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School Principals' Technology Leadership and Teachers' Technology Integration in Ghanaian Basic Schools

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ABSTRACT

The integration of Information and Communication Technology (ICT) in education has underscored the importance of school principals' technology leadership in influencing teachers' instructional practices. However, evidence from Ghanaian basic schools remains limited. This study examined the level of school principals' technology leadership (PTL), the extent of teachers' technology integration (TTI), and the influence of PTL on TTI in public basic schools within the Adjen-Kotoku Circuit of the Ga West Municipality, Ghana. Guided by Transformational Leadership Theory and Rogers' Diffusion of Innovations Theory, the study adopted a positivist paradigm and a quantitative cross-sectional survey design. A census approach was used to collect data from 198 teachers using validated instruments adapted from the Principal Technology Leadership Assessment Questionnaire and the Teacher Technology Integration Survey. Data were analysed using descriptive statistics and multiple regression analysis. The findings revealed that principals demonstrated a moderate level of technology leadership (M = 3.20, SD = 0.61), while teachers exhibited a high level of technology integration (M = 3.70, SD = 0.64). Regression results indicated a statistically significant positive relationship between PTL and TTI ($R = .44$, $R^2 = .19$, $p < .001$), showing that principals' technology leadership accounted for 19% of the variance in teachers' technology integration. Visionary leadership and digital citizenship emerged as significant predictors of TTI. The findings highlight the critical role of strengthening principals' leadership capacities to sustain effective technology integration in Ghanaian basic schools.

INTRODUCTION

Technology has significantly transformed contemporary human life, with Information and Communication Technology (ICT) permeating nearly every sector of society. Advances in ICT have reshaped industries such as commerce, manufacturing, banking, mining, agriculture, construction, and education, one of the most critical sectors for national development. As the Fourth Industrial Revolution accelerates through digitalisation, robotics, artificial intelligence, and automation, education systems are increasingly required to prepare learners for changing labour market demands. Despite these technological shifts, human-centred competencies remain essential, reinforcing the need for education systems to adapt teaching and learning processes to future skill requirements. Consequently, educational institutions must equip teachers with relevant technological competencies to support effective, efficient, and learner-centred instructional practices.

Within the school system, the principal occupies a central administrative and instructional leadership role and serves as a key agent in educational delivery (Hussain *et al.*, 2016; Naidoo, 2019; Ampomah & Oti-Agyen, 2023). As such, school principals are pivotal to the successful implementation of digital transformation in classrooms. Empirical evidence indicates that school administrators play a critical role in facilitating effective technology transfer within educational institutions (Bingimlas, 2009; Cantos & Callo, 2022; Ghavifekr & Wong, 2022). Dexter (2008) further emphasises that principals are often regarded as the cornerstone of school improvement, providing strategic direction that can either enable or hinder technology-driven change. This underscores the importance of principals taking the lead in promoting and supporting classroom technology integration. The technology leadership role of principals is therefore essential for establishing effective teaching and learning systems and for streamlining educational processes, including teachers' integration of technology into instruction (Gurr, 2000; Dodoo *et al.*, 2024).

Technology Leadership (TL) has emerged as a prominent construct within educational leadership, particularly in response to the demands of the technology-driven 21st century (Lanbon & Li, 2021; Gallego, 2023). TL is defined as the integration of leadership competencies with the effective use of technological resources, infrastructure, and digital tools to achieve organisational goals (Thannimalai & Raman, 2018). Similarly, Tiop and Talip (2020) conceptualise TL as the fusion of general leadership strategies with a deliberate focus on technology, encompassing access to technological resources, continuous professional development, and evolving patterns of technology use. Fundamentally, TL facilitates the alignment of ICT integration with a school's vision and objectives. Given the rapid advancement and increasing complexity of digital technologies, schools require leaders with strong technological proficiency. As the individuals responsible

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for managing school operations and digital environments, principals' technology leadership must remain responsive to emerging technological developments.

Globally, the technology-driven nature of the 21st century has redefined leadership functions within educational institutions. Increasing attention has been directed toward preparing educational leaders to respond effectively to technological demands, positioning technology leadership as one of the most actively researched areas in educational leadership (Chua & Chua, 2017; Lanbon *et al.*, 2020). Despite this growing scholarly interest, technology leadership among school principals has not received adequate attention within Ghana's educational system, particularly at the Primary and Junior High School levels in rural settings (Aboagye, 2019). Public basic schools in these contexts continue to face challenges related to weak technology leadership and limited technology integration among both principals and teachers.

The limited success of Ghana's Information Communication Technology for All (ICT4All) initiative has further highlighted deficiencies in school-level technology leadership. Although the initiative aimed to provide ICT devices and accessories to public Primary and Junior High Schools, particularly in rural areas, its objectives have not been fully realised. Scholars attribute this outcome partly to the absence of strong technology leadership capable of ensuring effective technology integration (Agangiba *et al.*, 2017; Mantey, 2017). As a result, the anticipated improvements in ICT-enhanced teaching and learning have not materialised as expected.

Additionally, assumptions regarding the technological backgrounds of school principals have raised concerns about their capacity to function effectively as technology leaders. It is commonly presumed that many principals, often in their forties or older, completed their education before computers were formally integrated into Ghana's school curriculum, potentially limiting their technological competence (Abraham *et al.*, as cited in Lanbon & Li, 2021). Several studies have demonstrated that the quality of school leadership strongly influences the successful integration of technology in instructional practices (Chang *et al.*, 2008; Roth & Price, 2016; Raman *et al.*, 2019). Consequently, principals' effectiveness as technology leaders may significantly influence the extent to which teachers integrate technology into classroom instruction (Brockmeier *et al.*, 2015; A'mar & Eleyan, 2022; AlAjmi, 2022; Nawawi *et al.*, 2022).

