

Digital Technology Integration in Public Secondary Schools Towards Developing a Lead-ICT Framework

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Index Terms:

digital-age instructional leadership, ICT integration, TPACK, SAMR model

Abstract. This study examined digital-age instructional leadership and its relationship with technology integration in public secondary schools. Specifically, it assessed leadership practices in terms of visionary leadership, digital resource management, professional learning, technology-supported supervision, and ICT policy implementation. It also determined teachers' level of technology integration using the Technological Pedagogical Content Knowledge (TPACK) framework and the Substitution, Augmentation, Modification, and Redefinition (SAMR) model. In addition, the study identified challenges encountered by teachers and analyzed differences between digital natives and digital immigrants in selected domains. A quantitative-descriptive and correlational research design was employed. Data were collected from teacher-respondents through a validated survey questionnaire. Statistical tools, including mean, standard deviation, regression analysis, and t-test, were used to analyze the data. Findings revealed that school leaders demonstrated a high level of digital-age instructional leadership, while teachers exhibited a very high level of technology integration, particularly in pedagogical practices. However, technology use was more evident at enhancement levels (substitution and augmentation) rather than at transformative levels (modification and redefinition). Teachers reported moderate to high levels of challenges, with student-related factors and limited access to resources emerging as the most significant barriers. Significant differences were found between digital natives and digital immigrants in selected areas of technology integration. Moreover, results indicated a statistically significant relationship between digital-age instructional leadership and teachers' level of technology integration. The study concluded that strengthening student readiness and improving resource availability are essential for achieving transformative ICT integration. A Digital-Age Instructional Leadership for ICT Integration framework was proposed to support improved teaching practices and enhanced student learning outcomes.

Introduction

The rapid evolution of digital technologies over the last two decades has significantly transformed the landscape of education worldwide. With the advent of the Fifth Industrial Revolution, schools were challenged to respond to shifting learning needs, technological demands, and evolving pedagogical expectations. In public secondary schools, the role of instructional leaders has become more complex, requiring them not only to oversee curriculum implementation but also to guide teachers in navigating technology-integrated learning environments. School leaders, particularly principals, play a pivotal role in shaping the vision, culture, and professional development necessary for successful technology integration in public secondary schools (Thannimalai & Raman, 2018; Schmitz et al., 2023; Omar & Ismail, 2020).

Despite increasing access to digital tools, many schools continued to struggle with effective, equitable, and purposeful technology integration. This research was grounded on the need to understand how digital-age instructional leadership can

meaningfully enhance teaching practices in public secondary schools, especially within contexts where resource limitations, digital divides, and professional readiness present persistent challenges.

In the Philippines, the Department of Education (DepEd) continuously pushed for technology-driven reforms such as the DepEd Computerization Program (DCP), Learning Management Systems (LMS), ICT literacy programs, and digital resources under the Basic Education Learning Continuity Plan. Yet, the success of these initiatives largely depends on the capacity of school leaders to sustain them. Instructional leaders serve as catalysts for change— setting visions, enabling teacher development, mobilizing resources, and fostering a culture that embraces innovation. Without strong digital-age leadership, technology in schools are on the risks of becoming underutilized, misaligned with pedagogical goals, or implemented in ways that reinforce, rather than reduce, educational inequities.

Nonetheless, even with the increasing availability of devices, stable internet connectivity, and digital platforms, many teachers still faced uncertainty regarding how technology should be integrated into their pedagogy. Some lacked confidence in using ICT tools; others struggled to redesign lessons that promote collaboration, creativity, higher-order thinking, or learner engagement. There were also educators who relied heavily on traditional lecture-based methods because they have not received sustained mentoring or instructional guidance on digital pedagogy. This gap highlighted the critical need for school leaders who can offer consistent support through modeling, mentoring, observing, and evaluating technology-enhanced teaching.

This research was anchored in the recognition that technology alone does not improve instruction; rather, it is the intentional and strategic leadership guiding its use that drives meaningful pedagogical change. Effective instructional leadership in the digital age requires new competencies—understanding digital tools, monitoring technology-enhanced teaching, supporting teachers' digital professional development, promoting innovative instructional approaches, and building a school culture that values responsible and ethical use of technologies. By exploring technology integration through the lens of instructional leadership, this study sought to understand the practices, challenges, attitudes, and leadership behaviors that contributed to improved teaching performance and student learning outcomes.

Methodology

Research Design

This study employed a mixed-methods research design, integrating quantitative and qualitative approaches to comprehensively examine how digital-age instructional leadership influences technology integration and teaching practices in public secondary schools. The design followed Creswell and Plano Clark's (2018) model, beginning with quantitative data collection and analysis, followed by qualitative inquiry to explain, validate, or expand on the quantitative results.

