



DIGITAL SELF-ASSESSMENT TOOL FOR PROMOTING ICT INTEGRATION IN  
GHANA'S PRIMARY SCHOOLS

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By Bernice Yawa Tsitsia

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Approval of the Thesis

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## Abstract

# DIGITAL SELF-ASSESSMENT TOOL FOR PROMOTING ICT INTEGRATION IN GHANA'S PRIMARY SCHOOLS

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The introduction of ICT in educational institutions is largely accepted as a decisive stimulus to the achievement of learning performance and better pedagogical efficiency at the global level. National policies in the Ghanaian context promote the use of ICT in all levels of formal education; however, there is limited substantive empirical data that explains its use at primary school level, especially in development of basic digital skills. This gap of evidence hinders policymakers, administrators and practitioners from detecting context-specific obstacles and establishing interventions that are specific. Whilst digital self-assessment tools are empirically tested and proven to be effective in assisting teacher professional development in the context of other settings, their use in Ghanaian primary education receives little academic focus. In line with this, the current paper intends to achieve dual purpose; to investigate the present condition of ICT integration in Ghanaian primary schools, and to design an empirically grounded and theoretically based prototype of Digital Self-Assessment Tool (DSAT). The study combined a survey of 335 primary school teachers with semi-structured interviews of ten teachers and educational authorities using a convergent mixed-method design. Statistical analysis of quantitative data was performed, and qualitative data were analyzed through content and thematic analysis. Triangulation was used to integrate both datasets. The findings outline the disproportionate ICT integration in primary schools which has been constrained by infrastructural factors, varying accessibility to professional

growth, and varied teacher confidence levels. Although the frameworks; TAM, the DOI theory, and TPACK, provided useful explanatory tools, they were insufficient when implemented separately. Important mediating variables such as availability of infrastructure, prolonged professional development, institutional support and workload demands were identified as critical factors in translating theory into classroom practice. The research presents teacher-informed prototype of DSAT, which shows possibilities of operationalizing empirical results and theoretical frameworks into a formative design artefact. This prototype is an initial steppingstone towards further validation and scaling which depends on pilot testing and fine-tuning. The study offers evidence-based policy suggestions on observing ICT competencies and presents feasible implications on developing reflective, self-managed professional learning among educators. Further proposed future research to pilot the DSAT in varied situations and test the longitudinal effects of the practice on teaching and learning.

## Declaration

I declare that this thesis has been composed solely by myself and that it has not been submitted, in whole or in part, in any previous application for a degree. Except where stated otherwise by reference or acknowledgment, the work presented is entirely my own.

## AI Acknowledgment

I acknowledge the use of artificial intelligence (AI) tools that supported specific aspects of this dissertation. ChatGPT (<https://chat.openai.com>) and Perplexity (<https://perplexity.ai>) were primarily used for proofreading, language refinement, and assistance in identifying current literature sources. For instance, typical prompts included: “*provide me with recent academic literature on...*” and “*proofread this section for clarity without altering meaning.*” Additionally, Grammarly (<https://app.grammarly.com>) and QuillBot (<https://quillbot.com>) were employed as writing assistants for grammar checking and minor phrasing adjustments during drafting. These tools complemented, but did not replace, my own critical engagement with the literature, methodological rigor, or interpretation of findings. I express my appreciation for their role in enhancing the clarity and presentation of this work.

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## Dedication

This dissertation is lovingly dedicated to my dear parents, Mr. Godwin Yao Tsitsia and Madam Regina Vlidzo Tsitsia, and to my cherished children, Dina, Semanu, Seraph, and David.

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## List of Abbreviations

BI	Behavioral Intention
DigCompEdu	Digital Computer Education
DLP	Digital Literacy Programme ()
DSAT	Digital Self-Assessment Tool
DLP	Digital Literacy Programme
DOI	Diffusion of Innovation
DSAT	Digital Self-Assessment Tool
ESP	Education Strategic Plan
GES	Ghana Education Service
HRM	Human Resources Management
ICT-CFT	ICT Competency Framework for Teachers
ICT	Information and Communications Technology
ICT4AD	ICT for Accelerated Development
ICTED	Information and Communications Technology in Education
ICTs	Information and Communications Technologies
IT	Information Technology
KG	Kindergarten
LMS	Learning Management Systems
LMICs	Low- and middle-income countries
MOE	Ministry of Education
LMS	Learning Management Systems
OLPC	One Laptop Per Child

PEOU	Perceived Ease of Use
PLC	Professional Learning Community
PU	Perceived Usefulness
SISOs	School Improvement Support Officers
SEL	Social-Emotional Learning
SPSS	Statistical Package for the Social Sciences
SSA	Sub-Saharan Africa
TAM	Technology Acceptance Module
TDC-S	Teachers' Digital Competences Scale
TEL	Technology-enhanced learning
TEL	Technology-Enhanced Learning
TPACK	Technological Pedagogical Content Knowledge
TPB	Theory of Planned Behavior
UI	User Interface
UNESCO	United Nations Educational, Scientific and Cultural Organization
UTAUT	Unified Theory of Acceptance and Use of Technology
OECD	Organization for Economic Co-operation and Development

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## CHAPTER 1: INTRODUCTION

### 1.1. Study Background

Primary education is the basis of the formal learning process, which influences the cognitive, social, and emotional development of children. It determines the foundation of literacy and numeracy as well as builds socio-emotional competencies of collaboration, resilience, and creativity that are essential in lifelong learning and engagement in complex societies (Black et al., 2021; Nilfyr and Ewe, 2025). The meta-analytical data prove that quality early education experiences are beneficial in promoting attention, language, reasoning, and socio-emotional growth (Mondi et al., 2021). Besides that, primary-level interventions on social-emotional learning (SEL) have been found to enhance emotional regulation, classroom behavior, and academic performance, especially during the support of participatory pedagogies and positive classroom climates (Wang et al., 2020; Hosokawa et al., 2024). Primary education, thus, serves two purposes: it establishes the basis of academic knowledge and the cognitive, social, and digital literacies needed in the 21st-century realities.

ICT has emerged as one of the primary sources of educational innovation in the global system. ICT-enhanced learning fosters interactive, inquiry-based learning pedagogies that are learner-centered and promote better engagement and learning processes (Tondeur et al., 2017; Voogt et al., 2016). ICT integration within education systems, including Finland, Singapore, and Estonia, is well-structured in the curriculum and educator professional development pathways, which facilitates literacy, computational thinking, and higher-order problem-solving abilities development (Haleem et al., 2022; van der Vlies, 2020). In this regard, ICT integration in primary

education goes beyond the development of digital skills to change the way learners learn, think, and cooperate.

The role of effective teacher preparation, continuous professional growth, and institutional promotion of effective ICT use is constantly emphasized in research. Effective programs focus on practical training, peer mentoring, and communities of practice that are based in school, which develop teacher confidence and flexibility (Taole, 2024; Paetsch et al., 2023; Liu et al., 2024). UNESCO also emphasizes the idea that ICT application in early education must conform to cognitive, social, and emotional development of children and the evidence confirms that properly designed digital tools promote collaboration, formative assessment, and personalized learning (Antoninis et al., 2023; Hajovsky et al., 2020; Kaminskienė et al., 2023).

Although it has the potential that has been demonstrated, ICT integration in primary education has been unequal, especially in low- and middle-income countries (LMICs). Variations in infrastructure, unstable electricity supplies, poor internet connections, and lack of teacher training remain some of the biggest obstacles to the meaningful and sustained use of ICT (Buabeng-Andoh, 2019; Van Deursen & Van Dijk, 2020; Abedi et al., 2024). Even though such regional initiatives as Kenya Digital Literacy Programme, Smart Classrooms, and Gauteng Online in South Africa have increased access, there are still concerns regarding teacher preparation, disproportionate distribution of resources, and insufficient pedagogical change (Langat, 2020; Gitih, 2024). These observations have shown that the successful ICT integration should be systemically supported by going beyond the infrastructure to involve teacher development and context-sensitive implementation plans.

Ghana is not an exception to these global and regional tendencies. Around the turn of the millennium, the government presented ICT-centered policies, such as the ICT for Accelerated

Development (ICT4AD) framework and the Education Strategic Plan (2018–2030), which focuses on using technology as an instrument of improving access, equity, and quality in the education system (ICT4AD, 2003; MoE, 2019). More recent interventions, such as the “One Teacher One Laptop initiative”, do reinforce an even stronger policy determination around technology-based education. Regardless, the implementation of these policies into the consistent classroom practice is still rather uneven, with the primary level being the area where the basic skills are developed. Infrastructural shortage, low internet access in schools in rural areas, insufficient ICT facilities, and limited access to professional growth of teachers are always recorded as long-term obstacles in empirical studies (Nyarko et al., 2021; Asare et al., 2023). Correspondingly, integration of ICT in Ghanaian schools is often not applied in a way that enables the change of pedagogical practice, but at the administrative level or in some basic uses of Information and Communication Technology (Zaman et al., 2023; Manu et al., 2024).

According to recent reviews done by the Africa Education Watch, the state of ICT infrastructure in the basic schools in Ghana was dire, and at the close of the 2022/2023 academic year, a mere 15% of the public primary schools and 13% of the public Junior High Schools (JHS) had functional ICT infrastructure (Africa Education Watch, 2024). The availability of electricity, which is a critical requirement for ICT integration, is also poor; according to the EMIS-based estimates, 44% of primary schools and 63.9% of JHS were connected to the national grid as of 2020 (Africa Education Watch, 2024; Tsapali et al., 2021). The complementary NGO reports based on national statistics also indicate that computers to teach and learn can be used in approximately 3.5% of schools at the primary level, which indicates severe shortages in digital devices (Impress Nova, 2025). The rural and deprived districts experience even greater imbalances in their provision of functional ICT facilities, with as few as 2% of basic schools in rural districts having functional

ICT facilities, unreliable electricity, lack of internet connectivity, and technical support greatly undermining the uptake of ICT (Africa Education Watch, 2025; Jacobs Foundation, 2020).

Another issue is associated with the digital competence and preparedness of teachers. Even though national policies see ICT-based pedagogy, empirical research still demonstrates that most basic-school teachers only have basic ICT proficiencies and lack confidence in using digital tools to deliver classroom tasks (Abroampa et al., 2025; Soh, 2020). In Ghana, a study in the Krachi East Municipalities revealed that teachers at basic schools exhibit basic knowledge of ICT and that most teachers need a lot of support to meaningfully integrate ICT in instruction (Soh, 2020). Similar research findings show that although teachers show favorable views on technology, their pedagogical uses of ICT are low because of insufficient training, insufficient infrastructure, and poor power supply (Baako & Abroampa, 2024; Wakil et al., 2023). The results indicate that the systemic constraints in the infrastructures and the lack of professional development of teachers remain a barrier to successful ICT integration in the Ghanaian basic education sector.

The other highly important gap is associated with the lack of systematic possibilities for teachers to systematically reflect on their ICT competencies. The international literature emphasizes that the value of self-assessment instruments is attributed to assisting teachers to assess their competencies, determine the opportunities to develop professionally, and align their practice with the requirements of the curricula (Kaminskiené et al., 2023; Meyer et al., 2021). Nonetheless, there is no digitally context-specific self-assessment instrument available in Ghana among primary school teachers to date, and teachers do not have a systematic reflection and competency development instrument.

Collectively, both Ghana and international studies highlight the existence of two needs, which are (a) systematic and context-sensitive knowledge of how ICT is being implemented into

teaching and learning at the primary level and (b) the capacity of a locally-fit reflective mechanism that allows teachers to measure their digital capability and recognize where they can grow professionally. Although the existing literature demonstrates the significance of such a reflective tool, no context-appropriate digital self-assessment tool is now available to Ghanaian primary teachers. The current research addresses this gap by examining the ICT integration practices and suggesting how a prototype Digital Self-Assessment Tool (DSAT) may be designed. The prototype is not piloted or tested during this study, but it represents a preliminary conceptual input, which can be used in the evolution of the prototype and empirical testing. These needs are critical in bridging the policy-practice gap that has existed long before the advent of ICT and helping to justify more effective ICT implementation in Ghanaian primary schools.

## **1.2 Statement of the Problem**

The adoption of Information and Communication Technology (ICT) in teaching and learning has become an international educational agenda, with its integration that is deemed to revolutionize pedagogy, stimulate learner activity, and enhance equitable knowledge access (Antoninis et al., 2023; Selwyn, 2021). It has been proven with high-income settings that long-term ICT implementation to support pedagogy, proper infrastructure, and teacher training will result in the improvement of literacy, collaboration, and digital skills (Voogt et al., 2016; Tondeur et al., 2017; Haleem et al., 2022). The examples of best practices used internationally, including Singapore and Finland, show that coherent policy, strong professional development, and constant monitoring can build digitally rich classroom settings in which students will flourish (Selwyn, 2021; Antoninis et al., 2023).

Nevertheless, in most of the low- and middle-income countries (LMICs), such as Ghana, ICT policy translation into classroom practice is full of endemic obstacles (Buabeng-Andoh, 2019;

Van Deursen & Van Dijk, 2020). Weak infrastructure, poor electricity supply, low internet access, poor access to digital technologies, and inadequate teacher training have all restricted innovation in teaching. Recent studies of the Education Management Information System (EMIS) data and civil society monitoring reports about Ghana show how big these issues are: by the close of the 2022/2023 academic year, an estimated 15% of primary schools and 13% of junior high schools had operational ICT systems, and as of 2020, only 44% of the primary schools and 63.9% of JHSs had access to the national electricity grid (Africa Education Watch, 2024; Ministry of Education, 2022).

On the international front, the 2023 Global Education Monitoring Report by UNESCO also indicates that global coverage of the pedagogical use of the internet by only about 40% of primary schools globally is one of the limitations and connectivity gaps that is prevalent as well, especially in LMICs (Burns, 2023). These structural obstacles lessen the chances to access the basic levels of digital literacy, which children need to engage in the knowledge economy of the 21st century. The government of Ghana has expressed ambitious policies in digital education, the most notable of which is the ICT for Accelerated Development (ICT4AD) framework and the Education Strategic Plan (2018-2030), both of which emphasize the role of technology in facilitating access, equity, and quality (ICT4AD, 2003; MoE, 2019). However, regardless of these intentions, there are still uneven translations of the policy into the long-term classroom practice on the primary level, especially in rural and underserved areas (Asare et al., 2023; Abedi et al., 2024). However, even with these expectations, the transfer of policy into primary-level classroom practice is not even (particularly in rural and underserved communities), regardless of the hopes (Asare et al., 2023; Abedi et al., 2024).

One of the major gaps that exists is the scarcity of empirical information on the adoption of ICT in Ghana's primary schools. A lot of the available research has focused on institutions at secondary and tertiary levels, and little of the systematic evidence has been registered about how ICT is being incorporated into the precursor phase of learning, where curiosity, cooperation, and digital literacy are initially formed (Nyarko et al., 2021; Abedi et al., 2024). With recourse to the available sector analyses, it can be noted that the distribution of ICT facilities and internet connectivity is extremely uneven between the regions and school types, with rural and deprived districts being particularly underprivileged in terms of access to electricity, computers, and connectivity (Africa Education Watch, 2024; Baako & Abroampa, 2023). In the absence of context-rich evidence on such a level, interventions will run a risk of inadequately fitting the classroom realities, thus strengthening the policy-practice gap and weakening the attempts at equitable digital education.

Another equally critical gap is the lack of a context-based digital self-assessment tool that could be used by teachers in Ghanaian primary schools. Digital self-assessment tools have been proven by international research to improve reflective practice, teacher confidence, and provide a possibility for specific and competency-focused development (Hajovsky et al., 2020; Kaminskiene et al., 2023; Meyer et al., 2021). Nevertheless, Ghana does not have such a structured instrument to motivate primary school educators to assess their ICT skills, determine professional learning requirements, and correlate practice with the curricular and policy expectations (Instefjord & Munthe, 2017; Syathroh, 2022; Nguyen & Habok, 2024). This is especially relevant in the light of national attempts to institutionalize ICT teacher competencies in certain frameworks including ICT Competency Framework of Teachers in Ghana which mandates practically oriented tools to facilitate classroom-level implementation (Dzidzornu & Xu, 2025).

Theoretically, the existing gaps can be enlightened in terms of three complementary frameworks. The Technological Pedagogical Content Knowledge (TPACK) framework (Mishra and Koehler, 2006) demonstrates the overlap between content, pedagogy, and technology and refers to the skills that teachers need to possess to integrate ICT into their practice. The Technology Acceptance Model (TAM) (Davis, 1989) puts more emphasis on the perceived usefulness and ease of use as the determinants of technology adoption. Meanwhile, the theory of diffusions of innovations (DOI) (Rogers, 2003, as cited in García-Avilés, 2020) takes a broader institutional and social perspective on ICT adoption, and how innovations permeate educational systems. Together, these frameworks not only guide the design of a digital self-assessment tool but also give analytical provisions of the ICT adoption behavior of teachers in primary schools in Ghana.

Without addressing those two issues, that is, the lack of empirical information on the integration of digital components at the primary level and the lack of a systematic, context-specific self-assessment system, the digital education agenda in Ghana stands a chance of stalling. These omissions are a threat to widen disparities between urban and rural education, affect the establishment of basic digital literacy, and limit the capacity to train young citizens of a knowledge-based economy (Asante, 2025; Kelly & Rutazihana, 2024).

This research work thus addresses these urgent gaps in two senses. First, it explores the status of ICT integration practices in Ghanaian primary schools based on a convergent mixed-method design. Second, it constructs a prototype of a locally relevant Digital Self-Assessment Tool (DSAT) based on theory and supported by empirical evidence. As a prototype to pilot and refine in the future, the DSAT is meant to be a diagnostic tool that will enable teachers to achieve reflection, evaluation, and improvement of their ICT integration practices. It is necessary to reiterate that, as far as the current thesis is concerned, the development of the DSAT is not taken

beyond the prototype phase, no experimental pilot testing or assessment of the tool is conducted, and this validation is flagged as a research gap that needs to be addressed in the future. By these complementary yet constrained contributions of reporting ICT integration practices and the creation of a prototype of the empirically and theoretically based DSAT, the study enables a ground base on which to advance the digital education reform in Ghana, professional development of teachers, and policy initiatives to resolve the unrelaxing digital divide in primary education.

### **1.3 Purpose of the Study**

The purpose of this study is twofold: (a) to examine the current state of ICT integration practices in Ghana's primary schools, and (b) to develop an empirically supported and theoretically based prototype of a Digital Self-Assessment Tool (DSAT) for primary school teachers. These two elements are complementary; empirical investigation of ICT practices of the teachers offers the contextual information needed, informing the design of the DSAT prototype. It is worthwhile to note that the DSAT that is generated in this study is a prototype that is to be piloted and refined in the future; there is no empirical assessment and usability test performed within the framework of this thesis. The research is, therefore, informed by the following specific objectives:

#### **1.3.1 Research Objectives**

1. To assess the current state of ICT integration practices in Ghana's primary schools.
2. To investigate contextual, pedagogical, and institutional considerations that may impact the perception and attitude of teachers towards the use of a Digital Self-Assessment Tool (DSAT).
3. To discover teacher-informed design specifications of a DSAT, specifically with respect to pedagogical and technological suitability to the classroom practice, and usability and accessibility in low-resource primary school settings.

4. To develop a prototype Digital Self-Assessment Tool (DSAT) based on the empirical evidence and guided by the TPACK, TAM and DOI models to respond to the contextual realities of ICT integration in Ghanaian primary schools.

These objectives are deliberately set toward developing prototypes, and not toward evaluation, and it aligns with the methodological scope and theoretical purpose of the study.

#### **1.4 Research Questions**

1. What is the current state of ICT integration practices in Ghana's primary schools?
2. What factors could influence teachers' perceptions and attitudes toward adopting a digital self-assessment tool (DSAT)?
3. What teacher-informed design needs, specifically with respect to pedagogical and technological congruency to classroom practices, usability, and accessibility in low-resource primary schools, can inform the design of a Digital Self-Assessment Tool (DSAT)?
4. How could the prototype Digital Self-Assessment Tool (DSAT) be designed to reflect Ghana's educational realities while drawing on empirical and established conceptual frameworks (TPACK, TAM, and DOI)?

#### **1.5 The Dual Purpose of the Study and Its Methodological Operationalization**

This study has a dual purpose: (a) to examine ICT integration practices in Ghanaian primary schools, and (b) to design a prototype of a Digital Self-Assessment Tool (DSAT) to support teachers' reflective practice. Despite their difference, these two purposes are methodologically related; as scholars of mixed methods state, the insights of empirical research provided by quantitative and qualitative strands can be systematically synthesized to help formulate educational intervention (Creswell & Clark, 2017; Fetters et al., 2013).

The research, hence, has operationalized its twofold aim as a convergent mixed-methods design where quantitative and qualitative data will be gathered and evaluated together and subsequently joined to produce a holistic interpretation of ICT practices and teacher requirements (Teddlie & Tashakkori, 2012). Under this method, the quantitative side explores the extent, trends, and predictors of ICT integration, and the qualitative side offers a more in-depth analysis of the views, the reported experiences, and the situational issues, as well as the perceived importance of a possible self-assessment tool among teachers. This form of integration is consistent with the best practice of mixed-methods, in which dataset integration increases the depth of interpretation and design-oriented results (Creswell & Creswell, 2017; Johnson et al., 2019).

The pedagogical, technological, and usability requirements that influence the DSAT prototype are a direct result of the empirical insights that are created by both strands. The application of empirical evidence in the design is consistent with the provisions of design-based research, which emphasize both theory-guided and contextual development based on real educational contexts (McKenney & Reeves, 2025). The DSAT prototype can achieve contextual relevance and responsiveness to the needs of teachers by connecting the empirical insights with design specifications. However, the present study is limited to prototype development without conducting empirical piloting, testing or validation. These are listed among priorities in future research (McKenney & Reeves, 2021; Mejeh et al., 2025).

## **1.6 Nature and Significance of the Study**

This section describes the general nature and significance of the study. It initially provides clarity to the nature of the research by placing it in the frames of ICT integration, teacher professional development, and design-oriented educational research in primary school education. It then recognizes the importance of the research by summarizing its empirical and conceptual

values, especially in relation to understanding the ICT integration practices in primary schools in Ghana and informing the development of a empirically informed and theoretically grounded DSAT prototype. Together, these subsections prove the appropriateness of the study in terms of scholarship, practice, and policy, and rightly place the DSAT within the domain of design artefact, as opposed to a tested intervention.

### **1.6.1 Nature of the Study**

To respond to the research questions of the study, a convergent mixed-methods design was applied. Such a design allows collecting both quantitative and qualitative data in parallel, where each strand is analyzed individually and combined in the process of interpretation. This method helps to develop a rich and context-based knowledge of ICT integration in Ghanaian primary schools (Creswell & Clark, 2017; Schoonenboom & Johnson, 2017). The justification of this design is its ability to provide both the breadth and depth of statistical and experience-based data to capture the patterns and contextually specific details of practice, challenges, and needs of teacher development. The respondents include in-service trained teachers and headteachers of the Ghanaian primary schools and key personnel of the Ghana Education Service (GES), particularly, Human Resource Management (HRM) staff, Information Technology (IT) coordinators, and School Improvement Support Officers (SISOs). These groups were chosen due to their close role in the delivery of instruction, implementation of ICT policy and professional development of the teachers and thus they are in a good position to give information about existing practices as well as to give contributions towards the creation of the Digital Self-Assessment Tool (DSAT) prototype. The DSAT in the context of this study is created to a prototype level and is expected to serve as a template to be used in piloting and validation later.

The data is collected using a multi-part questionnaire (consisting of closed- and open-ended questions) and semi-structured interviews. This two-tier approach offers quantitative and qualitative descriptions to answer the research questions. The study's theoretical frameworks, TPACK, TAM, and DOI, informed the design of the questionnaire and interview protocols such that both the strands can capture competencies, attitudes towards adoption, and contextual conditions of ICT integration of teachers. The quantitative responses were handled using descriptive statistics, such as the standard deviations, measures of central tendency, and measures of reliability. Content analysis was used to analyze open-ended responses of the questionnaire, whereas interview transcripts were analyzed through thematic analysis according to the structured protocol provided by Cernasev and Axon (2023). The comparison matrices and complementarity analysis were used to integrate the two strands, supporting the process of triangulation and strengthening the interpretive validity (Fetters and Freshwater, 2015). Such a methodological approach ensures that the results are reliable and have a contextual relevance and hence more applicable to the development of the DSAT. As a result, methodological design predicts rigor, contextual sensitivity, and practical relevance, which are the qualities that are considered critical in applied educational research (Ivankova & Plano Clark, 2018; Creswell & Creswell, 2017).

### **1.6.2 Significance of the Study**

Even though Information and Communication Technology (ICT) is broadly placed as a driver of enhancement of teaching and learning, there is still a lack of understanding of its practical implementation in primary education in numerous developing education systems. In the Ghanaian context, there is limited empirical evidence that captures the ways ICT is implemented in the primary school classrooms and how teachers are assisted to acquire the corresponding competencies. This research thus closes two interdependent gaps: the lack of empirical evidence

on the ICT integration practices at the Ghana's primary school level and the lack of a context-specific Digital Self-Assessment Tool (DSAT) that facilitates reflectivity in the professional practice of teachers. The significance of the study is justified in the following way:

To begin with, the study offers empirically based information that can be used in guiding educational leadership, planning, and policy formulation by documenting the applications of ICT in the normal classroom environment, as well as defining contextual barriers to successful integration. Available literature suggests that one of the risks that ICT policies may face at the implementation phase is insufficient data and context mismatch on the school level (Abedi et al., 2024; Nyarko et al., 2021). The results of the study can thus help the Ghana Education Service (GES) and the Ministry of Education to refine the ICT-related professional development initiatives; resource allocation plans as well as infrastructural investments in a manner that is responsive to the real needs and classroom realities of teachers.

Also, the prototype of the Digital Self-Assessment Tool (DSAT) represents the innovative, design-based input to the sphere of teacher professional development. According to previous studies, structured self-assessment may support reflective practice and improve professional self-efficacy and encourage instructional improvement (Kaminskienė et al., 2023; Kyndt et al., 2016). Within this study, the DSAT is theorized as a research-supported prototype that aims to allow teachers working with primary school learners to consider their competencies in ICT and their personal learning goals, as well as monitor their professional development over time. Its ability to be contextual, inexpensive, and able to adapt to low-resource contexts means that the tool can also supplement rather than act as a substitute for the formal training of an existing professional development structure, as well as aid teacher agency in the context of localized capacity-building efforts.

Furthermore, the study contributes to theoretical knowledge of ICT adoption in education. It provides a complex view on the adoption of ICTs by teachers based on Technological Pedagogical Content Knowledge (TPACK), the Technology Acceptance Model (TAM), and the Diffusion of Innovations (DOI) theory. TPACK previews the combination of pedagogical, technological and content knowledge, and Technological Acceptance Model (TAM) emphasizes the perceived ease of use and perceived usefulness as the key elements of technology adoption, at the same time the Diffusion of Innovations (DOI) model contextualizes the process of technology adoption with the wider social and institutional context (Jiménez Sierra et al., 2023; Lund, 2025; Wohlfart & Wagner, 2025). Combining these views and implementing them into a primary-school setting in a low- and middle-income nation, the study offers a theoretically based methodology that could potentially be useful to researchers and practitioners who work in similar educational settings.

Finally, the study is relevant in academic, policy, and professional spheres. A systematically reflective framework can help teachers in their professional development and the incorporation of ICT. Policy analysts can have access to context-sensitive empirical data, which can help to enhance the development of national programs, such as ICT4AD and the Education Strategic Plan. Curriculum developers and school administrators can use the findings to organize professional learning programmes based on the competencies portrayed by the teachers and the contextual constraints. The study's DSAT was conceived as a theoretically based and empirically informed diagnostic prototype, and as a blueprint of future piloting, refinement and validation but not an end-solution. The study provides a background input into the digital learning program in Ghana through creating context-related evidence and converting it into a design-oriented product. Beyond that, it provides knowledge that can be used in the continued work to enhance teacher professional

development and promote context-sensitive ICT integration in the country's primary school education (Tondeur et al., 2021).

### **1.7 Assumptions**

This study was based on several assumptions through which the findings were interpreted. First, it was assumed that the respondents answered the survey and interviewed questions with fairness and accuracy, thus representing their real practices and expectations of ICT integration. Self-reported information is prone to social desirability infection however, the threat was mitigated by applying anonymity, confidentiality, and neutral phrasing of items, which has been shown to reduce distortion of responses (Murdoch et al., 2014; Wang & Zang, 2025).

Further, the study had an assumption that the respondents were well-literate and possessed the basic digital competency to understand the research tools and provide meaningful answers. By acknowledging the difference in ICT proficiency, it was assumed that respondents would be able to perceive the items the same way.

Also, there was an assumption that the chosen sample was a sufficient representation of the teachers in the context of the study and that the experiences of the participants were a reasonable reflection of the overall systemic situation. This supposition corresponds to the standard methodological procedures in educational research when purposive or convenience sampling is used to produce context-specific knowledge (Adeoye, 2023).

In conclusion, the study assumed a theoretical framework of guiding the inquiry, i.e., Technological Pedagogical Content Knowledge (TPACK), the Technology Acceptance Model (TAM), and the Diffusion of Innovations (DOI) frameworks to be relevant to the context of the primary school in Ghana. Although the frameworks were developed in high-resource settings, the

existing literature proves the frameworks to be flexible and applicable to diverse educational settings (Tisdell et al., 2025).

### **1.7 Delimitations**

Delimitations refer to the purposeful boundaries which are laid by the researcher with the aim of narrowing down the scope of the investigation. The scope of this investigation has been carefully limited to include only teachers in public primary schools and a group of GES officials within a given area in Ghana, therefore allowing a detailed, contextually based analysis of the practices involving the integration of information and communication technology (ICT). The geographic specificity of the focus suggests that the derived findings should not be statistically extrapolated to the rest of the national educational system; instead, this sort of narrowing is endorsed by conventional standards in educational research, where it is considered that the richness of the contextual comprehension is more important than its breadth (Coker, 2022).

The study also narrowed down to focus on trained teachers and headteachers in the field, and relevant education officials, therefore, deliberately omitting students, untrained teachers, pre-service teachers, and parents. This choice was closely in line with the dual aim of the study to investigate the ICT integration practices and to develop a contextually appropriate prototype of DSAT. According to Tisdell et al. (2025), intentional sampling of groups of participants is a method used to strengthen the consistency between the research questions and the methodological approach at the expense of including more diverse perspectives.

Methodologically, the study was limited to the use of surveys and semi-structured interviews as the major data-collection tools. The intentions of the study were to record the perceived practices, perceptions and experiences of the respondents, so classroom observations,

experimental trials and intervention-based approach were deliberately avoided as the study did not intend to measure classroom behaviour enacted or the resulting outcome of the instruction.

Lastly, the model of the DSAT was purposely limited to the prototype based on empirical evidence and theoretical background. Neither did the artefact undergo piloting or refinement through the scope of the research because the main aim was to conceive and describe a context-sensitive design and not to perform implementation or evaluation. This is a delimitation that not only indicates the research design-oriented nature of the study, but also provides a clear base for future piloting, validation, and refining.

### **1.8 Publications Arising from the Thesis**

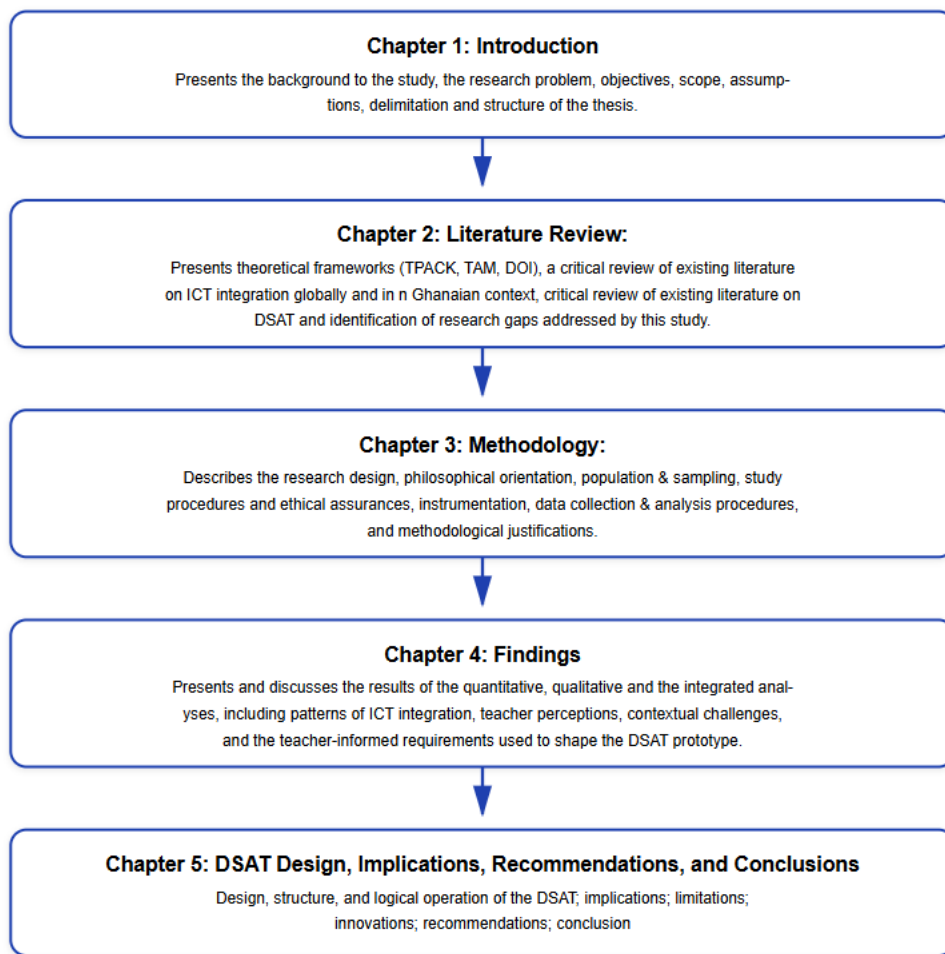
The following manuscripts have been developed from this thesis and submitted for publication:

1. [Bernice Yawa Tsitsia, Dr. Joyce Gikandi-Gitau]. (unpublished). *Assessing ICT Integration in Ghanaian Primary Schools: A Case of Contextual Factors that Shape this Practice in Developing Nations*. Submitted to *Acitya: Journal of Teaching and Education*.
2. [Bernice Yawa Tsitsia, Dr. Joyce Gikandi-Gitau]. (unpublished). *ICT Integration in Ghanaian Basic Schools: A Mixed-Methods Study of Teacher Competence and Systemic Challenges*. Submitted to *UGraSP*.
3. [Bernice Yawa Tsitsia, Dr. Joyce Gikandi-Gitau]. (unpublished). *Towards a Composite Theoretical Framework for ICT Integration: Adaptation of TPACK, DOI, and TAM in Ghana's Primary Schools*. Submitted to: *Africa Education Review*

Additional manuscripts are in preparation based on the design and conceptualization of the DSAT prototype.

## 1.9 Thesis Outline

Figure 1 provides a thought-reflective overview of the structural and conceptual development of the thesis, and it explains how the study moves forward in relation to the formulation of the problem and the contribution of knowledge. The figure shows the logical progression of the chapters, starting with the articulation of the research context, purpose, and guiding questions and continuing with the critical discussion of the relevant theoretical frameworks and empirical literature supporting the research. It also describes the methodical decisions behind the research design and the creation of empirical evidence and consequently, the findings are presented and interpreted. Finally, the figure presents the design process of the DSAT, and a critical analysis of the study implications, limitations, and contribution to theory, practice, and policy. In general, the figure showcases the consistency of the research process and emphasizes the contribution of each chapter to a cumulative and systemic development of knowledge regarding ICT integration in educational settings.

**Figure 1***Thesis outline*

## CHAPTER 2: LITERATURE REVIEW

### 2.1 Overview

The chapter provides a comprehensive review of literature pertinent to ICT integration in education, especially in primary school education and the contextual factors that affect the use of technology in the Ghanaian classroom environment. It begins with the analysis of three key theoretical frameworks that form the foundation of the study: Technological Pedagogical and Content Knowledge (TPACK), Technology Acceptance Model (TAM), and Diffusion of Innovation (DOI) theory, and provides a critical justification of their joint implementation despite their respective limitations. Emphasis is also placed on the emergent scholarship about teacher identity construction within the pedagogical scheme of TPACK implementation, and the behavioural and systemic antecedents of ICT integration as outlined by constructs of TAM and DOI. These theoretical paradigms, when combined, present a conceptual prism of multi-dimensionality, by which the current study interrogates teacher digital competence. The chapter proceeds with a discussion of the global and national patterns in ICT integration with an emphasis on convergence and divergence between the international trends and the Ghanaian setting. To compare the international results with the Ghana-specific ones, the comparative synthesis table (Table 3) is provided, explaining the structural and pedagogical gaps connected to ICT competencies and preparedness. It further analyses the empirical literature on the problem of ICT integration in Ghana and similar low-resource situations after considering an international review, thus identifying the gaps that have serious implications for policy and practice. These areas encompass infrastructure, curriculum alignment, teacher preparedness, professional development and the long-standing policy-practice gap that remains an obstacle to the implementation of ICT in the lower grades of school education.