Empirical studies examining the relationship between principals' technology leadership (PTL) and teachers' technology integration (TTI) have produced mixed and sometimes contradictory findings. While Celep and Tülübaş (2014) reported that PTL had a minimal influence on teachers' positive attitudes toward educational technology use, other studies identified a positive relationship between TL and TTI (Thannimalai & Raman, 2018; A'mar & Eleyan, 2022). Similarly, AlAjmi (2022) and Nawawi *et al.* (2022) found that PTL positively influenced teachers' technology integration. In contrast, Yahya and Raman (2020) reported no significant relationship between PTL and TTI. More recently, Baiden *et al.* (2023) suggested that principals' preparatory programmes could enhance teachers' technology integration through improved technology leadership.

Given these inconsistent findings, there is a clear need for further empirical investigation to either confirm or challenge existing evidence. Moreover, many of the studies cited were conducted outside Ghana, limiting their applicability due to contextual, cultural, and geographical differences. Although Baiden *et al.* (2023) examined this phenomenon in Ghana, their study focused on colleges of education, making it inappropriate to generalise the findings to basic school principals and teachers. To address this empirical and contextual gap, the present study seeks to assess the influence of school principals' technology leadership on teachers' technology integration within basic schools in the Adjen-Kotoku Circuit of the Ga West Municipality. These objectives guided the study:

1. To determine the level of school PTL in the Adjen-Kotoku circuit in the Ga West Municipality.
2. To assess the level of TTI in the Adjen-Kotoku circuit in the Ga West Municipality.
3. To assess the influence of school PTL on TTI in the Adjen-Kotoku circuit in the Ga West Municipality.

LITERATURE REVIEW

Theoretical Review

Transformational Leadership Theory

James MacGregor Burns introduced the concept of transforming leadership in 1978, defining it as a relationship characterised by mutual stimulation and elevation, transforming followers into leaders and potentially turning leaders into moral agents (Pawar, 2016; Okeke, 2019). Bernard Bass in 1985 developed this into transformational leadership, highlighting its role in expanding teachers' needs, enhancing confidence, modifying self-interest, and inspiring behavioural change toward achieving personal and organisational goals (Bolden *et al.*, 2003).

Transformational leadership encompasses vision, group goal acceptance, individualised support, intellectual stimulation, and high expectations (Balyer, 2012; Day *et al.*, 2016; Hutton, 2017). Principals who demonstrate transformational leadership motivate teachers, articulate a clear vision, foster cooperation, provide individualised support, and promote professional development to integrate technology into teaching (Okeke, 2019). This leadership approach encourages innovation, creativity, and adoption of new technologies, which is essential for schools to adapt to rapidly evolving educational technologies.

Rogers' Diffusion of Innovation (DOI) Theory

Rogers' DOI theory explains how innovations spread within a social system through communication channels over time, influencing adoption or rejection (Rogers, 2003). The key components include innovation, communication channels, time, and social system.

Innovation: Defined as an idea, practice, or object considered new by adopters (Rogers, 2003; Wani & Ali, 2015). The perceived attributes of innovation-relative advantage, compatibility, complexity, trialability, and observability-impact adoption decisions (Akman & Koçoglu, 2017).

Communication Channels: Effective communication, particularly among homophilous individuals, promotes understanding and adoption (Adnan & Jambari, 2016; Rogers, 2003).

Time: Involves the innovation-decision process, individual innovativeness, and rate of adoption. Adopters are categorised as innovators, early adopters, early majority, late majority, and laggards (Rogers, 2003).

Social System: Social structures, norms, opinion leaders, and change agents shape adoption behaviours. Innovation decisions may be optional, collective, or authority-driven, and consequences of adoption may be direct, indirect, anticipated, or unanticipated (Rogers, 2003; Gwayi, 2009). The DOI theory underscores the importance of teachers' perceptions, leadership support, and social networks in promoting technology adoption in schools (Cantos & Callo, 2022).

Conceptual Review

Technology Leadership

Technology leadership (TL) refers to principals' ability to influence institutional performance through technological expertise and leadership skills (Lanbon & Li, 2021). TL comprises visionary leadership, digital age learning culture, excellence in professional practice, systemic improvement, and digital citizenship (ISTE, 2014; Patrick, 2018; Chua & Chua, 2017). Effective TL equips schools to prepare students for a technologically-driven society, supporting both instructional and administrative technology integration (Lawrence & Tar, 2018; McLeod & Richardson, 2011).

School Principals' Technology Leadership (PTL)

PTL combines proficiency in technology use and leadership to enhance instructional and managerial effectiveness (Thannimalai & Raman, 2018; Lanbon *et al.*, 2020). Effective principals guide teachers in adopting technology, provide professional development, establish support networks, and integrate technology into curriculum and administration (Cantos & Callo, 2022; Hsieh & Hsiao, 2013). PTL is typically conceptualised in three domains: use of digital technologies for leadership content, development of principals' proficiency in technology, and preparation of principals as technology leaders (McLeod *et al.*, 2011; Richardson *et al.*, 2013).

Technology Integration (TI)

TI is the purposeful incorporation of technology into teaching and learning, enhancing instructional effectiveness and student learning outcomes (Hew & Brush, 2007; Summak *et al.*, 2010; Yilmaz, 2021). Effective TI emphasises content, pedagogy, and novel learning opportunities rather than mere technology use (Ruggiero & Mong, 2015; Ashrafzadeh & Sayadian, 2015).