Participants and Sampling Technique

Participants included eighty-five (85) public secondary school teachers (for perceptions of leadership and technology integration), and fifteen (15) School heads (for self-assessment of leadership practices). Stratified sampling was applied for teacher selection to ensure representation from urban and rural schools, small, medium, and large schools, and districts within the division while total enumeration was used for school heads.

Research Instrument

The study employed a researcher-developed survey questionnaire as the primary data-gathering instrument to assess the level of digital-age instructional leadership among school administrators, the extent of technology integration in teaching practices among public secondary school teachers, and the relationship between these two constructs. The development of the instrument was anchored on established theoretical frameworks such as the Technological Pedagogical Content Knowledge (TPACK) framework, the Substitution–Augmentation–Modification–Redefinition (SAMR) model, and the Technology Acceptance Model (TAM). These models provided the conceptual grounding needed to ensure theoretical coherence, content relevance, and construct validity.

The questionnaire was composed of four major parts. Part I, the Respondents' Profile, gathered demographic including age, Part II assessed Digital-Age Instructional Leadership using indicators adapted from the ISTE Standards for Education Leaders and related literature on technology leadership. This section was subdivided into five dimensions—Visionary Leadership, Digital Resource Management, Professional Learning and Capacity-Building, Technology-Supported Supervision and Instructional Monitoring, and ICT Policy Implementation. Respondents indicated their level of agreement using a four-point Likert scale ranging from 1 (Strongly Disagree) to 4 (Strongly Agree). Part III focused on Technology

Integration in Teaching Practices and measured teachers' technological, pedagogical, and content-related competencies based on the TPACK and SAMR models. Items assessed Technological Knowledge, Technological Pedagogical Knowledge, Technological Content Knowledge, TPACK integration, and instructional use of technology from Substitution to Redefinition. This section also used a five-point Likert scale ranging from 1 (Never) to 5 (Always) to measure the frequency or extent of technology use. Part IV identified Challenges in Technology Integration, including issues related to inadequate ICT resources, connectivity constraints, limited professional development, administrative barriers, and student-related concerns. Responses followed a five-point scale ranging from 1 (Very Low Extent) to 5 (Very High Extent).

Prior to the administration of the research instrument, the survey questionnaire underwent validity and reliability testing to ensure its accuracy and consistency. Content validity was established through expert review, where specialists in educational leadership and technology integration evaluated the items for relevance, clarity, and alignment with the study objectives. Reliability testing was conducted using Cronbach's alpha to determine internal consistency, with results indicating that the instrument was statistically reliable. These procedures ensured that the questionnaire was both valid and dependable for data collection.

Data Gathering Procedure

This study employed an explanatory sequential mixed-methods design (Creswell & Plano Clark, 2018), beginning with a quantitative phase that surveyed digital-age instructional leadership and technology integration, followed by a qualitative phase consisting of interviews, focus group discussions (FGDs), and document analysis. The qualitative phase was intended to elaborate, clarify, and deepen the interpretation of quantitative results. All procedures adhered to DepEd protocols and institutional ethics guidelines to ensure the responsible and ethical conduct of research.

The preparatory stage included securing all required approvals and clearances. The researcher obtained ethics approval from the university's Institutional Review and Ethics Board (IREB), permission from the Schools Division Office (SDO), and consent from individual school principals and teacher-respondents. The initial version of the survey questionnaire was prepared and subjected to pilot test and expert validation. A pilot test involving teachers and school heads outside the main sample was conducted to further refine the instrument, assess clarity, and evaluate reliability through Cronbach's alpha. Instrument revisions followed based on feedback and validation outcomes. Ethical considerations guided every stage of the data-gathering process. Participation was strictly voluntary, with informed consent obtained prior to all data collection activities. Confidentiality and anonymity were maintained through de-identification, secure data storage, and the use of pseudonyms in reporting.

Data Analysis Procedure

All data were imported and analyzed in a licensed version of IBM SPSS Statistics version 27.0.10 and R version 4.5.2 (R Core Team, 2025). This software is used entirely in the analysis. Descriptive procedures were used to analyze the data since these questions were intended to describe digital-age leadership, technology integration, and the perceived influence of challenges in implementing technology integration. Moreover, a multivariate analysis of variance (MANOVA) procedure was used to determine differences in technology integration across digital natives and immigrants, assuming $\alpha=.05$. This procedure was preferred over a series of independent t-tests to minimize the inflation of the family-wise error rate. A multivariate multiple regression procedure was used to investigate the influence of the encountered challenges to technology integration and the relationship between digital-age instructional leadership and the level of technology integration. All inferential procedures assumed $\alpha=.05$. Qualitative data analysis followed a thematic analysis process. Audio recordings from interviews and FGDs were transcribed verbatim, and field notes, observation checklists, and relevant documents were digitized.