The review also considers the latest academic research that examines the importance of self-assessment in the context of reflective practice, professional competence development, and its correspondence to continuing professional development (CPD). The insufficiency of Ghana-specific digital self-assessment tools used by teachers is given a focus, and this gap has been considered a driving factor that led to the creation of the Digital Self- Assessment Tool (DSAT) prototype outlined in this paper. Lastly, the chapter provides an intensive review of the extant empirical studies undertaken in the field, identifying methodological, contextual, and conceptual gaps.

## **2.2 Theoretical Frameworks**

This study uses three interconnected theoretical frameworks to examine ICT integration in primary education: the Technological Pedagogical Content Knowledge (TPACK) framework, the Diffusion of Innovations (DOI) theory and the Technology Acceptance Model (TAM). Each of the frameworks explains a different aspect of the phenomenon:

- a. TPACK (Mishra and Koebler, 2006) assumes that successful technology-enhanced teaching must involve the simultaneous mastery of the content, pedagogical and technological knowledge (CK, PK, TK).
- b. DOI (Rogers, 2003) describes the step-like procedures through which innovations, like digital tools, are communicated, adopted and spread throughout social and institutional systems.
- c. TAM (Davis, 1989) focuses on end-user beliefs about the usefulness and ease of use of technology, both of which influence attitude and behavioural intentions towards adoption and use.

Together, these frameworks provide a complex analytical approach to the examination of the depth of ICT integration in early-year classrooms, understanding the process of instructors

adopting their use, and the utilization of digital self-assessment tools. This review begins with a deep analysis of the TPACK model that offers a sound conceptual framework upon which to analyze the intersection of technology, pedagogy and disciplinary content in promoting effective didactic actions.

### **2.2.1 Technological Pedagogical Content Knowledge Framework (TPACK)**

Technological Pedagogical Content Knowledge (TPACK) is a framework that was originally defined by Mishra and Koehler (2006) as an expansion of Pedagogical Content Knowledge (PCK) described by Shulman (1986), but adds the aspect of technology, which plays a crucial role in effective teaching. It is an inclusive model of understanding effective integration of technology by teachers in relation to subject matter and pedagogy (Koehler et al., 2017; Mishra & Koehler, 2006).

The framework was developed due to the trend of greater adoption of digital technologies in the classroom, which required broadening the classic PCK and considering the knowledge of digital tools possessed by teachers (Voogt et al., 2016). Technology integration necessarily entails teachers balancing three primary areas, which are interdependent:

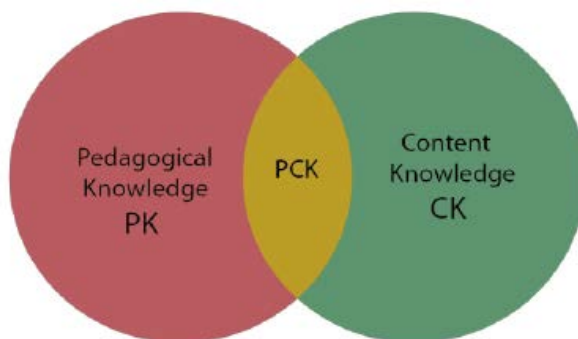
- a. Content Knowledge (CK): Knowledge of the topic that is taught,
- b. Pedagogical Knowledge (PK): Knowledge about the processes of teaching and learning,  
and
- c. Technological Knowledge (TK): Digital skills and abilities.

These spheres are dynamic and not independent of each other. The initial acronym TPCK was changed to TPACK to depict the holistic nature of the knowledge areas, emphasizing that the “A” signifies the whole package created by their interaction (Thompson & Mishra, 2007; Koh & Liang, 2017).

Effective ICT integration is achieved not through independent technical expertise but through overlaps of interrelation among CK, PK, TK, which leads to technology-enhanced instruction in contextual forms (Mishra, 2019; Tzafilkou et al., 2023; Jiménez Sierra et al., 2023). It is based on the pioneering PCK model by Shulman, who made it clear that successful teaching is not about subject-matter knowledge but about contextually responsive pedagogy. Figure 2 shows the PCK model developed by Shulman, which became the basis of TPACK development.

## Figure 2

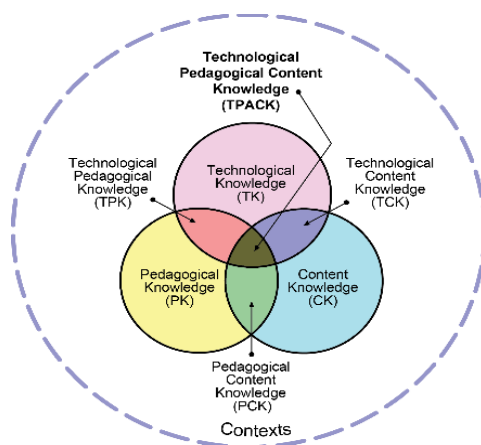
### *PCK Model*



*Image source: Adapted from Mishra and Koehler (2006).*

### **2.2.1.1 TPACK Framework: Core Knowledge Domains and Intersections**

The Technological Pedagogical Content Knowledge (TPACK) framework, developed by Mishra and Koehler (2006), makes a detailed conceptual model to explain the complex knowledge that teachers should have to effectively implement technology in the instructional practice. This framework is based on three areas of knowledge, (CK, PK, and TK) dynamically overlapping with each other, and providing teachers with the knowledge and tools to design and carry out technology-enhanced pedagogical experiences in contextually relevant ways. The TPACK model is presented in Figure 3, illustrating the overlap and integration of these critical knowledge bases.

**Figure 3***TPACK Model*

*Image source: Adapted from Mishra and Koehler (2006)*

These intersecting fields of knowledge highlight the fact that successful integration of technology does not occur through the isolated expertise in any one of these areas, but through the capacity of the teacher to fluidly merge content, pedagogy and technology to meet the needs of a particular instructional context (Koehler and Mishra, 2008; Schmid et al., 2024). The review below describes these domains and their overlaps and how the domains mutually guide the potential of teachers to design and implement technology-enhanced lessons.

### 1. Pedagogical Knowledge

Pedagogical Knowledge (PK) is the knowledge of teachers in terms of instructional strategies, classroom management, assessment, and learner development that goes beyond subject-specific knowledge. It provides the basis for designing student-centered instruction that meets the diverse needs of the students. Studies emphasize PK to a critical role in the successful integration of technology, because high levels of pedagogical competence allow meaningful learning to be undertaken through technology-enhanced learning (Saharuddin et al., 2025). The existing empirical evidence suggests that pedagogical knowledge is frequently linked to the educational

background of teachers, and the higher the qualifications, the greater the pedagogical competence (Li et al., 2022). Intended instructional design that takes into consideration cultural, cognitive, and socio-emotional diversity is also supported by robust PK (König et al., 2020). The ability to align sound pedagogy and digital tools within the educational contexts with technological enrichment is critical in the achievement of substantive learning outcomes (Voithofer et al., 2019). In addition, teachers who have well-developed pedagogical content knowledge (PCK) are more efficient in the application of ICT to deliver differentiated instruction because they can modify instruction to individual learners (Tan et al., 2022). Pedagogical practice is constantly changing, so constant reflection and professional development are necessary. Intensive efforts to strengthen PK led to better quality of instruction, longer-term pedagogical innovation, and better student learning outcomes (Louws et al., 2018; Prenger et al., 2019).

## **2. Content Knowledge**

Content Knowledge (CK) refers to an intense and extensive mastery of the subject area taught by a teacher. It includes factual information, conceptualizations, procedural abilities, and the disciplinary modes of inquiry and reasoning that are typical of the content domain (Mishra & Koehler, 2006; Koehler et al., 2017). In addition to accuracy, CK requires teachers to have the ability to interpret and package content in ways that are comprehensible, meaningful and developmentally relevant to their students. The high-quality CK is a key aspect of the successful pedagogy since it has a direct impact on the understanding, interest, and academic achievement of students (Tan et al., 2022). Teachers who have strong CK are well placed to detect critical concepts, anticipate misconceptions among students and implement informed instructional decisions. In Technological Pedagogical Content Knowledge (TPACK) framework, CK plays a critical role in the development of Pedagogical Content Knowledge (PCK), the specialized knowledge that

develops at the intersection of CK and Pedagogical Knowledge (PK) (Mishra & Koehler, 2006). PCK helps educators transform subject matter into pedagogical representations that are pedagogically powerful to help students learn and grasp knowledge in a deep manner (Tan et al., 2022; Kholid et al., 2023). In turn, strong CK does not just focus on consolidating subject-specific knowledge but also provides the necessary ground base that undergirds substantial integration of pedagogy and technology in technology-based teaching and learning settings

### **3. Technological Knowledge**

Technological Knowledge (TK) refers to the understanding and skills of teachers in various areas of technology, which involve the ability to purchase, select, edit, and adopt both existing and new digital tools in the classroom (Mishra & Koehler, 2006; Koehler et al., 2017). TK goes beyond primitive technical expertise by including an advanced understanding of technological affordance and limitations and provides the educator with the ability to make evidence-based choices about the use of such tools in the instructional practice (Willermark, 2018). Adept TK is not merely utilitarian in its nature; it represents a dynamic, flexible attitude towards technology that effectively takes into consideration the pedagogical, sociocultural, and ethical aspects (Petko et al., 2018). Teachers with strong TK have a greater ability to engage in critical evaluation of technology and anticipate its implications on classroom dynamics and use it to enhance learner engagement, creativity, and meaningful learning, rather than enacting digital objects onto the traditional pedagogical approach (Saubern et al., 2020; Chai et al., 2019). TK serves as a central foundational domain in the TPACK framework. It promotes the development of composite knowledge structures including Technological Pedagogical Knowledge (TPK) and Technological Content Knowledge (TCK), through the dynamic interaction with both Content Knowledge (CK) and Pedagogical Knowledge (PK) and leads to transformative and contextually sensitive use of technology in the learning context (Mishra & Koehler, 2006; Kholid et al., 2023). Therefore, with a good grounding

in TK, teachers are equipped to work in the rapidly changing technological environment, thus facilitating innovative and learner-based teaching methods.

#### **4. Pedagogical Content Knowledge**

Pedagogical Content Knowledge (PCK) refers to the specialized ability of educators to transform subject-matter content into meaningful, accessible and developmentally relevant learning experiences of learners (Shulman, 1986; 1987; 2013). It serves as a bridge between Content Knowledge (CK) and Pedagogical Knowledge (PK), thus enabling teachers to predict common student misconceptions and challenges, choose powerful representations, analogies, and examples, plan instructional models and sequences based on the prior knowledge and developmental level of students, and adjust teaching models to meet individual needs and learning styles of students (Celik, 2023).

PCK is not a content and pedagogy construct consisting of content and pedagogy added together; it is a whole, domain-specific type of professional knowledge that provides coherent, scaffolded teaching and learning and encourages deep conceptual learning in academic fields (Jin & Schmidt-Crawford, 2022). Recent conceptualizations emphasize the complexity of PCK that involves collective (shared by educators), personal (individual teacher interpretations), and enacted (realized in classroom practice) levels (Carlson et al., 2019). It builds up gradually through the continuous teaching experience, reflective practice, professional learning in groups, and deliberate teacher education programs (Akerson et al., 2017; Jin & Schmidt-Crawford, 2022). Longitudinal studies show that PCK is not an accidental byproduct of general coursework but must be explicitly developed, especially through the explicit combination of content and pedagogy to maintain instructional quality, especially in the sciences (Akerson et al., 2017).

In Technological Pedagogical Content Knowledge (TPACK), PCK represents the pedagogical background on which Technology Knowledge (TK) is embedded. Such an integration

makes it possible to build overarching Technological Pedagogical Content Knowledge (TPACK) and facilitates transformational and technology-enhanced teaching/learning (Mishra and Koehler, 2006; Kholid et al., 2023).

## **5. Technological Content Knowledge**

Technological Content Knowledge (TCK) refers to the understanding of the modalities by which technology may be used to represent, investigate, and augment specific subject-matter content by the faculty members (Mishra & Koehler, 2006; Koehler et al, 2017). It captures a comprehension of how digital tools, materials, and programs align to the conceptual structures, forms of representation, and methods of practice of a particular field, and thus allows instructors to re-design content in ways that make it more accessible, interesting, and conceptualized to learners.

TCK places more emphasis on content-based synthesis than on technology-based incorporation. Teachers with strong TCK deliberately choose and adjust technologies that reflect the inherent nature of the discipline, thus contributing to a more profound conceptual understanding, visualization of abstract concepts, and alternative representations that traditional approaches to practice might fail to achieve (Koh & Liang, 2017; Mouza et al., 2017). As an example, mathematics instructors often use dynamic geometry packages, graphing tools, or simulation platforms to help students to visualize and manipulate abstract ideas that can only be represented in static form.

Empirical studies regularly demonstrate that high levels of TCK are represented by a deliberate, pedagogically knowledgeable choice of technology that disseminates ideas of discipline, reorganize knowledge provision, and stimulates a transformational learning result in comparatively dissimilar topics (Koh, 2019; Saubern et al., 2020; Tunjera & Chigona, 2020; Rahmadi et al., 2023). In the TPACK model, TCK represents a key channel between Content

Knowledge (CK) and Technological Knowledge (TK), and thus forms the cornerstone of the building of Technological Pedagogical Content Knowledge (TPACK) and facilitative substantive subject-specific technological incorporation into teaching and learning.

## **6. Technological Pedagogical Knowledge**

Technological Pedagogical Knowledge (TPK) in the TPACK framework describes the knowledge that teachers have about the nature of the interaction between technology and pedagogy to influence and change the process of teaching and learning (Koehler & Mishra, 2016; Voogt & McKenney, 2017). It transcends technical skills to involve the capability of assessing the pedagogical opportunities and limitations of technologies and coordinates them with instructional plans and learning objectives. High TPK allows educators to apply technology intentionally to improve and innovate teaching instead of introducing tools to the already existing practices (Almerich et al., 2021; Saubern et al., 2020). Infrastructures, institutional supports, and cultural norms are some of the factors that affect the translation of TPK into practice by teachers. Studies indicate that despite the conceptual knowledge of teachers about the concept of TPK, systemic and organizational conditions are crucial to successful implementation, which emphasizes the integration of technology as a group and not an individual process (Luik et al., 2019; Tomczyk, 2024). There are important implications of TPK to teacher education and professional development. TPK programs with a specific intent to incorporate technology serve instructional innovation and make technology a driver of pedagogical purposes. These are more effective strategies that enable teachers to plan student-centered learning, accommodate active learning, and address the different needs of learners (Farjon et al., 2019; Tondeur et al., 2020; Foulger et al., 2017). Lastly, TPK focuses on flexibility and constant professional development. High-TPK teachers are more flexible in technology-intensive classes and can more easily incorporate new tools as the situation changes (Koh, 2019; Habibi et al., 2023; Jang & Tsai, 2018). Studies have

shown that TPK is not gained in short-term or isolated training but through the sustained, reflective, and iterative process of professional learning and can thus result in more effective and enduring technology integration (Wang et al., 2018; Scherer et al., 2018; Lachner et al., 2019).

## **7. Contextual Knowledge**

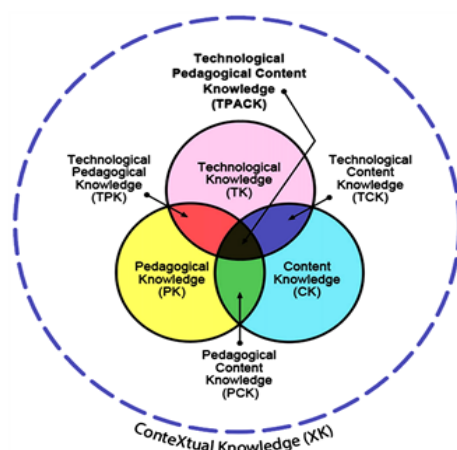
Even though the TPACK framework can be a valuable tool in the analysis of the connection between technology, pedagogy, and content, researchers believe that it cannot be complete without the direct consideration of context. Another invaluable addition is the insertion of Contextual Knowledge (XK), which acknowledges that ICT integration has been determined by the institutional policy, cultural expectations, and the infrastructural conditions (Ait Ali et al., 2023; Mishra, 2019). In this view, technology use is not only personal competency, but it is embedded in both organizational and socio-cultural settings. Evidence indicates that contextual influences may facilitate or limit the use of technological and pedagogical knowledge, which explains the necessity to address systemic constraints, policy priorities, and cultural norms to help teachers implement ICT in a meaningful way (Mackinnon, 2017; Rosenberg & Koehler, 2015; Chai, 2019; Mishra, 2019). Such a focus on context is consistent with the international frameworks including DigCompEdu, which emphasizes that the process of sustainable introduction of technology must be supported at an institutional/systemic level, rather than just individual teacher competence (Caena & Redecker, 2019). Likewise, it has been shown that, in the absence of organizational alignment, even prepared teachers have impediments to the implementation of technology-rich pedagogy (Tondeur et al., 2020).

In the updated TPACK models, XK tends to be represented as a general layer that impacts technology, pedagogy, and content, as it is so widespread in the formation of teacher knowledge and practice (Mishra, 2019; Swallow & Olofson, 2017). With context positioning as core and not peripheral, this broadened framework recognizes that sustainable ICT integration needs the

sensitivity of institutional, environmental, and cultural circumstances under which teaching takes place, as shown in Figure 4.

**Figure 4**

*Revised version of the TPACK Model with XK*



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### 2.2.1.2 Teacher Identity Formation within TPACK Adoption

In recent research, Technological Pedagogical Content Knowledge (TPACK) framework has been extended beyond a solely cognitive model of teacher knowledge to include how it is integrated with teacher professional identity, which covers dynamic self-perception, beliefs, values and roles that teachers create in their navigation of digitally mediated classrooms (Ruyang & Hedi, 2025; Taopan et al., 2025). In this sense, embracing TPACK implies the acquisition of knowledge, as well as an ongoing process of negotiating identity, through which teachers will adjust technological innovations to their own pedagogical self-concept.

Empirical evidence shows that the professional identity of teachers, which includes beliefs regarding teaching, self-efficacy using digital technologies, and innovativeness inclination, have a significant impact on the way in which they construct and apply TPACK in practice (Golzar et al.,

2025; Su, 2023). It is usually the case that, despite teachers being knowledgeable enough in all facets of technological knowledge (TK), pedagogical knowledge (PK) and content knowledge (CK), their readiness and confidence in using technology meaningfully is often contingent on the compatibility with their educator self-concept (Nazari & Seyri, 2023; Foreman-Brown et al., 2023).

In line with this, TPACK implementation is also being envisaged as a two-fold process, which involves the construction of knowledge and identity. Educators who consider themselves as inquiry teachers or as technology-positive educators tend to explore and integrate new digital technologies into their instruction (Ozden et al., 2024). On the other hand, when people feel that technology is not in line with their own teaching philosophy or when they have identity dissonance, they can oppose the ICT integration even when they have enough competence (Golzar et al., 2025; Foreman-Brown et al., 2023). The interpretive aspect of the issue is especially relevant to the resource-restricted environment, like the primary education system in Ghana, where structural obstacles are overlaid with the professional beliefs and values of the staff (Adu-Marfo & Asamoah, 2025; Asamoah et al., 2022).

Integrating identity-focused extensions of TPACK, this study acknowledges that the Digital Self-Assessment Tool (DSAT) should not merely support reflection on the domains of knowledge of teachers; however, it should also be able to help teachers reflect on how beliefs, values, and professional self-understanding contribute to and are influenced by their ICT practices. This method corresponds to recent literature that states that to integrate ICT sustainably, one should focus on both the construction of knowledge and the negotiation of identity (Taopan et al., 2025; Ruyang & Hedi, 2025).

### 2.2.1.3 Criticism Associated with TPACK Model in Literature

Although the Technological Pedagogical Content Knowledge (TPACK) framework has remained influential across many areas of educational technology and teacher education, it has been subjected to sustained academic criticism in various aspects. Among the most mentioned issues is one that is associated with conceptual clarity and construct limits. According to scholars, differences between the seven areas of knowledge are commonly unclear, and the boundaries between technological pedagogical knowledge (TPK), technological content knowledge (TCK), and TPACK itself are usually ambiguous, which leads to ambiguity in the interpretation and implementation (Kholid et al., 2023; Schmid et al., 2024). This imprecision of delineation makes theory refinement harsher and empirical exploration more difficult.

The second significant critique is on the issues of measurement and assessment. The discipline has mostly been dependent on self-report measures that are subject to social desirability bias, over-reporting and lack of uniform validity across samples (Zhang & Tang, 2021; Schmid et al., 2024). The lack of standardized, reliable, and objective measures, e.g. classroom observations or performance-based tests, has hindered the empirical validation of the framework.

Third, the translation of TPACK to practical classroom practice is still an issue. Despite the conceptual strength of the model, the in-service teachers often have a challenging time applying it in the real-life instructional context, which can be explained by a lack of long-term professional development, institutional support, and conflicting curricular imperatives (Kihzoza et al., 2016; Durukan et al., 2023). In the absence of any long-term scaffolding, TPACK is likely to be little more than an idealistic hypothetical concept instead of a radical pedagogical instrument.

Also, TPACK interventions have been criticized as fueling surface-level adoption of technology, as opposed to deep, transformative integration. Evidence-based research has also

shown that educators can emphasize the use of tools (e.g., the use of digital devices in performing conventional tasks) rather than using technology to achieve authentic learning experiences or pedagogical progress (Durukan et al., 2023; Rosenberg & Koehler, 2015).

Lastly, the framework has been criticized due to its narrow focus on contextual, sociocultural, and developmental influences. The critics point to the fact that it does not pay enough attention to the institutional culture, the presence of infrastructure, policy contexts, and the dynamic character of the teacher knowledge in the constantly changing technological settings (Rosenberg and Koehler, 2015; Schmid et al., 2024). Other researchers also argue that TPACK is merely a conceptual expansion of Pedagogical Content Knowledge (PCK) model by Shulman but is not a theoretical innovation (Lee et al., 2022).

To address these criticisms, scholars have advocated increased conceptual specificity, the creation of more effective and varied measurement methods and increased incorporation of contextual variables to maximize the practical usefulness and theoretical soundness of the framework (Schmid et al., 2024; Kholid et al., 2023).

#### **2.2.1.4 Justification for Using TPACK**

Despite the critique regarding the conceptual accuracy, theoretical vagueness, and procedural sparsity of the TPACK framework in presenting a multidimensionality of teacher knowledge necessary to successful technology integration, scholars recurrently confirm its enduring relevance in capturing the variety of teacher knowledge (Gatete, 2025; Schmidt et al., 2024). These criticisms often emphasize the challenge of defining and measuring the seven TPACK constructs and the tendency of the framework to infrequently depend on self-report measures, thus leading to the presence of bias (Schmid et al., 2024; Gonscherowski & Rott, 2023).

Despite these issues, recent systematic reviews confirm that TPACK is one of the most comprehensive and pedagogically based models to analyze the digital competence of teachers that can be empirically applied in different fields of education (Zou et al., 2022; Kholid et al., 2023). Nonetheless, through the existing controversies, TPACK remains a powerful and versatile conceptual framework that guides research and practice in a variety of educational settings, even in developing states in Africa (Njiku et al., 2023). Its main strength lies in its holistic portrayal of the intersections between content knowledge, pedagogical knowledge and technology knowledge, thus offering a critical basis of understanding the decision-making processes of teachers in technology-mediated learning settings.

Moreover, the most recent studies show that TPACK can be understood not only as a system of knowledge but also as a tool of reflection that allows teachers to theorize about the interrelation between their pedagogical identities, beliefs, instructional objectives, and technology options (Ozden et al., 2024; Wen et al., 2024). This reflexive aspect makes the framework highly relevant to the current research that aims at developing a prototype Digital Self-Assessment Tool (DSAT) based on the interests and conceptual foundations of teachers, thus allowing the primary school teachers in Ghana to explore both their knowledge and professional growth regarding ICT use.

Comprehensively, TPACK inclusion is rationalized in the scope of the present study since it provides a theoretically informed, context-oriented framework of teacher competence analysis, which promotes reflective practice, and pedagogical implications of ICT integration, which are core in the development of the DSAT.

### **2.2.2 Technology Acceptance Model (TAM)**

One of the most powerful models in explaining the adoption and use of technology is the Technology Acceptance Model (TAM) developed by Davis (1986). It highlights that the choice to adopt is typically informed by user perceptions more than just technical characteristics, which provides an understanding of cognitive and behavioral aspects of technology adoption in learning (Christou, 2022; Na et al., 2022).

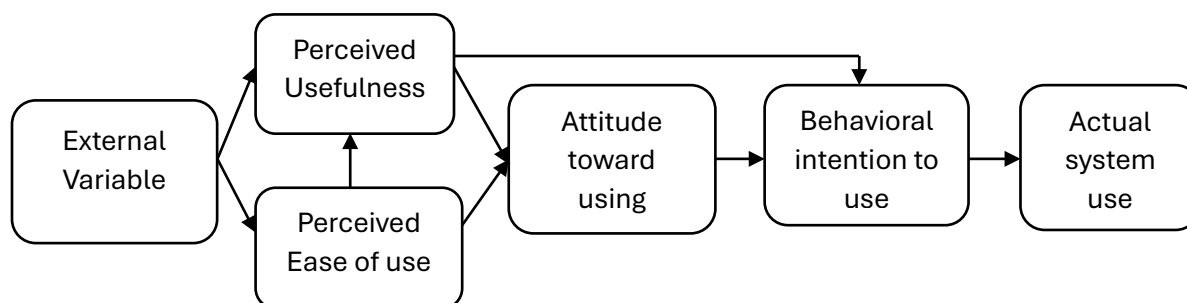
According to TAM, there are two key antecedents of adoption, which are Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) (Brar et al., 2022). PU is a measure of the degree to which a user thinks that technology's job performance can be improved, whereas PEOU is the measure of the degree to which a user thinks that technology can be used without struggles. Collectively, these constructs affect the attitude of the users towards technology, which in turn influences behavioural intention, and ultimately determines actual use (Venkatesh et al., 2016). Within a school setting, instructors would tend to much more readily embrace ICT tools that they regard as useful in both teaching and use and tend to shun those tools that are perceived as having overwhelmingly complicated or insignificant applications.

Despite its extensive use, TAM has been criticized as not focusing on contextual factors. Researchers believe that the model does not fully represent the role of cultural norms, institutional support, infrastructure, and peer dynamics in technology adoption (Aburbeian et al., 2022; Christou, 2022; Na et al., 2022). In low-resource contexts, such as teachers using adoption decisions, the systemic constraints of inadequate infrastructure or insufficient training may limit adoption decisions, whether positively or negatively perceived as useful or easy to use. These criticisms indicate that TAM can be effectively adapted to contextual foundation when used in complicated educational settings. However, TAM continues to be an effective basis of ICT

adoption studies because of its conceptual intensity, empirical strength, and explanatory potential across fields (Brar et al., 2022; Venkatesh et al., 2016). TAM is especially applicable in the case of Ghanaian primary schools in understanding the role of teacher perceptions on their readiness to embrace and continue with the use of ICT. TAM in this research enlightens the uptake of the Digital Self-Assessment Tool (DSAT) by teachers, whereby the usefulness and the ease of use are the most important predictors of implementation. The emphasis on perceptual and attitudinal variables makes TAM supplementary to the systemic view of DOI and the pedagogical integration emphasis of TPACK in terms of offering a comprehensive framework to analyze ICT adoption. Figure 5 provides the visual constructs of TAM.

**Figure 5**

*Technology Acceptance Model*



*Image source: Na, et al., (2022).*

### 2.2.2.1 Perceived Ease of Use and Perceived Usefulness

Perceived Ease of Use (PEOU) is the degree to which an individual thinks that technology could be used with a minimum of effort. In line with the Theory of Planned Behavior, the lesser perceived effort, the higher the possibility of adoption is (Arthur, 2022; Christou, 2022). Teachers in the educational setting are more likely to embrace intuitive technologies that do not require many cognitive or physical efforts. The Technology Acceptance Model (TAM) has shown

empirically that the tools that have been viewed as simple and easy to use are more easily adopted in classrooms (Zafar et al., 2019).

PEOU also has a direct effect on Perceived Usefulness. The convenience of technologies prompts users to appreciate the practical value of the technology, which reinforces favourable attitudes and intention to adopt (Zafar et al., 2019; Aburbeian et al., 2022). This relationship can be further improved by supportive and low-stress teaching environments that can decrease usability barriers and reinforce ease of use and perceived useability (Mailizar et al., 2021).

Perceived Usefulness (PU) is the extent to which people feel a technology would improve their work or professional performance (Arthur, 2022). In the education sector, PU has been closely linked with the perceptions of teachers regarding whether ICT enhances the quality of instruction, student engagement, and classroom efficiency. Researchers also indicate a significant correlation between PU and attitudes towards technology-enhanced learning, and when teachers are aware of the apparent instructional gains, they are more likely to adopt ICT (Alenazy et al., 2019; Aburbeian et al., 2022).

Collectively, PEOU and PU are the most competitive predictors of technology acceptance in the educational setting (Zafar et al., 2019). Even though later studies have expanded TAM to suggest other variables, including self-efficacy, external control, and job relevance, PU and PEOU still make up its conceptual center (Hong et al., 2021). These constructs will be additional cores of this study because the adoption of the Digital Self-Assessment Tool among Ghanaian primary school teachers would depend on the interpreted usefulness of the tool to teachers in their professional development and the perceived barriers to adoption due to the perceived difficulty of the tool to accommodate the existing teaching methods.

### **2.2.2.2 Limitations of the Technology Acceptance Model (TAM)**

Despite the popularity of the Technology Acceptance Model (TAM) in the literature, there are various limitations that have been noted. The model overemphasizes the perceived usefulness and ease of use over such aspects as peer influence, organizational support, and socio-cultural norms that are very influential determinants of adoption in the school and professional community (Ajibade, 2018; Alshammari & Rosli, 2020). TAM was mainly designed to describe individual-level acceptance and is not very effective in understanding collective or systemic adoption processes, which occur in the educational institution where policies, leadership, and organizational culture have a decisive influence.

Another weakness is that TAM does not consider social and environmental factors much. The model underutilizes influencing factors, including peer influence, organizational support, and socio-cultural norms that play a major role in influencing adoption in schools and professional communities by focusing on perceived usefulness and perceived ease of use (Ajibade, 2018; Alshammari & Rosli, 2020). In turn, its predictive validity might be lower in areas where the process of adoption is highly influenced by interpersonal and structural factors.

It has also been argued that TAM is based on subjective variables, especially behavioral intention to use technology as a proxy for actual use of technology. Empirical data indicate that intention may not be consistently converted into long-term or considerable use, and this raises doubts about how the model can help in the real-life adoption patterns, which frequently are iterative and context-specific (Ajibade, 2018).

Also, researchers suggest that TAM is indicative of technological determinism in that it concentrates on technology as a change agent and decreases human agency, resistance, and adaptability. This point of view may provide a simplified understanding of the interaction between

technology and society and underestimate the larger impact of socio-political and cultural factors on acceptance (Ferreira et al., 2022).

Lastly, the generalizability of TAM has been doubted because its fundamental constructs are not always predictive of adoption in all areas. In other settings, like entertainment technologies, people might adopt them based on their enjoyment or social identity instead of perceived usefulness (Ajibade, 2018). To counter these shortcomings, scholars have come up with extensions like TAM2, TAM3, UTAUT, and other models, which have included social influence, facilitating conditions, and organizational factors. These advances are with respect to the long-term significance of TAM and emphasize the necessity of more detailed frameworks to describe the adoption of technology in more multicultural and multidimensional environments.

### **2.2.2.3 Justification for Using TAM**

Technology Acceptance Model is arguably the most used model in studying technology acceptance in education due to its emphasis on both the cognition and behavioral components that determine how users adopt new technologies. It is relevant in determining the extent to which perception of efficacy and usability determines the readiness of educators to use ICT (Manu et al., 2024). These constructs are essential in shaping the pattern of professional development, support systems and institutional policies to respond to the practical context of teachers (Baako & Abroampa, 2024). Consequently, TAM serves as both an explanatory model and a diagnostic instrument for the identification of the long-standing barriers to ICT integration, such as the lack of training, a lack of technical support, and infrastructural limitations (Manu et al., 2024).

Technology Acceptance Model in this study serves as a guideline in the creation of a Digital Self-Assessment Tool. Focusing on PU and PEOU, TAM provides a systematic way of studying the way teachers assess the relevance and manageability of ICT tools. Previous studies justify this

method, Natia and Alhassan (2015) prove that self-reported PU and PEOU among teachers are effective predictors of meaningful ICT implementation. Basing DSAT on TAM, however, guarantees adherence to a theoretically supported model where teacher perceptions are placed at the center of adoption and continuous usage.

Applicability of TAM has also been empirically established in Ghanaian educational settings. Research by Gyamfi (2016) revealed that access to professional training and institutional support significantly contributed to acceptance of technology among pre-service teachers, which supports the relevance of TAM and the impact of contextual factors on the development of perceptions of usefulness and ease of use. Considering the current difficulties in the primary school system of Ghana, such as inequality in the distribution of resources and infrastructural constraints, TAM offers a framework that is theoretically sound and contextually attentive.

Lastly, TAM can be used as a supplement to other theoretical frameworks used in this study, Technological Pedagogical Content Knowledge (TPACK) and Diffusion of Innovations (DOI). Whereas TPACK is concerned with the interaction of technology with pedagogy and content, and DOI is concerned with adoption being embedded within larger social and institutional frameworks, TAM is concerned with the perceptions of the teachers as proximate factors that drive adoption behaviour.

### **2.2.3 Diffusion of Innovation Theory**

The concept of Rogers, Diffusion of Innovations theory (DOI), assumes that technology adoption is a social process in stages that includes the stages of knowledge, persuasion, decision, implementation, and confirmation (Dearing & Cox, 2018). Instead of considering adoption as a technical action, DOI presents it as a behavioral and social phenomenon that can be influenced by communication, interaction, and decision-making in particular settings (Badri et al., 2016). One of

the most notable contributions of DOI is the division of adopters into five groups: innovators (2.5%), early adopters (13.5%), early majority (34%), late majority (34%), and laggards (16%), (García-Avilés, 2020; Zainuddin et al., 2019). These groups have unique risk propensities, responsiveness to evidence and vulnerability to social influence. Innovators and early adopters generally are change agents, and they have their way to persuade others, whereas later adopters may need greater social pressure or institutional support. This distribution is usually modeled as a diffusion curve that is a bell shape as presented in Figure 6.

**Figure 6**

*Diffusion of Innovations model – Adopters Categories*

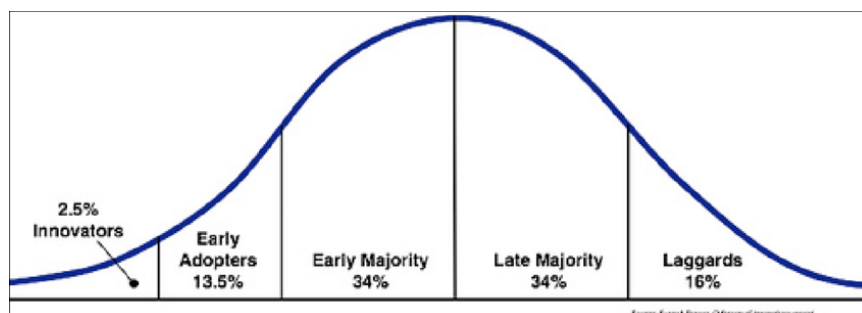


Image source: Wesley Fryer <https://www.flickr.com/photos/wfryer/1342355056/> licensed under CC BY <https://creativecommons.org/licenses/by/2.0/>

DOI provides an informative prism in which educational innovations are unevenly distributed in the social systems. Individual attitudes, peer networks, and contextual conditions have an impact on the adoption process, so the framework may be especially applicable in the education sector where educators serve as key change agents (García-Avilés, 2020). It is important to note that there is diversity in the adopter groups and therefore interventions should be designed to suit the various levels of readiness and to meet the different concerns.

The theory is particularly pertinent in situations where there are institutional inequalities and an imbalanced infrastructural capacity. Research indicates that the DOI is a successful tool to explain the differences in the adoption of technologies in schools and teacher education systems,

where institutional support, access to resources, and cultural norms play a key role (Uzumcu & Acilmis, 2024; Freires & Lopes, 2024). Persistent barriers to ICT integration in Ghana have been analyzed with the help of DOI, illustrating how inequality in infrastructure, alignment of policies and preparedness of teachers determine the results of adoption (Gyamfi, 2017).

