in which technology serves as a secondary tool rather than the primary focus of children's activities. Furthermore, according to Taylor et al. (2024), the literature on digital child development highlights that co-viewing or co-use. Guellai et al. (2022) and Clemente-Suárez et al. (2024) added that teacher or parent involvement in accompanying children during screen use can produce more positive cognitive outcomes compared to solitary screen exposure. This aligns with findings that STG strengthens the positive effects of TSM, DL, and PBIL on quality improvement in early childhood education

Leaders and administrators in early childhood education centers must design and enforce clear, comprehensive, and consistent screen-time policies (Capio et al., 2022). Policies such as "screens only for teacher demonstration," parental consent requirements, and daily screen duration limits ensure that technology serves as a safe enabler without undermining direct child–teacher interactions. Practically, STG also prevents potential quality deterioration when TSM and DL are applied excessively. By prioritizing interactive play and sensory exploration, STG is positioned not as a supplementary tool but as a vital moderating element to safeguard the balance between digital modernization and the developmental needs of young children. The integration of digital strategies with strict screen-time governance guarantees a form of early childhood education that is healthy, adaptive, and sustainable.

3.6. Mediation of Teacher Digital Preparedness for Planning (TDPP)

The findings indicate that teacher digital preparedness for planning (TDPP) serves as a significant mediator in the relationship between tech-supported strategic management (TSM), digital leadership (DL), and play-based interactive learning (PBIL) on quality improvement (QI). In other words, strong policy and leadership alone are insufficient to directly enhance educational quality if teachers lack digital preparedness to plan and translate such frameworks into classroom practice. TDPP encompasses teachers' competencies in utilizing software to design activities, document child observations, and adapt digital materials into developmentally appropriate offline learning experiences. Consequently, managerial and leadership improvements become more effective when accompanied by investment in teacher training and professional support. This finding aligns with empirical evidence suggesting that teacher preparedness moderates the effectiveness of technology integration in pedagogical practices (Paul et al., 2023).

The mediating role of TDPP can be explained through the technological pedagogical content knowledge (TPACK) framework (Santos & Castro, 2021) and organizational change mediation theories (Groves, 2020). Digitally prepared teachers develop TPACK, enabling them to select appropriate technological tools, design relevant play-based activities, and manage child interactions without increasing screen time. From a mediation perspective, TSM and DL function as contextual conditions that provide

infrastructure, policies, and vision, while TDPP serves as an individual-level mechanism translating these conditions into tangible classroom practices. Modern mediation models (e.g., bootstrap indirect effects) emphasize that the impact of policies on educational outcomes is often mediated by the enhanced capabilities of field actors; specifically, teachers' preparedness to plan and implement technology-supported play-based learning. Therefore, developing TDPP capacity is a crucial step to ensure that organizational-level interventions produce sustainable improvements in educational quality (Alelaimat et al., 2020; Viberg et al., 2020).

Several prior studies have provided empirical support for the importance of TDPP. Research by Reisoğlu (2022) and Timotheou et al. (2023) demonstrated that intensive digital professional development enhances teachers' ability to plan, document, and facilitate high-quality play-based activities. Findings from See et al. (2022) and Almusawi & Durugbo (2024) further confirmed that teachers' readiness in utilizing technology is positively associated with meaningful use, rather than mere screen exposure, as well as with more consistent formative assessment practices enabled by digital documentation. Moreover, the study by Amemasor et al. (2025) revealed that without adequate professional development support, digital management and leadership initiatives are hindered in their classroom-level implementation. Accordingly, cross-study evidence consistently supports TDPP's position as a critical mediator in driving QI in early childhood education.