Ethical Considerations

This study adhered to established ethical standards to protect the rights, dignity, and welfare of all participants. Prior to data collection, approval was secured from the Department of Education (DepEd) Schools Division Office and concerned school heads, and participation was strictly voluntary with informed consent obtained from all respondents. Participants were fully informed of the study's purpose, procedures, and their right to withdraw at any time without penalty. Confidentiality and anonymity were ensured through the use of codes or pseudonyms, and no personally identifiable information was disclosed. All data were used solely for academic purposes, securely stored in password-protected devices or locked storage, and handled in compliance with the Data Privacy Act of 2012 (Republic Act No. 10173). The study involved minimal risk, focusing only on professional practices and avoiding sensitive or intrusive questions. Furthermore, the researcher upheld academic integrity by properly citing all sources and ensuring honesty and transparency in data collection, analysis, and reporting, while maintaining respect, fairness, and professionalism throughout the research process.

Results and Discussion

Digital-Age Leadership

Table 1 shows that respondents strongly agreed that school instructional leaders demonstrate digital-age leadership across all five areas, since all composite means fall within the 3.25–4.00 range. Among the dimensions, visionary leadership obtained the highest mean ($M=3.65$, $SD=0.24$), suggesting that school heads are most clearly seen in setting direction, communicating expectations, and aligning ICT efforts with broader digital goals. This was followed by professional learning and capacity-building and technology-supported supervision and monitoring (both $M=3.60$, with $SD=0.29$ and $SD=0.23$, respectively), then ICT policy implementation ($M=3.59$, $SD=0.25$). These results imply that leadership is most visible in vision-setting, teacher support, and digitally aided supervision.

Indicators	M(SD)	Desc.
Visionary leadership	3.65(0.24)	SA
1. My school head articulates a clear vision for ICT use in teaching.	3.61(0.27)	SA
2. The school head sets realistic goals for technology integration.	3.64(0.26)	SA
3. The school's ICT initiatives align with the DepEd digital transformation plans.	3.69(0.32)	SA
4. The school head encourages innovation through digital tools.	3.66(0.30)	SA
5. The school head communicates expectations for ICT-integrated instruction	3.66(0.24)	SA
Digital resource management	3.44(0.36)	SA
1. The school head ensures adequate availability of ICT equipment.	3.53(0.43)	SA
2. The school invests in updating digital tools and facilities.	3.35(0.36)	SA
3. Technology resources are allocated fairly across departments/grade levels.	3.38(0.37)	SA
4. The school head regularly reviews ICT needs and gaps.	3.45(0.47)	SA
5. Procurement of ICT resources is transparent and systematic.	3.47(0.37)	SA
Professional learning and capacity-building	3.60(0.29)	SA
1. The school head provides opportunities for ICT-related training.	3.62(0.35)	SA
2. Teachers receive coaching on technology integration.	3.58(0.37)	SA
3. Peer mentoring about ICT use is encouraged.	3.55(0.31)	SA
4. The school head supports professional development aligned with digital skills.	3.71(0.28)	SA
5. ICT workshops address real instructional needs.	3.55(0.32)	SA
Technology-supported supervision and monitoring	3.60(0.23)	SA
1. Classroom observations include use of digital tools and strategies.	3.80(0.24)	SA
2. The school head uses digital platforms for instructional supervision.	3.55(0.25)	SA
3. Feedback on teaching performance includes ICT-based practice.	3.61(0.32)	SA
4. Digital tools (e.g., LMS, monitoring apps) help track teaching progress.	3.54(0.34)	SA
5. The school head uses ICT data to inform instructional decisions.	3.52(0.32)	SA
ICT policy implementation	3.59(0.25)	SA
1. The school has a clear ICT policy for teaching and learning.	3.60(0.30)	SA
2. Rules on ICT use are consistently implemented.	3.52(0.27)	SA
3. The school head ensures compliance with ICT ethical guidelines.	3.59(0.30)	SA
4. The school advocates digital citizenship among students.	3.57(0.30)	SA
5. Safety and privacy guidelines for digital learning are strictly enforced.	3.67(0.28)	SA

Note. SA = Strongly agree. $N = 15$ for all indicators.

Table 1. Descriptive Statistics for Digital-Age Instructional Leadership

Digital resource management posted the lowest, though still strongly agreed, mean ($M = 3.44$, $SD = 0.36$), which suggests that leadership in this area is present but comparatively less strong than in the other domains.