DOI application to the Ghanaian primary education would help guide the development of digital self-assessment and professional development programs. Determining the teacher placement in the adopter continuum will allow focused assistance: innovators and early adopters can be offered sophisticated training and leadership opportunities, whereas late adopters and laggards will need support and an instructional value of ICT demonstrated (Boateng et al., 2021; Tusiime et al., 2019). Through this, not only can the adoption pattern be explained, but also context-sensitive approaches can be steered to expedite the spread of ICT and scale the gap between national policy objectives and classroom use.

### **2.2.3.1 Key Elements in the Diffusion Process**

Guided by Rogers' Diffusion of Innovations (DOI) theory, four central elements: innovation, communication channels, the social system, and time shape the adoption and spread of new technologies in schools. These elements do not operate in isolation; rather, they interact in dynamic ways to influence whether, and how effectively, an innovation such as ICT tools or digital self-assessment platforms gains acceptance in educational contexts. When applied to education, these elements help explain why some schools or teachers quickly embrace digital innovations while others resist or adopt them only superficially.

The first element, innovation, refers to the introduction of a new idea, practice, or technology that seeks to solve a problem or improve existing approaches. In the DOI framework, the likelihood of adoption depends not only on the novelty of the innovation but also on the degree to which it demonstrates clear advantages over existing methods, its compatibility with existing

practices, and its perceived usefulness to potential adopters (García-Avilés, 2020). Innovations that are complex or difficult to use often face resistance, while those that are simple, intuitive, and responsive to user needs tend to diffuse more rapidly. In the educational sphere, this means that digital tools must be designed with teachers' professional contexts in mind. For instance, digital self-assessment platforms are far more likely to be accepted when they are user-friendly, flexible, and aligned with teachers' ongoing professional development needs (Kiugu et al., 2021). Conversely, tools that demand excessive training or appear irrelevant to daily teaching practice risk being abandoned. The success of ICT initiatives in schools, therefore, depends heavily on the degree to which the innovation is seen as an enabler of instructional quality rather than an additional burden.

A second critical element is communication channels, which determine how information about innovations is disseminated and interpreted among potential adopters. Rogers argued that communication is central to diffusion, with interpersonal interactions particularly those involving trusted peers or opinion leaders exerting greater influence than mass media in shaping adoption decisions (Miranda et al., 2024; García-Avilés, 2020). In education, this suggests that professional development programs, peer coaching networks, and collaborative teacher communities are more effective in fostering meaningful adoption than top-down directives or impersonal information campaigns (Aivazidi & Michalakelis, 2022). Teachers are more inclined to adopt new technologies when they hear about them from colleagues who can provide practical demonstrations, share authentic experiences, and offer reassurance about challenges. Opinion leaders within schools often function as role models, shaping the attitudes of their peers by endorsing or resisting innovation. This highlights the importance of cultivating teacher leaders and change agents who can champion ICT adoption, translating policy initiatives into trusted classroom practices.

Social system as the third element, underscores that diffusion occurs within specific communities whose structures, norms, and values profoundly shape adoption patterns. In educational contexts, the social system encompasses schools, teacher networks, and broader institutional environments. Palese and Schmid (2022) argue that adoption outcomes are strongly mediated by organizational structures, cultural expectations, and leadership practices. For example, schools where leaders actively support innovation, allocate resources for ICT infrastructure, and encourage collaboration among teachers are far more likely to achieve meaningful technology integration. Empirical studies confirm this, for example a study by Drossel et al. (2017) found that teachers' attitudes toward ICT, their collaborative practices, and the institutional support they received were decisive factors in determining whether digital tools became embedded in classroom routines. Importantly, the social system includes students and parents as well, whose engagement can shape teachers' willingness to adopt technologies. Equitable access to resources and opportunities for collective problem-solving within schools can create a culture of innovation that sustains long-term ICT use. Conversely, schools that lack supportive leadership or operate within rigid, hierarchical structures often experience superficial or fragmented adoption.

Finally, time is a crucial dimension of the diffusion process, reflecting the fact that adoption rarely occurs instantaneously but rather unfolds gradually across distinct stages. Taherdoost (2018) identifies these stages as knowledge acquisition, persuasion, decision-making, implementation, and confirmation, with teachers and institutions typically moving sequentially through them. This temporal element highlights the importance of pacing and continuity in adoption. Research underscores that educators require adequate time to experiment with, evaluate, and integrate new technologies into their teaching practices in ways that feel authentic and sustainable (Guillén-

Gómez & Mayorga-Fernández, 2020). When policymakers and administrators underestimate the incremental nature of this process and impose expectations of rapid transformation, the likely results are frustration, resistance, or only superficial technology use. As Kimmons and Hall (2018) emphasize, teachers must be afforded sufficient opportunities for adaptation and reflection; otherwise, well-intentioned ICT initiatives risk falling short of their intended impact. Moreover, time does not simply refer to duration but also to the historical and developmental context in which adoption occurs. Schools with prior exposure to ICT, for example, may progress more quickly than those encountering digital tools for the first time.

Overall, these four elements demonstrate that the diffusion of educational technologies such as ICT tools and self-assessment platforms is a complex and multidimensional process. Successful adoption depends not only on the inherent qualities of innovation but also on the ways information is communicated, the structures and cultures of the social system in which adoption occurs, and the temporal conditions that shape individual and institutional readiness. When viewed through the DOI lens, ICT adoption in Ghanaian primary schools can thus be better understood as a socially situated process that requires more than the provision of technology. It demands innovations that are usable and relevant, communication strategies that are collaborative and peer-driven, institutional cultures that are supportive and resource-equipped, and timelines that allow for gradual, sustainable change.

### **2.2.3.2 Criticism of the Diffusion of Innovations (DOI) Theory**

The theory of Diffusion of Innovations (DOI) has faced consistent criticism despite its prevalence in terms of assumptions on which it is based as well as the scope of its explanations. One of the key criticisms is that it models adoption as a linear process that is not as complex as is evident in real-world innovation. Empirical research demonstrates that adoption can be very

context-specific, recursive and nonlinear, including a series of experimentations, adaptation, delay and even rejection following early adoption (Sanchez-Prieto et al., 2019; Kamboj & Sharma, 2023). Policymaking, conflicting priorities and teacher capacity often interfere with the orderly sequence that DOI presupposes in educational settings. The other shortcoming is associated with a lack of focus in the theory on contextual influences. Even though DOI does not deny the importance of the social system, it provides weak information about the influence of cultural, economic, and political systems on the process of diffusion (Dedehayir et al., 2017). Studies have shown that institutional policies, school culture, and national economic conditions are strong mediators of technology adoption in education, in which the DOI is underrepresented (Luo et al., 2021). Such detachment from context limits the scope of the theory to developing settings, including Ghana, where infrastructural inequalities, disproportionate teacher training, and incoherent policies play a major role in influencing ICT adoption. DOI has also been criticized as implicitly technologically deterministic. Focusing on innovation as the key force of change, the framework underestimates human agency, resistance, and adaptation when it comes to determining the results of adoption (Ferreira et al., 2022). Practically, teachers rebrand, redesign or remodel technologies to fit classroom scenarios and cultural demands in ways that are not entirely reflected in the framing of DOI. Nevertheless, under critical application, DOI can be useful in the context of innovation diffusion despite these limitations.

Researchers underline that the concept of DOI should be complemented with the frameworks that predict the contextual dynamics and human agency (Camilleri & Camilleri, 2022). The integration is specifically relevant in Ghana, where primary education is exposed to institutional culture, leadership, and resource limitations, and thus ICT integration can enhance the educational environment (Sarfo et al., 2016; Gyamfi, 2017). Critical approach to DOI, thus,

enables deciding to preserve the strengths of the theory but also to overcome its shortcomings, turning it into a useful yet imperfect model to be used in the current work.

### **2.2.3.3 Justification for the Use of the DOI Theory**

The Diffusion of Innovations (DOI) model continues to be significant in the study of technology adoption due to its ability to provide a framework that provides a structured perspective in explaining the mechanism of dissemination of new ideas and practices in the social system. Its definition of innovation features relative advantages, compatibility, complexity, trialability, and observability remains influential in the current studies of digital adoption in schools and other learning settings (García-Avilés, 2020). Recent educational technology research confirms that these properties are primary towards defining whether teachers consider digital devices to be valuable, possible, and consistent with current pedagogical standards (Al-Rahmi et al., 2022; Aboagye, 2021). Consequently, DOI offers a valuable basis for the organizational, cultural, and individual factors enabling or impeding ICT adoption in educational institutions, especially in an environment where the adoption of technologies is informed by the lack of resources, social influence, and institutional practice (Carpenter & Green, 2022).

Despite its long-standing relevance, the Diffusion of Innovations (DOI) framework has been subjected to a consistent wave of criticism due to its linear, deterministic assumptions and its habit of oversimplifying the adoption of technology in schools by being complex, iterative, and social in nature. Recent researchers claim that DOI usually simplifies the contextual, cultural, and organizational processes, especially in low-resource school settings where the adoption patterns are not linear (Greenhalgh et al., 2017; García-Avilés, 2020). In addition, research on digital innovation in educational institutions also indicates that the adoption process of teachers is

predetermined by the local norms, leadership practices, and shared sense-making, which are not described by the classical DOI formulations fully (Carpenter & Green, 2022).

Still, the DOI framework remains a beneficial analytical tool to this study due to various reasons. Mainly, its focus on attributes of innovation offers a clear scaffold to identify the features of a digital self-evaluation tool that can either support or hinder its adoption, such as relative advantage, compatibility, trialability, and complexity, which empirical studies have shown to be connected with the adoption of digital tools by teachers (Al-Rahmi et al., 2022; Aboagye et al., 2021). Second, DOI predicts the central role of channels of communication, social networks, and leadership and power, which are the core of the comprehension of how digital innovations related to ICT are distributed in Ghanaian primary school communities, where the role of peer collaboration and headteacher leadership is a key factor in shaping digital activities (Lomo et al., 2025). Third, the system-level view of the DOI will be a complement to teacher-based models because it will shed light on the wider organizational and cultural statuses, e.g., infrastructural preparedness, normative behaviours, and school climate that determine the use of ICT tools in basic education (McDiarmid & Zhao, 2023).

Notably, the shortcomings of DOI are reduced in this research by its combination with TAM and TPACK. Although DOI contributes to the explanation of the nature of innovations and organizational diffusion dynamics, TAM offers an empirically based explanation of how perceived usefulness and perceived ease of use of teachers influence their behavioural intention to adopt digital tools relationships that are endorsed by both recent and previous educational technology research (Teo & Dai 2022). Simultaneously, TPACK also captures the pedagogical, technological, and content-specific skills that are considered essential to teachers to use digital tools in a

substantive fashion; the modern research also highlights the fact that TPACK development is deeply intertwined with teacher identities, beliefs, and digital self-efficacy (Scherer et al., 2020).

Along those lines, the construction of these theoretical frameworks provides a more comprehensive scholarly base over which the involvement of teachers with a Digital Self-Assessment Tool (DSAT) is being analyzed in a way that both personal thoughts and systemic implications at a macro level are not overlooked. Together, the three sets of theoretical frames provide an integrative analyzing prism: DOI explains the systemic and innovation level conditions that guide the adoption processes; TAM clarifies the psychological and perception determinants of individual acceptance; and TPACK clarifies the pedagogical and identity related aspect of teacher competence. This synthesizing combination will create a conceptually strong platform upon the dual purposes of this research, by making sure that the resulting framework is contextually sensitive to the realities of Ghanaian primary school teachers.

### **2.3 Summary of the Theoretical Frameworks**

The frameworks reviewed emphasize the multifaceted nature of ICT integration in education and the necessity of complementary approaches to gain not only a profound analytical insight but also applied usefulness. TPACK, the DOI theory, and the TAM have a unique but intersecting set of insights, which, together, form the foundation of this study.

TPACK has a particular focus on integrating technological, pedagogical, and content knowledge as the foundations of successful ICT use in the teaching process. Regardless of criticism associated with conceptual clarity and operationalization, its generalizability and robust empirical validation in the domain of teacher education and professional development render it highly appropriate to the research. TPACK, in the context of the Ghanaian primary school setting,

offers a platform on which the capacity of teachers to meaningfully incorporate technology in teaching can be evaluated and developed.

TAM places special emphasis on the determinants of adoption on the individual level, especially on Perceived Usefulness (PU) and Perceived Ease of Use (PEOU), which are always predictive of attitudes, intentions, and technology adoption. Despite its alleged lack of social and organizational factors, the conceptual clarity and predictive power of TAM make it a useful approach to the reasons behind the differences in teacher perceptions of the relevance and practicality of ICT tools. The TAM in this study would guide the design of the Digital Self-Assessment Tool (DSAT) to predict teacher perceptions as the focus of adoption.

DOI goes further to the systemic level that places the integration of ICT in the context of social, cultural and institutional contexts. It describes the diffusion process of innovations by adopters in the categories, the influence of leadership, peer influence, communication, and organizational culture that predict the path of adoption. The diffusion of Innovation theory can be useful, especially in defining contextual enablers and constraints that shall guide the adoption of information and communication technologies in Ghanaian learning institutions and also in enhancing the alignment of professional development programs with national ICT policy goals.

Together, the three theoretical perspectives give a multidimensional theoretical baseline. Diffusion of Innovation is used to measure systemic and contextual determinants, the Technology Acceptance Model measures individual perceptions and behaviors, and Technological Pedagogical Content Knowledge concerns pedagogical knowledge. Their synthesis would allow analyzing ICT integration differently and would be informative in designing a contextually responsive DSAT that suits Ghanaian primary school teachers.

### 2.3 Conceptual Framework

The three theoretical models used in this research include the Technological Pedagogical Content Knowledge (TPACK) model, the Technology Acceptance Model (TAM), and the Diffusion of Innovations (DOI) theory. All the frameworks provide different but complimentary insights into how educators interact, embrace, and continue using Information and Communication Technology (ICT) in education. Collectively, these models offer a conceptual framework of multidimensional models in studying ICT integration practices in Ghanaian primary schools and informing the design of a prototype of the Digital Self-Assessment Tool (DSAT) that is pedagogical and contextually sensitive.

The TPACK framework, in this research, offers a systematic perspective on the process of analyzing how teachers in primary school combine the use of digital tools with the subject matter and teaching methods. It predetermines the interaction of the technological, pedagogical and content knowledge as a condition of the effective introduction of ICT. TPACK can be applied to the context of Ghanaian primary schools to investigate the professional preparedness of the teachers to utilize ICT in a manner that may respond to the needs of the curriculum, classroom setting and learners (Jiménez Sierra et al., 2023; Aqib et al., 2025). TPACK is used analytically in this study to understand what teachers report about their competencies, and design-wise, to guide the domains and indicators that were included in the prototype of the DSAT, as opposed to measuring teacher effectiveness.

The Technology Acceptance Model (TAM) builds on this view by focusing on the assessment of the digital tools by teachers, especially on the perceived usefulness and perceived ease of use. TAM is utilized in the current study to investigate the psychological and attitudinal characteristics that might contribute to the willingness of teachers to implement ICT-related

innovations. In the context of the DSAT, TAM promotes design-related information, shedding light on the need to apply relevance, clear designs, and relevance to professional practice (Wohlfart & Wagner, 2025). Significantly, TAM is used in this case to inform the conceptualization of features and user experience of the prototype in question as opposed to anticipating or validating adoption results.

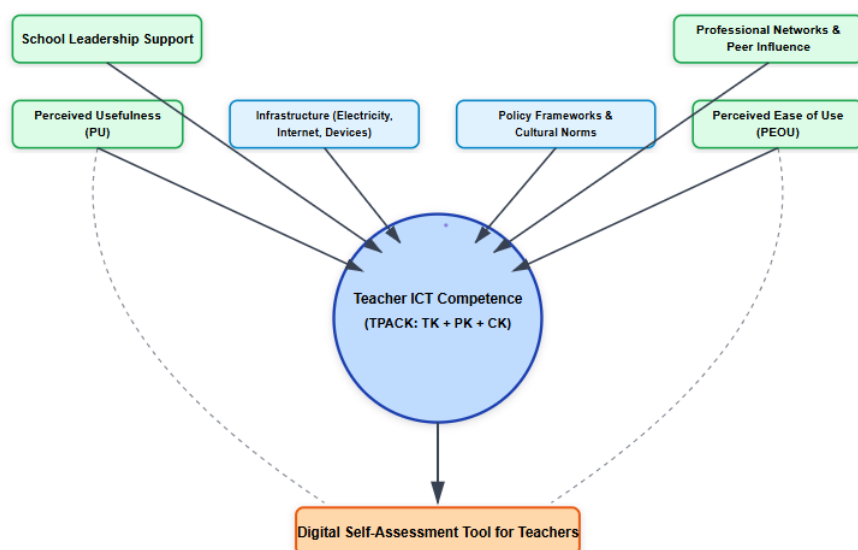
The framework is expanded by the Diffusion of Innovations (DOI) theory that places the technology adoption in the context of wider social and institutional factors. DOI offers a perspective through which it is possible to analyze how ICT practices are characterized by communication networks, leadership structures, institutional norms, and policy environments. In the context of the current study, DOI includes the analysis of systemic causes that affect ICT uptake in Ghanaian primary schools, including the impact of peer influence, the support of the administration, and alignment with the national policies on education (Jin et al., 2025; Lund, 2025). Regarding the DSAT, DOI provides a conceptual direction in thinking about how an instrument of this type could be implemented, nurtured, and maintained within the current educational frameworks, without assuming the concept of diffusion or scalability.

The combination of the three frameworks, the TPACK, TAM, and DOI, has been used to develop the conceptual premise of this research as in Figure 7. The schematic clearly identifies the relationship between four interrelated dimensions, which include

- i. access to the ICT infrastructure and the institution support;
- ii. perceptions of teachers and the usefulness and ease of the digital tools;
- iii. preparedness of the pedagogy and professional competencies; and
- iv. wider institution and the social environment.

The synthesis of these dimensions makes the framework reflect the dual goals of the research: to examine the current practice of ICT integration and to design DSAT prototype. Figure 7 is thus a visual and conceptual roadmap as it indicates how personal perceptions, teacher practices and systemic environments and features all intersect to form the take-up and sustenance of ICT in Ghanaian primary education system. The framework does not include causal relations or predictive information but provides an organizing frame of analysis and design to the scope of the present, exploratory, design-oriented research.

**Figure 7**  
*Conceptual Framework for ICT Integration in Ghanaian Primary Schools*



*Source: Researcher's Construct, (2025)*

## 2.4 Empirical Review

Empirical studies on the incorporation of Information and Communication Technology (ICT) into the learning context have grown significantly over the last two decades, hence depicting its growing significance in changing pedagogical practices on a worldwide level. Overall, the available literature indicates that the successful introduction of ICT can positively influence the design of instruction, the engagement of a learner, and support the process of acquiring core

competencies of the 21st century. However, the same empirical research also shows that the intensity and sustainability of ICT integration is extremely diverse in contexts that vary in terms of aspects of infrastructural capacity, teacher readiness, policy consistency, and socio-economic status. On the global scale, studies conducted by high-income countries show that continuous investment in infrastructure, connections, and teacher training allows the inclusion of digital technologies into classroom activities in a substantive way. On the other hand, research studies carried out in low- and middle-income nations have shown enduring constraints such as the paucity of resources, unsystematic policy application, and extreme urban-rural differences, which hinder the pedagogical power of ICT. These conflicting results underline the decisive role of contextual factors on adoption patterns and their consequent outcomes.

In Sub-Saharan Africa, there has been massive deployment of the ICT-in-education projects, which seek to mitigate the access and equity gaps. Even though such programs have increased exposure to digital tools and have contributed to the acquisition of basic digital skills, there is consistent, systematic empirical evidence of challenges related to sustainability, uneven resource distribution, and the inadequacy of teacher training. As such, the results suggest that being able to access alone is insufficient, the effective implementation of ICT requires a concerted emphasis on the pedagogical, institutional, and infrastructural levels. The available empirical studies on ICT integration in Ghana have been primarily focused on the secondary and tertiary levels of education and have provided minimal information on the primary school setting. This is an important oversight, considering the critical importance of primary education in the development of digital literacy, learning habits, and technological attitudes. Investigations into the primary school level repeatedly report some barriers, such as a lack of ICT facilities, unreliable power supply, and poor Internet coverage, especially in rural areas, and limited access to ongoing

professional growth. These restrictions put a limit on the ability of teachers to integrate ICT in learner-centered and pedagogically significant ways.

Another gap in the Ghanaian context is related to the lack of systematic digital self-assessment systems that could allow teachers to review and refine their ICT competencies. According to the international studies, self-assessment tools enhance reflective practice and contribute to the targeted professional growth; however, it is evident through the results of empirical studies that these mechanisms are not systematically accessible to primary-school teachers in Ghana. It is on this context that the current empirical review takes a multi-scalar approach, incorporating international, continental, and Ghana-specific literatures to shed light on trends, issues, and gaps of ICT integration. This method prefigures an idea that ICT adoption is situated contextually in such a way that it is formed through interactions between the global technological developments, national policy frameworks, and local school realities. These dimensions are further discussed in the subsequent sections to inform both empirical and design aspects of the study.

#### **2.4.1 ICT Integration: Global and Regional Perspectives**

Incorporation of ICTs in learning environments is a dominant topic of global academic investigation, and modern literature reaffirms that ICT has immense potential to improve the quality of instruction and encourage student engagement in a wide variety of learning environments. Recent system reviews and empirical research confirm that the implementation of ICT has the potential to significantly enrich the process of pedagogy, increase student motivation levels, and help to create a more dynamic training environment (Msambwa et al., 2024; Idowu, 2025). Empirical studies indicate that ICT integration not only increases teaching and learning practices but also leads to the gradual shift of pedagogy away from a teacher-centered to a learner-

centered pedagogical paradigm. This change is supported by the research report of ICT-boosted active learning, group activities, and individualized interactions in classrooms (Msambwa et al., 2024; Seleke, 2024;). Specifically, ICT supports active learning, collaborative interaction, and individualized learning pathways by provision of interactive activities, multimedia resources and platforms that are meant to support personalized interaction with students and development of skills relevant to the 21st century (Seleke, 2024; Krawczyk & Garabato, 2024; Ruijia et al., 2025).

Digital tools, such as e-books, interactive whiteboards, mobile learning, and adaptive platforms, have increased the ability of the educator to tailor instruction and meet the diverse needs of learners with a particular emphasis on primary education settings (Tondeur et al., 2017; Champa et al., 2019). Experimental results of high-income countries indicate that in case such technologies are systematically integrated with the set goals of the curriculum, they can create quantifiable improvements in the results of literacy and numeracy (Timotheou et al., 2023; Ruijia et al., 2025).

Within the framework of the highly developed education system, information and communication technologies (ICT) are more frequently used not only to deliver content but also to conduct formative assessment, collaboratively construct knowledge, and participate in the feedback-based pedagogical activities (Børte & Lillejord, 2024). Technology-enhanced learning research indicates that digital tools are most useful when used in assisting interaction, formative feedback, and student collaboration as opposed to being used only as a means of transmission-based instruction (Schindler et al., 2017; Stadler-Altman, 2024). The case of long-term national policies in countries like Singapore and South Korea shows how long-term investment in digital infrastructure and coherent ICT-in-education policies and structured professional development of educators may help to facilitate the embedded and pedagogically relevant integration of digital technologies in the process of teaching and learning (Bo, 2023; Tan et al., 2024; So et al., 2023).

The ICT master plans of Singapore, provided as an example show the possibilities of coordinated implementation to promote digital fluency, problem-solving abilities, and readiness to participate in knowledge-based economies (Jääskelä et al., 2017; Elston et al., 2022). These experiences demonstrate the significance of considering ICT integration as an educational system change, not an individual intervention of technology. Although ICT has gained much policy support, empirical research still shows that there is still a gap between policy aspirations and the classroom level of implementation. In high-income settings, new challenges are becoming more associated with the problem of digital inclusion, learner well-being, and curriculum responsiveness to new technologies like artificial intelligence and immersive learning environments (Selwyn, 2022). Low- and middle-income countries (LMICs), on the contrary, have a higher level of underlying limitations, such as poor infrastructure, lack of financial resources, and opportunities to train the teaching staff (Esfijani & Zamani, 2020). This digital divide goes further than access to devices and connection to include differences in the depth, quality and pedagogical sophistication of the ICT use based on socio-economic status, geographic location and institutional support structures (van Dijk, 2020).

Sub-Saharan Africa (SSA) offers a great deal of information on both opportunities and limitations created by technology-based reforms in large-scale programmes of ICT-in-education. National interventions like Kenya Digital Literacy Programme (DLP), Smart Classrooms in Rwanda, and Gauteng Online in South Africa have attempted to expand access to digital learning content, as well as to encourage the use of technology in primary and secondary education (Langat, 2020; Gitih, 2024). Despite the positive outcomes of such initiatives in the form of a higher level of digital exposure and engagement of learners, the systematic empirical assessments have consistently pointed to the sustainability issues related to maintenance of the devices, unequal

resources distribution, and insufficient pedagogical integration (Meyer & Gent, 2016; Omito, 2021; Mapisa & Makena, 2024). The structural limitations continue to be especially acute in the rural and underserved SSA settings. According to the empirical studies, unstable electricity supply, weak internet connectivity and high connectivity charges are some of the challenges that hinder the consistent use of ICT in many schools (Sepadi et al., 2025). Furthermore, the lack of trained ICT educators and little opportunity to engage in professional development undermines the ability of teachers to use technology pedagogically, and the ICT use remains limited to administrative tasks or low-level drill-and-practice tasks (Sithole & Mbukanma, 2024; Sepadi et al., 2025). These challenges further lead to the prolonged urban-rural inequalities where learners in urban schools have disproportionately higher access to digital learning opportunities as compared to those in rural schools (Adarkwah, 2021; Boateng, 2022).

Despite these limitations, recent findings show that contextualized and low-cost interventions can be used to alleviate some of these barriers to ICT integration. Projects like the iMlango initiative in Kenya that used satellite internet to deliver learning resources to primary schools in rural areas have been shown to have a huge impact on literacy rates and attendance rates among learners (Kiesel, 2016). Similarly, the new mobile-based interventions, such as WhatsApp-supported and AI-enhanced tutoring approaches tested in underprivileged areas have demonstrated encouraging outcomes in improving the performance of learners under the conditions of the limited infrastructures (Henkel et al., 2024). The above illustrations highlight the possibilities of adaptive and locally responsive technologies to bring the benefits of ICT to those areas where it is well-resourced. In general, the empirical experience of the world and the region support the transformative potential of ICT and emphasizes the overwhelming influence of the situational factors to determine both adoption and impact. The sustainable ICT incorporation requires more

than just hardware delivery; it necessitates integrated plans that integrate infrastructure advancement, instructor capacity building, pedagogical congruence and institutional assistance. In nations like Ghana whose opportunities and constraints are common to most of the sub-Saharan Africa, these international and regional experiences give paramount insights into how ICT interventions can be designed in a manner that is fair, flexible as well as sensitive to local education dynamics.

#### **2.4.2 ICT Use in Primary Education - Adoption, Pedagogy, and Learning Outcomes**

Primary education is a critical developmental stage of basic literacy, numeracy, and problem-solving skills and as such, a central point of the research into the pedagogical effectiveness of integrating ICT (Bo, 2025). The empirical support continuously suggests that the responsible use of ICT at the primary level of education can enrich the engagement of learners, diverse teaching, and achieve high-quality learning results, especially when aligned with the appropriate age-related pedagogical instruction and the effectiveness of a tutor-learner interaction (Schindler et al., 2017; Bo, 2025). The use of ICT in primary education has developed globally as a peripheral supportive aspect to a fully integrated approach in curriculum development, pedagogical delivery, and formative instruction, where pedagogical innovation goes hand in hand with technology use (Timotheou et al., 2023).

There is also further evidence about the impact of ICT on classroom work based on empirical studies that concentrate on digital tools. Interactive whiteboards (IWBs), Tablets and subject-specific educational applications have been associated with high learner motivation and performance due to their ability to support multimodal, interactive, and learner-friendly visual learning experiences, provided their implementation is matched with a suitable pedagogical strategy (Sung et al., 2016; Schindler et al., 2017). Lant and Lawson (2016) have noted that IWBs

enabled the use of visual and multimedia representations, thus helping a teacher to guide the learner through a shift in basic recall into higher-order activities of a structured teacher-guided experience. Likewise, Tombak and Ateşkan (2019) have also claimed that interaction with digital tools helped a teacher to facilitate the transition of abstract concepts to a higher-level practice in the context of a teacher-directed activity. All these results point to the idea that the pedagogical influence of ICT in basic school education is not necessarily mediated directly by the technology itself but instead by its use in instructional design.

In addition to subject-specific learning benefits, integration of ICT in primary education has been empirically associated with the acquisition of wider competencies in the 21<sup>st</sup> century, such as digital literacy, creativity, collaboration, and problem-solving skills (Ramnarain et al., 2023). Research based on the constructivist theory of learning suggests that digital learning environments, fostering peer interaction, inquiry-based learning and learner autonomy, are specifically helpful in facilitating these results. ICT's ability to expand learning beyond the physical classroom and promote the development of self-learning practices in young learners is also illustrated through empirical evidence of blended and hybrid learning settings, which increased dramatically throughout the COVID-19 pandemic (Jimoyiannis & Koukis, 2023).

Despite these advantages being documented, empirical research has consistently focused on the inequality in the use of ICT at the primary level. Using the Technology Acceptance Model (TAM), Zaman et al. (2023) found that classroom integration was often limited by practical barriers, such as a lack of training, appliances, and access to digital products, even though primary school teachers usually understood the importance of ICT in the classroom. This gap between the favourable attitudes and the real classroom practice of the teachers emphasizes the significance of technical proficiency and the ability to integrate pedagogical skills. According to research

conducted by Mayantao and Tantiado (2024) most teachers who had high levels of digital confidence utilized digital tools, including PowerPoint, Excel, Canva, and similar ones, more often and in a more creative manner, hence the necessity of professional development to facilitate effective usage of ICT.

These complexities are further demonstrated by regional evidence of Sub-Saharan Africa (SSA). According to Komba (2023), low levels of resource supply, ineffective internet access, and insufficient training have restricted the integration of ICT in primary schools in Tanzania. In the Eastern Cape of South Africa, Mapisa and Makena (2024) discovered that digital tools expanded the teaching opportunities, but also rural schools were constrained by the lack of equipment and the absence of technical assistance. In the same way, Murithi and Yoo (2021) also found that underutilization in Kenya was caused by sporadic professional development and intermittent policy frameworks, where ICT is generally available but not meaningfully integrated into teaching. All these points emphasize the fact that access to ICT is not enough, but that sustainable adoption requires well-developed support systems that encompass, but are not limited to, teacher training, curricular alignment, and institutional leadership.

However, the targeted interventions prove that the systemic barriers can be addressed in case ICT initiatives are context specific. The iMlango project in Kenya, which included satellite connectivity and e-learning tools in rural schools showed significant improvements in the reading levels of students and their engagement (Martin, 2025). The One Laptop per Child (OLPC) project in Rwanda, despite its unequal results, is a demonstration of the necessity of matching the delivery of technologies with effective teacher training and curriculum development. The study by Munyengabe et al. (2017) found that despite the ICT potential awareness created by OLPC, the implementation was limited by inadequate teacher training and the absence of pedagogical

cohesion. These lessons are similar to those by Ramnarain et al. (2023), who opine that teacher confidence, beliefs, and instructional practice can be more decisive factors than infrastructure in defining the level and quality of ICT usage.

Equity and inclusion are also very important issues regarding ICT integration in primary education. Research also shows that students in under-resourced settings, especially in rural schools, are prone to being further disadvantaged when they do not have frequent access to digital tools, thus increasing digital literacy disparities and digital employability gaps in the future (Van Dijk, 2020). At the same time, ICT also offers considerable opportunities of inclusive education, if its adoption is suitably differentiated. Donkor et al. (2024) illustrate that, given the sufficient availability of resources, teacher training, and the accessibility factor, differentiated instruction can be facilitated using assistive technologies and available digital platforms to provide learners with diverse needs with access to the learning process.

In general, the literature shows that the integration of ICT at the primary level has a transformative potential in the area of pedagogy and learning outcomes. The effects of it, however, depend on the systemic factors like infrastructure, institutional support, and long-term teacher professional development. The evidence shows that, though supply with hardware and implementation of policy initiatives is crucial; they are not enough. Multidimensional strategies are both necessary and required to transform meaningful and just ICT integration at the primary level through context-sensitive strategies that simultaneously capture the pedagogical and structural aspects. These observations, based on global and regional research are pivotal to the analysis of the Ghanaian specific path of ICT integration, where the interaction of policy aspiration, resource conditions, and teacher preparedness is still a key determinant.

### 2.4.3 Ghana's ICT in Education Landscape

Ghana has expressed its devotion to the integration of ICT in the education sector through a successive national policies and programmes that promote digital inclusion, improve the quality of instruction and make the education system to be aligned to the global technological trends. The ICT in Education Policy (MoE, 2015; 2018) is a detailed set of strategic priorities regarding the infrastructure growth, teacher preparation, curriculum implementation, and equal access. The policy is based on the previous policies, such as the ICT4AD Policy (2003), which placed ICT as a driver of socio-economic change, and the Education Strategic Plan (2010-2020), which recognized ICT as a separate subject and as a cross-cutting pedagogical instrument (MoE, 2015; BuabengAndoh, 2019).

Empirical studies put Ghana in a wider Sub-Saharan African context in which the national policies of ICT-in-education are clearly stated but disproportionately implemented on the school and classroom level (Asare et al., 2023). The constant prevalence of scholarship highlights a conspicuous conflict between policy aspirations and the realities of infrastructural shortage, teacher capacity anxieties and contextual constraints, which makes Ghana a relevant case when examining the practical implementation of ICT reforms.

Review and analytic studies of the ICT policy landscape in Ghana have shown that national structures are driven by equitable access, curricular integration and teacher professional development but the implementation has been fragmented. The systematic review by Asare et al. (2023) shows that policies that expressly advocate pedagogical integration of ICT only provide scanty information on how to sustain professional growth and establish school-level implementation strategies. Such a policy-practice gap is also reflected in school-based research, where teachers state that they are conversant with ICT policy goals, but they believe that there is

limited institutional support to mediate those goals into classroom practice (Baako & Abroampa, 2024). These results suggest that the coherence of policies in themselves is not enough to bring about instructional change without corresponding implementation mechanisms.

The empirical discourse in the studies is dominated by infrastructure and access. According to research carried out in public basic and secondary schools, access to electricity, working computers, and stable internet connectivity are some of the major predictors of ICT use by educators as an instructional tool (Baako & Abroampa, 2023; 2024). The lack of infrastructure affects rural and peri-urban schools disproportionately and thus the cycle of educational inequalities continues. Appianing (2025) noted that science educators in schools with under-resources often use their own devices or simply give up any ICT-based teaching because of poor power supply and inability to support technical issues. These infrastructural obstacles not only determine the frequency but also the quality of the ICT application in limiting chances of interactive and student-centered learning.

Another salient empirical dimension is the competence of teachers and their attitudes towards the use of information and communication technology (ICT). Various peer-reviewed studies present general positive attitudes to ICT, but pedagogical integration is limited. In their quasi-experimental study, Owusu et al. (2023) explored the situation in senior high schools and discovered that despite teachers attaching importance to ICT in terms of improving instruction, most of them did not have the pedagogical experience required to embed technology meaningfully in their lesson delivery. Baako and Abroampa (2024) also found that the confidence of teachers in using ICT tools depended mostly on their prior training and contextual support, and not policy requirements alone. Further evidence, based on teacher-training institutions, also shows that

exposure to ICT in pre-service education focuses on technical skills at the expense of pedagogical use, thus with little transfer to classroom practice (Baako & Abroampa, 2024).

Empirical studies on the use of ICT and student learning outcomes in Ghana are not very abundant, though they indicate an upward trend. Current evidence indicates that in a systematic and pedagogically effective approach to ICT implementation in education, it is possible to achieve positive learning outcomes. Indicatively, Owusu et al. (2023) observed that students in senior high schools who were instructed on genetics with the support of ICT achieved remarkably higher results than those who were taught using traditional approaches. Within the context of science education, Bayuo et al. (2022), found that ICT-based teaching of chemistry enhanced student interaction and theoretical understanding, but the long-term viability of such patterns was limited by the infrastructural and institutional constraints. Such results suggest that ICT can have a positive impact on learning, but it is possible only in those cases when it can be substantially supported and aligned with pedagogical goals.

School leadership and organizational support also have a central role in terms of integration of ICT. Empirical data provided by Lomo et al. (2024) proves that the practices of headteachers in leadership have significant effects on teachers who are willing and able to use ICT. Schools where leadership focused on training, maintenance and supportive supervision of ICT showed greater levels of classroom technology implementation compared to schools where ICT was considered a marginal issue. However, even headteachers themselves identified barriers, such as insufficient funding, lack of training, and competing administrative duties, which implies that enhancing leadership potential should be sought in the same direction as teacher development.