Teacher Technology Integration (TTI)

TTI refers to teachers' use of technology to facilitate instructional activities, including hardware (laptops, tablets) and software (MS Word, PowerPoint) (Danniels *et al.*, 2020; Dukuzumuremyi & Siklander, 2018). TTI is assessed both quantitatively (frequency of use) and qualitatively (level of technology exploitation and teaching quality). The RAT model categorises TI into Replacement, Amplification, and Transformation levels, emphasising innovation and engagement in learning (Hughes *et al.*, 2006; Renkl & Scheiter, 2017; Backfisch *et al.*, 2021). Teaching quality includes cognitive activation, personalised support, and effective classroom management (Fauth *et al.*, 2014; Praetorius *et al.*, 2018).

Conceptual Framework

The conceptual framework (Figure 1) depicts what was investigated in this study and the interconnections among the variables or constructs. The arrows pointing to school

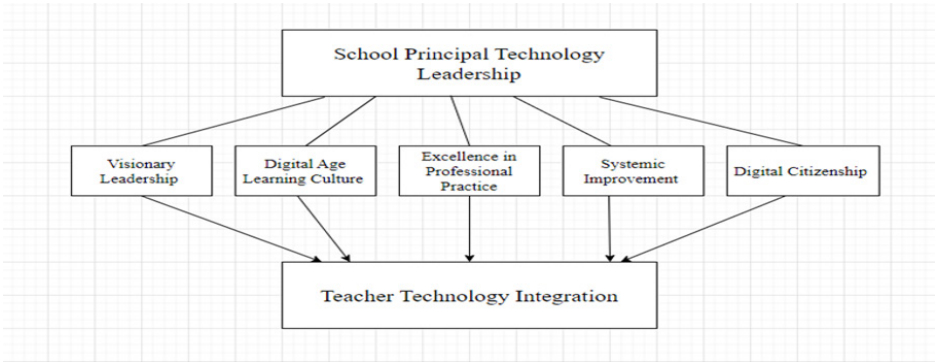

Figure 1: School principal, technology leadership, and teacher technology integration
Source: Authors' construct

principal technology leadership suggest that the school principal technology leadership can be explained by how well the school principal demonstrated those constructs/indicators. Therefore, these indicators were used to measure school PTL. Moreover, school PTL contributes to TTI; therefore, the study investigated the influence of school PTL on TTI. The study focused on the influence of each of the five indicators of school PTL on TTI,

therefore explaining the arrows pointing from the five indicators to teacher technology integration.

Empirical Review

Level of School Principals' Technology Leadership

Nawawi *et al.* (2022) examined the relationship between principals' technology leadership and teacher technology integration in the Central Region of Peninsular Malaysia. Using a quantitative survey design, the study targeted 29,987 teachers across Kuala Lumpur, Putrajaya, and Selangor, selecting 492 teachers through multi-level random sampling. Principals' technology leadership practices were assessed using the ISTE for Education Leaders (ISTE-EL) instrument (ISTE, 2018). Data analysis via SPSS indicated a very high level of technology leadership among principals (M = 4.38, SD = 0.53). AlAjmi (2022) investigated the impact of digital leadership on teachers' technology integration during the COVID-19 pandemic in Kuwait. The study employed a cross-sectional survey covering 197 public elementary schools across six districts. A sample of 517 respondents (113 principals and 404 teachers) was selected using random sampling. Principals' digital leadership was measured using the PTLA instrument (ISTE, 2014), covering five dimensions: visionary leadership (VL), excellence in professional practice (EP), digital age learning culture (DA), digital citizenship (DC), and systemic improvement (SI). Analysis using IBM SPSS revealed high levels of digital leadership: VL (M = 4.11, SD = 2.34), DA (M = 4.04, SD = 3.70), EP (M = 4.16, SD = 3.50), SI (M = 4.16, SD = 3.34), and DC (M = 4.10, SD = 2.80). Overall, digital leadership was rated high (M = 4.12, SD = 1.31). Cronbach's alpha for the instrument was .946, indicating strong reliability. Baiden *et al.* (2023) explored principals' technology leadership in Ghanaian Colleges of Education. Using a quantitative cross-sectional survey design, the study population included 13 principals and 610 teachers from the Bono, Ashanti, and Ahafo regions. A sample of 242 tutors was selected via simple random sampling, while all 13 principals participated. Data collected via a structured questionnaire, guided by the PTLA aligned with ISTE standards, were analysed descriptively using SPSS. The results indicated a moderate level of technology leadership among principals.

Level of Teacher Technology Integration

A'mar and Eleyan (2022) investigated teacher technology integration (TTI) across public schools in the West Bank of Palestine. The population consisted of 35,662 teachers from 1,792 schools and an equal number of principals across 17 districts. Electronic questionnaires were randomly distributed, yielding 953 teacher responses and 442 principal responses. The study employed the "Learning with ICTs: Measuring ICT Use in the Curriculum" tool (Jamieson-Proctor *et al.*, 2005; Jamieson-Proctor *et al.*, 2010). Reliability analysis yielded a Cronbach's alpha of .847. Descriptive statistics revealed a high level of TTI (M = 4.20). AlAjmi (2022) also assessed TTI in Kuwait. The study utilised a cross-sectional survey with 404 teachers from 197 elementary schools. TTI was measured using the TTIS instrument (Vannatta & Banister, 2009), evaluating administrative, instructional, and communication uses. Cronbach's alpha was .887. Results indicated high TTI among teachers (M = 4.15, SD = 0.804). Nawawi *et al.* (2022) evaluated TTI in Malaysia using the TPACK framework (Chai *et al.*, 2011; Schmidt *et al.*, 2009; Schmid *et al.*, 2020). Among 492 selected teachers, data analysis via SPSS revealed very high TTI (M = 4.27, SD = 0.45).