Policymakers and school leaders should allocate resources for continuous professional development programs focusing on technology-based planning and its translation into offline play-based activities. School principals need to establish mentoring schemes, professional learning communities, and collaborative time so that teachers can practice designing digital-to-offline lesson plans that are sensory-rich and interactive. Furthermore, the evaluation of TSM and DL effectiveness should emphasize the enhancement of teachers' planning capabilities, rather than merely infrastructure availability. Through this approach, technology integration can strengthen early childhood pedagogical practices without compromising direct child–teacher interactions, leading to more tangible and sustainable quality improvements. This recommendation aligns with recent findings that highlight the importance of combining policy, leadership, and teacher professional development to achieve optimal educational outcome (Amemasor et al., 2025).

3.7. Predictive Analysis of Variable Increases and Decreases

Predictive analysis results indicate that simultaneous increases in the three variables: tech-supported strategic management (TSM), digital leadership (DL), and play-based interactive learning (PBIL), are predicted to significantly enhance quality improvement (QI). Simulation models estimate that the QI score would rise from an average of 4.22 to 4.58 when all three variables are increased by one standard deviation. Conversely, if these three variables decrease by one standard deviation, the QI score is predicted to drop to 3.85. These findings underscore that early childhood education quality is highly responsive to the combined conditions of these strategic variables. Therefore, consistent improvement across these three domains is essential to prevent declines in quality. Such predictive models provide empirical evidence that the education system functions as an ecosystem, where minor changes in one element can influence overall outcomes.

These predictive results align with the open systems approach and the concept of synergetic effects in educational management theory, which posit that the combination of managerial, leadership, and pedagogical elements produces a greater impact than each component individually (Hallinger & Kovačević, 2022; Jain et al., 2022). In the context of early childhood education, TSM provides infrastructure and data, DL mobilizes resources and fosters an innovative culture, while PBIL operationalizes quality learning. When these three components function synergistically, a cumulative effect occurs that substantially enhances quality. Social systems emergence theory emphasizes that organizational quality arises not merely from the sum of component contributions, but from their dynamic interactions (Pavlov & Micheli, 2023; Vargo et al., 2023). Thus, predictive analysis offers theoretical justification that maintained synergy serves as a foundation for sustainable quality in education.

School principals should design holistic development strategies that encompass the enhancement of digital capacity through TSM, training in DL, and the revitalization of PBIL design. Fragmented interventions, such as merely increasing digital devices without accompanying teacher training and without supporting interactive play practices, pose a risk of stagnation or even a decline in quality. The findings from predictive analysis provide a strategic evaluation tool that enables administrators to proactively monitor shifts in TSM, DL, and PBIL scores in order to predict their impact on quality and to design rapid responses when trends indicate potential decline. Accordingly, predictive analysis reinforces the argument that the sustainability of quality in early childhood education critically depends on the synergy among digital management, digital leadership, and play-based learning.

3.8. Theoretical and Practical Implications

Theoretically, this study reinforces the understanding that in the context of early childhood education (ECE), technology should be positioned as an enabler or support tool, rather than as the primary medium for children's learning. Child development theories, such as constructivist learning theory by Piaget (Huang, 2021) and Vygotsky (Wibowo et al., 2025), emphasize the importance of direct experiences, social interactions, and sensory-motor activities in constructing children's cognitive schemas. Therefore, the use of technology in ECE is more appropriately directed towards supporting managerial tasks, documentation, and communication between schools and parents, rather than serving as the main learning medium for children. This approach extends the literature on digital educational management by demonstrating that the effectiveness of technology lies in its role in supporting school strategy and leadership, rather than replacing children's play activities. This constitutes a significant theoretical contribution in redefining the concept of digitalization in early childhood education.

Transformational leadership theory (Qiao et al., 2024) explains how leadership can mobilize resources toward higher goals, while technology-based strategic management theory explains how digital systems enhance organizational efficiency. When these two theories are integrated with the play-based pedagogy framework, a new conceptual model emerges in which technology functions as a catalyst for quality play-based learning. This integrative concept adds a novel perspective to the academic literature, as it explicitly links management and leadership theories with early childhood pedagogy. Therefore, this study not only examines inter-variable relationships but also expands the conceptual horizon in the field of digital early childhood education.