Empirical results are cut across by equity and contextual disparities. It is continually shown in studies that ICT integration in Ghanaian education is geographically, school type, and resource-

based stratified. Baako and Abroampa (2023) noted that the teachers that work in rural schools are faced with intensifying barriers, particularly the lack of good infrastructure and limited access to professional development. Such differences maintain a digital divide that reflects larger socio-economic disparities, which creates the concern that, inadvertently, ICT reforms may increase disparities in achievement unless equity is considered in the foreground through implementation.

Collectively, the existing body of empirical research on ICT integration in Ghanaian education demonstrates that there exists a complex and interconnected set of issues that include policy implementation, infrastructural access, teacher instructional capacity, school-level leadership, and equity. To generalize these converging trends and underline their significance to systemic educational change, the key results of the studies are summarized in Table 1.

**Table 1***Synthesis of Empirical Evidence on ICT Integration in Ghanaian Education*

<b>Theme</b>	<b>Empirical Evidence</b>
Policy enactment gap	The ICT policies may reflect the ambitious integration targets; however, empirical research reports that the translation of such integration targets in practice is weak because of the lack of implementation guidelines and professional development frameworks (Asare et al., 2023).
Infrastructure and access	The potential access to electricity, internet connectivity, and functional devices heavily preconditions the instructional usage of ICT by teachers, and structural inequalities remain an issue in under-resourced and rural schools (Baako & Abroampa, 2024; Appianing, 2025).
Teacher pedagogical capacity	Despite the most positive attitudes of the teachers towards ICT, the empirical measures of pedagogical integration show a lack of evidence of the sustained practice-oriented professional learning (Owusu et al., 2023; Baako & Abroampa, 2024).
ICT and learning outcomes	Empirical studies of improved student achievement are mostly based on ICT-focused and pedagogical interventions, meaning that value-adding to learning is based on instructional alignment to technology and not technology alone (Owusu et al., 2023; Bayuo et al., 2022).
School leadership	ICT integration is highly mediated by leadership practices of schools, where supportive headteachers support ICT integration and weak leadership limits its use at the classroom level (Lomo et al., 2024).
Equity and contextual disparities	The distribution of ICT integration is not even in the socioeconomic and geographic backgrounds, and it is a matter of concern that digital reforms could reproduce or even enhance current educational disparities (Baako & Abroampa, 2023).

According to the synthesized literature in Table 1, the empirical literature is aligned on this key point: Ghana ICT-in-education reforms are not driven by the mere presence of technology but rather by the institutional and pedagogical circumstances surrounding the usage of technology. The lack of infrastructure must be seen as a required yet inadequate account of limited ICT integration; instead, the reciprocity between the teacher's pedagogical capacity, administrator support, and implementation regulation becomes a determining factor of classroom practice. Notably, research studies that have documented positive learning results always place technology in coherent

pedagogical constructions, hence highlighting the shortcomings of access-based reform initiatives. The continued existence of strong equity imbalances only adds to the notion that, unless compensatory measures are exercised, ICT initiatives will only serve to reinforce structural inequalities, instead of alleviating them.

### ***Summary of Ghana's ICT in Education Landscape***

To sum up, findings on Ghana ICT in the education sector have demonstrated the existence of a system where policy intent is high, and implementation capacity is limited. The peer-reviewed literature repeatedly proves that the successful inclusion of ICT in the teaching and learning process is hindered by infrastructural limitations, lack of pedagogically oriented teacher training, and unequal leadership provision. There is a positive impact of targeted ICT interventions on student learning, yet such impacts are deeply dependent on contextual factors and are hard to maintain without supporting the systems. Literature, therefore, emphasizes the necessity of ICT reforms to make Ghana move beyond access and merely policy articulation to integrated strategies that combine both infrastructure development and improvement, continuous teacher development, school leadership capacity building, and equity-based implementation. This is an important strategy necessary to ensure that ICT plays a significant role in improving the quality of education and alleviating the level of disparity in the education system in Ghana.

#### **2.4.4 Barriers to ICT Integration in Education - Global and Ghana Specifics**

Despite the long-term international promotion of the digitalization of education and the growth of investment in educational technologies on a local and global level, empirical data still show that the introduction of information and communication technologies (ICT) into the common pedagogic practice is still low and unequal. In many education systems, the role of ICT is often placed on an auxiliary or nominal level instead of being viewed as a driver of any meaningful

pedagogical transformation. This paradox has a core conflict between the provision of technology and the transformation of pedagogy, which implies that access does not always ensure successful use in education (Selwyn, 2022). As it is reflected in literature, the barriers to ICT integration are increasingly conceptualized as systemic and multidimensional and include infrastructural constraints, teacher capacity, institutional leadership, policy implementation gaps, and socio-cultural factors. The nature of the interaction between these barriers at educational ecosystems defines the process of interpreting, adopting, and implementing technologies in classrooms. Although they might vary in terms of their relative strength when comparing the high-, middle-, and low-income forms, their endurance speaks to how hard it is to institutionalize ICT as a change agent pedagogical instrument and not a technological supplement.

This issue is especially acute in the low-resource environments, when structural inequalities overlap with capacity constraints to limit meaningful usage of ICT. In Sub-Saharan Africa and Ghana in particular, policies and massive projects at the national level on ICT-in-education are indicators of a high level of political commitment to digital inclusion. Yet, there are indications that such aspirations tend to be sabotaged by lopsided infrastructures, insufficient professional growth, institutional underpinning, and situational discrepancies between policy design and classroom realities. In this regard, to comprehend barriers to ICT integration, a comparative prism is necessary, which places the Ghana experience in the context of discussing ICT integration in the world and at the same time, being aware of the local state of educational, socio-economic, and institutional circumstances.

Considering the interdependence and multidimensionality of barriers to ICT integration, a disjointed or sequential overview is likely to lose the systemic processes that determine the applicability of technology in education. On this basis, the current review takes the form of a

thematic analysis approach that generates global and Ghana-specific literature on major areas of concern that affect ICT integration in education. In particular, the review is structured according to interconnected themes that are repeated throughout empirical and theoretical literature: infrastructural access and connectivity; professional development and digital competence of teachers; curriculum and pedagogical integration; institutional leadership and support; policy implementation and governance; and equity and inclusion. These themes do not stand as individual and hierarchical but are seen as mutually reinforcing dimensions that are collectively implemented to determine how ICT is practiced in schools and classrooms. The thematic sections are based on global studies to identify general trends and theoretical lessons, and then to place the Ghana experience into this international canvas. This comparative orientation makes it possible to critically analyze the relationship of structural constraints with professional capacity and institutional conditions in different contexts and generate similar outcomes of restricted or symbolic integration of ICT. This method allows the review to not only map the body of knowledge but also reveal conceptual and empirical gaps that guide the direction and input of the current study.

Table 2 offers a comparative thematic synthesis of the literature to give an overview of how barriers to ICT integration are conceptualized both on a global and Ghana-specific level. The table acts as an analytical guide that categorizes common themes and points of congruence and contextual difference. The following sections, consequently, extend this synthesis by critically exploring each of the themes further, especially focusing on the reproduction, adaptation or amplification of global patterns in the Ghanaian educational environment.

**Table 2***Comparative Thematic Analysis of Barriers to ICT Integration in Education*

<b>Theme</b>	<b>Global Evidence</b>	<b>Ghana-Specific Evidence</b>	<b>Analytical Implications</b>
<b>Infrastructure and Access</b>	Unreliable power supply, poor access to hardware, poor broadband internet access and prohibitively high internet access, especially in low and middle-income countries, are considered barriers to ICT integration. According to the latest experts, it is not the presence of devices that is important, but their reliable connection that enables meaningful engagement (Esfijani & Zamani, 2020). The COVID-19 pandemic revealed severe digital disparities between the OECD and non-OECD settings (Antoninis et al., 2023).	Ghanaian schools are affected by systemic infrastructural shortages such as unreliable power, top-quality ICT facilities, and internet connectivity, particularly in rural schools. Regional and institutional inequalities are high, which restricts the uniform use of ICT (Lomo et al., 2025). Higher technologies, including virtual reality, are not readily accessible because of connectivity as well as cost issues (Nyaaba et al., 2024).	Ghana is an illustration of the infrastructure predicaments that prevail in low-resource settings, meaning that access-focused policies should be backed by policy investments in reliability, affordability and sustainability.
<b>Teacher Digital Competence and Pedagogical Skills</b>	The successful ICT integration is closely correlated with the digital self-efficacy of teachers, their beliefs about pedagogy, and their further professional growth. Teachers across the world often have a positive attitude towards ICT but do not possess the pedagogical strategies that would enable them to effectively incorporate it (Ottenbreit-Leftwich et al., 2018; Tondeur et al., 2021). Most	In Ghana, teachers have a generally positive perception of information and communication technologies but indicate a lack of training in the integration of pedagogies. Although there is even basic digital literacy, the use of ICT is still administrative or presentation-based, and this is mainly due	The Ghanaian phenomenon supports the findings of other countries that teacher capacity and not access is the key determinant. Thus, there is a need to move the ICT utilization approach to a pedagogical one with the help of sustainable models of professional learning.

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	systems are dominated by short-term skills-based training (Angeli et al., 2016).	to the failure to match professional development programs with the goals of the curriculum (Abedi et al., 2024). The pre-service teacher education also fails to give sufficient priority to instructional design and reflective practice (Acquah, 2023).	
<b>Professional Development Models</b>	Professional development focuses on technical skills more than on the integration of pedagogical systems across the world, so teachers lack the ability to support higher-order learning (König et al., 2024). Embedded, long-term, and reflective models are scarcely common, but evidence suggests that they are more effective (Tondeur et al., 2018).	In Ghana, professional development is habitually intermittent, externally based and not in touch with classroom realities. There is also a lack of sufficient follow-up support, which narrows the ability of teachers to implement training into practice (Abedi et al., 2024).	Ghana exemplifies the general problem of the lack of professional development ecosystems in the world, and thus, the implication of the need to have long-term models that are school-based.
<b>Policy–Practice Gap</b>	Most countries have embraced ambitious ICT-in-education policies, but their implementation is hindered by poor funding, weak monitoring and evaluation systems, and inappropriateness of the context (Selwyn, 2022). Massive projects often lead to adoption symbolically and not substantially.	Although there were strong policy plans, including the ICT in Education Policy and the one-Teacher-one Laptop programme, the implementation process in Ghana has been skewed. The implementation of the policy into the classroom practice is hindered by financial disadvantages, inequalities in the region, and lack of institutional capacity	Ghana illustrates an all-consuming trend globally, where policy ambition outstrips the implementation capacity, hence it is imperative to develop a context-sensitive plan.

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<b>School Leadership and Institutional Support</b>	School leadership is a mediating factor in ICT integration throughout the globe. The insufficient support of leadership, conflicting administrative needs, and the lack of technical support decrease the efficient use of ICT resources (Selwyn, 2022).	(Lomo et al., 2025; Nyaaba, 2024).  The Ghanaian headteachers frequently have challenges with the implementation of ICT policies because of limited resources, insufficient technical support, and conflicting priorities (Lomo, 2025).	The capacity building of leadership is invaluable in Ghana, which is consistent with the global evidence that institutional support plays a decisive role in the sustainability of ICT initiatives.
<b>Curriculum Integration and Pedagogical Use</b>	ICT is frequently limited to ICT subjects, and there is not much trans-curricular integration. This limitation lessens the chances of learners acquiring higher-order skills of critical thinking and collaboration (Koehler et al., 2019).	The use of ICT in core subjects is intermittent and shallow. There is prevalence of teacher-centered pedagogies, thus restricting the transformative power of technology (Abedi et al., 2024).	The Ghana case also supports the international dilemma of ICT being more than a separate subject; it is a pedagogical instrument that cuts across the curriculum. Ghana illustrates the overlap between ICT challenges and issues of inclusion and equity, thus showing the need to implement differentiated and inclusive ICT policies.
<b>Equity, Inclusion, and Socio-Cultural Factors</b>	The integration of ICT often replicates the existing geographical, disability and socioeconomic status inequities. Inclusive learning environments do not necessarily have adapted technologies and properly trained staff (Burns, 2023).	The situation with inclusive classrooms in Ghana is sharp; teachers working with deaf learners do not have specific ICT-based tools, specialized training, and institutional support, which contributes to the development of adverse attitudes towards the use of technologies (Donkor et al., 2024)	Ghana illustrates the overlap between ICT challenges and issues of inclusion and equity, thus showing the need to implement differentiated and inclusive ICT policies.
<b>Overall Nature of Barriers</b>	Barriers to effective ICT integration are systemic, interdependent and are not	In general, Ghana is characterized by a tendency toward	Ghana represents a microcosm of the worldwide issues of

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susceptible to single solution interventions. As a result, multi-level, holistic interventions are becoming more recommended (Tondeur et al., 2018).	structural, pedagogical and institutional barriers, increased by resource shortages and geographic distinctions.	ICT integration in low-resource countries, which affirms the necessity of system-wide changes.
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Infrastructural and technological limitations are among the themes outlined in Table 2, as they form the basis of how far the other aspects of ICT integration, including teacher capacity, curriculum innovation, and support at the institutional level, can be realized. To this end, the following section examines infrastructural hindrances to ICT integration based on international evidence and later contextualizes the experience of Ghana in the broader global context.

### **1. Infrastructural Constraints and the Digital Divide**

Globally, the infrastructural barriers form one of the most systemic barriers to ICT integration. Some of the endemic issues in low- and middle-income countries include poor electricity supply, ineffective access to digital gadgets, insufficient broadband network, and excessive internet expenses (Esfijani & Zamani, 2020; Van Deursen & Van Dijk, 2020). In the recent literature, it is stressed that the degree and consistency of interconnection, as opposed to the availability of devices in question, are the conclusive factors determining meaningful online interaction (Burns, 2023). This difference has given the conversation a direction out of access-based digital divides and into what is now more conceptualized as a second-level and third-level digital divide, where differences are reflected in usage patterns, pedagogical application, and learning outcomes. These inequalities were brought to the fore by the COVID -19 pandemic. Even though several OECD nations quickly shifted to online and blended learning models because of the well-developed digital infrastructure, Sub-Saharan Africa was plagued by learning disruptions caused by a lack of access to devices and unreliable internet connections (Antoninis et al., 2023).

In the contexts where devices were already present, high data charges and unreliable connectivity posed a serious limitation to maintaining the engagement of learners, as reported in Kenya and Nigeria (Omito, 2021; Komba, 2023). These results highlight the fact that infrastructural investment by itself cannot be completed without corresponding consideration of affordability, maintenance, and long-term sustainability.

## **2. Teacher Readiness and Pedagogical Ability**

In addition to infrastructural factors, variables involving teachers are continually revealed as the most notable obstacles to information and communication technology (ICT) integration across various global settings. Cross-national studies reveal that the use of ICT in an effective way is closely related to digital self-efficacy of teachers, their beliefs on using ICT, and their opportunity to receive continuous, curriculum-related professional development (Ottenbreit-Leftwich et al., 2018; Tondeur et al., 2021). Despite the high percentage of teachers that report positive attitudes towards technology, an attitude does not guarantee pedagogically significant use. Sub-Saharan African teachers often express interest in ICT but lack the pedagogical skills that could allow them to integrate technology into learner-centered and constructivist pedagogy approaches (Buabeng-Andoh, 2019). This disconnection is broadly exacerbated by professional development models which focus on short-term technical skills as opposed to long-term pedagogical fusion. Angeli et al. (2016) and König et al. (2024) argue that these strategies limit the capacity of teachers to translate digital competencies into instructional strategies that help students to be critical thinkers, collaborators, and problem solvers. Therefore, ICT is often pushed to administrative work or strictly lecture-based delivery, thus strengthening the traditional teacher-centered pedagogies instead of questioning them.

## **3. Policy-Practice Disjunctions and Implementation Problems**

Another common theme in the academic literature is the lack of alignment between ambitious ICT-in-education policies and their implementation at the school and classroom level. Although many governments of countries declare detailed plans related to digital education, these policies are often sabotaged by a lack of funds, ineffective monitoring and evaluation frameworks, and an inability to respond to local realities (Selwyn, 2022). This trend is clearly displayed through comparative case studies in Africa. As an example, the Smart Classroom program in Rwanda reached the national scale; nevertheless, rural schools still face challenges in its usage due to the lack of sufficient infrastructure and a shortage of educators with the necessary skills (Gitiha, 2024). Likewise, the Gauteng Online programme in South Africa, which was aimed at expanding access to digital learning material, has also faced maintenance, technical and sustainability issues, which cause the underutilization of facilities (Mapisa & Makena, 2024). These examples illustrate that the lack of policy ambition without contextually sensitive implementation structures and institutionalized support systems tend to lead to symbolic and not substantive ICT integration.

#### **4. National Policies and Local Reality – Ghana Specifics**

Ghana illustrates numerous global trends in digital education and, at the same time, faces contextual challenges. Strong political commitment has been the basis of national projects in digital inclusion, as shown by the ICT in Education Policy (2015) and the One Teacher One Laptop (1T1L) programme. However, research reveals unequal application depending on geographical area, type of school and level of education. According to Lomo et al. (2025), the lack of financial support to ICT infrastructure, unreliable electricity access, and poor-quality internet access are some of the key factors that hinder the effective use of ICTs in Ghanaian schools, and they are more pronounced in rural schools and underserved regions. Structural inequalities are further reinforced by new technologies. According to Nyaaba et al. (2024), advanced solutions, including

virtual reality (VR), are still not widely available in teacher education institutions because of limited connectivity, prohibitive prices, and inaccessibility to specialized hardware. In turn, innovation is limited, which further increases the disparity between the aspirations of policies and the realities in the classroom.

## **5. Teacher Education, Leadership and Institutional Support in Ghana**

The preparedness of teachers is another key bottleneck to the ICT integration efforts in Ghana. Despite the general recognition of teachers of the pedagogical possibilities of ICT, many are insufficiently trained and institutionally supported when it comes to incorporating technology into instruction. Abedi et al. (2024) discovered that in those cases when teachers had the basic level of digital skills, professional development without curriculum adaptation reduced ICT application to administrative functions or superficial instructional assignments. Likewise, Acquah (2023) found that, whereas the level of digital competence among Colleges of Education lecturers is rather high, pre-service teachers are underprepared to implement ICT pedagogically because of a low focus on instructional design, reflective practice, and classroom-based application. School leadership also acts as an intermediary of policy-to-practice translation. The ability of the headteachers to operate national ICT policies is usually limited by limited institutional support, competing administrative demands, and insufficient resource allocation (Lomo, 2025). To make the implementation more equitable, Nyaaba (2024) highlights the necessity of policy frameworks that would clearly tackle the disparities in different regions.

## **6. Curriculum: Equity, Inclusion, and Curriculum Integration**

Equity and inclusion are another set of problems that complicate the challenges of the integration of information and communication technology (ICT) in Ghana. Donkor et al. (2024) report a lack of adapted ICT tools, special training, and institutional support to educators working

with deaf students in inclusive educational settings, further endorsing the negative attitudes toward the use of ICT in special education scenarios. These results highlight the overlap between ICT barriers and more general socio-cultural and equity issues. Additionally, the poor integration of ICT across curricular levels has been regularly recorded in the extant literature. Despite the promotion of ICT, as a separate subject, and as a transversal pedagogical tool, there is empirical evidence that its implementation is still largely concentrated in ICT-specific lessons (Abedi et al., 2024). In the basic discipline, integration is often non-persistent and shallow, and thus learners are not given a chance to advance into higher-order skills like critical thinking, teamwork, and digital literacy. This trend perpetuates teacher-centered pedagogical formulas and limits the disruptive power of ICT in primary school (Koehler et al., 2019).

### ***Barriers to ICT Integration in Education Summary***

Together, the literature suggests that ICT integration barriers are highly intertwined and mutually supporting. The inadequacy of infrastructure relates to teacher capacity weakness, poor institutional leadership, policy-practice, and the result is patterns of symbolic but not substantive adoption. Addressing these issues requires multi-level approaches that are holistic, which is to ensure infrastructure investment is matched with the costs of connectivity, continual professional development, enabling leadership, and policy application that is context specific. In low-resource settings like Ghana, there are new indications of the necessity to shift beyond access-based solutions to systemic changes that allow ICT to act as an agent of real pedagogical change (Tondeur et al., 2018).

### **2.4.5 Enablers of ICT Integration in Education**

Empirical studies invariably prove that the effective adoption of information and communication technologies (ICT) in learning environments depends not only on the availability

of the necessary infrastructure and digital resources but also on a variety of facilitating factors that determine the substantive insertion of technology into educational practice. These enablers work across different levels of the educational system, including competence and confidence of teachers, school leadership and culture, and the policy and monetary frameworks in general. The relationship between such enabling conditions is especially decisive in low-resource settings as resource and professional capacity differences tend to increase the implementation difficulties. ICT integration enablers can be explained through the synthesis of the empirical corpus in five domains in which different factors are interrelated and include: teacher-level capabilities, school-level circumstances, system-level facilitators, context-sensitive implementation plans, and monitoring-and-learning mechanisms. These areas do not operate individually but create an interconnected ecosystem that determines the intensity, sustainability and fairness of primary education in the use of ICT. The section outlines and explains some of these enablers as viewed by literature.

### **1. Teacher-Level Enablers: Competence, Confidence, and Pedagogy-in-Use**

The widespread recognition is that teachers are key players in the process of integrating information and communication technologies (ICT) in learning institutions, as their knowledge, perceptions, and teaching methods have a direct impact on implementing digital tools in classrooms. Empirical studies prove that increased digital competence enables educators to create learner-centered lessons, which allow collaboration, inquiry, and higher-order thinking (Redecker & Punie, 2017; Instefjord & Munthe, 2017). Notably, digital competence goes beyond technical skill to the pedagogical ability to integrate technology applications with the curricular goals and curriculum content.

The teacher's confidence, which is often defined as technological self-efficacy, also turns out to be a decisive predictor of ICT adoption. It has been shown that even in schools with

sufficient resources, educators with a low confidence level are less likely to engage in meaningful integration, but professional development models based on combining technical training and pedagogical reflection encourage more integration and instructional innovation (Voogt et al., 2016; Tondeur et al., 2018). This trend is supported by a study carried out in Ghana, where the team found that the confidence and ability of teachers in the implementation of ICT-enhanced lessons were significantly increased by long-lasting peer collaboration and reflective practice (Agyei & Voogt, 2021). Teacher competence, confidence and pedagogy in use today are essential enabling factors of ICT integration. These factors do not only influence how teachers perceive technology but also establish the effectiveness of mobilizing technology to enhance instructional practices and student performance.

## **2. School-Level Enablers: Infrastructure, Leadership, and Collaborative Culture**

The dynamics between infrastructure, leadership and collaborative culture determine the integration of ICT at the institutional level. The basic requirements of ICT use are reliable electricity, working devices and stable internet (Langat, 2020; Adarkwah, 2021). But it is always empirically demonstrated that the existence of infrastructure is never sufficient to ensure pedagogical integration. Instructional leadership has a very important facilitating role. School leaders with a strong vision of ICT use, strategic resource allocation, and encouragement of experimentation with digital pedagogies have a major impact on teacher adoption (Dexter & Richardson, 2020). Also very valuable is the existence of collaborative cultures that promote peer learning, mentoring and problem solving. It has been demonstrated that Professional Learning Communities (PLCs) and informal teacher networks are effective at maintaining the ICT integration by normalizing innovation and reducing the risk at a personal level (Drossel et al., 2017; Park & Byun, 2021). Strong teacher collaboration coupled with the presence of leadership

support in Ghanaian schools has been found as a major distinguishing factor between ICT sustained usage and superficial adoption (Nyarko et al., 2021).

### **3. System-Level Enablers: Coherent Policy, Financing, and Inclusion by Design**

System-wide enablers offer the structural requirements of scaling and maintenance of the ICT incorporation. Nationally approved policies that are coherent and consistent with curriculum changes create a common vision of digital transformation, and fragmented or inconsistent strategies tend to hamper the process (Antoninis et al., 2023). Funding is another very important enabler, since the successful integration of ICT needs to be funded not only before but after acquisition as well as during the maintenance and connectivity needs, technical support and professional development. The equity-based policy design is of special significance to low-resource settings. Empirical research warns that ICT projects can continue to widen inequality where they favor schools which are well endowed (Donkor et al., 2024). On the other hand, programmes focusing on rural and marginalized communities, low-bandwidth solutions, and assistive technology integration will have a higher chance of developing inclusive and equitable results (Howard et al., 2021).

### **4. Context-Responsive Implementation in Low-Resource Settings**

In a low-resource environment, practice-based evidence highlights the need to have context-sensitive implementation strategies that can adapt ICT initiatives to the realities of the locality. It has been shown that the interventions developed based on the principles of fit-for-context, including offline platforms, mobile-based apps, and solar-powered devices, achieve a greater uptake and sustainability rates compared to those that merely recreate high-resource models (Tulinayo et al., 2018; Adarkwah, 2021). Moreover, incremental models of professional

development, such as peer coaching and micro-teaching, also allow educators to use ICT progressively without burdening the existing workload (Tondeur et al., 2021; König et al., 2024).

## **5. Monitoring, Research, and Learning Loops**

Lastly, embedding continuous monitoring, research and learning systems helps in effective ICT integration. Empirical literature underlines that monitoring must go beyond the use of counting devices to include the analysis of the way technology is utilized pedagogically, the way in which the engagement of learners transforms, and the way in which instructional practices can be changed with time (König et al., 2024). Intensive feedback processes between classroom activity, school management, and policy formulation are a prerequisite to maintain innovation and resolve disparities in the use of ICT in schools.

### ***Enablers of ICT Integration Summary***

In general, empirical literature shows that the integration of ICT is enabled by the dynamic and interrelated system of conditions that acts at the teacher, school, and system levels. The competence and confidence of teachers, leadership and collaborative cultures, coherent systems of policies, persistent funding, and context-specific implementation plan all serve to make or break the ICT adoption as superficial or transformative. In Ghana, coordinating these enablers using an integrated and evidence-based strategy is paramount in enhancing the ICT integration to move beyond symbolic adoption to the long-term pedagogical contribution. In Ghana, harnessing these enablers in a coordinated manner will be central to moving ICT integration beyond sporadic adoption toward sustained, pedagogy-driven practices that enhance teaching and learning outcomes. This synthesis not only underscores the importance of a multi-level approach but also provides a framework for identifying leverage points that can maximize the impact of ICT in primary education.

### 2.4.6 Comparison between Global and Ghanaian ICT Integration Trends

Whereas there exists a large volume of documented literature on the barriers to ICT integration in education, there has been an equivalent body of literature on the general patterns and trajectories that influence the adoption and embedding of technology in educational systems. In order to project the Ghanaian experience into these broader processes, Table 3 presents a comparative synthesis of the prevailing global patterns of ICT integration and the Ghanaian trends thereof based on peer-reviewed empirical research.

**Table 3**

*Global vs Ghanaian ICT integration Trends*

<b>Dimension</b>	<b>Global ICT Integration Trends</b>	<b>The trends of ICT Integration in Ghana</b>
<b>Policy orientation</b>	Transition to systems based, pedagogical digital transformation models with a focus on learning outcomes and teacher practice (Voogt et al., 2015; Tondeur et al., 2017).	Strong policy framing supports ICT integration, but the main roles are on access and inclusion of curriculum components, without much attention on long-term pedagogical changes (Asare et al., 2023).
<b>Infrastructure provision</b>	High-resourced systems in OECD countries are becoming increasingly characterized by an increasing trend towards pervasive connectivity, one-to-one or shared-use device structures, and cloud-based platforms (Fraillon et al., 2019).	Although the number of devices deployed and connection points has relatively increased gradually, infrastructural differences remain apparent between urban and rural schools, limiting the ability of the system to integrate across the board (Agyei & Voogt, 2011; Buabeng-Andoh, 2019; Baako, 2024).
<b>Teacher professional development</b>	Ongoing, practice-based professional learning, in which pedagogy, content, and technology are grounded on TPACK models, has become prominent (Tondeur et al., 2017).	Professional development is seen as episodic and mostly skills-based with a lack of sufficient classroom coaching or subject matter pedagogy (Agyei & Voogt, 2011; Baako, 2024).

<b>Pedagogical use of ICT</b>	The application of ICT in supporting student-centered learning, collaborative inquiry, formative assessment and personalized learning has increased in high-capacity systems (Voogt et al., 2015).	Teacher-centered approaches, including presentations and information retrieval, are mainly supported by ICT utilization, whereas learner-centered or inquiry-based pedagogy is still underused (Buabeng-Andoh, 2019).
<b>Assessment integration</b>	An increase in the correspondence between ICT and formative assessment, learning analytics, and feedback mechanisms facilitates learner advancement (Fraillon et al., 2019).	The integration of ICT in assessment processes is low; tests are more paper-based and exam-based (Owusu et al., 2023).
<b>Leadership and school culture</b>	Instructional leadership and school-wide digital strategies as mediating variables to effective ICT integration are strongly emphasized (Tondeur et al., 2017).	The role of leadership is recognized but unequal; integration of ICT is commonly based on individual headteachers instead of institutionalized school-centered strategies (Lomo et al., 2024).
<b>Equity orientation</b>	The focus on policy towards inclusion, digital equity, and compensatory support of disadvantaged learners is gaining momentum, a post-COVID-global trend (Tondeur et al., 2017).	Digital inequalities remain in place at both the socio-economic and geographic levels, and there is a lack of specific compensatory policies (Baako et al., 2023).
<b>Evidence on learning outcomes</b>	The mixed evidence suggests that ICT improves learning outcomes in the context of promoting pedagogically consistent designs, which can be summed up in meta-analytic agreement (Voogt et al., 2015).	Small-scale or subject-specific interventions have yielded the most positive learning outcomes, and little evidence has been found to support the impact of the interventions at a bigger system-wide scale (Owusu et al., 2023; Bayuo et al., 2022).

As Table 3 shows, the ICT integration path in Ghana follows major global patterns regarding policy intent but takes completely different directions in terms of implementation depth and systemic coherence. Compared to the global trends, where educational change is increasingly focused on pedagogical change, formative assessment, and continuous professional learning,

access-based initiatives and disjointed professional development continue to be the primary mark of the Ghanaian experience. The contrast implies that the main challenge in Ghana is not where policy should be heading, but rather the institutional capability that must be available to implement the international best practices into local restrictions. This comparative viewpoint emphasizes how it is necessary to go beyond infrastructural growth to more integrated, pedagogy-based reform paradigms, in case ICT can play any significant role in enhancing learning on a large scale.

#### **2.4.6 Self-Assessment Tools for ICT Integration in Education**

Self-evaluation tools tailored to the integration of information and communication technology (ICT) have increasingly become widely acknowledged tools of value in empirical literature as essential mechanisms to leverage digital competence, pedagogical decision-making, and readiness among teachers to actively integrate technology within classroom teaching in a purposeful and significant way. Such tools provide well-organized frameworks that help teachers to reflect on their current abilities, the goals of professional development, and set specific learning goals (Tondeur et al., 2021). Regular results in recent research point to the conclusion that structured self-evaluation is the foundational aspect of reflective practice, which enhances the internalization of the pedagogical value of ICT in teachers and increases the likelihood of sustained and learner-oriented use of the technology (Howard et al., 2021; König et al., 2024). The international document, e.g., the ICT Competency Framework of Teachers, created by UNESCO (ICT -CFT) and the European DigCompEdu model provide progressive standards used to measure teacher ICT competence in various areas (Caena & Redecker, 2019). According to recent empirical studies, there has been a shift in the use of fixed checklist-like instruments to platforms that can produce adaptive feedback and customized professional developmental trajectories, where learning analytics and artificial intelligence are especially likely to be combined

(Nguyen & Habók, 2024). Such innovations have achieved an unprecedented topicality in the post-pandemic conditions, where blended and hybrid learning frameworks require ongoing pedagogical readjustment (van der Vlies, 2020).

There is a great deal of variability in the design and scope of the ICT self-assessment instruments across contexts. Most of the tools are based on established conceptual frameworks, including Technological Pedagogical Content Knowledge (TPACK) and the Substitution-Augmentation-Modification-Redefinement (SAMR) model, which prompt teachers to question the correspondence between technology, pedagogy, and content (Drugova et al., 2021). Instruments based on rubrics are still common, with their ability to present well-defined statements of performance at progressive levels of competence, such as the six-tier proficiency map of DigCompEdu (Caena & Redecker, 2019). SELFIE is an example of digital platforms used to build on top of these approaches, providing online assessments with visualized feedback dashboards on the institutional level.

The evidence on the effectiveness of self-assessment tools is mostly positive. The findings of Tondeur et al. (2021) indicated that constant use of self-assessment tools was linked to greater teacher self-efficacy and increased the use of digital resources in learner-centered teaching. Caena and Redecker (2019) also discovered that the teachers who received automated feedback in digital self-assessment platforms were much more likely to make changes in pedagogical practices in the short term. Comparably similar trends are observed in studies carried out in Sub-Saharan Africa, though with a smaller number. The digital lesson planning and formative assessment practices were also enhanced by mobile-based teacher support interventions in Nigeria, mainly among early-grade teachers, regardless of the infrastructural limitations (Adesina et al., 2025). To control the adoption of ICT and its use in South Africa, Mapisa and Makena (2024) found that self-assessment

that is embedded in Professional Learning Communities (PLCs) intensified the use of ICT, particularly in rural schools. Empirical evidence specific to Ghana is rather scarce; nonetheless, according to Acquah (2023), pre-service teacher education that introduces structured self-reflection may help to improve both the level of ICT competence and confidence.

Nevertheless, along with their promise, empirical research also reveals some significant shortcomings of ICT self-assessment tools. One of the most common issues is associated with the accuracy of self-reported data since teachers can under or overestimate their competencies because of the lack of benchmarking, the social desirability bias, or low self-efficacy (Zhang et al., 2022). The contextual relevance is also another issue: most tools are created in the high-income context, and they might not be sensitive to infrastructural realities, education-focused priorities, or cultural values in low- and middle-income nations (Buabeng-Andoh, 2019). Studies indicate that these restrictions can be alleviated by putting the user-centered design and actionable feedback as well as integration with peer or mentor support mechanisms, to increase the developmental value of self-assessment tools (Nguyen & Habók, 2024).

#### **2.4.6.1 Self-Assessment Tools for ICT Integration in Ghana**

The implementation of organized ICT self-assessment instruments in the primary education sector of Ghana is relatively low as compared to more digitally advanced education systems. However, there is new empirical evidence suggesting that such instruments have a significant potential in addressing the long-term teacher ICT competence gaps. Though institutionalized large-scale, standardized self-assessment mechanisms are not yet in place, related practices, including reflective teaching, competency-based continuing professional development (CPD) and organized peer review, are gradually becoming increasingly prominent in teacher development programmes (Abakah et al., 2022).

Recent research highlights the need to consider structured self-assessment in the teaching educational institutions of Ghana. A study by Acquah (2023) established that pre-service teachers in Colleges of Education were usually left with little time to critically assess their ICT capabilities on frames to achieve unequal preparedness to work in technology-intensive classrooms. Although these teachers had positive attitudes towards ICT, their level of confidence in the use of digital tools to deliver subject-specific instructions, especially in STEM subjects, was low. This leads to the empirical assumption that incorporating structured ICT self-assessment in pre-service curricula may help to identify competence gaps at an earlier point in time and allow professional growth plans to be more focused. On the in-service level, Mano et al. (2024) found that various Ghanaian educators had no definite standard with which to measure ICT competence, and assessments instead were based on informal self-understandings, as opposed to formal system frameworks like the ICT-CFT framework of UNESCO or the DigCompEdu framework. A pilot study based on DigCompEdu aimed at creating a mobile-compatible self-assessment tool was applied in two districts in the Eastern Region of Ghana. The results showed that the teachers felt a greater sense of personal strengths and areas of improvement, which subsequently informed further planning on ongoing professional development. However, the adoption had constraints because of inadequate digital literacy among the staff, intermittent internet connectivity, and failure to fit the overall ICT plans of the school (Nguyen & Habok, 2024).

The rural-urban digital divide is one of the most urgent contextual challenges in Ghana, which has a direct negative impact on the viability and effectiveness of self-assessment tools. As argued by Abedi et al. (2024), teachers working in rural settings often have limited access to information and communication technology (ICT) and other resources and limited opportunities to develop professionally, which interferes with their ability to access or utilize online self-

assessment tools. In turn, mobile-first or offline adaptations, which could be built into highly utilized applications, like WhatsApp or USSD services, could be a fairer alternative. This strategy is supported by empirical data provided by Henkel et al. (2024), who have shown that a tutoring system built with AI, based on WhatsApp, was scalable and cost-effective in rural Ghana, hence indicating the possibility of mobile-based intervention to overcome infrastructural limitations.