At the indicator level, the highest rating was for including digital tools and strategies in classroom observations ($M = 3.80$, $SD = 0.24$), followed by support for professional development aligned with digital skills ($M = 3.71$, $SD = 0.28$) and alignment of ICT initiatives with DepEd digital transformation plans ($M = 3.69$, $SD = 0.32$). In contrast, relatively lower ratings were seen in updating digital tools and facilities ($M = 3.35$, $SD = 0.36$) and in the fair allocation of technology resources across departments or grade levels ($M = 3.38$, $SD = 0.37$), pointing to resource-related aspects as the less strongly perceived part of digital-age leadership.

The standard deviations, which are generally low to moderate, also suggest that responses were fairly consistent across participants, especially in supervision and visionary leadership, although views were a bit more varied in some resource management indicators.

Technology Integration

Table 2 shows that public secondary school teachers perceived their level of technology integration as generally very high, with all five major areas falling in the “Always” range. Among the domains, technological pedagogical knowledge had the highest mean ($M = 4.49, SD = 0.55$), indicating that teachers most consistently integrate technology into teaching strategies, learning activities, collaboration, and classroom management. This was followed by technological pedagogical content knowledge ($M = 4.31, SD = 0.66$), technological knowledge ($M = 4.30, SD = 0.58$), and technological content knowledge ($M = 4.30, SD = 0.68$), which suggests that teachers also report strong confidence in using digital tools, understanding how these tools work, and aligning them with lesson content.

Indicators	M(SD)	Desc.
Technological knowledge	4.30(0.58)	A
1. I can troubleshoot basic computer or device issues.	4.02(0.84)	O
2. I use productivity tools (Docs, Sheets, Slides, etc.) efficiently.	4.57(0.66)	A
3. I understand how various digital tools function.	4.36(0.67)	A
4. I explore new technologies independently.	4.29(0.69)	A
5. I keep myself updated with emerging ICT tools.	4.26(0.76)	A
Technological pedagogical knowledge	4.49(0.55)	A
1. I select appropriate digital tools based on learning activities.	4.50(0.74)	A
2. I use technology to support collaborative learning.	4.60(0.56)	A
3. I modify instructional strategies based on available ICT tools.	4.54(0.59)	A
4. I manage classroom engagement through digital platforms.	4.33(0.70)	A
5. I integrate technology to differentiate instruction.	4.49(0.67)	A
Technological content knowledge	4.30(0.68)	A
1. I use subject-specific apps or technologies in my lessons.	4.32(0.75)	A
2. I design learning activities requiring students to use digital tools.	4.18(0.76)	O
3. I enhance content understanding using digital simulations/videos.	4.27(0.78)	A
4. I align digital materials with my curriculum standards.	4.36(0.76)	A
5. I modify content materials using technology.	4.35(0.78)	A
Technological pedagogical content knowledge	4.31(0.66)	A
1. I combine content, pedagogy, and technology effectively.	4.39(0.68)	A
2. I create ICT-enhanced learning materials aligned with curriculum goals.	4.24(0.77)	A
3. I apply digital tools that improve student understanding.	4.36(0.74)	A
4. I incorporate technology to present complex concepts clearly.	4.35(0.75)	A
5. I design tasks requiring students to create digital outputs.	4.23(0.84)	A
Substitution, augmentation, modification, and redefinition	4.23(0.63)	A
1. I use technology as a substitute for traditional tasks (Substitution).	4.26(0.73)	A
2. I use technology to enhance tasks with functional improvements (Augmentation).	4.25(0.71)	A
3. I modify tasks significantly using digital tools (Modification).	4.18(0.73)	O
4. I design transformative tasks not possible without technology (Redefinition).	4.07(0.73)	O
5. I integrate ICT at different levels depending on learning needs.	4.38(0.64)	A

Note. A = Always. O = Often. N = 84 for all indicators.

Table 2. Descriptive Statistics for Technology Integration in Teaching Practices

The lowest, though still in the “Always” range, was substitution, augmentation, modification, and redefinition or SAMR ($M = 4.23, SD = 0.63$), implying that while technology is regularly used in instruction, the more advanced or transformative uses are slightly less frequent than the other forms of integration.

At the indicator level, the highest mean was for using technology to support collaborative learning ($M = 4.60, SD = 0.56$), followed by efficient use of productivity tools ($M = 4.57, SD = 0.66$) and modifying instructional strategies based on available ICT tools ($M = 4.54, SD = 0.59$). In contrast, the relatively lower means were seen in troubleshooting basic computer or device issues ($M = 4.02, SD = 0.84$) and designing transformative tasks not possible without technology ($M = 4.07, SD = 0.73$), both of which fall in the “Often” range. This pattern suggests that teachers strongly perceive themselves as regular users of technology in planning and instruction, while more technical problem-solving and more transformative uses of ICT are practiced somewhat less consistently.