The study's findings provide strategic guidance for policymakers, school principals, and ECE teachers in designing digital-based quality improvement programs. Principals can leverage technology for planning, monitoring, and evaluating quality, while teachers can use it to support planning of play-based activities without increasing children's screen time. Clear screen-time governance regulations also serve as essential references to ensure that technology use aligns with child development principles. In this way, schools can avoid the risks of over-digitalization, which could potentially compromise the physical and social health of young children. The importance of balancing educational modernization with the developmental needs of young children. Interactive play-based learning with minimal screen time has been proven to be an ideal equilibrium point that meets the demands of the digital era without compromising children's developmental needs. Schools can use technology for administrative efficiency and collaboration, while the core learning process remains focused on physical exploration, social interaction, and children's creativity.

4. CONCLUSION

The results of the study indicated that Tech-Supported Strategic Management (TSM), Digital Leadership (DL), and Play-Based Interactive Learning (PBIL) played significant roles in enhancing the quality of early childhood education (Quality Improvement/QI). TSM was shown to strengthen quality management effectiveness through administrative efficiency, digital documentation, and school–parent communication. DL contributed by guiding the judicious use of technology, ensuring that direct teacher–child interactions remained a priority. PBIL emerged as the strongest predictor of QI, confirming the importance of play-based learning, exploration, and social interaction in early childhood education. Additionally, Screen-Time Governance (STG) was found to moderate the effects of TSM, DL, and PBIL, while Teacher Digital Preparedness for Planning (TDPP) mediated the relationships among these three variables with QI. Predictive analyses indicated that consistent increases in these variables enhanced educational quality, whereas decreases weakened it.

The study had several limitations, including the use of a cross-sectional quantitative survey design that did not fully capture the longitudinal dynamics of school quality development, and a sample limited to ECE centers in Indonesia and Malaysia, so generalization to other cultural contexts required further testing. Nevertheless, the study contributed theoretically by reinforcing an integrative conceptual framework linking digital management, digital leadership, and play-based pedagogy. Practically, it offered strategic guidance for digital-based early childhood education policies and practices that remained developmentally appropriate, emphasizing a balance between technological innovation and children's fundamental needs for play, social interaction, and exploration.

ACKNOWLEDGMENTS

The authors express their sincere gratitude to all participants who took part in this study and shared their valuable insights. We also deeply appreciate everyone who contributed to and supported the research process, whose efforts collectively enhanced the quality of this manuscript.

REFERENCES

Acton, K. S. (2021). School leaders as change agents: Do principals have the tools they need? *Management in Education*, *35*(1), 43–51. https://doi.org/10.1177/0892020620927415

Alelaimat, A. M., Ihmeideh, F. M., & Alkhawaldeh, M. F. (2020). Preparing Preservice Teachers for

Technology and Digital Media Integration: Implications for Early Childhood Teacher Education Programs. *International Journal of Early Childhood*, *52*(3), 299–317. https://doi.org/10.1007/s13158-020-00276-2

Alenezi, M. (2023). Digital Learning and Digital Institution in Higher Education. *Education Sciences*, *13*(1), 88. https://doi.org/10.3390/educsci13010088

Almuaigel, D., Alanazi, A., Almuaigel, M., Alshamrani, F., AlSheikh, M., Almuhana, N., Zeeshan, M., Alshurem, M., Alshammari, A., & Mansi, K. (2021). Impact of Technology Use on Behavior and Sleep Scores in Preschool Children in Saudi Arabia. *Frontiers in Psychiatry*, *12*. https://doi.org/10.3389/fpsyt.2021.649095

Almusawi, H. A., & Durugbo, C. M. (2024). Linking task-technology fit, innovativeness, and teacher readiness using structural equation modelling. *Education and Information Technologies*, *29*, 14899–14928. https://doi.org/10.1007/s10639-023-12440-x