Influence of Principals' Technology Leadership on Teacher Technology Integration

Thannimalai and Raman (2018) examined the effect of principals' technology leadership on TTI in Malaysian secondary schools. A sample of 645 teachers and 90 principals was selected using systematic random sampling. Principals' leadership was measured using PTLA (ISTE, 2009), and teachers' technology integration via "Learning with ICTs" (Proctor *et al.*, 2003; Jamieson-Proctor *et al.*, 2005, Jamieson-Proctor *et al.*, 2010). Pilot testing demonstrated Cronbach's alpha values of .93 (PTL) and .94 (TTI). SPSS analysis indicated a significant relationship between PTL and TTI, $F(1, 88) = 9.64$, $p = .003$, $R = .31$, $R^2 = .10$. AlAjmi (2022) found a significant positive impact of principals' digital leadership on TTI in Kuwait. Pearson correlation and multiple regression analysis showed that digital leadership explained a significant portion of variance in TTI ($R = .309$, $B = .195$, $F = 11.732$, $p = .001$). Nawawi *et al.* (2022) reported a strong positive relationship between principals' technology leadership and TTI using PLS-SEM. The study found that PTL significantly predicted TTI ($R^2 = .356$, $\beta = .413$; $t = 5.761$, $p = .001$). A'mar and Eleyan (2022) also demonstrated that PTL indicators significantly influenced TTI among Palestinian teachers: VL ($\beta = .073$, $t = 2.250$, $p = .024$), DA ($\beta = .161$, $t = 3.474$, $p = .001$), EP ($\beta = .109$, $t = 2.379$, $p = .017$), SI ($\beta = .234$, $t = 5.195$, $p = .001$), and DC ($\beta = .266$, $t = 8.650$, $p = .001$), accounting for 54.1% of the variance in TTI ($R^2 = .541$, $Q^2 = .247$).

MATERIALS AND METHODS

Research Approach and Design

This study adopted a positivist paradigm and employed a quantitative approach, consistent with the assumptions of positivist philosophy. A cross-sectional survey design was used to explore participants' perspectives on the phenomenon under investigation. The study was conducted within the Adjen-Kotoku circuit, an educational division of the Ga West Municipality. The population comprised 198 basic public-school teachers. Given the relatively small population size, a census approach was employed to include all teachers in the study.

Data Collection Instrument

Data were collected using a structured questionnaire,

selected for its efficiency and ability to provide respondent anonymity, thereby reducing potential response bias (Kwarteng & Sappor, 2021). The questionnaire was divided into two sections. Section A collected demographic information, including gender, age, and teaching experience. Section B assessed school principals' technology leadership (PTL) and teacher technology integration (TTI). PTL items were adapted from AlAjmi's (2022) Principal Technology Leadership Assessment Questionnaire (PTLAQ), which comprises five subscales: visionary leadership (VL, 7 items), digital awareness (DA, 9 items), educational planning (EP, 8 items), support and innovation (SI, 8 items), and digital communication (DC, 6 items). TTI was measured using 20 items adapted from Vannatta and Banister's (2009) Teacher Technology Integration Survey (TTIS). All items were rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). A pilot study was conducted at Kwashikuma Methodist Basic School, Ga West Municipality, with 20 teachers who shared similar characteristics with the study population. This sample size aligns with Saunders *et al.* (2009), who recommend a minimum of 10 respondents for pilot testing. Reliability of the instrument was assessed using Cronbach's alpha. Pilot results indicated high internal consistency across subscales: VL (.94), DA (.92), EP (.88), SI (.90), DC (.91), and TTI (.98), with an overall reliability of .98, surpassing the acceptable threshold of .70 (AlAjmi, 2022; Nawawi *et al.*, 2022). After full data collection, Cronbach's alpha values remained robust: VL (.81), DA (.78), EP (.79), SI (.77), DC (.83), and TTI (.96), with an overall alpha of .94, confirming instrument reliability.

Data Processing and Analysis

Collected data were coded and analysed using IBM SPSS. Descriptive statistics, including frequencies and percentages, were used to summarise respondents' demographic information. Research Objectives 1 and 2 were addressed using means and standard deviations to assess the levels of PTL and TTI. A standard deviation below 1 indicated homogeneity of responses, while values of 1 or higher suggested heterogeneity. Mean scores were interpreted according to the scale in Table 1.

Table 1: Level of mean value interpretation

Score	Level
1.00 – 1.80	Very low
1.81 – 2.60	Low
2.61 – 3.40	Moderate
3.41 – 4.20	High
4.21 – 5.00	Very high

Adapted: AlAjmi (2022), Nawawi et al. (2022)

Research Objective 3 was examined using Multiple Regression analysis at a 95% confidence level to determine the influence of PTL subscales on TTI. This approach quantified the predictive contribution of each PTL construct to variations in teacher technology integration.

Ethical Considerations

Adhering to research ethics safeguards the rights of respondents and enhances the integrity of the research (Kang & Hwang, 2021). To uphold ethical standards in the research process, these steps were employed. The study was carried out in accordance with the University of Education, Winneba code of conduct for conducting research. Prior to data collection, ethical protocols were followed to ensure the anonymity of respondents and protect their information from third-party usage (confidentiality). The researchers ensured that all respondents were informed of the purpose of the study when soliciting their consent before administering the questionnaires to them.

RESULTS AND DISCUSSIONS

The results and discussion are based on the demographic information of the respondents and the research objectives that guided the study. The results and discussion were organised under the headings that correspond to the specific research objective that is being addressed. The results are presented using tables.

Demographic Information of Respondents

The demographic information, consisting of respondents' gender, age, and teaching experience were descriptively analysed with frequency and percentage (%) because these statistical tools are appropriate to measure categorical data. The results of the respondents' demographic information are presented in Table 2.