The standard deviations, which are generally moderate, further indicate that responses were fairly consistent across teachers, although some indicators showed wider variation than others.

Challenges in Technology Integration

The descriptive results in Table 3 show that the perceived influence of challenges in implementing technology integration ranged from moderate extent to high extent across the four areas. Among the dimensions, student-related challenges had the highest mean ($M = 3.64, SD = 0.93$), indicating that student capability was seen as the most influential concern. This was followed by resource-related challenges ($M = 3.29, SD = 0.99$) and administrative and policy challenges ($M = 3.16, SD = 1.06$), both at the moderate extent level, while teacher-related challenges had the lowest mean ($M = 2.88, SD = 1.00$), also interpreted as moderate extent.

Indicators	M(SD)	Desc.
Resource-related challenges	3.29(0.99)	ME
1. Limited availability of ICT devices (e.g., computers, tablets, laptops).	3.45(1.09)	HE
2. Unstable or slow internet connection in the school.	3.60(1.11)	HE
3. Insufficient computer laboratories or ICT rooms.	3.54(1.30)	HE
4. Lack of multimedia equipment (e.g., projectors, smart boards) for instruction.	3.40(1.22)	HE
5. Limited technical support for ICT-related issues.	3.11(1.04)	ME
6. Outdated or obsolete ICT equipment.	3.14(1.18)	ME
7. Insufficient software or licensed digital learning tools.	3.29(1.23)	ME
8. Limited access to digital teaching and learning resources.	3.14(1.12)	ME
9. Frequent technical problems during ICT-supported lessons.	3.10(1.13)	ME
10. Inadequate maintenance of existing ICT facilities.	3.14(1.16)	ME
Teacher-related challenges	2.88(1.00)	ME
1. Limited confidence in using advanced digital tools.	2.89(1.12)	ME
2. Insufficient training in technology integration for teaching.	3.12(1.15)	ME
3. Difficulty modifying lessons to integrate ICT effectively.	2.90(1.08)	ME
4. Difficulty managing classroom behavior when students use devices.	2.88(1.12)	ME
5. Difficulty assessing student outputs created through ICT.	2.87(1.10)	ME
6. Limited time to prepare technology-integrated lessons.	3.06(1.12)	ME
7. Resistance to changing traditional teaching methods.	2.82(1.09)	ME
8. Lack of familiarity with emerging educational technologies.	2.82(1.08)	ME
9. Difficulty aligning technology use with curriculum standards.	2.79(1.14)	ME
10. Anxiety or fear of technical failure during lessons.	2.68(1.16)	ME
Student-related challenges	3.64(0.93)	HE
1. Students have varying levels of digital skills.	3.55(1.08)	HE
2. Not all students have access to devices or internet at home.	3.93(1.10)	HE
3. Students are easily distracted when using technology.	3.68(1.20)	HE
4. Students lack digital citizenship and online safety skills.	3.57(1.17)	HE
5. Students struggle with following ICT-based instructions.	3.60(1.09)	HE
6. Students rely too much on technology instead of critical thinking.	3.88(1.13)	HE
7. Students misuse devices for non-academic purposes.	3.74(1.18)	HE
8. Students have difficulty collaborating online for academic tasks.	3.58(1.10)	HE
9. Students show low motivation toward ICT-based activities.	3.23(1.24)	ME
10. Students lack basic troubleshooting skills when technical issues arise.	3.68(1.07)	HE
Administrative and policy challenges	3.16(1.06)	ME
1. Inconsistent enforcement of ICT-related policies.	3.15(1.18)	ME
2. Limited budget allocation for ICT improvements.	3.62(1.10)	HE
3. Lack of incentives for teachers who integrate technology.	3.40(1.12)	HE
4. Limited monitoring and evaluation of ICT implementation.	3.19(1.19)	ME
5. School-wide ICT plans are unclear or outdated.	3.08(1.26)	ME
6. Insufficient leadership support for technology integration.	3.01(1.27)	ME
7. Limited opportunities for continuous ICT-related professional development.	3.08(1.32)	ME
8. ICT initiatives are not aligned with school goals.	2.93(1.27)	ME
9. Delays in procurement of ICT equipment and resources.	3.07(1.21)	ME
10. Lack of clear guidelines on acceptable and effective ICT use.	3.05(1.17)	ME

Note. ME = Moderate extent. HE = High extent. N = 84 for all indicators.