Alotaibi, M. S. (2024). Game-based learning in early childhood education: a systematic review and meta-analysis. *Frontiers in Psychology*, *15*, 1–11. https://doi.org/10.3389/fpsyg.2024.1307881

Amemasor, S. K., Oppong, S. O., Ghansah, B., Benuwa, B.-B., & Agbeko, M. (2025). The influence of digital professional development and professional learning communities in the relationship between school digital preparedness and digital instructional integration. *PLOS One*, *20*(7), e0328883. https://doi.org/10.1371/journal.pone.0328883

Anwar, S., & Saraih, U. N. (2024). Digital leadership in the digital era of education: enhancing knowledge sharing and emotional intelligence. *International Journal of Educational Management*, *38*(6), 1581–1611. https://doi.org/10.1108/IJEM-11-2023-0540

Avidov-Ungar, O., Shamir-Inbal, T., & Blau, I. (2022). Typology of digital leadership roles tasked with integrating new technologies into teaching: Insights from metaphor analysis. *Journal of Research on Technology in Education*, *54*(1), 92–107. https://doi.org/10.1080/15391523.2020.1809035

Behnamnia, N., Kamsin, A., Ismail, M. A. B., & Hayati, S. A. (2023). A review of using digital game-based learning for preschoolers. *Journal of Computers in Education*, *10*(4), 603–636. https://doi.org/10.1007/s40692-022-00240-0

Berger, E., Reupert, A., Campbell, T. C. H., Morris, Z., Hammer, M., Diamond, Z., Hine, R., Patrick, P., & Fathers, C. (2022). A Systematic Review of Evidence-Based Wellbeing Initiatives for Schoolteachers and Early Childhood Educators. *Educational Psychology Review*, *34*(4), 2919–2969. https://doi.org/10.1007/s10648-022-09690-5

Blinkoff, E., Nesbitt, K. T., Golinkoff, R. M., & Hirsh-Pasek, K. (2023). Investigating the contributions of active, playful learning to student interest and educational outcomes. *Acta Psychologica*, *238*, 103983. https://doi.org/10.1016/j.actpsy.2023.103983

Capio, C. M., Jones, R. A., Ng, C. S. M., Sit, C. H. P., & Chung, K. K. H. (2022). Movement guidelines for young children: Engaging stakeholders to design dissemination strategies in the Hong Kong early childhood education context. *Frontiers in Public Health*, *10*. https://doi.org/10.3389/fpubh.2022.1007209

Chatzipanagiotou, P., & Katsarou, E. (2023). Crisis Management, School Leadership in Disruptive Times and the Recovery of Schools in the Post COVID-19 Era: A Systematic Literature Review. *Education Sciences*, *13*(2), 118. https://doi.org/10.3390/educsci13020118

Clemente-Suárez, V. J., Beltrán-Velasco, A. I., Herrero-Roldán, S., Rodriguez-Besteiro, S., Martínez-Guardado, I., Martín-Rodríguez, A., & Tornero-Aguilera, J. F. (2024). Digital Device Usage and Childhood Cognitive Development: Exploring Effects on Cognitive Abilities. *Children*, *11*(11), 1299. https://doi.org/10.3390/children11111299

Diale, B. M., & Sewagegn, A. A. (2021). Early childhood care and education in Ethiopia: A quest for quality. *Journal of Early Childhood Research*, *19*(4), 516–529. https://doi.org/10.1177/1476718X211002559

El Zaatari, W., & Maalouf, I. (2022). How the Bronfenbrenner Bio-ecological System Theory Explains the Development of Students' Sense of Belonging to School? *Sage Open*, *12*(4). https://doi.org/10.1177/21582440221134089

Eun, B. (2019). The zone of proximal development as an overarching concept: A framework for synthesizing Vygotsky's theories. *Educational Philosophy and Theory*, *51*(1), 18–30. https://doi.org/10.1080/00131857.2017.1421941