From Table 2, of the 198 respondents who participated in the study, female teachers constituted the majority, accounting for 73.7% of the sample, while males represented 26.3%. In terms of age distribution, the largest proportion of respondents fell within the 36-40 years category (30.3%), whereas both the "Below 30 years" and "Above 40 years" groups accounted for the lowest percentages, each at 20.7%. Overall, 79.3% of the respondents were between 30 and 40 years of age, suggesting that the majority were youthful and young adults, likely familiar with contemporary digital and technological tools. Regarding teaching experience, 29.3% of the respondents had 6–10 years of service, followed by 23.2% with 1–5 years of experience. Those with more than 20 years of teaching experience comprised the smallest group at 10.1%. These findings indicate that the sample was predominantly composed of relatively young and moderately experienced teachers, potentially well-positioned to engage effectively with technology integration in educational settings.

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Table 2: Demographic Information of Respondents

Variable	Sub-scale	Frequency (n)	Percentage (%)
Gender	Male	52	26.3
	Female	146	73.7
Age (in years)	Below 30yrs	41	20.7
	Between 31-35yrs	56	28.3
	Between 36-40yrs	60	30.3
	Above 40yrs	41	20.7
Teaching experiences	Between 1-5yrs	46	23.2
	Between 6-10yrs	58	29.3
	Between 11-15yrs	44	22.2
	Between 16-20yrs	30	15.2
	Above 20yrs	20	10.1

Source: Field Data (2024)

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Level of School Principals' Technology Leadership

The essence of this research objective was to determine whether school principals of public basic schools' level measure up to the level of TL expected of them to demonstrate in the various schools under their leadership. The results are indicated in Table 3.

Table 3: Level of School Principals' Technology Leadership

No.	Statement	Mean	SD
VL1	My school principal creates and implements a strategic plan to utilise technology in realising the school's vision for technology integration	2.90	1.14
VL2	My school has programmes and policies that promote technology integration, particularly those based on research-informed practices	2.95	1.09
VL3	My school principal includes all teachers in the planning process for utilising technology in the school	3.22	1.04
VL4	My school has a clear vision aimed at achieving full technology integration to support effective professional practices	3.19	1.07
VL5	My school principal ensures my participation in activities designed to discover best practices for utilising technology in school management, such as attending conferences and district meetings	3.27	1.22
VL6	My school principal communicates the vision for technology use and clarifies expectations among all stakeholders within the school	2.88	1.18
VL7	My school principal ensures I use technology to gather and analyse data for developing the school improvement plan	3.16	1.08
	Visionary Leadership	3.08	.76
DA1	My school principal offers top-notch professional development to enhance technology integration and enhance students' learning outcomes	3.39	1.03
DA2	My school principal evaluates teachers' training needs related to technology use	3.52	1.06
DA3	My school principal acknowledges and rewards teachers who incorporate technology creatively in their teaching	3.12	1.16
DA4	My school principal provides a learning environment equipped with technology resources to support diverse and individualised learning needs	3.20	1.17

DA5	My school principal guides teachers in using technology to analyse and interpret student data, thereby improving teaching practices	3.44	1.04
DA6	My school principal models best practices in using technology for teaching, serving as a role model for all teachers	3.31	1.18
DA7	My school principal encourages teachers to regularly and effectively use technology in their teaching to enhance students' critical thinking and problem-solving abilities	3.40	1.04
DA8	My school principal supports teachers who want to participate in events focused on technology in education by offering time off or financial assistance	3.20	1.22
DA9	My school principal promotes the use of technology to enhance teaching	3.22	1.17
	Digital Age Learning Culture	3.31	.67
EP1	My school principal uses technology evaluation results for decision-making and professional development purposes	3.27	1.07
EP2	My school principal models the use of technology for all administrative tasks, setting an example for the staff	3.32	1.06
EP3	My school principal ensures that I stay updated with the latest technological products that can be applied in education	3.43	1.05
EP4	My school principal facilitates communication among administrators, teachers, parents, and the community using various technological tools	3.38	1.15
EP5	My school principal ensures that I use technology to support, develop, and improve school operations, including file archiving, budget management, and handling student information	3.42	1.10
EP6	My school principal encourages participation in professional development activities to improve administrative technology use	3.50	1.08
EP7	My school principal motivates both teachers and administrators to use technology to enhance their productivity	3.41	1.09
EP8	My school principal values the technology-driven initiatives presented by staff and teachers	3.40	1.12
	Excellence in Professional Practice	3.39	.69
SI1	My school principal assists in addressing frequent technical issues related to computer use	3.17	2.45
SI2	My school principal allocates an adequate budget to support the use of technological tools	3.09	1.14
SI3	My school principal is dedicated to upgrading hardware and software to enhance the school's operations' performance	3.18	1.11
SI4	My school principal provides specialised staff, such as IT coordinators and network technicians, to assist with the use of technology in the school	3.15	1.15
SI5	My school has a well-defined policy for the ongoing acquisition, maintenance, upgrading, and replacement of technological tools	2.91	1.18
SI6	My school principal evaluates the specifications and costs of hardware and software before purchasing	3.23	1.11
SI7	My school principal inspires all staff and teachers to use technology for data analysis and interpretation, helping to share school operations results	3.25	1.08
SI8	My school principal provides sufficient support for using technology in school operations, including monitoring attendance and tracking students' grades	3.12	1.10
	Systemic Improvement	3.14	.84
DC1	My school principal ensures that technology resources meet the needs of all students across all grade levels	2.53	1.07
DC2	My school principal ensures that all staff respect intellectual property rights and promotes this concept among school stakeholders	2.91	1.01
DC3	My school principal provides health guidelines related to technology use, such as correct posture at computers and appropriate screen time limits	2.96	1.04
DC4	My school has clear policies and guidelines for the safe, legal, and ethical use of technology resources	3.14	1.06

DC5	All technology resources in my school are safeguarded and protected during student use	3.18	1.06
DC6	My school principal provides equal access to technology resources for all students	3.21	1.10
	Digital Citizenship	2.99	.78
	Overall level of principals' technology leadership	3.20	.61

Source: Field Data (2024)