Table 3. Descriptive Statistics for the Perceived Influence of Challenges Experienced in Technology Integration

At the indicator level, the strongest concerns were students not having access to devices or the internet at home ($M = 3.93$, $SD = 1.10$), students relying too much on technology instead of critical thinking ($M = 3.88$, $SD = 1.13$), and students misusing devices for non-academic purposes ($M = 3.74$, $SD = 1.18$), all under high extent. Resource-related concerns such as unstable or slow internet connection ($M = 3.60$, $SD = 1.11$), insufficient computer laboratories or ICT rooms ($M = 3.54$, $SD = 1.30$), and limited ICT devices ($M = 3.45$, $SD = 1.09$) were also rated high.

In the administrative area, limited budget allocation for ICT improvements ($M = 3.62$, $SD = 1.10$) and lack of incentives for teachers who integrate technology ($M = 3.40$, $SD = 1.12$) reached the high-extent level, whereas most teacher-related concerns remained only moderate, with insufficient training ($M = 3.12$, $SD = 1.15$) and limited time to prepare ICT-integrated lessons ($M = 3.06$, $SD = 1.12$) as the more noticeable ones. These results imply that the most strongly felt barriers come from students' access, behavior, and skills, followed by school resource and support conditions, while teacher readiness concerns are present but comparatively less influential.

The inferential results in Table 4 further show that the influence of these challenges on technology integration differs by dimension. The overall regression models were statistically significant for technological knowledge (TK; $F = 2.60$, $p = .042$, $\eta_p^2 = .116$), technological pedagogical content knowledge (TPCK; $F = 2.75$, $p = .034$, $\eta_p^2 = .122$), and SAMR ($F = 2.58$, $p = .044$, $\eta_p^2 = .116$), indicating moderately strong relationships between the set of challenges and these aspects of technology integration. However, the overall models for technological pedagogical knowledge (TPK; $F = 1.78$, $p = .142$, $\eta_p^2 = .082$), technological content knowledge (TCK; $F = 2.27$, $p = .069$, $\eta_p^2 = .103$), and overall technology integration ($F = 1.24$, $p = .221$, $\eta_p^2 = .074$) were not statistically significant.

		SR	TR	SC	AS	Overall ^a
TK	<i>t</i>	-1.86	-1.79	1.84	0.81	2.60*
	<i>p</i>	.059	.068	.064	.412	.042
	η_p^2	.042	.038	.042	.007	.116
TPK	<i>t</i>	-1.15	-1.25	2.14*	-0.33	1.78
	<i>p</i>	.224	.197	.032	.743	.142
	η_p^2	.015	.016	.053	.001	.082
TCK	<i>t</i>	-1.67	-1.23	2.81*	-0.47	2.27
	<i>p</i>	.087	.209	.007	.644	.069
	η_p^2	.022	.015	.076	.002	.103
TPCK	<i>t</i>	-1.60	-0.65	2.83*	-1.58	2.75*
	<i>p</i>	.097	.501	.006	.115	.034
	η_p^2	.019	.004	.076	.025	.122
SAMR	<i>t</i>	-2.16*	-0.38	2.16*	-1.03	2.58*
	<i>p</i>	.027	.696	.031	.302	.044
	η_p^2	.044	.002	.044	.008	.116
Overall	<i>F</i> (5,75)	0.93	0.80	1.35	1.48	1.24
	<i>p</i>	.464	.552	.253	.206	.221
	η_p^2	.059	.051	.083	.090	.074

Note. TK = Technological knowledge. TPK = Technological pedagogical knowledge. TCK = Technological content knowledge. TPCK = Technological pedagogical content knowledge. SAMR = Substitution, augmentation, modification, and redefinition. SR = School resources. TR = Teacher readiness. SC = Student capability. AS = Administrative support.

^a The overall column presents the *F*-statistic of the corresponding technology integration with $df_M = 4$, $df_R = 79$ instead of the *t*-statistic.

^b The omnibus *F*-statistic for the overall correlation has $df_M = 20$, $df_R = 312$.

* Significant at $\alpha = .05$ level.

Table 4. Inferential Statistics for the Influence of Challenges Encountered to Technology Integration

At the predictor level, student capability challenges showed a significant positive relationship with TPK ($t = 2.14$, $p = .032$, $\eta_p^2 = .053$), TCK ($t = 2.81$, $p = .007$, $\eta_p^2 = .076$), TPCK ($t = 2.83$, $p = .006$, $\eta_p^2 = .076$), and SAMR ($t = 2.16$, $p = .031$, $\eta_p^2 = .044$), suggesting that as student-related difficulties increase, these dimensions of technology integration are also more strongly implicated. In contrast, school resource challenges had a significant negative relationship only with SAMR ($t = -2.16$, $p = .027$, $\eta_p^2 = .044$), which implies that resource shortages are linked with lower performance in the more transformative uses of technology. Teacher readiness and administrative support did not show statistically significant relationships with any of the technology integration dimensions, based on the reported *p*-values. Overall, the statistics suggest that among the four challenge areas, student capability is the most consistently related factor, especially for the more applied and higher-level dimensions of technology integration.