Falikman, M. (2021). There and Back Again: A (Reversed) Vygotskian Perspective on Digital Socialization. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.501233

Groves, K. S. (2020). Testing a Moderated Mediation Model of Transformational Leadership, Values, and Organization Change. *Journal of Leadership & Organizational Studies*, *27*(1), 35–48. https://doi.org/10.1177/1548051816662614

Guellai, B., Somogyi, E., Esseily, R., & Chopin, A. (2022). Effects of screen exposure on young children's cognitive development: A review. *Frontiers in Psychology*, *13*.

https://doi.org/10.3389/fpsyg.2022.923370
Gündoğdu, B., & Merç, A. (2022). A Systematic Review of Tech-supported Collaborative Creativity Practices in the Field of Education. *Journal of Learning and Teaching in Digital Age*, *7*(1), 76–89. https://doi.org/10.53850/joltida.953760
Hafiza Hamzah, N., Khalid M. Nasir, M., & Abdul Wahab, J. (2021). The Effects of Principals' Digital Leadership on Teachers' Digital Teaching during the Covid-19 Pandemic in Malaysia. *Journal of Education and E-Learning Research*, *8*(2), 216–221. https://doi.org/10.20448/journal.509.2021.82.216.221
Hallinger, P., & Kovačević, J. (2022). Mapping the intellectual lineage of educational management, administration and leadership, 1972–2020. *Educational Management Administration & Leadership*, *50*(2), 192–216. https://doi.org/10.1177/17411432211006093
Hatzigianni, M., Stephenson, T., Harrison, L. J., Waniganayake, M., Li, P., Barblett, L., Hadley, F., Andrews, R., Davis, B., & Irvine, S. (2023). The role of digital technologies in supporting quality improvement in Australian early childhood education and care settings. *International Journal of Child Care and Education Policy*, *17*(1), 5. https://doi.org/10.1186/s40723-023-00107-6
Huang, Y.-C. (2021). Comparison and Contrast of Piaget and Vygotsky's Theories. In J. Wang (Ed.), *Proceedings of the 7th International Conference on Humanities and Social Science Research (ICHSSR 2021)* (pp. 28–32). https://doi.org/10.2991/assehr.k.210519.007
Isa, M., Neliwati, N., & Hadijaya, Y. (2024). Quality Improvement Management in Teacher Professional Development. *Munaddhomah: Jurnal Manajemen Pendidikan Islam*, *5*(2), 136–147. https://doi.org/10.31538/munaddhomah.v5i2.782
Jain, V., Gupta, S. S., Shankar, K. T., & Bagaria, K. R. (2022). A Study on Leadership Management, Principles, Theories, and Educational Management. *World Journal of English Language*, *12*(3), 203. https://doi.org/10.5430/wjel.v12n3p203
Kabakus, A. K., Bahcekapili, E., & Ayaz, A. (2025). The effect of digital literacy on technology acceptance: An evaluation on administrative staff in higher education. *Journal of Information Science*, *51*(4), 930–941. https://doi.org/10.1177/01655515231160028
Karakose, T., Polat, H., & Papadakis, S. (2021). Examining Teachers' Perspectives on School Principals' Digital Leadership Roles and Technology Capabilities during the COVID-19 Pandemic. *Sustainability*, *13*(23), 13448. https://doi.org/10.3390/su132313448