On the policy level, Ghana has policy frameworks that offer some foundation for integrating self-assessment instruments into teacher development frameworks. As an example, the ICT in Education Policy (MoE, 2015) and the Teacher Professional Development Framework also emphasize the need for continuous competency assessment and self-reflection; however, neither policy document specifies a standardized ICT self-assessment tool (Buabeng-Andoh & Baah, 2020). Lack of a national mandate has resulted in a disjointed process of adoption that has been dominated by donor-funded programs or uncoordinated school programs. Using the international policy discussion, the correspondence of verified self-assessment tools to national teacher standards and CPD credit systems can provide a feasible incentive mechanism and can improve alignment of national ICT priorities (Caena & Redecker, 2019; van der Vlies, 2020).

Notably, as revealed by studies, self-assessment tools in Ghana cannot be perceived as single-handed remedies but a part of a bigger ecosystem of teacher support. Tondeur et al. (2021) suggest that the best way to engage in self-assessment is in combination with post-intervention strategies, including peer mentoring, joint lesson planning, and the possibility to access custom online training modules. In the Ghanaian context, the Professional Learning Community (PLC) is a pre-existing system that can enable that integration. The studies in Kenya, where similar educational problems dominate, suggest that the implementation of self-assessment tasks into PLC

meetings can not only increase the accuracy through peer validation but also stimulate team-based approaches towards closing the outlined skill gaps (Ngao & Sang, 2024).

In conclusion, although ICT self-assessment tools are not fully institutionalized in the primary education system in Ghana yet, there is empirical evidence that they provide a perspective to enhance the competence and confidence of teachers in digital pedagogy. Self-assessment tools used in conjunction with national professional development models and adjusted to local infrastructural realities and placed within networks of mutual support can play an important enabling role in equitable and sustainable ICT integration.

#### ***2.4.6.2 Framework-Based Digital Self-Assessment Approaches***

An emerging body of literature identifies digital self-assessment as a useful and more validated method of diagnosing digital competence of teachers, promoting personalized professional development (PD), and aligning the instructional practice with institutional or national standards (Scherer et al., 2020; Redecker & Punie, 2017; Cabero-Almenara et al., 2021). With its grounding in the framework of coherent competence, self-assessment instruments may be considered valid and used to determine strengths and weaknesses across different areas: digital pedagogy, assessment, resource production, and learner empowerment (Aydin et al., 2024; López-Nuñez et al., 2024). Modern designs are moving towards making assessment increasingly related to the developmental paths so that the measurement of competence is followed by practical recommendations on PD (Aydın et al., 2024; López-Nuñez et al., 2024).

The alignment of frameworks continues to be an essential factor in the perceived reliability and the extended usage of self-assessment instruments. DigCompEdu is particularly an influential framework in the international community, and several validation and adaptation studies have reported its usefulness in teacher self-reflection, programme evaluation, and monitoring system-

level (Cabero-Almenara et al., 2023). On an organizational level, the streamlined and reliable SELFIE tool has been developed after undergoing psychometric assessment tests, and it offers an effective way of measuring the digital capacity of institutions and informing school improvement planning (Cachia et al., 2024). Even though SELFIE focuses on school-level preparedness and not personal competence, it demonstrates how complementary feedback loops between system levels can be created by framework-based tools (Cabero-Almenara et al., 2023; Cachia et al., 2024).

In addition to European settings, there have been several teacher-level instruments that have been validated. Tondeur et al. (2017) created an ICT-competence tool among preservice teachers that is still actively used in teacher education studies. More recently, Aydin et al. (2024) introduced the Teachers' Digital Competences Scale (TDC-S) that gives evidence of excellent reliability and construct validity in the primary and secondary context and suggests its application to guide teacher training and PD. The necessity of contextualization in the transfer of digital competence instruments to other education systems is also highlighted by other scholars who note that such tools need to be adjusted to national and cultural contexts (Tondeur et al., 2017; Aydin et al., 2024).

Three principles of effective self-assessment mentioned in systematic reviews include being based on recognized frameworks, including DigCompEdu; offering diagnostic detail based on various domains of competence; and producing actionable feedback based on PD structures and career development pathways (López-Nuñez et al., 2024; Cabero-Almenara et al., 2023). The principles can also be used to reduce self-assessment bias by means of iteration, observational or portfolio-based evidence triangulation, as well as by means of calibration in communities of practice (López-Nuñez et al., 2024; Cabero-Almenara et al., 2023).

Eventually, the theoretical and empirical strands come to a convergence on two implications that are practical. To begin with, the best use of validated self-assessment tools is as part of wider change models that comprise school-wide capacity building (e.g. SELFIE-informed planning) and teacher-wide capability building (e.g. DigCompEdu-aligned PD, micro-credentials). Second, teacher beliefs and perceived competence and usefulness continue to be significant predictors of the future usage of technology, which further supports the importance of self-assessment as a motivational factor and a PD-focused tool (Pozas & Letzel, 2023). A comparative review of the most prominent framework-based self-assessment tools is given in Table 4, giving an overview of their scope, strengths, limitations, and applicability to ICT integration in education.

The synthesis above demonstrates that despite such instruments as DigCompEdu and the TDCs framework having significant tools of diagnostic capacity, the successful implementation of such models into contexts as the example of Ghana, will of course depend on engaged contextual modification, the integration of equity-specific design considerations, and alignment with already functioning national-level professional development models (Cachia et al., 2024; Pozas and Letzel, 2023).

**Table 4***Comparative Overview of Framework-Based Digital Self-Assessment Tools*

<b>Tool / Framework</b>	<b>Focus &amp; Scope</b>	<b>Strengths</b>	<b>Limitations / Challenges</b>	<b>Key References</b>
<b>DigCompEdu</b> (European Framework for the Digital Competence of Educators)	Individual teacher competence across 6 areas (e.g., pedagogy, assessment, learner empowerment, professional engagement).	Widely validated; diagnostic granularity; adaptable to multiple contexts; strong PD alignment.	Originally developed for European contexts may require contextual adaptation in LMICs.	Cabero-Almenara et al., 2023; López-Nuñez et al., 2024
<b>SELFIE</b> (Self-reflection on Effective Learning by Fostering Innovation through Educational Technologies)	School-level digital capacity (infrastructure, teacher practices, leadership, learner engagement).	Supports system-level monitoring; psychometrically refined; generates actionable feedback loops for schools.	Focuses on organizational capacity rather than individual teacher competence.	Cachia et al., 2024
<b>ICT-Competence Instrument</b>	Preservice teachers' ICT competence in teacher education programs.	Foundational in teacher ICT competence research; widely cited; adaptable in teacher training.	Developed for preservice teachers less suited for in-service staff.	Tondeur et al., 2017
<b>TDC-S (Teachers' Digital Competence Scale)</b>	Teacher-level self-assessment (primary to secondary contexts) of digital competences.	Strong reliability and construct validity; explicitly linked to PD pathways; scalable across contexts.	Newer instruments require more cross-cultural validation and longitudinal studies.	Aydin et al., 2024
<b>Other National / Contextual Models</b>	Country-specific adaptations of DC frameworks for local needs (e.g., UNESCO	Context-sensitive; addresses cultural and infrastructural realities; enhances policy alignment.	Fragmented; limited comparability across countries;	Various (see Education & Information Technologies;

ICT-CFT adaptations).	uneven adoption.	Buabeng-Andoh, 2019)
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### 2.4.7 Gaps in Literature

Even though ICT has been established globally as a driving force of pedagogical innovation and learner engagement, there are still significant gaps in literature. On the international scale, most studies have concentrated on secondary and tertiary education, especially in technologically developed economies where the infrastructure and the level of readiness are elevated (Tan et al., 2022). Though these studies have worthwhile pedagogical implications, they are not very helpful to teacher contexts that are resource-challenged and in primary schools. Furthermore, the focus of global research is often on infrastructure and access, and little is done to focus on teachers' digital competence, self-assessment practices, policy ambitions, and classroom realities (Hennessy et al., 2022).

Empirical research in Sub-Saharan Africa (SSA) has reported extensive projects like Kenya (Digital Literacy Programme), Rwanda (Smart Classrooms) and South Africa (Gauteng Online) (Langat 2020; Gitiha, 2024). Nevertheless, the analysis of these interventions always demonstrates the issues of sustainability, such as a lack of technical support, uneven readiness of teachers, and ineffective monitoring systems (Kayombo et al., 2024). Much of the SSA literature is descriptive, mapping the infrastructural and financial barriers (Van Deursen & Van Dijk, 2020), but provides little context-specific framework of how to address these issues specifically at the primary education level, where ICT integration may bring a long-term developmental impact.

These differences are more pronounced when reduced to Ghana. Even though the research into ICT integration on the secondary and tertiary levels has grown over the recent years (Abedi et al., 2024), comparatively few studies specifically investigate the use of ICT in the context of primary education (Buabeng-Andoh, 2021). Practical experience shows that the policies of the

country expressed in frameworks such as the ICT for Accelerated Development (ICT4AD) Policy and the ICT in Education Policy (2015) have not been realized down to the ground level. The existing evidence indicates that the national policy expectations, such as the ICT4AD Policy and 2015 ICT in Education Policy, have not been comprehensively achieved on the primary level because of infrastructural gaps, the lack of teacher capacity, and poor integration in pedagogy (Nyarko et al., 2021; Asare et al., 2023). This disjointedness indicates a seriousness of policy intention and classroom-based implementation in the primary education system in Ghana.

Another and perhaps more crucial gap is connected to the lack of empirical studies on the topic of teacher-initiated digital self-assessment tools in Ghanaian primary schools. Although the use of self-assessment tools in promoting reflective practice, tracking professional development, and improving the ICT integration skills of teachers has become a response to the need to incorporate the most effective methods in international education (Kaminskienė et al., 2023; Meyer et al., 2021), there is currently no digital version of self-assessment that is validated by the Ghanaian context and suitable for use in primary education. The existing frameworks are largely imagined in high-resource contexts and poorly capture the situation in Ghana in terms of curriculum frameworks, the infrastructural conditions, or systems of teacher professional development. These gaps are systematically synthesized in Table 5, which compares what has already been studied with areas that remain underexplored, thereby providing clear justification for the present study. The synthesis also shows the lack of models that are empirically based and context-oriented that combine teacher competence development, reflective self-assessment, and policy alignment at the primary education level.

**Table 5***Synthesis of Literature Gaps in ICT Integration in Education*

<b>Level</b>	<b>What is Known (Existing Evidence)</b>	<b>What is Missing (Gaps in Literature)</b>
<b>Global</b>	Extensive research on ICT in secondary and tertiary education, especially in developed economies (Tan et al., 2022). Focus has largely been on infrastructure provision, device access, and digital resource availability.	Limited focus on ICT integration in primary education, particularly in low-income or resource-constrained settings (Sucipto et al., 2024). The analysis of teacher digital pedagogy, identity formation, and contextual constraints is a seldom-analyzed topic in global studies (Scherer & Siddique, 2020). At the foundational level, reflective self-assessment practices or digital competence tracking are studied in very few studies (Engeness, 2021).
<b>Regional (SSA)</b>	There has been extensive documentation of large-scale national ICT projects (e.g., Kenya and its DLP, Rwanda and its Smart Classroom Project, South Africa and its Gauteng Online). The most prevalent barriers are the ineffective infrastructure, the lack of technical assistance, the lack of digital pedagogy, and unprepared educators (Kayombo et al., 2024; Van Deursen and Van Dijk, 2020).	Studies are usually descriptive and concentrate on obstacles and not on sustainable pedagogical interventions (Tondeur et al., 2017). Not many studies offer context-sensitive evidence-based models of ICT integration in the low-resource primary schools (Ofosu-Asare, 2024). Minor focus is on teacher-led systems like digital self-assessment tools which enable educational institutions to diagnose ICT requirements and direct CPD engagement (Aldossary, 2022).

<b>Ghana</b>	National ICT4AD Policy (2003) and ICT in Education Policy (2015) articulate ambitious digital integration goals (MoE, 2015). Empirical studies exist primarily at secondary and tertiary levels (Abedi et al., 2024).	Very limited studies examine ICT integration in primary schools, despite this being the foundational stage of literacy and numeracy development (Buabeng-Andoh & Baah, 2020). There have also been persistent gaps in policy ambition-classroom practice, with infrastructural shortage, teacher digital preparedness, and curriculum integration being some of the issues (Asare et al., 2023). There are no studies that suggest structured, scalable aids that assist primary school teachers in evaluating their digital competence and developing it (Manu, 2024).
<b>Teacher Self-Assessment</b>	International digital competence frameworks (UNESCO ICT-CFT; DigCompEdu) demonstrate the value of structured self-assessment for reflective teaching, competence development, and CPD alignment (Kaminskienė et al., 2023; Meyer et al., 2021).	The literature on Ghana-specific studies of digital self-assessment tools with teachers of primary schools practically does not exist (Acquah, 2023; Nguyen and Habo, 2024). There exists no current teacher self-assessment instrument that has been validated in accordance with the Ghana primary curriculum, the realities of the Ghanaian school infrastructure, CPD systems, and teacher professionalism. The assessment of teacher competence is informal and unstable (Buabeng-Andoh & Baah, 2020), which does not allow for establishing specific development objectives. This is a significant practical and theoretical gap, and the DSAT suggested in this paper provides a prototype that addresses this gap in concept. Nevertheless, its usefulness needs to be piloted and validated in the future to become a fully functional tool.

### *Narrative Synthesis According to Table 5*

The synthesis given in Table 5 depicts an obvious and repeated trend within global, regional, and national literature: although ICT integration has been thoroughly researched, there are still enormous gaps in conceptual, methodological, and practical approaches, especially at the

primary school level. Studies around the world are primarily oriented towards infrastructure and digital access, but they do not study how digital identities, pedagogical beliefs, and reflective self-assessment practices of teachers determine the use of technology in a classroom (Sucipto et al., 2024). The literature on Sub-Saharan Africa still focuses on systemic obstacles like insufficient infrastructure and teacher preparation but presents less evidence-based and context-sensitive models on how to transcend these obstacles in low-resource primary schools. In the area, studies are more descriptive than exploratory, and little effort has been made to investigate teacher-led processes, including digital self-assessment instruments that require teachers to engage in reflective practice and the long-lasting development of their professional skills and competencies (Tondeur et al., 2017).

The gaps are even more noticeable in Ghana. Although national ICT policies are ambitious, empirical studies focus on higher learning institutions, such as secondary and tertiary institutions, and do not explore the context of primary school (Buabeng-Andoh & Baah, 2020; Abedi et al., 2024). The ongoing implementation lapses due to the lack of infrastructural facilities, the unreadiness of teachers, and the lack of alignment with the curriculum still make significant ICT use in basic schools rather challenging (Asare et al., 2023). More importantly, no research, so far, suggests a systematized and scalable digital self-assessment instrument that fits the Ghanaian curriculum and CPD framework, as well as the realities of primary education. Overall, these gaps indicate that future research studies should anticipate teacher identities, levels of competencies, and reflective practices, as well as consider contextual obstacles to the integration of ICT.

## **2.5 Summary of Reviewed Literature**

The literature reviewed presents evidence that ICT integration is a key characteristic of modern educational reform which can provide the opportunity to digital interactive, collaborative,

and learner-centered pedagogy with sufficient support through infrastructure, policy support, and teacher professional development. Although the high-income settings have progressed to digitally enhanced learning settings, most of the low- and middle-income nations still experience systemic limitations restricting significant implementation. In Sub-Saharan Africa, national ICT programs have widened access, but the lack of sustainability occurs because of the infrastructural voids, inadequate teacher preparedness and intermittent monitoring systems.

The reviewed literature revealed that ICT has a promising future in the primary education setting, yet its implementation tends to be superficial, not considering the insufficient preparation of teachers, inadequate digital skills, and the discrepancy of curriculum requirements and classroom realities. In Ghana, despite the presence of national policies stating the clear objectives of digital learning, empirical studies indicated the presence of ongoing inequality in the infrastructural facilities, educator preparedness, and curriculum delivery, especially in the underprivileged primary schools. The importance of digital self-assessment tools (DSATs) in facilitating reflective practice, determining the level of competence, and contributing to professional development is also emphasized in international studies. Nevertheless, as it has been set out above in this chapter, these instruments are yet to be calibrated into the Ghanaian primary education setting.

In conclusion, the available literature highlights the transformative nature of ICT and the structural, pedagogical and professional obstacles that continue to limit its effective incorporation in the Ghanaian primary schools. These insights guide the scope of the current research, where the researcher focuses on the practices of ICT integration and the development of a prototype Digital Self-Assessment Tool (DSAT) to suit the primary education system of Ghana.

## CHAPTER THREE: METHODOLOGY

### 3.1 Overview

The chapter outlines the methodological approach used in this investigation. It clarifies the philosophical orientation that guided the study, the general research design, the mixed-methods approach that was chosen, data collection procedures, participant selection methods, data analysis methods, and ethical issues considered. Together, all these elements are combined and coordinated in such a way that they produce coherence, transparency, and methodological rigour. The study is situated in a pragmatic epistemological position, which supports methodological pluralism and prefers the use of methods that are most suited to answer multifaceted, practice-based research questions. In line with this, a convergent mixed-method design was chosen where both the quantitative and qualitative strands were granted equal allowances. The quantitative part helped to identify the measurable patterns and trends related to the sphere of ICT integration, and the qualitative part provided a profound, contextual interpretation of the experience, perception, and expectations of teachers towards the use of ICT and digital self-assessment. The chapter further elaborates on the rationale behind the adoption of mixed-method design and demonstrates the use of triangulation to enhance the credibility and validity of the findings. It also explains how the selected methodological approach supports the goals of the study, especially regarding the translation of the empirical results into the form of a developmental design of the Digital Self-Assessment Tool (DSAT) prototype.

Later divisions explain the population of the study and sampling methods. The quantitative element involved the use of probability sampling procedures, and purposive sampling was applied in the qualitative element. The chapter continues with the description of the data collection tools and instruments, such as the structured questionnaire and semi-structured interview guide, and the

procedures of piloting, refinement, and administration of the tools to make them understandable, valid, and context appropriate. This is followed by the explanation of the analytical strategy. Quantitative data were put through the relevant statistical procedures, and qualitative data were analyzed by using thematic and content analysis. The measures taken to ensure reliability and trustworthiness, such as the systematic coding processes and the verification strategies, are outlined as well.

Finally, the chapter covers ethical issues, such as informed consent, confidentiality, the preservation of the rights of the participants, and compliance with institutional and national ethical standards of educational research. Figure 8 presents the methodology flow diagram of the study.

**Figure 8**  
*Research Methodology Flow Diagram*



*(Image Source: Researcher's Construct, 2025)*

### 3.2 Research Approach and Design

This section provides a description of conceptual and methodological principles that informed the study, starting with the philosophical assumptions supporting the research, then the

mixed-methods design, weighing choices, and the general research approach. The paper is based on a pragmatic worldview, which embraces methodological adaptability and focuses more on the production of practical, contextually pertinent knowledge. In this paradigm, a convergent mixed-method design was used to combine the quantitative and qualitative data to achieve a complete picture of ICT integration in primary schools and the teacher-informed needs to design a Digital Self-Assessment Tool (DSAT). The section also expounds on how research aims were matched to certain methodological undertakings, how strands of data were combined, and how the empirical findings obtained were used to update the prototype of the DSAT.

### **3.2.1 Philosophical Assumptions -Pragmatism**

The study is based on the pragmatic school of thought, which defines knowledge as useful in understanding how to solve practical issues in the world (Creswell & Creswell, 2017; Morgan, 2014). Pragmatism is often considered an adequate philosophical premise of mixed-methods research due to its focus on methodological flexibility, the contrasting of different types of evidence, and concentrating on the practical implications of the research choices (Creswell & Clark, 2023; Shannon-Baker, 2016). Instead of giving preference to one epistemological standpoint, pragmatism allows a researcher to utilize both quantitative and qualitative methods in such a manner that is most appropriate in solving the research issue. Modern scholarship on mixed methods emphasizes that pragmatic orientation allows simultaneous application of both numerical data and contextual meaning to produce holistic and practical knowledge without belief in the abstraction of strictly positivist and/or constructivist premises (Doyle et al., 2016; Mertens, 2023). This stance is in line with the objectives of the current research, which has a dual goal to explore the practices of ICT integration in Ghanaian primary schools and to extrapolate empirically supported design requirements to create a prototype of a Digital Self-Assessment Tool (DSAT).

The pragmatic approach upholds the combination of survey data, capturing the trends of ICT access and usage, with the qualitative data, which clarify the lives of teachers, their difficulties, and their willingness to engage in digital self-assessment.

Pragmatism is especially suited to educational technology research where challenging, context-specific issues tend to be sufficiently interpreted by integrating several methodological approaches (Creamer, 2021; Creswell & Clark, 2023). The pragmatic paradigm in this study offers consistent logic to the application of convergent mixed-method design, where findings could be triangulated and the information would be more interpretively valid. In addition, the design-based nature of the research is consistent with fundamental pragmatic assumptions. Pragmatism focuses on the argument that research must be employed in enhancing educational practice by making contributions that are both theoretically enlightened and practically applicable (Biesta, 2020; Morgan, 2014). In this orientation, the design of the DSAT as a research-based prototype is not put forward as a definitive solution, but rather, as a provisional and formative design product based on empirical evidence. The pragmatic philosophical approach, thus, supports the methodological decisions of the study and incorporation of results into knowledge that will inform future refinement, piloting and validation of the DSAT.

### **3.2.2 Mixed Methods Research Design**

Mixed methods research (MMR) is a collection of research designs that incorporates the quantitative and qualitative methods in a systematic way to deal with complex research issues. These types of classification help researchers to choose designs that are consistent with their philosophical position, research goals, and contextual limitations and provide methodological coherence and transparency. Instead of focusing on a specific methodological tradition above another, the mixed-method research exploits the advantages of both approaches and empowers a

researcher to answer the questions that cannot be sufficiently explored using a single methodological perspective (Creswell & Clark, 2017). Ultimately, mixed-method research is based on the belief that social and educational phenomena are complex and situational. Quantitative methods add breadth by applying patterns, relationships, and trends on larger samples, whilst the qualitative methods add depth by applying the experiences, meanings, and contextual realities of participants (Tashakkori & Teddlie, 2010). The deliberate combination of these types of evidence improves the ability to explain, justify triangulation, and increases the credibility and validity of the results (Fetters et al., 2013).

This design comes in handy, especially in applied and educational research, wherein the aim of the research is not only description but also informing of practice, policy, and design decisions. According to scholars, a mixed-methods study is most appropriate to the challenges of answering the question of the so-called real-world issues that can be examined and measured in their outcomes and human meaning, technology adoption, career development, and instructional innovation (Creswell & Creswell, 2017; Ivankova & Clark, 2018). It allows researchers to study both processes and outcomes and, therefore, promote a more comprehensive conceptualization of the operation and reasons behind interventions to operate under certain conditions. The MMR is often philosophically connected to pragmatism, which puts much more importance on the research question and practical implications of the inquiry than on the adherence to one epistemological position (Morgan, 2014). Under this approach, methodological decisions are motivated by the best interests of the research problem, and not ideological adherence to the paradigms of positivism or interpretivism. Such flexibility allows scholars to choose, mix, and merge the methods in a manner that will answer the contextual constraints and research objectives (Shannon-Baker, 2016).

Notably, this study design is not about parallel use of qualitative and quantitative methods, but about a purposeful procedure of combination. Integration can be done at various points in the study, such as in design, data collection, analysis, interpretation, or reporting (Fetters & Molina-Azorin, 2020). Mixed methods research, when done in its rigorous form, can provide greater knowledge than the sum of its components, providing subtle, practical, and contextually rich knowledge.

### ***3.2.2.1 Mixed Methods Research Designs Classifications***

Generally, mixed methods designs have been classified into sequential designs and concurrent designs, based on the sequential or simultaneous timing and inclusion of qualitative and quantitative strands.

In sequential mixed methods designs, the research has several stages, but the strand of the methodology used in one stage provides information about the second one. There are two such explanatory sequential and exploratory sequential designs. With explanatory sequential designs, the quantitative data is gathered and analyzed then a qualitative investigation is done to elaborate or explain the initial findings. It is especially helpful in situations when statistical trends or correlations need to be interpreted in deeper terms. On the other hand, exploratory sequential designs use qualitative data collection to explore phenomena that are not well studied or those whose significance is not known, as well as to identify pertinent variables or create insights that will guide future quantitative measurement or testing. These types of designs are particularly useful when there is a lack of previous research or when context-sensitive tools must be designed.

Conversely, concurrent (or convergent) mixed methods designs gather qualitative and quantitative data during the same stage of the study. The two datasets are analyzed separately, but in the interpretation, there is a combination of the two to test convergence, divergence or

complementarity. This design allows the researcher to gain a depth and breadth of the quantitative trends, plus the depth of qualitative experiences concurrently, giving the research greater explanatory power because of the triangulation. The usage of convergent designs is especially fitting in situations when the data strands are given equal treatment and when the goal is to establish a complex picture of a phenomenon over a given period (Creswell & Clark, 2017). In general, these mixed methods typologies offer adaptable and guided ways of combining the various manifestations of evidence. When implemented with rigour, they enable the researcher to tackle sophisticated educational challenges, including ICT integration by blending quantifiable patterns with a contextual and experiential understanding which makes the results of research more plausible and therefore more applicable in practice.

Considering the dual purpose of the study to examine the current status of ICT integration practices in Ghanaian primary schools and, develop an empirically supported and theoretically informed prototype Digital Self-Assessment Tool (DSAT), a concurrent (convergent) mixed methods design was implemented. The following section explains the rationale behind this choice and how it was operationalized in the current study.

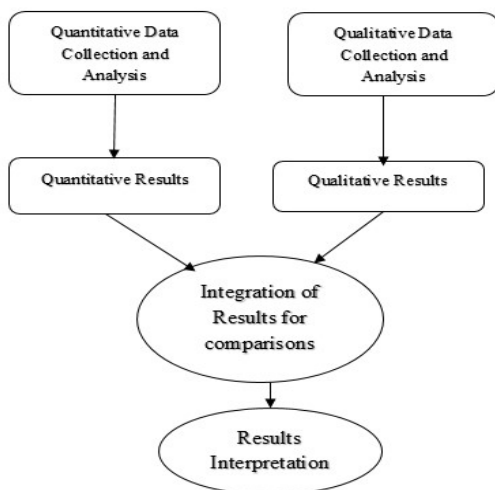
### ***3.2.2.2 Concurrent (Convergent) Design***

The current study employed the convergent (concurrent) mixed-method research design, which requires simultaneous gathering and independent processing of qualitative and quantitative data, and the subsequent synthesis at the interpretive phase. The convergent design allows investigators to question a phenomenon in heterogeneous terms in one step of a study, thus facilitating a direct comparison and synthesis of results (Schoonenboom & Johnson, 2017).

Considering a pragmatic philosophical focus, the study combined quantitative and qualitative data to effectively cover the goals of the research (Creswell & Clark, 2017).

Quantitative data were collected through structured questionnaires having measures on the degree of ICT integration, perception of teachers towards the proposed digital tool, and essential design requirements. To obtain the experiences, difficulties, and expectations of teachers regarding the use of ICTs and design demands of the DSAT prototype, qualitative data were collected using semi-structured interviews and the responses provided by teachers to the open-ended questionnaires. These two strands of data were interpreted separately and later combined in the process of interpretation. The combination of these fragments of data increases explanatory strength and enhances the validity of the findings through triangulation (Guetterman et al., 2015). This kind of design is particularly appropriate when qualitative and quantitative data are given equal weight and when the research task is to develop a holistic picture of the phenomenon that is being studied. As illustrated in Figure 9, the convergent mixed methods design demonstrates the parallel collection of quantitative and qualitative data streams and their integration during the interpretation stage.

**Figure 9**  
*MMR Approach and Convergent Design*



*Image source: Creswell & Clark (2007)*

### ***3.2.2.3 Justification for the use of Mixed Methods Approach***

The rationale of using a mixed methods approach in this research is based on the complexity of the research problem, as well as the pragmatic philosophical position guided by the study. ICT integration in primary school is a complex phenomenon, which involves infrastructural, teacher competence, practice, instructional, policy implementation, and user attitudes to digital tools. These dimensions cannot be entirely described by one methodological tradition. Mixed-methods research, thus, offers a suitable methodology for coming up with an in-depth and multi-dimensional insight into these interrelated elements (Creswell & Clark, 2023). There are several considerations that informed this methodological choice.

To begin with, quantitative approach was critical to determining patterns, prevalence and determinants of ICT integration among a relatively large number of samples. The use of survey data made it possible to determine levels of competence, determine the predictors of technology acceptance, and evaluate the readiness and perceptions of teachers regarding the design of a Digital Self-Assessment Tool (DSAT). Nevertheless, only quantitative findings would not be sufficient to reflect the contextual intricacies or pedagogical issues confronting these educators in these settings. To examine these contextual dimensions deeply, qualitative approaches were needed. The interviews and open-ended responses were informative on the perception, expectation, and practical needs of teachers, and are important in designing a contextually relevant DSAT. This depth-oriented evidence is particularly necessary when creating a prototype of educational technology that can be further refined and piloted in the future (McKenney & Reeves, 2021; Creswell & Poth, 2018).

The mixed-method approach thus, improves the validity and credibility of findings due to triangulation. The combination of quantitative and qualitative strands leads to converging evidence

that helps to make stronger interpretations and diminishes chances of misrepresentation or biases (Fetters & Molina-Azorin, 2020). This is more so in research where one is not only seeking to examine practices, but also to come up with a useful intervention like the DSAT, which is based on empirical data and is also consistent with actual circumstances. Lastly, the mixed-method approach played a critical role in addressing the two-fold objective of this study. Quantitative data revealed the main gaps in the competences and trends in the use of technologies, whereas the qualitative data elucidated the needs of the users, contextual issues, and design choices. Integrating these datasets produced a coherent evidence base that directly shaped the DSAT's conceptual structure and functional requirements. Such a methodological fit corresponds to the design-oriented research methodology, where the use of empirical data in the development of educational tools is constantly repeated (McKenney & Reeves, 2021).

Overall, the significance of the mixed-methods approach was informed by the fact that (a) the breadth and depth of ICT integration in Ghana primary schools will be best captured, (b) the methodological triangulation will increase the validity, and (c) a strong empirical basis will be attained to design a prototype DSAT that is contextually relevant, theoretically supported, and practically implementable in future pilot.

#### ***3.2.2.4 Equal Weighting of Quantitative and Qualitative Strands***

The quantitative and qualitative strands of the convergent mixed-methods design were given equal weight in this study. The choice aligns with the current mixed-methodological literature, which holds that equal priority should be given to all strands when each of them offers unique but equally necessary knowledge needed to deliver the research objectives (Creswell & Clark, 2023; Doyle et al., 2016). In this study the quantitative strand offers measurable and generalizable trends in the practices of ICT integration by teachers, their level of competence, and

their perceptions about a prospective DSAT prototype. These data provide a general structural insight into the phenomenon, which includes trends, frequencies, and determinants that cannot be acquired with the help of qualitative inquiry alone. The semi-structured interviews and open-ended responses offer richness, color, and meaning that can be used to interpret the quantitative patterns and place them in the context of the true situation in the primary school environment in Ghana. Equal weight was thus required since neither of the strands could, individually, fully respond to the dual objectives of the study. With both strands being prioritized, statistical trends and contextual interpretations then have an equivalent impact on the development of the prototype of the DSAT as required by the principles of design-based educational research (McKenney & Reeves, 2021). In that way, the equal weighting decision represents the pragmatic inclination of the study and promotes the methodological consistency because both types of data play a valuable and significant role in the interpretation of findings resulting in the creation of the DSAT prototype.

#### ***3.2.2.5 Research Strategy and Alignment to Research Objectives***

The pragmatic philosophical approach and convergent mixed-methods design employed in this study resulted in a coherent research strategy that enabled each research goal to be fulfilled through relevant and complementary methodological processes. Mixed-method scholars believe in the necessity of matching research goals with particular data sources and analysis processes to guarantee research methodological consistency and transparency (Creswell & Clark, 2023; Molina-Azorin & Feters, 2016). This kind of alignment also supports the interpretive integration of quantitative and qualitative strands, especially in convergent designs in which datasets are analysed independently and combined at the interpretative stage (Shorten & Smith, 2017).

The quantitative and qualitative strands in this research involved the same set of core constructs associated with ICT integration practices and design requirements of a digital self-

assessment tool (DSAT). The quantitative aspect provided quantifiable data on the levels of ICT integration, as well as the relevant design anticipations of the DSAT. Complementarily, the qualitative element, i.e., semi-structured interviews and open-ended survey questions, provided deep contextual information that expanded and justified the quantitative results, eliciting the views, experiences, and rationales of the participants. The combination of these strands allowed the more comprehensive and analytically strong interpretation of findings and, thus, the design-based approach to educational research where the existing empirical evidence is used to inform the creation and improvement of educational prototypes in the form of digital prototypes (McKenney & Reeves, 2021).

Table 6 provides a tabular overview of how the matched methodological activities were pursued with each of the research objectives. This type of mapping is based on the best practices of methodological transparency and enhances auditability in mixed-method research (Clark et al., 2021; Schoonenboom & Johnson, 2017).

**Table 6***Alignment of Research Objectives, Methods, and Applications*

<b>Research Objective</b>	<b>Method(s) Used</b>	<b>How the Method Was Applied</b>
Objective 1: To assess the current state of ICT integration practices in Ghana's primary schools.	Quantitative survey; open-ended survey items; semi-structured interviews	The survey questions were designed to capture frequency, types, and purposes of ICT use; the open-ended questions and interviews were used to give contextual explanations of the integration practices, constraints, and enabling conditions.
Objective 2: To examine the factors that could influence teachers' perceptions and attitudes toward adopting a digital self-assessment tool (DSAT).	Quantitative survey (perception and attitude scales); qualitative interviews	Items in the surveys focused on the perceived usefulness, ease of use, confidence, and willingness to use a DSAT. Interviews were used to find out more about attitudinal motivators, concerns, and motivational issues behind the potential adoption of DSAT.
Objective 3: To identify teacher-informed requirements for the design of the DSAT including pedagogical and technological features, usability, and accessibility considerations.	Semi-structured interviews; open-ended survey items	The desired features, interface preferences, and accessibility needs (e.g. offline or mobile-first) and pedagogical expectations were stated by teachers in line with local realities of classrooms in low-resource settings. These informed the specifications of features in the DSAT.
Objective 4: To design and develop a prototype of a contextually relevant DSAT grounded in TPACK, TAM, and DOI.	Design-based synthesis of quantitative findings; qualitative interview data; theoretical mapping (TPACK, TAM, DOI)	To identify important feature requirements, quantitative items were analyzed in the context of perceived usefulness, ease of use, level of ICT competence, and factors of adoption. Qualitative interviews responses give in-depth teacher-generated design issues, such as functionality desired, usability preference, accessibility limitation and contextual adaptation. Results of the two strands are combined and streamlined onto TPACK (competence domains), TAM (perceived

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usefulness and ease of use), and DOI (adoption conditions) to define the content structure of the DSAT, what the interface is expected to look like, and what the prototype is supposed to handle. The outcome of this process is a prototype of DSAT that must be piloted and validated in the future.

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### ***3.2.2.6 Methodological Linkage to DSAT Prototype Design***

One of the main objectives of this research is to design a prototype of a contextually relevant Digital Self-Assessment Tool. It is thus necessary to explain how the methodological decision undertaken in this study assists and guides the design of this tool. The convergent mixed methods that the study followed allowed a systematic combination of the quantitative and qualitative results, each delivering evidence that was complementary and needed to design educational technologies with the user in mind. This methodological coherence guarantees that the prototype of the DSAT is not a theoretical product of a conceptual nature, but the product that is empirically based on the actual practice of teachers, their needs, and the realities of their contexts.

To begin with, quantitative data provides statistical results about the level of ICT competence of teachers, trends in using technology, and predictors of technology acceptance. These findings revealed the digital competence areas that need to be tested and developed thus guiding core structure and content areas of the DSAT. Indicatively, competence descriptors and reflective indicators integrated in the tool were direct results of areas where teachers mentioned low confidence or limited integration. This is in accordance with the principles of design-based research, which requires basing tool design on the identified needs of users (McKenney & Reeves, 2021). The existing studies on design-based educational instruments also prove the importance of quantitative evidence in the awareness of domain-specific gaps, which subsequently inform the

construction and further development of assessment models (Aydin et al., 2024; López -Nuñez et al., 2024).

Also, the qualitative strand that comprised interviews and open-ended responses to the survey included rich and contextualized accounts that expanded on the expectations of the teachers, design preferences, perceived barriers and usability requirements. These insights played a significant role in how the DSAT would work in low-resource settings, such as simplicity requirement, mobile accessibility, offline availability, and reflective prompts. These findings are consistent with the best practices in user-centered design, which states that meaningful technological tools should mirror the lived experiences and the preferences of the targeted users (McKenney and Reeves, 2021; Kaminskienė et al., 2023). Furthermore, the combination of quantitative and qualitative results, conducted in the interpretation stage, enabled the study to unify empirical findings into a coherent group of design specifications. Convergent mixed-methods logic assumes that both depth (QUAL) and breadth (QUAN) are valuable to produce both empirically and contextually suitable design requirements (Fetters & Molina-Azorin, 2020).