The findings, as shown in Table 3, revealed that, excellence in professional practice construct has the highest mean (M = 3.39; SD = .69), followed by DA (M = 3.31; SD = .67), while digital citizenship construct has the lowest mean (M = 2.99; SD = .78). Among the five constructs used in determining the technology leadership of the respondents' principals, the study found that the principals had moderate level in each of the constructs, that is; VL (M = 3.08), DA (M = 3.31), EP (M = 3.39), SI (M = 3.14), and DC (M = 2.99). The standard deviation of each of the constructs was less than 1, suggesting that the responses among the respondents were homogenous (i.e., small variations in respondents' opinions). Overall, results indicate that principals have a moderate level (M = 3.20; SD = .61) of technology leadership. This implies that principals of basic schools within the Adjen-Kotoku circuit in the Ga West Municipality have a moderate level of TL. This shows the commitment of principals in their efforts to enhance technology use in their schools by teachers to improve students' learning. Also, the study found that teachers within the Adjen-Kotoku circuit believe that their principals have demonstrated their technology leadership by providing a moderate level of VL, DA, EP, SI, and DC. The teachers revealed that their principals involve them in the planning process for using technology in the school, provide adequate support to facilitate the use of technology in their teaching and learning activities, encourage them to use technology frequently and effectively in teaching to improve students' learning, and provide them with high-quality professional development to support the TI to enhance student learning.

The findings suggest that principals are moderately successful in modelling technology use and fostering a supportive culture, but fall short in articulating compelling visions and promoting ethical technology practices, both of which are essential to inspire and sustain innovation. Similarly, from Rogers' (2003) Diffusion of Innovations Theory, the moderate leadership implies that principals are not fully acting as effective change agents to accelerate adoption, particularly in addressing digital ethics and resource sustainability. The study supports Baiden *et al.* (2023), who also found a moderate level of PTL in their study, but this was not the case for Nawawi *et al.* (2022) and AlAjmi (2022) in the literature. Although the study found that principals demonstrated TL, the level of TL was moderate, but for the findings of both Nawawi *et al.* (2022) and AlAjmi (2022), the level of school PTL were high, respectively. These results highlight contextual challenges such as resource constraints, limited professional development, and weak policy frameworks, underscoring the need for deliberate interventions to strengthen principals' visionary capacity, digital citizenship promotion, and role as transformational leaders who drive systemic improvement and innovation diffusion in schools.

Level of Teachers' Technology Integration

The essence of this research question was to determine the level of TI among teachers at the public basic school level. Table 4 presents the results.

Table 4: Level of Teachers' Technology Integration

No.	Statement	Mean	SD
TU1	I incorporate ICT in the classroom to ensure my students gain 21st-century knowledge	3.77	.84
TU2	I utilise ICT in the classroom to help my students understand and engage with the evolving knowledge economy	3.75	.75
TU3	I apply ICT in the classroom to help my students to critically assess their own values and those of their community	3.64	.89
TU4	I use ICT in the classroom so that my students can combine different media to create appropriate products	3.62	.89
TU5	I integrate ICT in the classroom to foster a scientific understanding of the world among my students	3.69	.85
TU6	I employ ICT in the classroom to facilitate communication between my students and others, both locally and globally	3.70	.88
TU7	I use ICT in the classroom to encourage my students to build knowledge by integrating different areas of the curriculum	3.71	.88
TU8	I implement ICT in the classroom to help my students develop proficiency in the subjects they study	3.73	.85

TU9	I integrate ICT in the classroom to enhance my students' intercultural understanding	3.72	.85
TU10	I use ICT in the classroom to help my students synthesise the knowledge they have gained	3.71	.85
TU11	I incorporate ICT in the classroom to enable my students to apply the knowledge they have acquired	3.70	.84
TU12	I employ ICT in the classroom to help my students plan and manage curriculum-related projects	3.65	.92
TU13	I use ICT in the classroom to facilitate independent learning, allowing students to learn at their own pace, in their own time, and from their chosen location	3.61	.89
TU14	I apply ICT in the classroom to promote collaborative knowledge-building among my students	3.65	.93
TU15	I incorporate ICT in the classroom to engage my students in ongoing curriculum activities	3.68	.85
TU16	I use ICT in the classroom to raise students' awareness of the societal implications of ICT-driven global technologies	3.77	.78
TU17	I employ ICT in the classroom to enable my students to participate in formative and/or summative assessments	3.69	.91
TU18	I use ICT in the classroom to help my students develop a deeper understanding of the topics they study	3.73	.88
TU19	I integrate ICT in the classroom to motivate my students to complete curriculum-related tasks	3.67	.87
TU20	I use ICT in the classroom to support and enhance my students' learning processes	3.80	.83
	Overall level of teachers' technology integration	3.70	.64

Source: Field Data (2024)

As shown in Table 4, the findings revealed that the mean values of all the items assessing teachers' technology integration were greater than 3.4, suggesting that the respondents demonstrated agreement with the performance of these behaviours within their schools. With respect to the individual items, "I use ICT in the classroom so that my students are able to support their learning process" obtained the highest mean (M = 3.80; SD = .83). This implies that teachers understand the support that ICT provides to students' learning, and actively incorporate it into classroom activities. Conversely, the item "I use ICT in the classroom so that my students are able to be involved in independent learning through access according to their own pace, time, and place" obtained the lowest mean score (M = 3.61; SD = 0.89). Despite being the lowest, this mean still reflects a high level of technology integration, indicating that teachers effectively guide students in using ICT for self-directed learning. Overall, the study found that the respondents have a high level (M = 3.70; SD = .64) of technology integration. This suggests that the teachers within the Adjen-Kotoku circuit in the Ga West Municipality actively integrate technologies into instructional activities in their respective basic schools. The teachers' high level of TI is supported by the findings that they use ICT in the classroom to help students gain knowledge of the 21st century, to make students aware of the implications of ICT-based global technology towards society, and to help students become skilled in the subject they are studying. Also, the teachers' use of ICT in the classroom confirms the suggestion that incorporating technologies into teaching can enhance students' learning and empower them to engage in a digitalised society (Mayer, 2020).