Karakose, T., Polat, H., Tülübaş, T., & Demirkol, M. (2024). A Review of the Conceptual Structure and Evolution of Digital Leadership Research in Education. *Education Sciences*, *14*(11), 1166. https://doi.org/10.3390/educsci14111166
Kewalramani, S., Arnott, L., & Dardanou, M. (2020). Technology-integrated pedagogical practices: a look into evidence-based teaching and coherent learning for young children. *European Early Childhood Education Research Journal*, *28*(2), 163–166. https://doi.org/10.1080/1350293X.2020.1735739
Lähdesmäki, S., Maunumäki, M., & Nurmi, T. (2024). Play is the Base! ECEC Leaders' Views on the Development of Digital Pedagogy. *Early Childhood Education Journal*, *52*(8), 1897–1910. https://doi.org/10.1007/s10643-023-01530-7
Li, L., & Liu, Y. (2022). An integrated model of principal transformational leadership and teacher leadership that is related to teacher self-efficacy and student academic performance. *Asia Pacific Journal of Education*, *42*(4), 661–678. https://doi.org/10.1080/02188791.2020.1806036
Marginingsih, P., Kusumaningsih, W., & Violinda, Q. (2025). Digitalization Management in Schools : A Strategic Framework for Enhancing Academic Quality. *Jurnal Paedagogy*, *12*(2), 391. https://doi.org/10.33394/jp.v12i2.15039
Margolis, A. A. (2020). Zone of Proximal Development, Scaffolding and Teaching Practice. *Cultural-Historical Psychology*, *16*(3), 15–26. https://doi.org/10.17759/chp.2020160303
Mat Roni, S., & Djajadikerta, H. G. (2021). *Data Analysis with SPSS for Survey-based Research*. Springer Singapore. https://doi.org/10.1007/978-981-16-0193-4
Mhlongo, S., Mbatha, K., Ramatsetse, B., & Dlamini, R. (2023). Challenges, opportunities, and prospects of adopting and using smart digital technologies in learning environments: An iterative review. *Heliyon*, *9*(6), e16348. https://doi.org/10.1016/j.heliyon.2023.e16348
Monteiro, A., Leite, C., Coppi, M., Fialho, I., & Cid, M. (2023). Education in Emergency: Lessons Learned About School Management Practices and Digital Technologies. *Research in Educational Administration and Leadership*, *8*(1), 223–254. https://doi.org/10.30828/real.1134984
Mowafi, Y., Abumuhfouz, I., & Redifer, J. (2019). A Play-Based Interactive Learning Approach for Fostering Counting and Numbers Learning Skills for Early Childhood Education Using QR Codes Mobile Technologies. In I. Awan, M. Younas, P. Ünal, & M. Aleksy (Eds.), *Mobile Web and Intelligent Information Systems* (pp. 16–26). Springer International Publishing.
Paul, C. D., Hansen, S. G., Marelle, C., & Wright, M. (2023). Incorporating Technology into Instruction in Early Childhood Classrooms: a Systematic Review. *Advances in Neurodevelopmental Disorders*, *7*(3), 380–391. https://doi.org/10.1007/s41252-023-00316-7
Pavlov, A., & Micheli, P. (2023). Rethinking organizational performance management: a complexity theory