Technology Integration across Digital Age

Table 5 shows that digital natives consistently obtained higher mean scores than digital immigrants across all dimensions of technology integration. The largest difference appeared in technological knowledge (TK), where digital natives had a mean of 4.43 compared with 3.95 for digital immigrants, and this difference was statistically significant ($p = .004$, $\eta_p^2 = .142$), indicating a large group difference. Significant differences were also found in technological pedagogical knowledge (TPK), with means of 4.60 for digital natives and 4.19 for digital immigrants ($p = .009$, $\eta_p^2 = .111$), and in technological content knowledge (TCK), with means of 4.42 and 3.97, respectively ($p = .039$, $\eta_p^2 = .085$). These effect sizes suggest that the differences in TPK and TCK are moderate in magnitude.

Technology integration	Group	Descriptives		Comparison		
		<i>M</i>	<i>SE</i>	<i>t</i>	<i>p</i>	η_p^2
TK	Natives	4.43 _B	0.07	3.03*	.004	.142
	Immigrants	3.95 _A	0.11			
TPK	Natives	4.60 _B	0.07	2.71*	.009	.111
	Immigrants	4.19 _A	0.11			
TCK	Natives	4.42 _B	0.08	2.16*	.039	.085
	Immigrants	3.97 _A	0.14			
TPCK	Natives	4.42 _A	0.08	2.00	.054	.071
	Immigrants	4.03 _A	0.13			
SAMR	Natives	4.33 _A	0.08	1.94	.054	.062
	Immigrants	3.97 _A	0.13			

Note. TK = Technological knowledge. TPK = Technological pedagogical knowledge. TCK = Technological content knowledge. TPCK = Technological pedagogical content knowledge. SAMR = Substitution, augmentation, modification, and redefinition. Overall statistics: $V = 0.15$, $F(5,78) = 2.71$, $p = .026$, $\eta_p^2 = .148$. Different subscripts denote statistically significantly different group means at $\alpha = .05$. *Significant at $\alpha = .05$ level.

Table 5. Difference in Technology Integration across Digital Natives and Immigrants

In contrast, although digital natives still posted higher means in technological pedagogical content knowledge (TPCK; 4.42 vs. 4.03) and SAMR (4.33 vs. 3.97), these differences were not statistically significant at the .05 level ($p = .054$ for both), even if their effect sizes ($\eta_p^2 = .071$ for TPCK and $\eta_p^2 = .062$ for SAMR) fall within the moderate range.

The pattern of results implies that digital natives tend to report stronger technology integration in teaching than digital immigrants, with the clearest and statistically supported differences appearing in their technological knowledge, technological pedagogical knowledge, and technological content knowledge.

Digital-Age Instructional Leadership and Technology Integration

Table 6 shows that the relationship between digital-age instructional leadership and technology integration varies across the different dimensions of technology integration. Based on the overall tests, the set of leadership variables had a significant relationship with technological pedagogical content knowledge (TPCK; $F = 3.77$, $p = .004$, $\eta_p^2 = .194$) and SAMR ($F = 3.20$, $p = .010$, $\eta_p^2 = .172$), and both effect sizes indicate a strong relationship. In contrast, the overall relationships for technological knowledge (TK; $F = 0.95$, $p = .451$, $\eta_p^2 = .058$), technological pedagogical knowledge (TPK; $F = 1.65$, $p = .156$, $\eta_p^2 = .096$), technological content knowledge (TCK; $F = 1.59$, $p = .173$, $\eta_p^2 = .092$), and overall technology integration ($F = 1.17$, $p = .259$, $\eta_p^2 = .070$) were not statistically significant.

		VL	DRM	PLC	TSM	IPi	Overall ^a
TK	<i>t</i>	1.22	-0.15	-1.36	0.21	0.92	0.95
	<i>p</i>	.204	.880	.180	.829	.344	.451
	η_p^2	.017	< .001	.023	.001	.010	.058
TPK	<i>t</i>	1.14	-0.63	-1.47	0.56	1.31	1.65
	<i>p</i>	.247	.515	.147	.560	.181	.156
	η_p^2	.015	.004	.026	.004	.020	.096
TCK	<i>t</i>	1.64	0.16	-1.72	0.55	0.63	1.59
	<i>p</i>	.093	.874	.090	.577	.526	.173
	η_p^2	.037	< .001	.046	.005	.005	.092
TPCK	<i>t</i>	1.67	0.08	-2.41*	0.06	2.34*	3.77*
	<i>p</i>	.092	.932	.017	.952	.019	.004