Finally, theoretical triangulation enhances the methodological route towards the design of the DSAT prototype. TPACK was used to identify technological, pedagogical, and content-related areas of competence; TAM was used to focus on the perceptions of usefulness and ease of use, which make a tool more acceptable; and DOI was used to make considerations regarding the conditions under which innovation is more likely to be adopted, including compatibility and trialability. The combination of the three structures was warranted to make the DSAT prototype empirically based as well as conceptually sound and futuristic.

In conclusion, though the DSAT was not piloted or validated at this point, a limitation noted in Chapter Five, the methodological process adopted is a rigorous basis upon which the prototype

development is to proceed and forms the baseline on which subsequent testing will be carried out. The DSAT, which was created in this study, is, therefore, a theoretically informed, empirically determined pilot study that can be refined, tested, and scaled by future research.

### **3.3 Population of the Study**

A population in research is the whole set of people, objects, or units on which a researcher wants to make a conclusion or extrapolate results (Ahmad et al., 2023). Populations are usually categorized around a set of common traits: either geographical area, demographics, occupation, or time (Thacker, 2020; Creswell & Creswell, 2017). The target population in this research was primary school teachers and sampled officials in the Ghana Education Service (GES) from South Dayi District in the Volta Region of Ghana. The presence of both teachers and GES officials mirrors the dual nature of the study (1) to gain an insight into the ICT integration practices through the lens of classroom implementers' perspective and (2) to achieve a system-level perspective through teachers, educational administrators and support staff. The officials from the GES that were taken into consideration to carry out this research include the Human Resource Management (HRM) staff, ICT coordinators, and School Improvement Support Officers (SISOs) all from the South Dayi District Education Directorate. For this study, public primary schools were classified into two categories:

1. Early Grade: Kindergarten to Basic Three (KG1–B3)
2. Upper Grade: Basic Four to Six (B4–B6)

The district records indicate that the South Dayi District has 37 public primary schools, as at the time of the study, with an average of 12 teachers, that is, including the head teachers. This creates the projected figure of 444 teachers. Along with that, the project population of the GES district education office staff, which included SISOs, HRM officers, as well as ICT coordinators,

was about 15 people. As such, the overall population size that forms the target population is approximated to be 459 individuals.

### **3.3.1 Sample and Sampling Techniques**

A sample is a subset of a population created through a methodological approach but commonly chosen to represent the features of the whole group and make valid conclusions (Ahmad et al., 2023; Etikan & Bala, 2017). Consistent with the mixed-methods design, this research used a mix of probability and non-probability sampling. This pluralistic sampling approach guaranteed statistical representativeness to the quantitative part and richness of contextual insights at the qualitative stage.

#### ***3.3.1.1 Inclusion and Exclusion Criteria***

It is a methodological requirement to establish clear inclusion and exclusion criteria to make sure that the study sample is representative of the target population defined and that all respondents have the characteristics necessary to provide useful and valid data (Patino & Ferreira, 2018). Outlined below are the inclusion and exclusion criteria for this study:

##### **1. Inclusion Criteria**

Participants were deemed eligible for inclusion in this study based on the following professional and contextual criteria:

- i. **Public Primary School Teachers:** All trained and in-service educators, including classroom teachers and headteachers, actively working in public primary schools within the study area. This encompassed both the Early Grade (Kindergarten to Basic Three) and Upper Grade (Basic Four to Six) levels.

- ii. Ghana Education Service (GES) Officials: District-level administrators whose functions directly relate to pedagogy, technology, and human resource management in primary schools:
  - a. Human Resource Management (HRM) personnel
  - b. Information Technology (IT) coordinators
  - c. School Improvement Support Officers (SISOs)

These groups were strategically selected as they collectively represent the primary implementers and administrators of ICT integration in the educational institutions in the district.

## 2. Exclusion Criteria

To maintain the homogeneity and relevance of the participant pool, the following individuals and institutions are excluded from the study:

- i. **Untrained Teachers:** Individuals lacking formal teaching qualifications were excluded to ensure that all participants possessed a professional pedagogical background relevant to the study's core focus on ICT integration within formal instructional practices.
- ii. **Pre-service Teachers:** Student teachers or individuals under internship within the study area are also excluded.
- iii. **Private Schools:** All private primary schools are excluded to maintain the focus exclusively on the specific policy context and administrative structure of public education within the study area.

### 3.3.1.2 Sampling Approach

In mixed-methods research, sampling is a vital methodology choice because it determines the credibility, transferability, and depth of interpretation of the results (Etikan & Bala, 2017). Generally, sampling methods fall into two general categories, namely, probability and non-

probability, both of which apply to various research purposes and epistemological orientations. It is, however, important to give a brief overview of both, to justify the technique taken in this study.

## **1. Probability Sampling**

Probability sampling is any method where all in the target population have a known and non-zero probability of being selected. Ordinary techniques are simple random sampling, stratified sampling, cluster sampling and systematic sampling. In quantitative studies, probability sampling can be used since it increases representativeness and statistical generalization (Acharya et al., 2013). The quantitative aspect in this study used a systematic, multistage probability sampling plan that would capture a representative cross-section of teacher population in the district to maximize external validity and generalizability:

### **a. Stratified Sampling at the Circuit Level**

To ensure proportional representation in case of geographical and institutional differences in the district, stratification was used, which aligns with the recommendations of minimizing sampling bias and improving representativeness in educational studies (Etikan & Bala, 2017; Lohr, 2021). The study district comprised of public schools that were arranged in six circuits, and each circuit represented a separate stratum. The circuits contain 37 public primary schools.

### **b. Simple Random Sampling of Schools**

Five schools were selected in each stratum applying simple random sampling, which resulted in a final sample size of 30 schools out of the 37-school population. The practice minimized selection bias and enhanced the external validity and generalizability of the results (Taherdoost, 2021).

**c. Complete Enumeration (Census) within Selected Schools:**

Following the selection of the 30 schools, a complete enumeration (census) was applied within each stratum (circuit). All trained and in-service teachers who met the defined inclusion criteria were invited to participate, resulting in an eligible pool of approximately 360 individuals. The inclusion of all eligible teachers within the selected schools maximized intra-school representativeness and ensured the capture of diversity across teaching assignments, subject expertise, and years of professional experience factors known to significantly influence attitudes and practices toward technology integration (Tondeur et al., 2019). Crucially, the sampling framework intentionally incorporated both school leadership (headteachers) and classroom teachers, acknowledging that supportive leadership is a critical determinant of successful ICT adoption and sustainability (Dexter, 2019; Scherer et al., 2021; Lohr, 2021).

**3.3.1.3 Non-Probability Sampling (Interview Phase)**

Non-probability sampling entails the selection of respondents, which is based on the discretion of the researcher, availability, or other particularities of the study (Creswell & Clark, 2017). Purposive sampling, convenience sampling, and quota sampling techniques are some examples of non-probability sampling. Mixed-methods and qualitative studies tend to employ non-probability methods, particularly when the aim is to gain detailed and context-related information as opposed to generalization (Palinkas et al., 2015). Such methods are especially applicable to research where the respondents must fulfill a certain criterion, like primary school teachers involved in the integration of ICT, or where the practical considerations hold the respondents back to the schools or districts randomly.

**a. Purposive Sampling**

A purposive sampling strategy was employed in the qualitative aspect of this research to identify ten participants to conduct in-depth interviews. The sample included a Director of Human Resource Management, an ICT Coordinator, and two School Improvement Support Officers (SISOs) of the South Dayi District Office of the Ghana Education Service (GES). Furthermore, four classroom teachers and two headteachers who had earlier been involved in the quantitative phase were purposively selected to take part in the interview. This sampling strategy was used to cover both representation and inclusion of information-rich cases to meet the requirements of the best practice in qualitative sampling of mixed methods research (Patton, 2015).

### ***3.3.1.3 Justifications of the Sampling Techniques and Sample Size***

The methodological framework of this study predetermined the combination of the concepts of probability and non-probability sampling methods to guarantee the balance of the targeted expertise and the statistical representativeness in the process of data collection.

#### **a. Justification of Sampling Techniques**

The purposive sampling strategy was chosen clearly to capture the views of the stakeholders whose professional abilities and experience made them critical sources of information in the aspects of ICT integration and policy execution. The use of different administrative and institutional levels of participants, such as district officials, school heads, and classroom practitioners, allowed the study to represent the broad range of perspectives. This conscious strategy made sure that various voices in the educational ecosystem were captured, and this produced qualitative data that included leadership views, institutional interests, and classroom realities. This targeted approach is consistent with the methodological principles of data depth and enrichment in the context of qualitative inquiry (Creswell & Poth, 2016).

In the quantitative arm, stratified random sampling was exploited to sample the schools involved, which is a methodological essentiality that reduces selection bias and enhances the external validity of survey-based research studies (Stratton, 2021). Besides, the option of seeking responses amongst all the qualified teachers in the sampled schools was critical. The study attains methodological rigor by balancing stratification, which has the advantage of breadth by covering all the educational circuits, with the census methodology that delivers depth by providing a rich representation of various professional thoughts. This bi-directional focus contributes greatly to the reliability and overall generalizability of the findings to the South Dayi district context (Etikan et al., 2016; Taherdoost, 2020). This strict adherence to best practices in mixed-methods educational research makes the well-constructed sampling structure reinforce the validity of further inferences and the opportunity of contextual transferability (Creswell & Clark, 2023).

The coordinated sampling structure reflects the modern guidelines of mixed-method inquiry, where the simultaneous use of different methodologies results in complementary quantitative and qualitative data. These data sets can be triangulated successfully to strengthen the validity and interpretive power of the results in general (Creswell & Plano Clark, 2023; Sharma et al., 2023).

#### **b. Justification of Sample Size**

The sample size used to collect the questionnaire data was 360, and the sample size used to conduct the interview was ten, which was based on a specific target population of some 459 individuals (444 teachers and 15 GES officials). Even though this sample size, as a proportion of the target population value, is larger than the minimum sample size proposed by the Krejcie and Morgan model (Memon et al., 2021), it increases the statistical power and enhances the generalizability of results (Muyembe, 2023). The conscious choice to slightly expand the sample,

more specifically, in the context of the questionnaire data collection, was informed by modern methodological standards according to which a context-specific rationale of sample size is preferred over absolute adherence to simple tabular values (Lakens, 2022; Serdar et al., 2021). Increasing the sample size allowed the study to increase its statistical power and to make its parameter estimates more precise. This inclusive nature was effective in ensuring that various views were represented in a heterogeneous educational environment, hence making the findings valid, relevant, and applicable in the South Dayi District.

#### ***3.3.1.4 Rationale for District Selection***

The choice of the study area was determined by both methodological and practical as well as contextual considerations according to the provisions of mixed-methods research. The selected district has significant differences in the ICT access and infrastructure, including both rural and peri-urban school environments. This heterogeneity presents an appropriate environment to conduct research on the variation in practices of ICT integration and preparation of teachers in different resource settings (Africa Education Watch, 2023; Abedi et al., 2024). Accessibility and feasibility were essential factors during the selection. The permission of the District Education Directorate was sought, and the geographic limits of the district made easy coordination of the information collection process within the stipulated time frame and budgetary restrictions. Researchers associated with mixed-methods research emphasize that the feasibility and its accessibility in the study area are valid criteria according to which the location of the study is determined, especially in the case of a study conducted to explore a particular phenomenon that is not intended to be extended to the entire population (Creswell & Clark, 2023).

Even though Ghana is a multiregional country with different degrees of ICT infrastructure, due to the choice of one district, it was possible to conduct an in-depth, context-driven study of

the actions of ICT with sufficient methodological integrity. The inclusion of schools within the rural and peri-urban areas in the district was critical in ensuring that the study was able to capture the relevant differences in aspects of ICT access, exposure of teachers to training, electrical reliability, and resource distribution, which are well-documented aspects that can influence ICT integration in Ghana (Nyarko et al., 2021). Complete rural-urban stratification in multiple districts was not established because of logistical and sampling factors, such as travel distance, lack of ICT infrastructure records in schools, and factors related to the ethical approval. However, internal diversity within the chosen district can be viewed as a small but self-sufficient environment in which the national disparities are reflected and allows for the interpretation of the contextual challenges affecting the prerequisites of ICT integration and DSAT design.

The selected district, in its turn, is methodologically adequate to the exploratory goals of the study and provides a heterogeneous enough background to produce empirical knowledge that would be used in the process of creating a context-specific prototype of the DSAT.

### **3.4 Research Materials and Instrumentation**

This study examines the situation of ICT integration at Ghanaian primary schools and how a digital self-assessment tool can be developed to allow teachers to track and reflect on their use of technology. In answering the four guiding research questions, two key data collection tools were used: a questionnaire (including closed- and open-ended questions) and a semi-structured interview schedule. Based on the convergent mixed methods design, quantitative and qualitative methods were conducted simultaneously to give full coverage of the research issue (Creswell & Clark, 2017; Schoonenboom & Johnson, 2017). The use of a multi-instrument methodology further increased the credibility of the study, as the data triangulation process allowed the results to cross-

verify with the methods, which widened the scope of the investigation and provided greater validity (Dawadi et al., 2021).

The questionnaire acted as the key quantitative device, aimed at identifying measurable trends of using ICT, perception of teachers, and design preference towards the digital self-assessment tool. The closed-ended questions promoted statistical analysis, whereas open-ended questions enabled the participants to expound on their experiences and worldviews, thus supplementing the quantitative data. Qualitative data was collected through the interview schedule which elicited rich narratives that supplemented and put the survey data into context. The two instruments were tailored to fit local pedagogical structures, the role of teachers, and the contingencies of the available ICT resources. The focus was on the reduction of bias, the improvement of item specificity and relevance to the professional setting of the participants. This intensive design cycle enhanced the ecological soundness of the instruments, such that the information gathered gains the practical intricacies of ICT adoption in the Ghanaian primary schools.

### **3.4.1 Questionnaire Development**

Following methodological recommendations by Al Sharef (2018), the existing instruments were considered with the possibility of adaptation, but significant contextual variations were observed, which required the creation of a new, context-specific questionnaire. International standardized measures were considered not to be able to fully reflect the realities of ICT integration in primary school education, especially in the Ghanaian context (DeVellis & Thorpe, 2021; Kalkbrenner, 2021). Al Sharef (2018) emphasizes that in educational technology research, a researcher must adjust or develop a new instrument to make it valid and relevant to the current research parameters. Additionally, an emerging literature emphasizes key areas that are critical in

evaluating ICT integration (Tondeur et al., 2017; Petko et al., 2018). Based on these insights, these dimensions were captured in the questionnaire as follows:

- a. Self-efficacy of teachers in using ICT in teaching.
- b. Possible perceived obstacles and impediments to ICT integration.
- c. Teacher attitudes to technology adoption in education.
- d. Professional needs relating to the use of ICT.
- e. Infrastructure and resource availability.
- f. Features of currently used technologies.
- g. Local contextual issues that may determine the adoption of ICT.
- h. Perceived forces influencing the implementation of the DSAT (e.g., lack of training, infrastructural problems, slowing down change)
- i. Perceived attributes and the requirements of the proposed prototype of DSAT.
- j. Contextual design issues of the DSAT prototype (e.g., usability, compliance with curriculum, perceived utility)

The inclusion of these domains made sure that the survey did not end with the patterns of ICT use but produced actionable information that can be used to design and implement the digital self-assessment tool. The instrument was designed in a way that it combined closed-ended questions, which can be analyzed statistically, and open-ended questions, thus allowing the respondents to expand on their experiences and views. This two-fold format is in line with a convergent mixed-methods design and adds to the ability of the instrument to provide empirical evidence in parallel with shaping the user-oriented design of the intended tool. It, therefore, increases the feasibility and possible applicability of the DSAT prototype in practice, recognizing

that its implementation and sustainability can only be guaranteed by repeated testing and validation (Vongkulluksn et al., 2018).

#### ***3.4.1.1 Structure and Content of the Questionnaire***

The questionnaire of the study consisted of three major sections, which were strategically placed according to the four guiding research questions so that they cover all research objectives. This correspondence allowed systematization of data collection both in the quantitative breadth and in the qualitative depth following the best practices in the design of mixed-method instruments (Creswell & Clark, 2023; Gray, 2024). To facilitate triangulation of numerical and narrative data, the tool combined closed ended as well as open-ended questions. The closed-ended questions were presented using a five-point Likert scale (Strongly Disagree, Disagree, Undecided, Agree, Strongly Agree), which is highly recommended by scholarly studies to provide interpretable and reliable attitudes, perception, and practices measures (Joshi et al., 2015). Open-ended questions were also placed to enable the participants to expand on their answers, hence generating more context-specific information and uncovering insights that would not be visible in a more structured format (Rouder, 2021).

The introduction part captured demographic data, including gender, age, teaching experience years, and professional qualification. These variables were considered crucial, as the previous literature shows that the ICT integration depends not only on technological access but also on the demographic and professional features of the teachers (Buabeng–Andoh, 2021; Tondeur et al., 2018). The second section dealt with the study's objective one. Questions in this section explored the frequency and modes of ICT use among teachers, the perceived benefits, and the challenges facing them in their practice. The design involved the capturing of access-related concerns as well as pedagogical aspects of integrating ICT.

The study's objectives two, three, and four were examined in the third section, and these explore the educators' views on the design requirement of the DSAT prototype. This emphasis is consistent with the principles of user-centered design, which emphasizes developing educational technology solutions that are indicative of the real needs, situations, and limitations of the final users (Bower, 2019; Persico & Steffens, 2017). The structured questions were also followed by open-ended ones that offered chances to the participants with the purpose of expressing divergent opinions, suggesting new ideas, and noting cultural/contextual factors that the researcher did not predict.

### **3.4.2 Interview Schedule**

The interview schedule was meant to supplement the questionnaire to give it a qualitative depth and a context-specific expansion on the four guiding research questions. It was structured in such a way that it fits with the questionnaire and thus helped in the analysis to triangulate data well. The semi-structured nature allowed the participants to provide real-life examples and personal experience, which contributed to the depth and realism of the findings. According to the best practice of mixed-methods research, the interviews were to be used to investigate the why and how behind the patterns of the quantitative data and, thus, to make sure that the study would capture not only the quantifiable trends but also explanatory stories (Creswell & Plano Clark, 2023; Gray, 2024). The questions were semi-structured, with guiding questions that were pre-determined but flexible to explore the answers of the participants further. This design allowed not only to compare the responses of participants but also allowed considering the emergent yet pertinent themes (Tondeur et al., 2017; Castillo-Montoya, 2016). To increase validity and reliability, the interview schedule has been reviewed by three experts in educational technology and one expert in qualitative research methods. Their feedback was used to revise the question wording, order,

and the prompts to make them clear, culturally appropriate, and could evoke detailed responses. Furthermore, as the interviews were required to inform user-centered design of the Digital Self-Assessment Tool (DSAT), detailed descriptions of the needs of the teachers, practical challenges, and expectations were collected, which could not have been presented solely by a questionnaire.

### **3.4.3 Pilot Testing of Research Instruments**

Piloting testing was included as one of the essential quality assurance measures to underpin the development, refining, and calibration of the research tools. Pilot testing is commonly seen as paramount to evaluating both feasibility, clarity, and contextual suitability before full-scale data collection and uncovering methodological and logistical problems when operating in natural field settings (Malmqvist et al., 2019). This study was piloted with 40 subjects, which is about 10 percent of the expected sample size of 364. This ratio corresponds with the standard methodological practice in educational and social science studies, which usually suggests pilot samples of 10-20 percent to strengthen the reliability and credibility of the instruments (Hazzi & Maldaon, 2015; Bujang et al., 2024). The pilot concentrated on the main data collection tools, namely the questionnaire (closed and open-ended questions) and the semi-structured interview guide. The prototype of the Digital Self-Assessment Tool (DSAT) has not been piloted yet; rather, it was created later as a theoretically and empirically informed blueprint based on the key findings of the main study, with piloting and validation listed as the future research directions.

#### ***3.4.3.1 Purpose and Methodological Contribution of the Instrument Piloting***

The pilot stage was conducted to serve three main purposes:

1. To test the practicality of the data collection process in the Ghanaian primary education setting;

2. To test the clarity of the items and their cross-cultural relevance to reduce ambiguity and misinterpretation; and
3. To test the level of consistency with which the instruments measure the intended constructs among participants (Kallio et al., 2016).

This measurement is consistent with the literature on methodology that emphasizes piloting as a mechanism of strengthening the validity of a study and reducing risks associated with the design itself (Fraser et al., 2018).

#### ***3.4.3.2 Findings and Refinement***

The outcome of the pilot test demonstrated several problems that had to be revised. First, linguistic adaptation was required to make the cultural and conceptual equivalence of the chosen words possible. Second, some of the items in the questionnaires were ambiguous, and thus, they had inconsistent interpretations requiring amendments. Third, there arose logistical issues in schools with different infrastructural statuses, which led to changes to the data collection processes. The next iterative revisions were made to improve reliability and make the instruments consistent with the subject of the study (ICT integration and tool design). This operation reinforced the consistency between quantitative and qualitative components of the research (Schoonenboom & Johnson, 2017). Chapter Four presents detailed reliability results of the pilot test.

### **3.5 Variables and Operational Definitions**

In mixed methods research, operational definitions ensure conceptual clarity by translating abstract constructs into measurable indicators that can be consistently applied across both quantitative and qualitative strands. They function as a bridge between research questions, data collection instruments, and subsequent analysis, thereby strengthening construct validity and analytical coherence (Amare et al., 2023; Liu, 2022). The present study derives its key variables

directly from the research questions and defines them below with corresponding dimensions and measurement strategies.

### 1. **Variable 1:** ICT Integration Practices in Primary Schools

**Operational Definition:** This construct captures the breadth and quality of ICT integration in teaching and learning at the primary school level. It encompasses six domains:

- a. ICT Tools Used in Teaching – the types and frequency of technologies deployed in instruction.
- b. Challenges in ICT Integration – barriers and constraints encountered in classroom application.
- c. Assessment of ICT Integration – teachers’ perceptions of ICT’s effectiveness in enhancing pedagogy and learning outcomes.
- d. Teacher Confidence and Experience with ICT – self-reported levels of skill, comfort, and confidence in ICT use.
- e. Professional Development Opportunities and Support – access to and participation in ICT-focused training, mentoring, and technical support.
- f. Teacher Beliefs and Perspectives – underlying attitudes toward ICT’s relevance in education.

**Measurement:** Data were collected via a five-point Likert scale (1 = strongly disagree to 5 = strongly agree). Quantitative indicators were analyzed using descriptive statistics, while open-ended responses and interview data were thematically coded to provide contextual depth (Creswell & Plano Clark, 2023).

### 2. **Variable 2:** Perceived Factors that Could Influence Teachers’ Adoption of the Digital Self-Assessment Tool (DSAT)

**Operational Definition:** This construct examines the determinants that could shape teachers' readiness and willingness to adopt the Digital Self-Assessment Tool (DSAT). It is grounded in the Technology Acceptance Model (TAM), which emphasizes Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) as central predictors of technology adoption, while also incorporating contextual enablers relevant to educational settings (Marikyan & Papagiannidis, 2023).

**Dimensions:**

- a. Perceived Usefulness (PU): The extent to which teachers believe the DSAT will enhance their instructional practice and professional development.
- b. Perceived Ease of Use (PEOU): The degree to which the DSAT is seen as user-friendly, intuitive, and compatible with teachers' workload.
- c. Contextual Enablers and Barriers: Factors such as access to technical support, alignment with teaching practices, availability of professional development, and encouragement from peers or school leadership.

**Measurement:** Quantitative survey items (measured on a Likert scale) capture the strength of teachers' perceptions of PU and PEOU. Qualitative data (interviews) are thematically coded to identify contextual influences both enablers and barriers that could shape adoption.

3. **Variable 3:** Teacher-informed requirements for the DSAT

**Operational Definition:** This variable identifies the technological, pedagogical, usability and accessibility features that teachers consider essential for tool effectiveness, drawing from literature on usability, engagement, and educational technology design (Aslam et al., 2020).

**Measurement:** Quantitative survey items asked participants to rank feature preferences by importance. Open-ended responses and semi-structured interview provided elaboration, qualitative coding was used to generate deeper design insights.

4. **Variable 4:** Contextually Design Recommendations for the Digital Self-Assessment Tool.

**Operational Definition:** This construct reflects participants' design-oriented suggestions focused on usability, accessibility, and contextual fit, informed by principles of user-centered design in education technology (Marikyan & Papagiannidis, 2023).

**Measurement:** Structured survey responses were summarized quantitatively to reveal design trends, while qualitative data underwent thematic analysis to develop actionable recommendations.

The summary of the operational definitions of the key variables in the study is shown in Table 7 and is solely based on the research questions and theoretical framing. As shown, the constructs are broken down into measurable dimensions and linked with corresponding strategies for data collection and analysis. Presenting the definitions in this structured form provides conceptual clarity, enhances consistency across both the quantitative and qualitative strands of the mixed methods design, and strengthens construct validity (Amare et al., 2023; Liu, 2022). The table also demonstrates how theoretical models such as the TAM and user-centered design principles are applied to the operationalization of the DSAT.

**Table 7**  
*Operational Definitions of Key Variables*

<b>Variable</b>	<b>Operational Definition</b>	<b>Dimensions</b>	<b>Measurement Strategy</b>
ICT Integration Practices in Primary Schools	Extent and quality of ICT use in teaching and learning.	1. ICT tools used 2. Challenges 3. Effectiveness 4. Teacher confidence 5. PD & support 6. Beliefs/perspectives	Likert scale (1–5); descriptive statistics; thematic coding of qualitative data
Perceived Factors that could influence Teachers' Adoption of DSAT	Determinants shaping teachers' readiness and willingness to adopt the DSAT, grounded in TAM.	a. Perceived Usefulness (PU) b. Perceived Ease of Use (PEOU) c. Contextual enablers and barriers (support, alignment, peer influence)	Likert-scale survey items; descriptive & inferential statistics; thematic analysis of qualitative responses
Teacher-informed requirements for the DSAT	Teachers' preferences for tool design features ensuring usability and pedagogical effectiveness.	Feature preferences, ranked by importance	Quantitative ranking; qualitative thematic analysis
Design Recommendations for DSAT	Teachers' suggestions for usability, accessibility, and contextual appropriateness.	Usability, accessibility, contextual fit	Quantitative summary; thematic analysis

### 3.6 Study Procedures and Ethical Assurances

The recruitment and management of study participants was conducted through a structured protocol to ensure rigorous compliance with established ethical and administrative mandates. Formal ethical clearance was the initial requirement, secured from the UNICAF University Research Ethics Committee (UREC), which authorized the commencement of data collection (Creswell & Plano Clark, 2023). This institutional review process upheld the fundamental ethical principles of respect for persons, beneficence, and justice, thereby guaranteeing the protection and

rights of all participants throughout every stage of the study. Following institutional clearance, formal administrative permission was sought and obtained from the Ghana Education Service (GES) Regional Directorate, which granted the necessary authorization to conduct fieldwork within the defined jurisdiction. This administrative approval was transparently communicated to the South Dayi District Directorate to inform local authorities of the planned activities, ensuring full alignment with local educational governance structures.

### **3.6.1 Ethical Assurances**

Research ethics encompasses the core principles, rules, and standards governing responsible conduct in studies involving human participants, ensuring their rights, dignity, and safety are protected throughout the entire research process. Contemporary ethics frameworks universally reaffirm that safeguarding participant welfare is non-negotiable in credible educational research (Sánchez et al., 2023). This study was conducted in full adherence to the UNICAF University Code of Ethical Conduct for Research and strictly aligned with internationally recognized ethical frameworks, including the Belmont Report and the Declaration of Helsinki.

The Belmont Report establishes the foundational principles of respect for people, beneficence, and justice that underpin all ethical human research (Nagai et al., 2022). Similarly, the Declaration of Helsinki, recognized globally across various disciplines, mandates that research prioritize participant welfare and uphold their health, dignity, and rights over scientific gains, insisting that local ethical statutes must reinforce, not diminish, these protections (Kurihara et al., 2023). The following specific ethical considerations were rigorously observed:

#### **1. Informed Consent**

Before data collection, participants were provided with comprehensive, clear verbal and written explanations of the study's objectives, purpose, and scope. The researcher personally reviewed these details with the participants, emphasizing the voluntary nature of participation and the absence of any coercion. Participants were explicitly informed that they retained the right to withdraw from the study at any time without consequence, and that any data provided before withdrawal would be immediately excluded from analysis. Participants were actively encouraged to seek clarification beyond the written materials, fostering a shared, interactive consent process. This adheres to current best practices, which emphasize that informed consent should be an ongoing dialogue not merely a one-time signature to ensure both sustained understanding and voluntariness (Kadam, 2017). This approach is foundational to the ethical principle of respect for people, as articulated in the Belmont Report, which mandates consent to be both voluntary and informed (Xu et al., 2020). Contemporary descriptions of informed consent emphasize three core components disclosure, comprehension (capacity), and voluntariness, all of which were rigorously upheld in this study's procedures (O'Sullivan et al., 2020; Xu et al., 2020).

## **2. Privacy and Anonymity**

Anonymity was thoroughly upheld throughout the study. The instruments, including questionnaires and interview guides, were deliberately structured to avoid collecting any personally identifying data (such as names or school-specific identifiers not essential to the study).

This methodological approach aligns with best practices in qualitative and mixed-methods research, where de-identification and pseudonymization are fundamental to maintaining participant confidentiality and preventing potential re-identification (Diaz & Stam, 2023). Researchers are therefore encouraged to remove direct identifiers, carefully assess indirect

identifiers, and apply suitable anonymization techniques early in the research lifecycle, particularly during data transcription (Diaz & Stam, 2023; Godfrey-Faussett, 2022).

### **3. Academic Integrity**

All stages of this research, from data collection and analysis through to final reporting, were executed with an unwavering commitment to academic integrity, emphasizing honesty, transparency, and respect for intellectual property. All referenced literature, theoretical frameworks, and constructs were meticulously cited using APA 7th standards, ensuring rigorous attribution and scholarly credibility. To enhance trustworthiness and confirmability, key indicators of qualitative rigor, the study maintained detailed documentation (an audit trail) and provided clear methodological reporting. These practices bolster research dependability by allowing future researchers to trace methodological decisions and processes (Ahmed, 2024). Additionally, the researcher practiced reflexivity, which involved systematically considering and mitigating personal biases, assumptions, and positionality throughout the research process. Reflexivity is recognized for enhancing ethical rigor and depth in qualitative and mixed-methods research, ensuring that findings authentically reflect participants' perspectives (Johnson et al., 2020; Jamieson et al., 2023). By combining transparency through audit trails and reflective practice through reflexivity, the study upheld a high standard of academic integrity and trustworthiness, especially suited for exploring educational phenomena in real-world settings.

#### **3.7 Data Collection and Analysis**

The study adopts a convergent mixed-methods design, which strategically emphasizes the simultaneous collection and integration of both quantitative and qualitative data streams to comprehensively address the research objectives. Given the exploratory and developmental focus of the study, particularly the design of a context-specific DSAT prototype, formal statistical

hypotheses were deliberately not employed. Instead, the investigation is guided by clearly defined research objectives and questions.

The quantitative strand seeks to identify measurable patterns and associations in teachers' ICT integration practices and adoption factors, while the qualitative strand provides in-depth, explanatory insights into contextual realities and teacher-informed requirements. The integration of these complementary strands significantly strengthens the overall validity and ensures that the findings are both empirically grounded and contextually meaningful. The successful integration of these methods enabled the research to leverage the complementary strengths of both quantitative and qualitative paradigms.

By employing cross-methodological comparisons between the two datasets, the convergent design facilitated the corroboration or enrichment of quantitative patterns through qualitative interpretation. This strategy not only bolstered the credibility of the findings but also enabled the study to address its research questions from multiple vantage points, yielding a more comprehensive understanding of the multifaceted factors shaping ICT adoption in the context under study (Fàbregues et al., 2024).

### **3.7.1 Data Collection Process**

Following the attainment of institutional ethical clearance from the University's Research Ethics Committee (UREC) and subsequent formal administrative authorization from the Ghana Education Service (GES) Regional Directorate, the researcher proceeded to conduct the study within the South Dayi District's basic schools.

The district's administrative structure comprises six autonomous educational circuits. Therefore, the selection of the sample schools was rigorously aligned with these established cluster groupings to ensure equitable representation across the educational landscape. Key logistical

support was provided by the district's Human Resource Management (HRM) personnel and the ICT coordinators, who furnished essential administrative data and facilitated access to the participating institutions. Consistent with the convergent mixed-methods design, both quantitative and qualitative data collection activities were carried out concurrently during the study period.

Prior to formal data collection, the researcher initiated informal, pre-field visits to engage with school administrators and teachers. This preliminary engagement is recognized as an essential best practice in educational research, vital for establishing rapport, fostering trust, and enhancing data quality (Bartlett, 2017). Based on feedback received during the pilot phase, which indicated low response rates from online attempts, a critical methodological adjustment was implemented: the study shifted to face-to-face, paper-based administration of the questionnaire. This decision was necessary to better suit the local context, which is characterized by varying levels of digital access and limited internet connection. This strategy aligns with broader findings in survey research that demonstrate how in-person or paper-based modes yield substantially higher participation rates than online surveys, particularly in settings with limited technological infrastructure (Braekman et al., 2022).

Data collection spanned five consecutive days. Questionnaires were personally distributed to participants, accompanied by an explanation of the study's aims and the principles of voluntary participation. To accommodate teachers' schedules, respondents who required more time were permitted to complete the questionnaires overnight, with collection managed by school heads and retrieved by the researcher. In parallel, semi-structured interviews were conducted with a purposive sub-sample, consisting of two headteachers, four classroom teachers, one HRM coordinator, one IT coordinator, and two School Improvement Support Officers. Interview responses were documented primarily through handwritten notes due to technical limitations

regarding audio recording equipment in the field, as well as the discomfort expressed by most participants with the recording. To ensure the highest degree of accuracy and validity, immediate post-interview verification sessions were conducted, whereby participants reviewed the raw notes to confirm that the recorded responses accurately reflected their intended meaning.

### **3.7.2 Data Analysis Process**

The study's analytical framework was systematically developed to ensure that both the quantitative and qualitative data streams contributed meaningfully to the achievement of the research objectives (Creswell & Creswell, 2017). The research employed a parallel analysis strategy within the convergent mixed-methods design, where each data strand was analyzed independently and then subsequently merged. This approach remains a widely endorsed strategy for maximizing validity and interpretive depth in complex mixed-methods research (Shorten & Smith, 2017).

#### ***3.7.2.1 Quantitative Data Analysis Process***

The quantitative data collection instrument (the questionnaire) was logically partitioned into three core sections demographic assessment, ICT adoption factors, and digital self-assessment tool evaluation to directly align with the research questions and facilitate systematic analysis. The use of a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree) provided measurable items while enabling respondents to express specific degrees of attitude.

The analysis employed the statistical software packages SPSS, Microsoft Excel and Jamovi. SPSS remains highly valued in social science research due to its long-standing presence and comprehensive analytical capabilities (Masuadi et al., 2021). Conversely, Jamovi was utilized for its intuitive interface, open-source accessibility, and seamless integration with R, which

supports reproducible workflows and enhances its appeal for educational research (Şahin & Aybek, 2019). The following systematic analytical steps were implemented:

1. **Descriptive Statistics:** Computed means, standard deviations, and frequencies were used to systematically summarize responses across all measured items. Additionally, the analysis assessed the distributional properties of the data by calculating skewness and kurtosis values, along with their standard errors, to evaluate potential deviations from normality assumptions.
2. **Data Visualization:** Quantitative results were displayed using clear tables and appropriate graphical representations to aid in the interpretation and efficient communication of the findings.