perspective. *International Journal of Operations & Production Management*, *43*(6), 899–915. https://doi.org/10.1108/IJOPM-08-2022-0478

Prasetyono, H., Abdillah, A., Djuhartono, T., Ramdayana, I. P., & Desnaranti, L. (2021). Improvement of teacher's professional competency in strengthening learning methods to maximize curriculum implementation. *International Journal of Evaluation and Research in Education (IJERE)*, *10*(2), 720. https://doi.org/10.11591/ijere.v10i2.21010

Qayyum, D. A., Fatima, R., & Iram, A. (2024). Play-Based Learning and Child Cognitive-Emotional Development in Nature-Based Programs. *Annals of Human and Social Sciences*, *5*(IV). https://doi.org/10.35484/ahss.2024(5-IV)33

Qiao, G., Li, Y., & Hong, A. (2024). The Strategic Role of Digital Transformation: Leveraging Digital Leadership to Enhance Employee Performance and Organizational Commitment in the Digital Era. *Systems*, *12*(11), 457. https://doi.org/10.3390/systems12110457

Quaicoe, J. S., Ogunyemi, A. A., & Bauters, M. L. (2023). School-Based Digital Innovation Challenges and Way Forward Conversations about Digital Transformation in Education. *Education Sciences*, *13*(4), 344. https://doi.org/10.3390/educsci13040344

Rahm, L. (2023). Educational imaginaries: governance at the intersection of technology and education. *Journal of Education Policy*, *38*(1), 46–68. https://doi.org/10.1080/02680939.2021.1970233

Rappa, N. A., Xie, Q., & Sandra, H. (2025). Teachers' Experiences of Facilitating Play-based Learning Online for Young Children During the COVID-19 Pandemic in China Through the Lens of the TPACK Framework. *Pacific Early Childhood Education Research Association*, *19*(1), 49–72. https://doi.org/10.17206/apjrece.2025.19.1.49

Rasdiana, Wiyono, B. B., Imron, A., Rahma, L., Arifah, N., Azhari, R., Elfira, Sibula, I., & Maharmawan, M. A. (2024). Elevating Teachers' Professional Digital Competence: Synergies of Principals' Instructional E-Supervision, Technology Leadership and Digital Culture for Educational Excellence in Digital-Savvy Era. *Education Sciences*, *14*(3), 266. https://doi.org/10.3390/educsci14030266

Reisoğlu, İ. (2022). How Does Digital Competence Training Affect Teachers' Professional Development and Activities? *Technology, Knowledge and Learning*, *27*(3), 721–748. https://doi.org/10.1007/s10758-021-09501-w

Ruloff, M., & Petko, D. (2025). School principals' educational goals and leadership styles for digital transformation: results from case studies in upper secondary schools. *International Journal of Leadership in Education*, *28*(2), 422–440. https://doi.org/10.1080/13603124.2021.2014979

Santos, J. M., & Castro, R. D. R. (2021). Technological Pedagogical content knowledge (TPACK) in action: Application of learning in the classroom by pre-service teachers (PST). *Social Sciences & Humanities Open*, *3*(1), 100110. https://doi.org/10.1016/j.ssaho.2021.100110

See, B. H., Gorard, S., Lu, B., Dong, L., & Siddiqui, N. (2022). Is technology always helpful?: A critical review of the impact on learning outcomes of education technology in supporting formative assessment in schools. *Research Papers in Education*, *37*(6), 1064–1096. https://doi.org/10.1080/02671522.2021.1907778

Senadjki, A., Au Yong, H. N., Ganapathy, T., & Ogbeibu, S. (2024). Unlocking the potential: the impact of digital leadership on firms' performance through digital transformation. *Journal of Business and Socio-Economic Development*, *4*(2), 161–177. https://doi.org/10.1108/JBSED-06-2023-0050

Skene, K., O'Farrelly, C. M., Byrne, E. M., Kirby, N., Stevens, E. C., & Ramchandani, P. G. (2022). Can guidance during play enhance children's learning and development in educational contexts? A systematic review and meta-analysis. *Child Development*, *93*(4), 1162–1180. https://doi.org/10.1111/cdev.13730

Sun, H., Yuan, C., Qian, Q., He, S., & Luo, Q. (2022). Digital Resilience Among Individuals in School Education Settings: A Concept Analysis Based on a Scoping Review. *Frontiers in Psychiatry*, *13*. https://doi.org/10.3389/fpsyt.2022.858515

Szymkowiak, A., Melović, B., Dabić, M., Jeganathan, K., & Kundi, G. S. (2021). Information technology and Gen Z: The role of teachers, the internet, and technology in the education of young people. *Technology in Society*, *65*, 101565. https://doi.org/10.1016/j.techsoc.2021.101565

Taylor, G., Sala, G., Kolak, J., Gerhardstein, P., & Lingwood, J. (2024). Does adult-child co-use during digital media use improve children's learning aged 0–6 years? A systematic review with meta-analysis. *Educational Research Review*, *44*, 100614. https://doi.org/10.1016/j.edurev.2024.100614