		VL	DRM	PLC	TSM	IPI	Overall ^a
SAMR	η_p^2	.038	<.001	.085	<.001	.063	.194
	<i>t</i>	1.99*	0.85	-2.74*	0.55	1.58	3.20*
	<i>p</i>	.044	.388	.007	.576	.108	.010
Overall	η_p^2	.032	.009	.091	.004	.025	.172
	<i>F</i> (5,74)	0.70	0.43	1.90	0.35	2.46*	1.17b
	<i>p</i>	.629	.828	.104	.878	.040	.259
	η_p^2	.045	.028	.114	.023	.143	.070

Note. TK = Technological knowledge. TPK = Technological pedagogical knowledge. TCK = Technological content knowledge. TPCK = Technological pedagogical content knowledge. SAMR = Substitution, augmentation, modification, and redefinition. VL = Visionary leadership. DRM = Digital resource management. PLC = Professional learning and capacity-building. TSM = Technology-supported supervision and monitoring. IPI = ICT policy implementation.

^a The overall column presents the *F*-statistic of the corresponding technology integration with $df_M = 5$, $df_R = 78$ instead of the *t*-statistic.

^b The omnibus *F*-statistic for the overall correlation has $df_M = 25$, $df_R = 390$.

*Significant at $\alpha = .05$ level.

Table 6. Relationship between Digital-Age Instructional Leadership and Technology Integration

At the predictor level, ICT policy implementation (IPI) showed a significant positive relationship with TPCK ($t = 2.34$, $p = .019$, $\eta_p^2 = .063$) and with overall technology integration ($t = 2.46$, $p = .040$, $\eta_p^2 = .143$), suggesting that stronger ICT policy implementation is associated with higher levels of these outcomes. Professional learning and capacity-building (PLC), however, showed significant negative relationships with TPCK ($t = -2.41$, $p = .017$, $\eta_p^2 = .085$) and SAMR ($t = -2.74$, $p = .007$, $\eta_p^2 = .091$), both indicating moderately strong relationships in magnitude. In addition, visionary leadership (VL) had a significant positive relationship with SAMR ($t = 1.99$, $p = .044$, $\eta_p^2 = .032$), although the effect size suggests only a weak relationship.

The remaining coefficients for digital resource management (DRM) and technology-supported supervision and monitoring (TSM), as well as the other non-significant coefficients, indicate no statistically supported relationship with the technology integration dimensions at the .05 level. Overall, the statistics suggest that digital-age instructional leadership is more strongly associated with the deeper and more transformative aspects of technology integration, particularly TPCK and SAMR, than with the more basic technology knowledge dimensions.

Conclusion and Recommendations

Based on the findings, the following conclusions are drawn: 1) Digital-age instructional leadership is effectively practiced in public secondary schools, particularly in setting vision and supporting teachers. 2) Teachers are highly competent in integrating technology, though mostly at enhancement rather than transformation levels. 3) Student readiness and resource availability are the primary barriers to effective ICT integration. 4) Leadership significantly influences technology integration, confirming its critical role in educational innovation. 5) Generational differences exist in effective technology integration, but they diminish in higher-level instructional applications.

Based on the conclusions, several recommendations were proposed: school leaders were encouraged to strengthen resource management systems to ensure the equitable distribution of ICT tools, enhance monitoring and evaluation mechanisms for ICT integration, and provide targeted professional development focusing on transformative technology use; teachers were encouraged to engage in continuous capacity-building programs emphasizing advanced ICT integration aligned with SAMR levels and to develop strategies that improve student digital literacy and responsible technology use; schools and the education department were encouraged to invest in ICT infrastructure, including stable internet connectivity and updated equipment, formulate policies addressing digital equity among students, and provide incentives for innovative ICT-based teaching practices; and future researchers were encouraged to explore student-related variables affecting ICT integration, examine the longitudinal effects of digital leadership on teaching outcomes, and conduct intervention-based studies aimed at improving SAMR-level integration.

The research also proposed Leadership for Effective and Adaptive Digital ICT Integration (LEAD-ICT) Framework that is anchored on the study's findings that instructional leadership significantly influences technology integration, teachers demonstrate high readiness in integrating technology in the classroom, but transformative use, Substitution, Augmentation, Modification, Redefinition (SAMR) remains limited, student-related challenges and resource constraints are primary barriers, and digital natives show stronger integration, but gaps exist across teacher groups.

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Competing Interests Statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this article.

Data Availability Statement

The data used in this research can be accessed through a formal request to the author of the study.

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Appendices

No appendices are attached to this study.