### *3.7.2.2 Qualitative Data Analysis Process*

#### **a. Interview Responses**

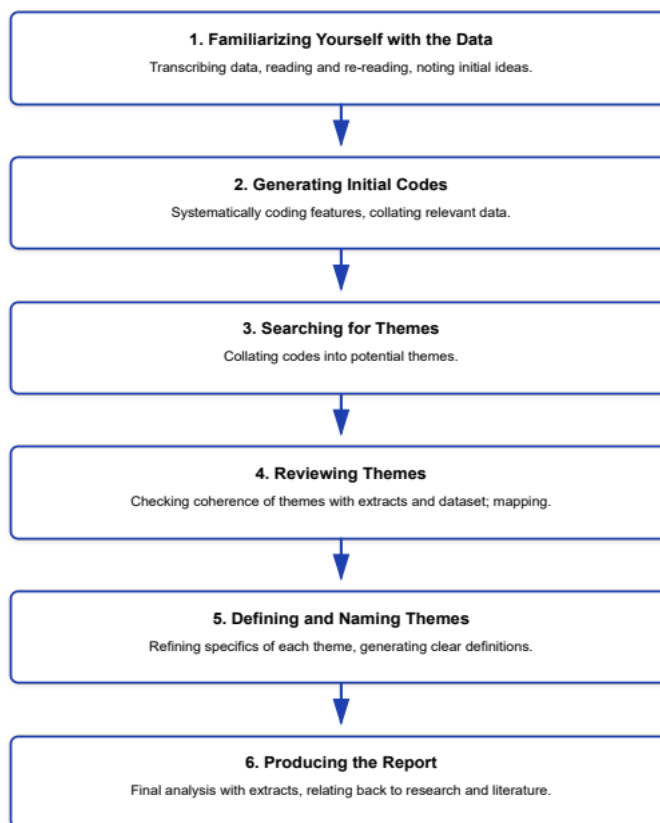
The study employed thematic analysis to systematically identify, analyze, and interpret patterns within the interview data. Thematic analysis is a method widely recognized for its flexibility, clarity, and rigor in qualitative research (Nowell et al., 2017; Braun & Clarke, 2022). This approach was particularly appropriate for investigating participants' experiences of ICT integration and their informed perspectives on the conceptual design requirements of the DSAT prototype. The analytical process strictly adhered to the six-phase framework of thematic analysis developed by Braun & Clarke (2006), a model frequently recommended in educational research for its transparency and methodological robustness (Creswell & Creswell, 2017). The phases are outlined below and visually represented in Figure 10 (adapted from Braun & Clarke, 2006).

1. **Familiarizing Yourself with the Data:** Interview responses were transcribed verbatim, read, and re-read to ensure deep immersion in the dataset, with initial ideas noted throughout this process.

2. **Generating Initial Codes:** Systematic coding was conducted across the entire dataset to capture salient features, with relevant data collated under each code.
3. **Searching for Themes:** Codes were then organized into potential themes, and all related data extracts were gathered to support their development.
4. **Reviewing Themes:** The preliminary themes were critically reviewed in relation to the coded extracts and the dataset, producing a coherent thematic “map” of the analysis.
5. **Defining and Naming Themes:** Each theme was refined to clearly articulate its scope and meaning, ensuring alignment with the research questions, and given a concise, representative name.
6. **Producing the Report:** A comprehensive analytic narrative was constructed, integrating thematic descriptions with vivid and compelling verbatim quotations. This final phase situated the findings within the study’s conceptual frameworks and the wider literature, thereby enhancing their scholarly contribution and transferability.

By combining systematic coding with iterative review, the analysis maintained methodological transparency and rigor (Nowell et al., 2017). The use of a structured thematic process was particularly appropriate for this study, as it ensured that teachers’ experiences and perspectives on ICT integration and DSAT adoption were authentically represented, while findings remained aligned with the study’s theoretical frameworks (TPACK, TAM, and DOI).

**Figure 10**  
*Phases of the Thematic Data Analysis*



*Image source: Adapted from Braun & Clarke, (2006).*

### **b. Open-ended Responses**

The textual data from the open-ended questionnaire items were examined using quantitative content analysis, a systematic and replicable method for making valid inferences from textual data (Krippendorff, 2018). This method is valuable for capturing participants lived experiences, perceptions, and attitudes in social science research (Assarroudi et al., 2018). The analysis employed a dual-emphasis approach, interpretation, and enumeration to enhance the triangulation of qualitative insights with quantitative survey data (Vaismoradi & Snelgrove, 2019; Kyngäs, 2020). The following five iterative stages, adapted from the Braun and Clarke (2006) framework, were employed:

1. First-order Coding: Responses were repeatedly reviewed, and initial descriptive codes were assigned to capture the overall meaning, supporting credibility by maintaining close contact with the raw text.
2. Second-order Coding: Initial codes were refined and clustered under more precise labels, allowing for clearer differentiation and increasing dependability.
3. Numerical Coding: Each distinct concept was assigned a numerical identifier to enable frequency counts, support replicability and ensure confirmability.
4. Categorization: Codes were grouped into broader thematic categories, forming an interpretive framework aligned with the research questions, thus enhancing transferability.
5. Frequency Analysis: The prevalence of each thematic category was calculated (noting instances of missing data), strengthening cross-validation with survey findings and supporting methodological triangulation.

This layered, rule-based approach reflects established best practices in qualitative content analysis. The iterative cycles of coding refine raw responses into meaningful categories (Saldaña, 2021), while systematic categorization ensures trustworthy results (Erlingsson & Brysiewicz, 2017) and allows patterns to bridge qualitative depth with quantitative breadth (Williams et al., 2019; Assarroudi et al., 2018).

### ***3.7.2.3 Integrated Data (Quantitative and Qualitative) Analysis Process***

The formal integration of quantitative and qualitative findings within a convergent mixed-methods design constituted a central methodological strength of this study. Consistent with the framework by Creswell and Clark (2017), both data streams were collected within a similar timeframe, analyzed separately, and subsequently merged to generate a more comprehensive understanding of the research problem. This design capitalized on complementary strengths:

quantitative methods provided statistical breadth and generalization potential, while qualitative approaches offered rich, contextually grounded insights into teachers lived experiences with ICT integration and the DSAT.

The integration of findings was achieved through a systematic process of comparison and convergence, focusing on three key outcomes:

1. **Convergence:** Identifying areas where quantitative and qualitative findings corroborated each other, thereby bolstering the credibility of the results.
2. **Complementarity:** Highlighting how different strands addressed distinct but interconnected aspects of ICT integration and DSAT adoption, thereby broadening the scope of understanding.
3. **Divergence:** Recognizing and thoroughly examining points of apparent contradiction between datasets, which prompted deeper reflection on potential contextual, methodological, or epistemological explanations (Guetterman et al., 2015).

To operationalize this integration, the study employed joint displays matrix, a widely recommended analytic technique in mixed-methods research (Guetterman et al., 2015). Joint displays facilitated the systematic alignment of statistical results with emergent qualitative themes enabling the clear visualization and narrative synthesis of both consistencies and discrepancies across the datasets. As highlighted by Creamer (2023), such syntheses advance transparency and support theory development by linking empirical evidence to conceptual frameworks.

By adopting this combined approach, the study ensured that statistical findings were contextually situated within participants lived experiences, while qualitative insights were supported by evidence of their broader prevalence. This integrative process enhanced the overall validity, reliability, and transferability of the conclusions. As emphasized in recent scholarship, mixed-methods integration is particularly valuable in low-resource educational contexts, where

the fusion of quantitative evidence with qualitative perspectives generates evidence-based and contextually sensitive implications for stakeholders (Krippendorff, 2018; Erlingsson & Brysiewicz, 2017).

#### ***3.7.2.4 Ensuring Coding Reliability and Trustworthiness***

The reliability and trustworthiness of the qualitative analysis were crucial elements in ensuring methodological rigour in this mixed-methods study. To do this, several approaches in line with the accepted qualitative research requirements were used (Nowell et al., 2017). These methods contributed to the credibility, dependability, confirmability, and transferability of the results, and thus, to the strength of the analytical background on which the DSAT design considerations were based.

To start with, due to the use of intensive interaction with the data in the form of multiple readings of interview transcripts and open-ended responses, the credibility of the study was improved. Reflexive memo-writing tactics were used to complement this approach and enable the researcher to document the analytical decisions, the insights that have emerged, and the possible biases (Saldaña, 2021). Member checking, which happened informally, was then undertaken, and a small sample of the participants was consulted to ensure that the emergent thematic interpretations were the correct meaning.

Also, reliability was enhanced by ensuring an audit trail was carefully kept, with a record of every step in the coding and thematic development process. This contained documentation of codebooks, theme updates, analytic memorandums, and procedural decision making, thus making the study replicable and transparent (Nowell et al., 2017). In the case of the content analysis of the open-ended answers, the numerical coding procedures were based on definite rules that would be

consistent throughout the dataset, so the classification and enlistment of the textual data were uniform (Krippendorff, 2018).

Furthermore, confirmability was also considered through the systematic separation of the accounts of the participants and the interpretation of the researcher. This was done by applying line-by-line coding and constant comparison across transcripts, and thus, the findings were based on the data but not on assumptions of the researcher (Erlingsson and Brysiewicz, 2017). Peer debriefing had been performed with an academic colleague who had no role in the data collection process, but revised selected excerpts, the coding choices, and thematic summaries to ensure analytic consistency and question possible biases.

Finally, transferability was also achieved through the provision of rich, descriptive accounts of professional experience, school settings, and experiences by participants with ICT integration. Transferability is also reinforced using verbatim quotes in reporting the findings, as it enables the readers to determine how the themes can apply to other environments (Braun & Clarke, 2021). Collectively, these measures made qualitative analysis systematic, transparent, reliable, and therefore, support the validity of the insights used to inform the DSAT prototype design.

### **3.8 Summary of Chapter Three – Research Methodology**

This chapter introduced the methodological structure, which informed the research, the philosophical assumptions, research approach, research design, sampling methods, data collection tools, data analytic strategies, and considerations of ethical concerns. Based on a pragmatic paradigm, the research followed a convergent mixed-method design to fit the multidimensional character of the ICT integration in primary schools in Ghana and to produce evidence to shape the design of a prototype DSAT. Pragmatism allowed the flexibility to use both the quantitative and qualitative strands, which allowed the study to balance quantifiable trends with detailed contextual

data. The chapter explained why a mixed-methods approach was used and how quantitative and qualitative data were gathered at the same time and analyzed independently and combined at the interpretation stage. An extensive research plan was provided, where each research objective was elaborated to be in line with proper methods and data sources.

The chapter further explained the sampling structure of the study that incorporated a combination of both probability-based approaches in the quantitative strand and purposive sampling in the qualitative strand. This guaranteed statistical representativeness on one hand, as well as the inclusion of information-bearing views of teachers, headteachers, SISOs, IT coordinators, and district HRM officers, on the other hand. The process of instrumentation was detailed with the creation, pilot testing, and revision of instruments such as the teacher survey and teacher interview schedule.

Data analysis procedures were described in detail: quantitative data were analyzed with the help of descriptive and inferential statistics, and qualitative data were analyzed with the help of thematic analysis and content analysis. Other steps to enhance trustworthiness, including keeping an audit trail, uniform coding processes, member checks and peer debriefing were also described. Critically, the chapter explained how the methodological decisions informed and justified the design of the prototype of the DSAT. The conceptual framework, competence areas, and usability factors of the tool were based directly on insights provided by quantitative measures of ICT integration, as well as qualitative descriptions of teacher needs, constraints and expectations.

Although the prototype has not been tested in the current research, the methodology provides a very robust empirical basis towards future iterative testing and validation. In general, this chapter shows that the methodological choices were consistent, rigorous, and reasonably aligned with the objectives of the study. The steps described in this section form the foundation of

the validity of the discussions made in Chapter Four and their applicability in the further design of the DSAT prototype.

## CHAPTER 4: FINDINGS

### 4.1 Overview

This chapter presents and interprets the findings of the study. The study pursued dual purpose: (a) to examine the current state of ICT integration practices in Ghana's primary schools, and (b) to design a prototype of a contextually relevant Digital Self-Assessment Tool (DSAT) for teachers, guided by established conceptual frameworks. The opening section establishes the trustworthiness of the study, outlining procedures undertaken to ensure methodological rigor. These include validity and reliability in the quantitative strand, credibility and confirmability in the qualitative strand, and integration checks within the mixed-methods design.

The subsequent sections present empirical findings. Variable 1 explores the current state of ICT integration practices in Ghana's primary schools. Here, statistical trends and qualitative accounts are synthesized to illustrate patterns of ICT use, infrastructural challenges, professional development gaps, and prevailing teacher attitudes. Variable 2 explores perceived factors that could influence teachers' perceptions and attitudes toward adopting the DSAT. This variable examines infrastructural enablers, pedagogical drivers, motivational considerations, and contextual barriers that are perceived to shape adoption readiness. Variable 3 explores teacher-informed requirements that could guide the design of the DSAT. Findings identify functional specifications, usability features, and content priorities necessary for effective and sustainable tool development. Variable 4 explores contextually design recommendations for the DSAT prototype to reflect Ghana's educational realities. This variable consolidates contextual design recommendations, including interface principles, contextual adaptability, and strategies to foster teacher ownership and long-term use.

Across all four variables, findings are presented in a structured progression: quantitative analysis, qualitative interpretation, integrated synthesis, and evaluation of findings. The chapter concludes with a consolidated summary.

#### **4.2 Establishing the Trustworthiness of Data**

In mixed-methods research, trustworthiness extends beyond the narrow confines of internal and external validity to encompass the credibility, dependability, confirmability, and transferability of findings across both quantitative and qualitative strands. This study adopts a convergent mixed-methods design; hence, attention to trustworthiness was embedded at every stage from the design of instruments, through data collection, to the analysis and integration of results. The concept of trustworthiness, as described by Connelly (2016), is multidimensional and refers to the authenticity, integrity, and methodological rigor through which the study is conducted. In qualitative research, where the interpretation of the researcher is a critical element of the investigation, the creation of trustworthiness becomes particularly relevant. Since such studies are interpretative in nature and context dependent, their results are subject to scrutiny. As Korstjens and Moser (2018) argue, qualitative research is not aligned with traditional conceptions of validity and reliability that are used in the quantitative traditions; therefore, it must be assessed using alternative standards of rigor.

In this study, the credibility of the integrated findings was supported through the application of established procedures for each component of the research. Quantitative trustworthiness was evaluated using well-defined measures of validity and reliability, while qualitative trustworthiness was assured through strategies such as prolonged engagement, data triangulation, member checking, and peer debriefing. Integration-level trustworthiness was ensured by systematically comparing, contrasting, and synthesizing findings from both strands,

thereby reinforcing convergence and explaining divergence where present. The sections that follow present the procedures undertaken to ensure trustworthiness.

#### **4.2.1 Quantitative Trustworthiness**

In the quantitative component, trustworthiness was addressed through the dual processes of validity and reliability testing. These measures ensured that the survey instruments not only aligned with theoretical constructs underpinning the study but also produced stable and consistent results over repeated applications.

##### ***4.2.1a Validity***

Validity refers to the degree to which an instrument accurately measures the concept it is intended to assess (Leung, 2015; Creswell & Creswell, 2017). Two primary forms of validity were prioritized in this study:

1. **Construct Validity:** Construct validity assessed the extent to which instrument items sufficiently covered the theoretical dimensions of ICT integration practices and the creation of a digital self-assessment tool. This process was necessary to properly match the operationalized constructs with the theoretical frameworks. In line with the relevant literature, construct validity was investigated via theoretical coherence and factor-based view to ensure that items are structurally consistent with the constructs they are designed to measure (Ranganathan & Caduff, 2024). The approach reflects the modern theory of validity, which views construct validation as a combination of theoretical process and empirical validation (Newton and Shaw, 2014).
2. **Content Validity:** The content validity was achieved by a systematic expert review to see whether the items used in the survey were appropriate to cover the domains of interest. Critical

evaluation of the instrument was performed by subject-matter specialists, including the supervisor of the researcher, based on scope, clarity, and correspondence to the objectives of the study. This procedure adhered to modern content validation studies with a particular focus on expert panels and Content Validity Ratios (CVR) and Content Validity Indexes (CVI) to measure agreement and representativeness (Polit & Beck, 2017).

The process of validation was iterative. Expert feedback was used to refine the instruments, ensuring both semantic clarity and conceptual coverage. Additionally, pilot testing was conducted before the main data collection to identify ambiguities, refine question wording, and enhance the structure of the instrument. The pilot phase also helped detect potential methodological weaknesses, such as items prone to misinterpretation or constructs inadequately captured.

#### ***4.2.1b. Reliability***

Reliability relates to the consistency and stability of measurement (Leung, 2015). An instrument is reliable if it produces similar results under consistent conditions, independent of external influences. In this study, internal consistency reliability was assessed using Cronbach's Alpha ( $\alpha$ ), calculated for each construct corresponding to the four main research questions. Following the guidelines of Barbera et al. (2020) and Zakariya (2022),  $\alpha$  values above 0.70 were considered acceptable, with values above 0.90 indicating excellent reliability.

Across all constructs, Cronbach's Alpha values exceeded the recommended thresholds, ranging from 0.829 to 0.950. This confirmed that the instrument's items coherently measured the intended latent traits. High reliability coefficients were consistent with the standards for educational research tools (Rak & Wrześniowski, 2023), reinforcing the robustness of the quantitative findings. Table 8 presents the Cronbach's Alpha coefficients for all constructs in the

study. The results confirm high internal consistency across all scales, with  $\alpha$  values ranging from 0.829 to 0.950.

**Table 8**

*Cronbach's Alpha Values for Study Constructs*

<b>Variable &amp; Research Question</b>	<b>Construct</b>	<b><math>\alpha</math></b>	<b>No. of Items</b>
<b>Variable 1</b> – ICT Integration Practices in Primary Schools ( <b>RQ1</b> )	ICT Tools Used for Instructional Purposes	.895	6
	Challenges Encountered in Integrating ICT	.931	9
	Self-Assessment of ICT Integration in Teaching	.926	7
	Experience and Confidence in ICT Use	.932	9
	ICT Supports and Professional Development	.921	8
	Beliefs and Perspectives of ICT Integration	.900	5
<b>Variable 2</b> – Adoption Influencers ( <b>RQ2</b> )	Factors That Could Influence Perceptions and Attitudes Toward the Tool's Use (Determinants that could shape teachers' readiness and willingness to adopt the DSAT).	.950	9
<b>Variable 3</b> – Teacher-informed requirements for the DSAT ( <b>RQ3</b> )	Perceived User-Friendliness and Accessibility of the Tool (Teachers' preferences for tool design features ensuring usability, technical and pedagogical effectiveness).	.829	5
<b>Variable 4</b> – Conceptually Design Recommendations for DSAT ( <b>RQ4</b> )	Perceived Expected Features and Functionalities of the Tool (Teachers' suggestions for usability, accessibility, and contextual appropriateness).	.928	9

*Note.*  $\alpha$  = Cronbach's Alpha; RQ = Research Question.

#### 4.2.2 The Qualitative Component

Trustworthiness in the qualitative strand was addressed using the four established criteria of credibility, dependability, confirmability, and transferability (Stahl & King, 2020). These criteria are widely regarded as benchmarks for ensuring rigor in qualitative inquiry, functioning as methodological counterparts to validity and reliability in quantitative paradigms. More recent scholarship further stresses that these criteria are not simply procedural “add-ons” but should be embedded in the entire research design, guiding the researcher's stance, data collection, and interpretation practices (Nowell et al., 2017; Korstjens & Moser, 2018). In this study, careful

attention was given to each criterion, with credibility positioned as the cornerstone of analytic rigor.

#### **4.2.2.1 Credibility**

1. **Prolonged Engagement and Persistent Observation:** The researcher invested sustained time in interacting with participants through multiple qualitative techniques (semi-structured interviews and open-ended survey questions). This sustained engagement allowed the collection of refined, context-rich accounts and helped build rapport and trust, thereby reducing the risk of superficial or distorted responses (Korstjens & Moser, 2018). Prolonged engagement also served to uncover patterns that might not have been visible in shorter encounters.
2. **Data Triangulation:** Multiple data sources, including interviews, and open-ended questions, were systematically compared to corroborate emerging insights. Triangulation in qualitative research, bringing together multiple data sources, methods, or perspectives, also deepens the interpretive richness by revealing points of agreement and divergence across findings, leading to a more comprehensive and refined understanding of the phenomenon under study (Fusch et al., 2018).
3. **Member Checking:** Participants were invited to review and validate summaries of their responses. This process provided opportunities to confirm accuracy, clarify meaning, or refine interpretations. While some scholars caution that member checking should not be seen as infallible (Birt et al., 2016), in this study, it functioned as an important dialogic mechanism to align the researcher's interpretations with participants' intended meanings.
4. **Peer Debriefing:** Emerging findings and interpretations were regularly reviewed with supervisor. Such external critique challenged assumptions, exposed blind spots, and minimized the risk of idiosyncratic bias (Nowell et al., 2017). This collaborative scrutiny contributed to more balanced and reflexive interpretations, enhancing the robustness of the findings.

Conclusively, these strategies created a layered system of credibility checks that ensured the study's findings were both trustworthy and contextually faithful. Rather than privileging one method, credibility was cultivated through an iterative interplay of prolonged engagement, triangulation, member reflection, and peer interrogation. This combination aligns with contemporary calls to see trustworthiness practices as integrated processes rather than discrete checklists (Nowell et al., 2017).

#### ***4.2.2.2 Dependability***

Dependability in qualitative research corresponds to reliability in quantitative traditions and reflects the extent to which findings are consistent and could be replicated under similar conditions (Nowell et al., 2017). Ensuring dependability requires the research process to be transparent, systematic, and well-documented so that others can follow the decision-making trail. In this study, dependability was achieved through the creation of an audit trail detailing the data collection protocols, coding decisions, and analytic memos, enabling external reviewers to trace the logic of interpretation. In addition, iterative coding procedures were employed, with coding frameworks refined and checked against data subsets to establish stability over time. Peer auditing was also applied, whereby supervisors critically reviewed the coding process, helping to ensure that thematic patterns were not distinctive but grounded in the dataset. These strategies are consistent with established benchmarks for methodological rigor in qualitative inquiry, with contemporary guidance emphasizing the importance of systematically documenting procedures to guard against researcher bias (Korstjens & Moser, 2018).

#### ***4.2.2.3 Confirmability***

Confirmability ensures that the findings are shaped by participants' perspectives rather than the researcher's preferences or assumptions (Nowell et al., 2017). This was pursued by embedding

reflexivity throughout the research cycle. The researcher maintained reflective journals to document assumptions, emerging insights, and potential biases, thus making their positionality explicit. Triangulation of data sources further strengthened confirmability by demonstrating that interpretations were not contingent upon a single method or perspective but emerged from multiple converging lines of evidence. Contemporary qualitative research literature highlights these practices as indispensable for establishing rigor and minimizing subjective bias (Nowell et al., 2017; Korstjens & Moser, 2018).

#### ***4.2.2.5 Transferability***

Transferability in qualitative research refers to the degree to which findings may be meaningfully applied to other contexts. Unlike statistical inference, transferability is primarily achieved through the provision of “thick description,” rich, detailed accounts of participants, settings, and processes that enable readers to determine the relevance of the findings to their own unique contexts (Korstjens & Moser, 2018).

In this study, thick description was meticulously pursued by presenting granular contextual details regarding Ghana’s primary school ICT infrastructure, teacher professional profiles, and specific pedagogical realities. This approach ensures that readers operating within similar low-resource educational systems can accurately judge the applicability of the study’s findings. By situating findings within these defined sociocultural realities, this research aligns with contemporary scholars emphasizing that meaningful transfer depends on contextual resonance rather than universal claims (Nowell et al., 2017). Furthermore, the boundaries of inference were clearly documented through detailed reporting of the purposive sampling strategies, supporting the reader’s ability to critically assess the potential for transferability.

### **4.2.3 Integrated Trustworthiness**

In a convergent mixed-methods design, integrated trustworthiness extends beyond assessing each strand in isolation to evaluate the quality and credibility of the inferences drawn from merging the datasets (Creswell & Plano Clark, 2017). This integration requires a systematic process of comparing and combining quantitative and qualitative findings to determine areas of convergence (where results align), divergence (where results differ), and complementarity (where each dataset adds unique insights). In this study, methodological triangulation was employed to strengthen the validity of the integrated findings. Integration followed a joint display analysis approach, whereby findings from each strand were juxtaposed in structured matrices to identify patterns and relationships. This process:

- a. Enhanced credibility by cross-verifying evidence across data types.
- b. Improved completeness, by capturing both measurable trends and detailed contextual explanations.
- c. Supported practical relevance by ensuring that the final recommendations for the digital self-assessment tool were grounded in both empirical evidence and lived experiences.

Through this deliberate integration, the study not only validated the findings of each methodological strand but also produced a richer, more comprehensive understanding of ICT integration in Ghanaian primary schools. The resulting insights are thus more robust, actionable, and context-sensitive than those derived from a single methodological approach.

### **4.3 Presentation of Results**

Considering the complexity of the research problem, a convergent mixed-methods design was chosen to produce a wholesome conceptualization of ICT integration practices and the inferences in designing a Digital Self-Assessment Tool (DSAT). This methodology encompassed

simultaneous gathering and examination of both quantitative and qualitative data, allowing the derivation of statistically obtained patterns with deep contextual understanding (Creswell, 2017; Moseholm & Fetters, 2017). The suitability of this design can be supported by the fact that the issues of ICT integration in primary education involves both quantifiable indicators of practice (e.g., frequency of ICT use, access to resources, confidence levels, perceptions of teachers, experiences, and contextual factors) and qualitative aspects (e.g. the perceptions of teachers, their experiences, and contextual conditions).

The quantitative strand provided a thorough picture of the trends in the teacher cohort (N = 335), which allowed conducting a systematic evaluation of the research questions of the study. Descriptive statistics demonstrated evident trends in the use of ICT, perceived barriers, level of confidence, access to professional development, and perceptions about ICT incorporation. Within the various constructs, the mean scores were always below or above the scale midpoint, which is a sign that there was a high degree of consensus among respondents instead of scattered or vague opinions. These statistical trends support the structural and systemic quality of ICT integration problems, as opposed to individual or personal-level problems. At the same time, the qualitative strand offered explanatory richness by explaining how the statistical trends that were observed in the quantitative element manifest in everyday school settings. The narratives of interviews and open-ended responses provide understanding of the real-world situation of the numeric data, emphasizing the lack of resources, problems with confidence, professional isolation, and the lack of formal monitoring systems. More importantly, the qualitative data did not replace the quantitative ones, but contextualized, supported, and, in some cases, even refined them, especially in cases where survey findings implied apparent optimism or unanimity.

To ensure analytical consistency, the findings are systematized based on the four main variables of the study that are associated with the research questions and the objectives. The quantitative results of each variable are provided first, followed by the narrative interpretation that prefigures the important statistical trends, magnitude of effects, and distributional features. Following these findings are qualitative evidence that either converge, diverge or improve on the statistical results, these are then followed by an integrated synthesis that acts as a weaver of the two strands.

Generally, this combined prism of the presentation of the findings provides a fair and sound description of the ICT integration in Ghanaian primary schools. The findings demonstrate not only the current tendencies but also the causes of their existence and their influence on the willingness of teachers to use reflective instruments like the suggested DSAT.

#### **4.3.1 Data Analysis Measures**

In line with the convergent mixed-methods design of the study, quantitative and qualitative data were processed according to the procedures that were suitable in each case and then combined to enhance the overall explanation of the results. The structure of the analytical process was designed in such a way that it would provide methodological rigor in each strand and, at the same time, allow meaningful comparisons and syntheses across datasets. Quantitative analysis of data was based on summarizing trends of ICT access, use, and teacher attitudes. Conversely, the qualitative analysis explored the experience, meanings, and contextual understandings of participants on ICT integration and digital self-assessment. These analyses were performed independently and then they were brought together in the integration phase. Integration of findings entailed a methodical analysis of convergence, divergence, and complementarity of quantitative

and qualitative findings, hence increasing the plausibility and explanatory richness of the research. Each of the analytical phases has detailed procedures as presented in the sub-sections below.

#### ***4.3.1.1 Quantitative Phase Analysis***

The quantitative phase of the study involved the administration of a structured questionnaire to a target sample of 360 eligible participants drawn from six educational circuits within the study area. A total of 335 complete questionnaires were retrieved, representing a high response rate of 93%. This strong level of participation enhances the reliability of statistical analyses by ensuring broad representation of the target population and minimizing the risk of non-response bias. All subsequent quantitative analyses are therefore based on the responses of these 335 participants.

The quantitative phase examined nine primary constructs, organized under four outcome variables aligned with the overarching research objectives and questions. A detailed summary of these outcome variables and their corresponding constructs are provided in Table 9. The table also showed the conceptual alignment between the outcome variables, constructs, and the specific research questions they address, thereby serving as a blueprint for interpreting the results in subsequent sections. These constructs were systematically developed to operationalize the research objectives, ensuring that each focal area of the investigation could be measured, analyzed, and interpreted in a structured and academically rigorous manner. All items within the constructs were measured on a five-point Likert scale, [Strongly Disagree (SD) = 1, Disagree (D) = 2, Undecided (UD) = 3, Agree (A) = 4, and Strongly Agree (SA) = 5], to capture respondents' levels of agreement with the presented statements.

In the analysis, both descriptive and inferential techniques were employed. Descriptive statistics, principally measures of central tendency (means) and variability (standard deviations), were used to summarize participants' responses and identify overall trends. These measures

provided insight into distribution patterns within the dataset, allowing for the detection of group-level patterns and statistical outliers (Agresti et al., 2022). Beyond descriptive statistics, the analysis also examined the distributional characteristics of the data. Specifically, skewness and kurtosis values (with their respective standard errors) were computed to assess deviations from normality. Skewness statistics indicate the degree of asymmetry in the data distribution, while kurtosis values reflected the extent to which the data were peaked or flat relative to a normal curve. The quantitative analyses were conducted with the help of; the Statistical Package for the Social Sciences (SPSS), JAMOVI, and Microsoft Excel. These software platforms supported the execution of descriptive statistics, normality testing, and reliability analysis as well as the production of visual and graphical summaries. The use of multiple analytical tools enhanced methodological robustness and provided cross-validation of results.

**Table 9**

*Study Variables and their Constructs*

<b>Variables</b>	<b>Constructs</b>
1. Current Level of ICT Integration	<ul style="list-style-type: none"> <li>a. ICT Tools used for instructional purposes</li> <li>b. Challenges associated with ICT integrating</li> <li>c. Self-evaluation of ICT Integration in Teaching</li> <li>d. Experience and confidence in ICT use</li> <li>e. ICT Supports and Professional development</li> <li>f. Beliefs and Perspectives of ICT Integration</li> </ul>
2. Perceived Factors that could influence Teachers' Adoption of DSAT	<ul style="list-style-type: none"> <li>a. Factors that could influence perceptions and attitudes towards the tool's use.</li> </ul>
3. Teacher-informed requirements for the DSAT	<ul style="list-style-type: none"> <li>a. Perceived user-friendliness and accessibility issues of the tool.</li> </ul>
4. Design Recommendations for DSAT	<ul style="list-style-type: none"> <li>b. Perceived expected features and functionalities of the tool.</li> </ul>

**4.3.1.2 Qualitative Phase Analysis**

The qualitative strand of the study was based on data generated from semi-structured interviews and open-ended questionnaire responses, which provided narrative accounts of

participants' experiences, beliefs, and perspectives on ICT integration in primary education. This dataset was particularly valuable for capturing contextual and affective dimensions of technology adoption that quantitative measures alone could not adequately reveal. For analytic purposes, interview participants were grouped into two categories: educational officials and headteachers (coded A1–A6), and classroom and subject teachers (coded B1–B4).

The analysis process followed a systematic, multi-stage procedure grounded in thematic and content analysis. First, interview and questionnaire responses were transcribed, anonymized, and repeatedly reviewed to establish familiarity with the data. During this immersion stage, preliminary codes were generated and subsequently refined into broader categories through constant comparison across cases. Guided by Braun and Clarke's (2019) thematic analysis framework, this process enabled the identification of higher-order themes such as teachers' conceptualizations of ICT integration, perceived benefits and constraints, and institutional and infrastructural factors shaping technology use. In parallel, content analysis was applied to the open-ended questionnaire responses to systematically examine recurring themes, concepts, and categories. Together, these approaches offered a structured means of identifying, coding, and categorizing the recurring ideas and narrative structures embedded in participants' accounts (Neuendorf, 2018).

#### ***4.3.1.3 Integration of Quantitative and Qualitative Findings***

The integration of datasets in this study rigorously adhered to the principles of triangulation within the convergent mixed-methods framework. To facilitate systematic comparison and synthesis, a Joint Display Matrix (side-by-side integration) was employed. This matrix provided a structured platform where quantitative statistical findings were directly aligned with qualitative thematic insights, enabling convergence, divergence, and complementarity to be systematically

observed and analyzed. The use of a Joint Display Matrix thus significantly strengthened the analytic process by enhancing the transparency of how the two distinct strands of evidence were brought together. This methodological complementarity was paramount, ensuring that conclusions were not only statistically robust but also enriched by contextually grounded insights.

#### **4.3.2 Presentation of Demographic Information**

The initial section of the questionnaire gathered demographic and professional profile data from respondents to enable descriptive analysis of the sample and to allow subsequent exploration of possible relationships between participant characteristics and the study variables. The demographic variables included:

1. Gender – coded as *1 = Male, 2 = Female, and 3 = Other.*
2. Age group – coded into four categories: *1 = 30 years or less, 2 = 31–40 years, 3 = 41–50 years, and 4 = 51 years or above.*
3. Teaching experience – coded as *1 = Less than 5 years, 2 = 5–10 years, 3 = 11–20 years, and 4 = Over 20 years.*
4. Teaching level – coded as *1 = Lower Primary and 2 = Upper Primary.*
5. Teaching role – coded as *1 = Class Teacher and 2 = Subject Teacher.*
6. Highest academic qualification – coded as *1 = Certificate A, 2 = Diploma in Basic Education (DBE), 3 = Bachelor of Education (B.Ed.), and 4 = Master’s Degree or higher.*

These demographic categories were carefully designed to capture both the personal characteristics and professional background of the respondents, enabling a deeper understanding of the sample compositions. Table 10 presents the detailed distribution of respondents across each demographic category.

**Table 10***Demographic Characteristics of Respondents (N = 335)*

<b>Characteristic</b>	<b>Category</b>	<b>n</b>	<b>%</b>
<b>Gender</b>	Male	164	49
	Female	171	51
	Other	0	0
<b>Age Group (years)</b>	30 or less	160	47.8
	31–40	123	36.7
	41–50	39	11.6
	51 or above	13	3.9
<b>Teaching Experience</b>	Less than 5 years	93	27.8
	5–10 years	67	20
	11–20 years	106	31.6
	Over 20 years	69	20.6
<b>Teaching Level</b>	Lower Primary	192	57.3
	Upper Primary	143	42.7
<b>Teaching Role</b>	Class Teacher	307	91.6
	Subject Teacher	28	8.4
<b>Highest Academic Qualification</b>	Certificate A	21	6.3
	Diploma in Basic Education (DBE)	130	38.8
	Bachelor of Education (B.Ed.)	147	43.9
	Master's degree or higher	37	11

*Note. Percentages may not total 100 due to rounding.*

#### ***Narrative summary of Table 6***

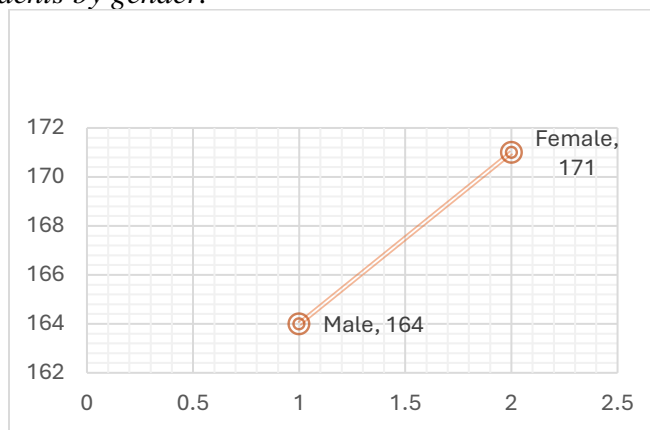
Table 6 summarizes the demographic characteristics of the 335 respondents. Gender distribution was nearly balanced, with males accounting for 49% and females 51% of the sample. In terms of age, the largest group comprised respondents aged 30 years or younger (47.8%), followed by those aged 31–40 years (36.7%). Smaller proportions were aged 41–50 years (11.6%) and 51 years or above (3.9%). Teaching experience was more varied, with 31.6% (n = 106) having 11–20 years of experience, 20.6% (n = 69) with more than 20 years, 20% (n = 67) reporting 5–10 years, and 27.8% (n = 93) having less than 5 years of experience. Regarding teaching level, 57.3% (n = 192) taught in the lower primary grades (Kindergarten to Primary 3), while 42.7% (n = 143) taught in the upper primary grades (Primary 4 to Primary 6). Most participants (91.6%, n = 307)

were class teachers responsible for teaching all subjects to a specific class, whereas 8.4% (n = 28) were subject teachers specializing in specific disciplines. In terms of academic qualifications, 43.9% (n = 147) held a Bachelor of Education degree, 38.8% (n = 130) had a Diploma in Basic Education, 11% (n = 37) possessed a Master's Degree or Higher, and 6.3% (n = 21) held a Certificate A.

Figures 11 to 16 provide visual summaries of the demographic distributions presented in Table 10. Each bar chart or pie chart corresponds to one demographic variable (Gender, Age Group, Teaching Experience, Teaching Level, Teaching Role, and Qualification). This visual representation facilitates quick interpretation by highlighting predominant categories, patterns, and proportional differences within the sample.