The study found that teachers in Ghanaian public basic schools demonstrate a moderately high level of technology integration, with ICT predominantly used to support learning, develop 21st-century skills, and engage students in the knowledge economy. While these practices reflect progress, they suggest that ICT use remains functional rather than transformative. From the lens of Transformational Leadership Theory, this indicates that principals may provide some intellectual stimulation and support, but do not fully inspire innovative, vision-driven applications of technology. Consistent with Rogers' (2003) Diffusion of Innovations Theory, teachers' practices reflect an early majority stage of adoption rather than widespread institutionalised use. The study supports the findings of A'mar and Eleyan (2022), which indicated that the teachers' level of TI was high. The level of teachers' TI was also revealed to be high in AlAjmi (2022) and Nawawi *et al.* (2022), respectively. Although the study's findings confirmed the findings of A'mar and Eleyan (2022), AlAjmi (2022), and Nawawi *et al.* (2022), the obtained mean value was lower than the mean values of these studies in the literature. Unlike this study, the overall mean values of A'mar and Eleyan (2022), AlAjmi (2022), and Nawawi *et al.* (2022) were 4.20, 4.15, and 4.27, respectively. This may be likely due to infrastructural constraints, limited professional development, and weak visionary leadership. These findings underscore the need for principals to strengthen their transformational leadership behaviours and act as effective change agents

to accelerate the diffusion and deepen the impact of technology integration in Ghanaian schools.

Influence of School Principals' Technology Leadership on Teachers' Technology Integration

The research objective aimed to measure the extent to which PTL contributes to TTI. The independent variable was PTL (i.e., VL, DA, EP, SI, and DC). In contrast, the dependent variable was teachers' technology integration. The study specifically assessed the extent to which variations in TTI can be attributed to variations in constructs of TL demonstrated by school principals. Prior to the regression analysis, tests for normality, multi-collinearity, and auto-correlation of data were checked. The results are shown in Tables 5, 6, 7 and 8.

Table 5: Test for Normality

	TTI	**VL**	**DA**	**EP**	**SI**	**DC**	**PTL**
Mean	3.700	3.082	3.313	3.391	3.135	2.987	3.198
5% Trimmed mean	3.753	3.040	3.321	3.404	3.138	2.991	3.188
Std. Dev.	.637	.764	.672	.695	.845	.781	.610
Median	3.850	2.929	3.333	3.500	3.250	3.000	3.184
IQR	.35	1.14	.89	.88	1.25	1.17	.76
Skewness	-1.724	.737	-.164	-.293	.144	-.006	.338
Kurtosis	3.920	-.276	-.185	-.250	1.294	-.341	-.041
Kolmogorov-Smirnov[a]:							
Statistic	.233	.122	.096	.073	.120	.067	.088
Df	198	198	198	198	198	198	198
Sig.	.000	.000	.000	.013	.000	.030	.001

Visionary leadership (VL), digital age learning culture (DA), excellence in professional practice (EP), systemic improvement (SI), and digital citizenship (DC)

Source: Field Data (2024)

As presented in Table 5, the mean-median analysis indicates that the mean value of PTL (M = 3.20) and TTI (M = 3.70) in comparison with their median value of PTL (Mdn = 3.18) and TTI (Mdn = 3.85), respectively, differ slightly. This indicates that the variables (PTL and TTI) are approximately not normal. This was also confirmed by the Kolmogorov-Smirnov test of normality, which suggests that variable data is not normally distributed if $p < .05$. The Kolmogorov-Smirnov results (sample size ≥ 50) were used because the study's sample size is > 50. From Table 5, all the Kolmogorov-Smirnov sig. values for the variables showed $p < .05$; therefore, the variables or constructs are not normally distributed.

Table 6: Model Summary

Model	**R**	**R Square**	**Adjusted R Square**	**Std. Error of the Estimate**	**Durbin-Watson**
1	.435	.189	.168	.581	1.730

a. Predictors: (Constant), DC, EP, DA, VL, SI

b. Dependent Variable: Teachers' technology integration,

Source: Field Data (2024)

Table 7: ANOVA

Model		**Sum of Squares**	**Df**	**Mean Square**	**F**	**Sig.**
1	Regression	15.116	5	3.023	8.957	.000[b]
	Residual	64.807	192	.338		
	Total	79.922	197			

a. Dependent Variable: TTI

b. Predictors: (Constant), DC, EP, DA, VL, SI

Source: Field Data (2024)

Table 8: Multiple Regression Coefficients

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	2.396	.236		10.145	.000		
	VL	-.187	.079	-.224	-2.375	.019	.475	2.105
	DA	.173	.092	.183	1.890	.060	.451	2.219
	EP	.120	.082	.131	1.462	.146	.523	1.912
	SI	.067	.073	.090	.926	.355	.452	2.211
	DC	.229	.073	.281	3.145	.002	.528	1.893

a. Dependent Variable: Teachers' technology integration

Source: Field Data (2024)

Concerning the assumptions, both predictor(s) and dependent variables were not normally distributed. According to Kumari and Yadav (2018), data that is not normally distributed can be analysed using regression when some of the regression assumptions (i.e., multi-collinearity, auto-correlation) are met. The value for Tolerance (VL = .48, DA = .45, EP = .52, SI = .45, DC = .53) and VIF (VL = 2.11, DA = 2.22, EP = 1.91, SI = 2.21, DC = 1.89) (see Table 8) indicated that there was little or no multi-collinearity. According to Gaur and Kumar (2009), a tolerance value > .1 and a Variance Inflation Factor (VIF) < 10 are considered acceptable. Also, there was little or no auto-correlation (Dublin-Watson = 1.73) (see Table 6). This is because a Durbin-Watson value that lies within 1.5 to 2.0 is an acceptable range (Hair *et al.*, 2010).