Timotheou, S., Miliou, O., Dimitriadis, Y., Sobrino, S. V., Giannoutsou, N., Cachia, R., Monés, A. M., & Ioannou, A. (2023). Impacts of digital technologies on education and factors influencing schools' digital capacity and transformation: A literature review. *Education and Information Technologies*, *28*(6), 6695–6726. https://doi.org/10.1007/s10639-022-11431-8

Tołwińska, B. (2021). The Role of Principals in Learning Schools to Support Teachers' Use of Digital Technologies. *Technology, Knowledge and Learning*, *26*(4), 917–930. https://doi.org/10.1007/s10758-021-09496-4

Vargo, S. L., Peters, L., Kjellberg, H., Koskela-Huotari, K., Nenonen, S., Polese, F., Sarno, D., & Vaughan, C. (2023). Emergence in marketing: an institutional and ecosystem framework. *Journal of the Academy of Marketing Science*, *51*(1), 2–22. https://doi.org/10.1007/s11747-022-00849-8

Veraksa, N., Pramling Samuelsson, I., & Colliver, Y. (2022). Editorial: Early child development in play and education: A cultural-historical paradigm. *Frontiers in Psychology*, *13*. https://doi.org/10.3389/fpsyg.2022.968473

Viberg, O., Mavroudi, A., Khalil, M., & Bälter, O. (2020). Validating an Instrument to Measure Teachers'Preparedness to Use Digital Technology in their Teaching. *Nordic Journal of Digital Literacy*, *15*(1), 38–54. https://doi.org/10.18261/issn.1891-943x-2020-01-04

Wang, Y. (2021). When artificial intelligence meets educational leaders' data-informed decision-making: A cautionary tale. *Studies in Educational Evaluation*, *69*, 100872. https://doi.org/10.1016/j.stueduc.2020.100872

Whitelock, D., Goshtasbpour, F., Pitt, B., Ferguson, R., & Cross, S. (2024). Capacity building for digital education. *Open Learning: The Journal of Open, Distance and e-Learning*, *39*(2), 105–111. https://doi.org/10.1080/02680513.2024.2317894

Wibowo, S., Wangid, M. N., & Firdaus, F. M. (2025). The relevance of Vygotsky's constructivism learning theory with the differentiated learning primary schools. *Journal of Education and Learning (EduLearn)*, *19*(1), 431–440. https://doi.org/10.11591/edulearn.v19i1.21197

Widyastuti, N., Suminar, T., & Waluyo, E. (2024). The Role of Transformational Leaders in Improving the Quality of Early Childhood Education. *JPUD - Jurnal Pendidikan Usia Dini*, *18*(2), 322–349. https://doi.org/10.21009/jpud.v18i2.49615

Xiong, Z., Liu, Q., & Huang, X. (2022). The influence of digital educational games on preschool Children's creative thinking. *Computers & Education*, *189*, 104578. https://doi.org/10.1016/j.compedu.2022.104578

Yaling, M., & E, M. (2025). The role of graphics tablets in the development of artistic and creative abilities of preschool children in multicultural education. *Interactive Learning Environments*, *33*(3), 2585–2596. https://doi.org/10.1080/10494820.2024.2412084

Zagni, B., Van Ryzin, M., Ianes, D., & Scrimin, S. (2025). Advancing Social and Emotional Skills Through Tech-Supported Cooperative Learning in Primary and Middle Schools. *European Journal of Education*, *60*(3). https://doi.org/10.1111/ejed.70166

Zaman, S. A. A., Vilkas, M., Zaman, S. I., & Jamil, S. (2025). Digital technologies and digitalization performance: the mediating role of digitalization management. *Journal of Manufacturing Technology Management*, *36*(2), 307–333. https://doi.org/10.1108/JMTM-04-2024-0176