The multiple regression revealed that there is a positive relationship (R = .44) between PTL and TTI. The findings indicated $F(5,192) = 8.96$, $p < .001$, $R^2 = .19$ at .05% significance level. The p-value of .001 indicates that there is a statistically significant influence of PTL on TTI; therefore, the null hypothesis is rejected. The coefficient of determination (R^2) from the model means that PTL accounted for 19% of the explained variability of TTI in the classroom; therefore, the model is significant. As shown in Table 8, the regression model was constant $\beta = 2.396$ ($t = 10.145$, $p < .001$), indicating that even when the predictors are held constant, teachers' technology integration would be 2.396. Therefore, if the respondents perceived that the principals lacked effective technology leadership, they would still have some level of technology integration.

Also, the findings from Table 8 showed that in terms of the PTL constructs, not all the constructs had a significant influence on TTI. Visionary leadership ($\beta = -.224$, $t = -2.375$, $p = .02$), and Digital citizenship ($\beta = .281$, $t = 3.145$, $p = .002$) significantly influence TTI. This implies that a unit change in VL and DC would result in a -.224 and .281 change in the level of TTI. Moreover, Digital age learning culture ($\beta = .183$, $t = 1.890$, $p = .06$; $p > .05$), Excellence in professional practice ($\beta = .131$, $t = 1.462$, $p = .15$; $p > .05$), and Systemic improvement ($\beta = .090$, $t = .926$, $p = .36$; $p > .05$) did not significantly influence TTI. Additionally, the Adjusted R^2 is an estimate of effect size, which is .17, denoting a very small effect size, based on Sawilowsky's (2009) classification of effect size. The estimated regression equation for predicting the relationship between PTL and TTI is given as follows:

Teachers' technology integration (TTI) = 2.396 - .224(VL) + .281(DC)

The findings of the study affirm that principals' technology leadership significantly shapes the extent to which teachers integrate technology in their classrooms, consistent with Transformational Leadership Theory, which emphasises the role of leaders in inspiring vision, modelling innovation, and supporting change. The significance of visionary leadership and digital citizenship suggests that while articulating a clear technology vision and promoting ethical digital practices can encourage adoption, a vision that is not matched with adequate resources and follow-through may undermine teacher commitment. From the perspective of Rogers' (2003) Diffusion of Innovations Theory, this underscores the importance of leadership in moving teachers from functional adoption toward deeper, transformative use of technology. The study supports the findings of Thannimalai and Raman (2018) and Nawawi *et al.* (2022), who found that PTL has a positive and significant effect on TTI. Likewise, the findings of the study support AlAjmi (2022), who revealed that principals' digital leadership have a positive impact on TTI; therefore, principals' digital leadership play a significant role in TTI. Moreover, the findings of the study are echoed by A'mar and Eleyan (2022), who found a significant and positive relationship between digital citizenship and TTI.

Regarding visionary leadership, although the study found a significant relationship, just like A'mar and Eleyan (2022), the standardised coefficient was negative ($\beta = -.224$), unlike A'mar and Eleyan (2022), where it was positive ($\beta = .073$). Additionally, the study's findings on DA, EP, and SI in relation to their influencing effect on TTI were not supported by A'mar and Eleyan (2022). This is because A'mar and Eleyan (2022) revealed that these PTL constructs (i.e., DA, EP and SI) have a significant

and positive influence on TTI. Collectively, the findings suggest that principals must go beyond articulating a vision to actively model digital responsibility, provide sustained professional learning opportunities, and create enabling environments that accelerate the diffusion of innovative practices among teachers.

CONCLUSION

The study concluded that principals of basic public schools within the Adjen-Kotoku circuit in the Ga West Municipality have a moderate level of TL. The principals of basic schools within this educational circuit are showing leadership with respect to facilitating the use of technology in their respective schools. Accordingly, it is concluded that teachers saw their principals as being effective in demonstrating VL, DA, EP, SI, and DC within their respective schools. This implies that the basic school principals possess competencies to facilitate and ensure technology use by teachers, students, and administrative staff within their schools. This could lead to improvement in teachers' teaching competence, an increase in students' competencies, and quality education. With regard to the technology integration of teachers, the study concluded that teachers within basic public schools in the Adjen-Kotoku circuit in the Ga West Municipality are highly effective in integrating technology in the classroom. This implies that the teachers possess a great deal of technological knowledge, skills and attitudes to use in teaching and learning activities and to ensure effective implementation of the standard-based curriculum (SBC). This has the potential to improve students' learning and the quality of education.

Finally, the study concluded that school PTL positively influence TI of the teachers. Accordingly, the study concluded that among principals' technology leadership characteristics, which were measured, only VL and DC are significant factors that influence teachers' technology integration. Therefore, principals should ensure improvement in other measures like DA, EP, and SI, which were not found to be significant factors that influence the TI of teachers.

Recommendations

The study recommended that school principals participate in seminars, workshops, and technology-focused professional development programmes to enhance their knowledge, skills, and attitudes towards technology leadership. It is recommended that, due to rapid technological changes, teachers should participate in frequent training and workshops so that they can continue to demonstrate effective technology integration through developing more advanced knowledge and skills on the use of technologies in their classroom interaction with their students. It is also recommended that the MoE, in partnership with GES, should ensure that principals demonstrate high levels of technology leadership that would continue to enhance technology integration among teachers. Frequent monitoring and evaluation of principals' performance and teachers' technology integration should be carried out to inform targeted interventions and policy adjustments.

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