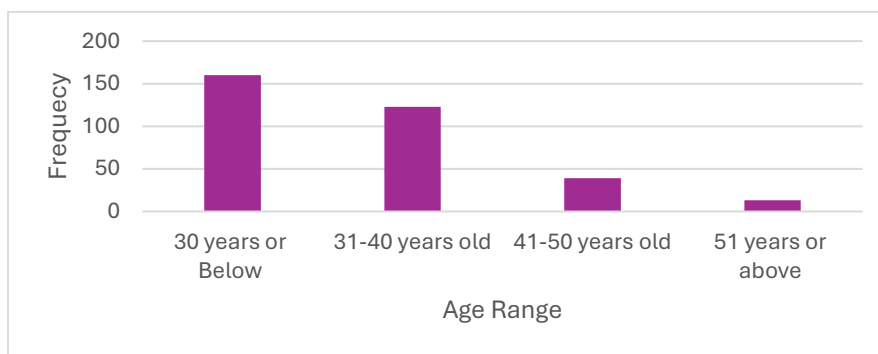
### Figure 11

*Distribution of respondents by gender.*

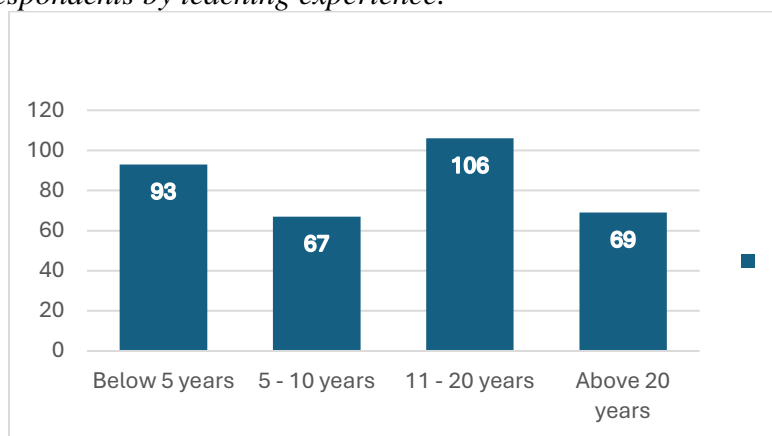


### Figure 12

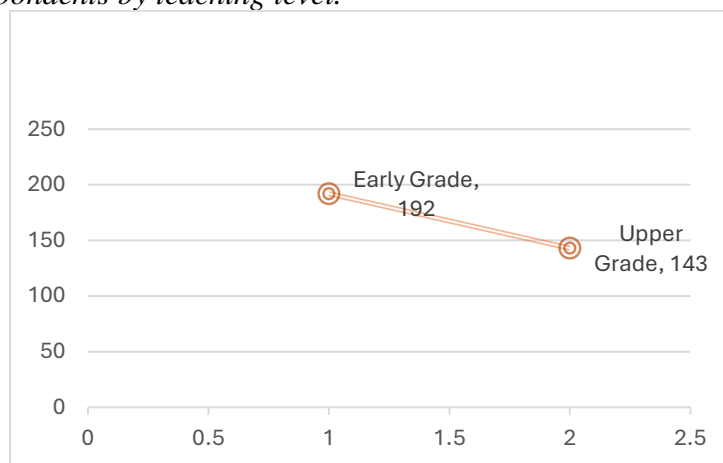
*Distribution of respondents by age group.*



**Figure 13**  
*Distribution of respondents by teaching experience.*

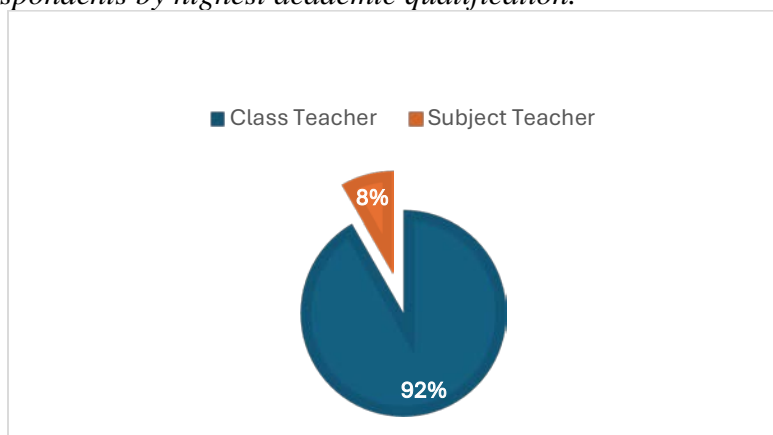


**Figure 14**  
*Distribution of respondents by teaching level.*

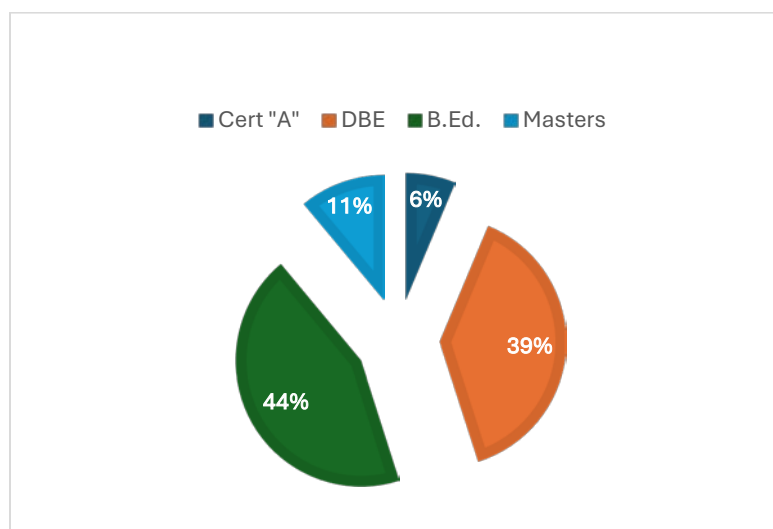


**Figure 15**

*Distribution of respondents by highest academic qualification.*

**Figure 16**

*Distribution of respondents by Academic Qualification*



### **4.3.3 Current State of ICT Integration Practices in Primary Schools**

This section outlines the findings with respect to Research Question 1 (RQ1), expected to assess the current situation of ICT integration practices in Ghana's primary schools. The synthesis of the analysis is based on quantitative survey data obtained from 335 teachers and qualitative analysis based on interviews and answers provided by the open-ended questionnaire. The aggregate of these data strands gives an empirical-based baseline that includes the level of ICT

usage, teacher competence, resource accessibility and the level of institutional support throughout the area of study.

The quantitative results provide a statistical picture of the practices of ICT integration in a holistic way clear and consistent trends are observed in various aspects, including ICT tools usage, perceived barriers, confidence and competency measures, career development, and teacher beliefs. The average scores, distributional properties and normality check present evidence of systemic limitations, rather than specific difficulties, thus providing a population-wide view of the ICT integration state. By adding to this statistical avenue, the qualitative results provide a contextual and explanatory depth, revealing how the quantitative tendencies are lived and perceived by teachers and educational authorities in the context of the school environment.

The responses to open-ended questions and interview narratives help to see through the practical essence of the numerical patterns and point out the limitations in infrastructures, shortages of professional training, and the unavailability of formal monitoring mechanisms. The presentation will thus be in three interconnected phases:

- a. The quantitative questionnaire results define the extent and the prevalence of the ICT integration practices and issues;
- b. Qualitative narratives offering explanations and contextualization behind the statistical trends;  
and
- c. An integrated synthesis that identifies convergent, complementary, and divergent areas to the two data strands.

#### ***4.3.3.1 Quantitative Findings: Current State of ICT Integration Practices in Primary Schools***

The results of the quantitative strand analysis of the current state of ICT integration are organized around six construct areas: (1) ICT tools used for instructional purposes, (2) challenges

associated with ICT integration, (3) self-evaluation of ICT integration in teaching, (4) experience and confidence in ICT use, (5) ICT support and professional development, and (6) teachers' beliefs and perspectives on ICT integration. Presented as follows are the findings for each construct in turn.

### 1. ICT Tools Used for Instructional Purposes

Table 11 presents teachers' self-reported use of various ICT tools in instructional practice.

**Table 11**

*ICT Tools used for instructional purposes*

<b>Items</b>	<b>N</b>	<b>Mean</b>	<b>SD</b>	<b>Interpretation</b>
RQ1 A1: Learning management systems	335	1.33	0.469	Low usage - teachers disagree they use LMS
RQ1 A2: Presentation software use	335	1.42	0.789	Low usage - teachers disagree they use presentation software
RQ1 A3: Video conferencing applications	335	1.08	0.268	Very low usage - strong disagreement with using video conferencing
RQ1 A4: Interactive whiteboard use	335	1.29	0.454	Low usage - teachers disagree they use interactive whiteboards
RQ1 A5: Social media utilization	335	1.4	0.49	Low usage - teachers disagree they use social media platforms
Digital evaluation tools	335	1.19	0.391	Very low usage - teachers strongly disagree they use digital evaluation tools

#### *Narrative summary of Table 11*

The mean scores for all six ICT tools ranged from 1.08 to 1.42, indicating very low to low levels of classroom use. Among these, video conferencing software recorded the lowest uptake ( $M = 1.08$ ,  $SD = 0.268$ ), reflecting minimal integration of synchronous online platforms. Digital evaluation tools also showed limited use ( $M = 1.19$ ,  $SD = 0.391$ ). Slightly higher, though still low, mean scores were observed for learning management systems, interactive whiteboards, social media platforms, and presentation software, with the latter two showing the comparatively highest adoption. Overall, the results suggest that while some tools are marginally more common, ICT remains underutilized in instructional practice.

## 2. Challenges Encountered in Integrating ICT

Table 12 summarizes teachers' perceptions of the challenges associated with ICT integration in their instructional practice.

**Table 12**

*Challenges encountered in integrating ICT*

<b>Items</b>	<b>N</b>	<b>Mean</b>	<b>SD</b>	<b>Interpretation</b>
RQ1 B1: Insufficient availability of suitable technology or software	335	4.64	0.593	Very high challenge - strong agreement about insufficient technology
RQ1 B2: Insufficient technical assistance or training available	335	4.14	0.946	High challenge - agreement about insufficient technical assistance
RQ1 B3: Not enough time to prepare technology-infused lessons	335	4.07	0.97	High challenge - agreement about time constraints
RQ1 B4: Concern regarding students' digital literacy	335	4.23	0.962	High challenge - agreement about student digital literacy concerns
RQ1 B5: No adequate easily accessible digital resources	335	4.56	0.743	Very high challenge - strong agreement about inadequate resources
RQ1 B6: Worries regarding technology reliability and safety	335	4.08	0.968	High challenge - agreement about reliability and safety concerns
RQ1 B7: Challenges finding suitable digital resources aligned with curriculum	335	4.14	0.982	High challenge - agreement about curriculum alignment difficulties
RQ1 B8: Resistance from learners or colleagues	335	3.9	1.109	Moderate to high challenge - agreement about resistance to change
RQ1 B9: Anxiety about classroom control or educational progress	335	3.67	1.274	Moderate challenge - some agreement about classroom control anxiety

***Narrative Summary of Table 12***

Mean scores across the nine items ranged from 3.67 to 4.64, suggesting that teachers perceived most challenges ranging from moderate to very high. The most critical challenges were linked to the insufficient availability of appropriate technology or software ( $M = 4.64$ ,  $SD = 0.593$ ) and the lack of adequate, accessible digital resources ( $M = 4.56$ ,  $SD = 0.743$ ), both reflecting strong consensus among respondents. Other frequently reported barriers included limited technical assistance and training, time constraints in preparing ICT-based lessons, students' digital literacy

gaps, and concerns about technology reliability and safety, all of which scored above 4.00, indicating consistently high challenge levels. Difficulties in sourcing curriculum-aligned digital resources were also emphasized ( $M = 4.14$ ,  $SD = 0.982$ ). Comparatively lower, though still notable, were challenges related to resistance from learners or colleagues ( $M = 3.90$ ,  $SD = 1.109$ ) and anxiety about classroom management or learning progress when using ICT ( $M = 3.67$ ,  $SD = 1.274$ ). Overall, these results highlight infrastructure and resource constraints as the most pressing barriers, with attitudinal and classroom management concerns emerging as less prominent but still relevant.

### 3. Self-Evaluation of ICT Integration in Teaching

Table 13 presents teachers' self-reported approaches to assessing their proficiency in ICT integration.

**Table 13**  
*Evaluation of ICT Integration in Teaching*

Items	N	Mean	SD	Interpretation
RQ1 C1: Determined proficiency by evaluating student performances	335	1.32	0.467	Low evaluation activity - disagreement with using this method
RQ1 C2: Evaluate ability by observing learner behavior	335	1.17	0.379	Very low evaluation activity - strong disagreement with using this method
RQ1 C3: Evaluate competency by receiving student feedback	335	1.27	0.462	Low evaluation activity - disagreement with using this method
RQ1 C4: Evaluate skills based on co-worker feedback	335	1.25	0.472	Low evaluation activity - disagreement with using this method
RQ1 C5: Evaluate ability by analyzing student work	335	1.2	0.482	Low evaluation activity - disagreement with using this method
RQ1 C6: Evaluate proficiency using surveys and questionnaires	335	1.17	0.397	Very low evaluation activity - strong disagreement with using this method
RQ1 C7: I do not evaluate my own competency in ICT integration	335	4.2	0.942	Strong agreement with evaluating their competency (reverse-coded item)

#### *Narrative Summary of Table 13*

Overall, teachers reported very low engagement with self-evaluation practices for ICT integration, with mean scores across all six methods ranging narrowly from 1.17 to 1.32. This indicates that reflective or feedback-based approaches to assessing ICT proficiency are rarely adopted. In contrast, strong agreement with the reverse-coded item “I do not evaluate my own competency in ICT integration” ( $M = 4.20$ ,  $SD = 0.942$ ) further underscores the absence of systematic self-assessment practices among respondents.

#### **4. Experience and Confidence in ICT Use**

Table 14 presents teachers’ self-reported levels of experience and confidence in using ICT tools for instructional purposes.

**Table 14***Experience and confidence in ICT use*

<b>Items</b>	<b>N</b>	<b>Mean</b>	<b>SD</b>	<b>Interpretation</b>
RQ1 D1: Believe I can effectively integrate ICT tools	335	1.04	0.2	Extremely low confidence - strong disagreement with effective integration ability
RQ1 D2: Confident using basic technology tools	335	1.14	0.393	Very low confidence - strong disagreement with basic tool confidence
RQ1 D3: Confident solving technical problems	335	1.23	0.46	Low confidence - disagreement with technical problem-solving ability
RQ1 D4: Feel qualified due to ample ICT experience	335	1.26	0.458	Low confidence - disagreement with qualification statement
RQ1 D5: Capable of leading students in online research	335	1.29	0.532	Low confidence - disagreement with online research leadership ability
RQ1 D6: Expertise in educational websites/apps/platforms	335	1.09	0.368	Very low confidence - strong disagreement with having expertise
RQ1 D7: Believe in capacity to create technology-enhanced activities	335	1.3	0.497	Low confidence - disagreement with creation capacity
RQ1 D8: Make use of online platforms to enhance teaching	335	1.27	0.484	Low confidence - disagreement with using online platforms
RQ1 D9: At ease including multimedia elements	335	1.31	0.617	Low confidence - disagreement with multimedia comfort
RQ1 D10: Sure about incorporating educational software/apps	335	1.17	0.397	Very low confidence - strong disagreement with software incorporation confidence

*Narrative Summary of Table 14*

Mean scores across the ten items ranged from 1.04 to 1.31, indicating very low to low levels of confidence in ICT use. The lowest confidence was reported in teachers' belief in their ability to effectively integrate ICT tools, with similarly weak self-evaluation in the use of basic technology and educational software. Overall, the findings reveal a pervasive lack of confidence in ICT-related competencies, suggesting that teachers feel underprepared to integrate technology meaningfully into their instructional practice.

## 5. ICT Supports and Professional Development

Table 15 presents the results on the level of ICT-related support available to teachers and their access to professional development opportunities.

**Table 15**

*ICT Supports and Professional development*

<b>Items</b>	<b>N</b>	<b>Mean</b>	<b>SD</b>	<b>Interpretation</b>
RQ1 E1: Development opportunities frequently provided	335	1.19	0.414	Very low support - strong disagreement with frequent opportunities
RQ1 E2: Enough chances to participate in workshops	335	1.07	0.258	Extremely low support - strong disagreement with workshop opportunities
RQ1 E3: Expert trainers brought to school	335	1.32	0.485	Low support - disagreement with expert trainer provision
RQ1 E4: Professional learning communities introduced	335	1.39	0.507	Low support - disagreement with learning communities' existence
RQ1 E5: Regular needs assessment surveys conducted	335	1.34	0.527	Low support - disagreement with needs assessment activities
RQ1 E6: Gained experience through practical learning opportunities	335	1.37	0.628	Low support - disagreement with practical learning opportunities
RQ1 E7: Can refer to online collection of ICT resources	335	1.15	0.378	Very low support - strong disagreement with online resources availability
RQ1 E8: School pays for external ICT training	335	1.33	0.471	Low support - disagreement with funding for external training

*Narrative Summary of Table 15*

Mean scores ranged from 1.07 to 1.39, indicating uniformly low to very low levels of ICT-related support and professional development opportunities. The lowest-rated area was access to workshops. Slightly higher, though still minimal, support was reported for initiatives such as expert facilitation, professional learning communities, and practical learning experiences. Overall, the findings point to a significant systemic gap: teachers receive little institutional backing or sustained professional development, leaving them underprepared to integrate ICT effectively into their teaching practice.

## 6. Beliefs and Perspectives of ICT Integration

Table 16 presents respondents' beliefs and perspectives on the integration of ICT in teaching and learning.

**Table 16**

*Beliefs and Perspectives of ICT Integration*

<b>Items</b>	<b>N</b>	<b>Mean</b>	<b>SD</b>	<b>Interpretation</b>
RQ1 F1: ICT integration holds significance in teaching	335	4.45	0.626	Very positive belief - strong agreement with ICT significance
RQ1 F2: ICT will positively influence student achievement	335	4.58	0.696	Very positive belief - strong agreement with positive influence
RQ1 F3: Current ICT integration adequately equips students	335	1.13	0.335	Very negative assessment - strong disagreement that current integration is adequate
RQ1 F4: ICT tools/resources easily available in school	335	1.16	0.431	Very negative assessment - strong disagreement with resource availability
RQ1 F5: More investment needed to support ICT integration	335	4.63	0.483	Very strong agreement - strong belief in need for more investment

*Narrative Summary of Table 16*

The findings highlight a clear distinction between strong positive beliefs about ICT's importance and potential, and very negative assessments of the current state of ICT provision in schools. Teachers expressed very positive beliefs about the role of ICT in education. They strongly agreed that ICT integration is significant in teaching ( $M = 4.45$ ,  $SD = 0.626$ ) and that it can positively influence student achievement ( $M = 4.58$ ,  $SD = 0.696$ ). However, there was very strong disagreement with the adequacy of current ICT integration practices. Respondents reported that current integration does not adequately equip students ( $M = 1.13$ ,  $SD = 0.335$ ) and that ICT tools and resources are not easily available in schools ( $M = 1.16$ ,  $SD = 0.431$ ). Finally, there was overwhelming consensus that greater investment is needed to support ICT integration ( $M = 4.63$ ,  $SD = 0.483$ ).

### 4.3.3.1.1 Descriptive Statistics and Distributional Characteristics of Teachers' ICT

#### Integration Practices

Table 17 presents descriptive statistics for six constructs measuring different aspects of ICT integration practices in the schools: (a) ICT tools used for instruction, (b) challenges encountered, (c) self-evaluation, (d) experience and confidence, (e) supports and professional development, and (f) beliefs and perspectives.

**Table 17**

*Summary of the mean scores for each construct items*

	Mean	SD	Skewness		Kurtosis	
			Skewness	SE	Kurtosis	SE
RQ1A: ICT Tools used for instructional purposes	1.28	0.186	0.929	0.133	0.8939	0.266
RQ1B: Challenges encountered in integrating ICT	4.16	0.64	-1.051	0.133	1.0702	0.266
RQ1C: Self-evaluation of ICT Integration in Teaching	1.65	0.211	-0.27	0.133	0.2864	0.266
RQ1D: Experience and confidence in ICT use	1.21	0.297	1.509	0.133	2.362	0.266
RQ1E: ICT Supports and Professional development	1.27	0.255	0.75	0.133	0.5936	0.266
RQ1F: Beliefs and Perspectives of ICT Integration	3.19	0.333	-0.609	0.133	-0.0169	0.266

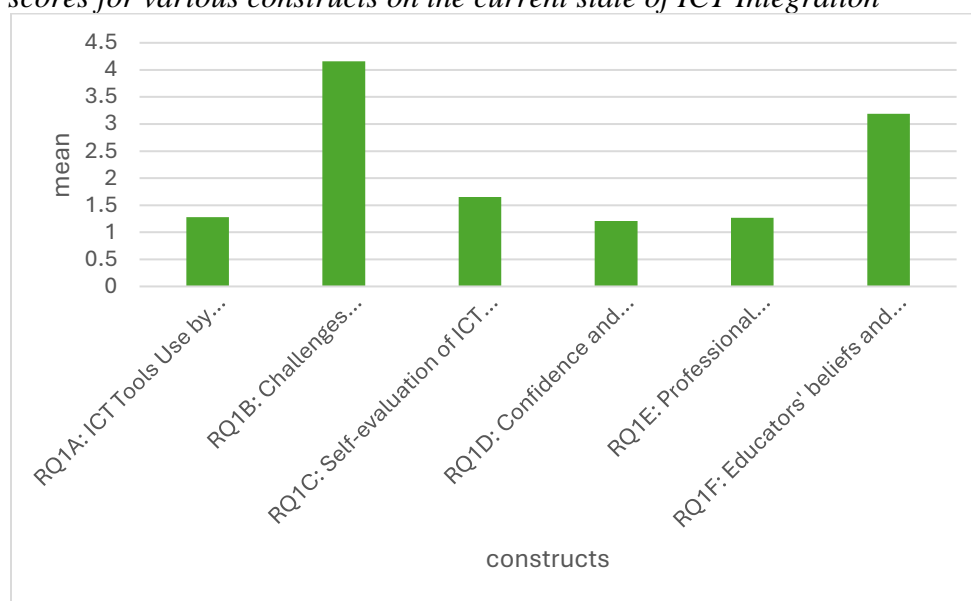
#### *Narrative Summary of Table 17*

The Mean scores across the constructs in Table 17 ranged from 1.21 to 4.16, with notable variation. Teachers reported low usage of ICT tools ( $M = 1.28$ ,  $SD = 0.186$ ), low self-evaluation ( $M = 1.65$ ,  $SD = 0.211$ ), and low confidence and support ( $M = 1.21$ ,  $SD = 0.297$ ;  $M = 1.27$ ,  $SD = 0.255$ , respectively). These are all well below the midpoint of the scale. Conversely, teachers expressed very high scores for beliefs ( $M = 3.19$ ,  $SD = 0.333$ ) and identified serious challenges ( $M = 4.16$ ,  $SD = 0.64$ ) as barriers to integration. The visualization for Table 17 shows the mean scores of teachers' ICT integration practices across the six constructs is presented in Figure 17.

The distributional characteristics further illustrate these patterns. Positive skewness values for ICT tools, confidence, and support indicate clustering at the lower end of the scale, consistent with widespread limitations in practice and support. Negative skewness for challenges and beliefs reflects strong agreement that ICT challenges are widespread, couple with strong recognition of ICT's value. Kurtosis values ranged from  $-0.017$  to  $2.362$ , suggesting generally peaked distributions with low variability, particularly in confidence ( $kurtosis = 2.362$ ).

**Figure 17**

*The mean scores for various constructs on the current state of ICT Integration*



#### 4.3.3.1.2 Overall Quantitative Summary on State of ICT Integration

Table 18 summarizes the overall analysis of the variable Current State of ICT Integration Practices.

**Table 18**

*Overall Quantitative Summary of Results on the Current State of ICT Integrations*

	N	Mean	SD	Skewness		Kurtosis		Shapiro-Wilk	
				Skewness	SE	Kurtosis	SE	W	p
Current Level of ICT Integration	335	2.11	0.152	-0.507	0.133	0.528	0.266	0.982	< .001

### *Narrative summary of Table 18*

The aggregate mean of 2.11 (SD = 0.152) from Table 18 confirms that ICT integration is at a very low level in Ghanaian primary schools. Although teachers strongly believe in ICT's potential (as seen in Table 16), their actual classroom practices remain minimal, reflecting the gaps between attitudes and implementation. The overall distribution aligns with this conclusion. The negative skewness ( $-0.507$ , SE = 0.133) indicates that most teachers' scores fell on the low end, with only a few reporting moderate integration. The kurtosis value (0.528, SE = 0.266) suggests modest peakedness, highlighting limited variability across respondents. Finally, the Shapiro–Wilk test ( $W = 0.982$ ,  $p < .001$ ) confirms non-normality, largely driven by clustering at the lower bound, consistent with the systemic nature of poor ICT access, confidence, and support. Altogether, the analyses from Tables 16 and 17 paint a consistent picture: teachers' ICT integration practices in Ghanaian primary schools are extremely limited in practice but highly positive in belief. Teachers overwhelmingly recognize ICT's importance and its potential to improve learning outcomes, yet their actual ability to integrate it is constrained by insufficient tools, low confidence, minimal professional development, and inadequate institutional support.

#### ***4.3.3.2 Qualitative Findings: Current State of ICT Integration Practices***

##### **4.3.3.2.1 Interview Data – Current state of ICT Integration**

A thematic analysis of the interview transcripts was conducted to explore the current state of ICT integration in primary schools. The analysis proceeded through familiarization, coding, theme identification, and refining categories. This process ensured that participants' perspectives were meaningfully represented while highlighting recurrent and unique viewpoints. The interview data were drawn from two groups: educational officials and headteachers (coded A1–A6), and classroom teachers (coded B1–B4). Across these two groups, several overarching themes emerged,

including availability and access to ICT tools, institutional and infrastructural challenges, teachers' competence and confidence, professional support and training, and perceptions of ICT's role in teaching and learning. Each theme captures the realities of ICT integration, illustrating both enabling and constraining factors. Table 19 summarizes these emergent themes, codes, and illustrative quotations, providing a deeper understanding of the current practices and perceptions of ICT integration in primary school.

**Table 19**

*Current State of ICT integration – (Interview responses)*

Theme	Code	Excerpt: Examples (GES Official, Teachers)
Teacher Competencies	Competency Gap	"Range of competencies...differentiated support" (A1) "... they may lack the specific skills needed to effectively integrate ICT into their teaching practices" (A3). "Many teachers lack training in technology skills for pedagogical strategies to effectively integrate technology into their teaching" (B1). "Limited skills...teaching practices" (B3) "I believe primary school teachers have some of the needed competencies for effective ICT integration, but there are still gaps that need to be addressed" (B2). "... vary depending on factors such as age, years of experience...." (A2) "Basic technology skills... they may lack the pedagogical knowledge to use ICT effectively" (B2)
	Pedagogical Knowledge & Technology Skills	"Some teachers have a basic foundation of applying technology, but there is a gap in their knowledge of how to use the technology most effectively for the best learning outcomes in their subjects and levels." (B4)
Professional Development	Lack of Programs	"There are no particular professional learning programs currently...." (A1) "Till date no professional development program has been designed..." (A2) "Need for training...learning outcomes" (B1).
	Reasons for Lack	"Limited funding...competing priorities" (A5) "... resources are limited..." (A2) "...perceived priority...rural school environment" (A4)
Current Level of Integration	Very Low	"Very low, ...most teachers have historically relied on traditional methods" (A1). Participant B1, indicated "...because of lack of resources, our school has many challenges in incorporating technology."
	Low	"Low. Currently the level of integration technology is still low..." (A2).

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		<p><i>"I would rate the ICT integration by teachers in our school as low..." (B2).</i></p> <p><i>"Moderate...access to technology is currently lacking in our schools..... of teaching" (A3).</i></p> <p><i>"...Moderate, while there are some instances of technology use, there is room for improvement..." (B3).</i></p> <p><i>"Lack of computers, projectors and reliable internet ..., we do not have enough advanced resources ..." (A2). "The computer lab has a few outdated computers...internet connectivity is not reliable..." (B1).</i></p> <p><i>".... lack of easily accessible technical support may intimidate teachers when integrating ICTs..." (A5). "Insufficient training and professional development opportunities for teachers to develop their ICT skills" (B1). "Inadequate support and guidance from school management and education authorities..." (B3).</i></p> <p><i>"Some teachers believe that technology would distract students or could replace valuable face-to-face interaction between the teachers and students." (A6). Participant B2 is of the view that "...some teachers are shy about using technology because of a lack of confidence. Further, resistance to change and existing teaching methods also discourage the adoption of ICT in teaching."</i></p> <p><i>"I think there is difficulty in finding technology tools that nicely fit into the curriculum..." (A1). "Teachers may find themselves strapped for time ... and there may not be enough time to plan and prepare ... adequately." (A4) "Our performance reviews typically concentrate on curriculum delivery and teaching practices, without placing a strong emphasis on technology integration" (B4).</i></p> <p><i>"I am not aware of any procedures developed for the monitoring and evaluation of teachers' progress in ICT integration" (A1). "...there is no formal way to see how teachers bring technology into lessons..." (A6). "To the best of my knowledge, there is no formal system that supervises and evaluates teacher progression in its ICT integration...." (B1).</i></p> <p><i>"Self-assessment helps teachers identify areas where they need further training or support to improve their ICT integration skills" (A1).</i></p> <p><i>"Through self-assessment, teachers can pinpoint specific areas where their ICT integration skills require further development" (A2). "Engaging in self-assessment allows teachers to analyze their use of ICT in the classroom" (A4). "Self-assessment provides a valuable opportunity for teachers to learn ..." (A5).</i></p>
Factors impeding Integration	Moderate	
	Lack of Resources	
	Lack of Training & Support	
	Concerning Teacher Confidence & Attitudes	
	Curriculum Alignment	
Monitoring & Evaluation	No Formal System	
Value of Self- assessment	Identify Strengths & Weaknesses	

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		"...teachers that are able to assess are able to identify areas they require further training..." (B1).
		"By way of this self-assessment, they can find out what to improve ... and keep on stirring their potential in ICT integration..." (B4)
Support Needed for Effective Integration	Technology Resources	"Equipping schools with more computers, tablets (if budget allows), projectors, and ensuring reliable internet access would be a game-changer" (A1). "Internet accessibility should be provided in schools..." (B1). "Teachers should attend professional development workshops and training sessions..." (B2). "Teachers should be provided with ongoing technical support and advice from ICT experts" (B3).
	Incentives and recognition	Innovativeness in the use of ICT in teaching must be rewarded through incentives or recognition...(B2).
	Partnerships and resources	"Mentorship programs and peer collaboration opportunities to share best practices in ICT integration" (A6). "Collaborate with industry partners or technology companies to provide schools with cutting-edge tools and resources..." (B4).

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### ***Narrative Summary of Interview Findings - State of ICT Integration from Table 19***

The key themes, and subthemes where applicable, inferred from the interview data as shown in Table 19, together with their corresponding codes are presented as follows.

#### ***Theme 1: Teacher Competencies***

The interviews with both educational officials and teachers consistently highlighted significant competency gaps in the integration of ICT into classroom practice. Respondent A1 emphasized that *"there is a continuum of competencies that needs differentiated support,"* suggesting that teachers demonstrate varying levels of technological capability that require tailored interventions. Similarly, A3 noted that teachers *"may not have had the precise knowledge regarding how to adopt ICT into classroom teaching or learning activities,"* pointing to a lack of specialized skills for effective ICT use. Teachers' voices reinforced this view. Respondent B1 stated, *"Many teachers seem not to have technology skills for teaching pedagogy on how to apply ICT in teaching,"* while B3 echoed this concern, stressing *"limited skills in applying technology*

*to teaching practices.*” The findings thus indicate a persistent gap between basic technological familiarity and the pedagogical knowledge required to integrate ICT meaningfully into instruction.

The results further showed differences in competencies influenced by factors such as age and years of experience. As A2 observed, competencies “can vary according to some features, including age or years of experience.” Likewise, B4 offered a more multi-layered insight: “*Some teachers have some idea of using the technology, but they do not possess the in-depth knowledge on how this technology can be utilized to its fullest potential in helping to teach the subjects and classes.*” This suggests that while some educators may exhibit rudimentary technology literacy, they often lack the training to align ICT use with subject-specific pedagogies.

### ***Theme 2: Professional Development***

A second theme that strongly emerged from the interview data was the absence of structured professional development opportunities tailored to ICT integration. Respondents consistently noted that no systemic or ongoing programs currently exist to enhance teachers’ competencies in this area. As A1 explained, “... *at the moment, there are no specific professional learning programs available for teachers.*” Similarly, A2 observed, “... *up to now, there is no professional development program to meet the teachers’ needs to improve their skills.*” These views point to a critical gap in institutional support for teachers’ professional growth in ICT. The absence of such programs was attributed to several underlying reasons. Respondent A5 highlighted financial constraints, noting, “*There isn’t enough funding...*”. This was reinforced by A2’s observation that “*There are not many resources available.*” A4 added another dimension, pointing to competing institutional priorities: “... *the perceived priority is not high enough, especially in rural school environments.*” Taken together, these perspectives illustrate that systemic and

resource-based barriers continue to obstruct the establishment of sustained professional development initiatives for ICT integration.

### ***Theme 3: Current Level of Integration***

The results also indicate that the present level of ICT integration in primary schools is generally low, and the answers fall in three descriptive categories: *very low*, *low* and to a smaller extent *moderate*. Some participants described ICT use as being “*very low*” and indicated that traditional teaching practices still prevail in classroom instruction. As one official (A1) remarked, “*most teachers have, with time, relied on ordinary practices.*” Another respondent reinforced this perspective, noting that the “*... level of use of ICT is at its lowest.*” Such accounts point to a situation where most educators continue to operate within conventional pedagogical frameworks, with ICT playing a minimal role in everyday instruction. Other respondents described the integration level as simply “*low.*” Participant A2, for instance, observed that ICT use in classrooms remains “*still low, with little progress over time.*” Similarly, a teacher (B2) acknowledged, “*I would rate the ICT integration by teachers in our school as low.*” These responses reflect a shared perception that, although some initial efforts may have been made, ICT adoption has not advanced substantially across schools. Only a small minority of participants considered the current level of ICT integration to be “*moderate.*” For example, respondent A3 suggested that “*while there are some instances of technology use, access to ICT remains limited, restricting its impact.*” Likewise, B3 commented that “*ICT use is moderate; there are isolated cases of effective use, but generally, there is significant room for improvement.*”

These views suggest that while schools are not entirely devoid of ICT practices, the integration process is still at a growing stage. The dominant trend remains low adoption, with

structural, infrastructural, and pedagogical barriers constraining progress. Even in cases where ICT use is described as moderate, it is portrayed as inconsistent and limited in scope.

***Theme 4: Factors Mitigating ICT Integration***

The findings highlighted several systemic and contextual barriers that continue to impede the effective integration of ICT in schools. These factors span from resource constraints to teacher-related challenges and structural issues within the curriculum.

1. **Resource Constraints:** The most frequently cited challenge was the lack of adequate technological resources. Respondents emphasized that without sufficient hardware and reliable infrastructure, ICT integration cannot be effectively realized. As one official (A2) noted, *“Lack of computers, projectors, and reliable internet spells limitation on ICT integration.”* A participant (B1) expanded on this, stating that *“the computer lab has a few old computers, and, in addition, the internet connectivity reliability is a problem for the feasibility of using technology for teaching purposes.”* These accounts reveal that both the quality and quantity of resources remain insufficient to support large-scale ICT adoption.
2. **Inadequate Training and Support:** Another barrier relates to the limited availability of professional training and technical support. One participant explained that teachers are often *“discouraged by the lack of easily accessible technical support when implementing ICTs.”* Similarly, another respondent observed that *“there is not sufficient capacity and professional growth that would enhance a greater understanding of ICT knowledge and use by teachers.”* These findings reflect both structural gaps in professional development provision and the absence of ongoing support that might encourage teachers to experiment with technology.
3. **Teacher Confidence and Attitudes:** The study also revealed attitudinal and psychological barriers. Some teachers reportedly harbor skepticism about the pedagogical value of ICT. For

instance, participant A6 suggested that *“teachers still think negatively; they think that technology would interfere with pupils’ learning.”* Others struggled with confidence, as B2 explained: *“some teachers are shy about using technology because of a lack of confidence.”* Resistance to change, combined with apprehension about technological complexity, thus creates additional hurdles to ICT integration.

4. **Curriculum-Related Barriers:** Structural constraints within the school curriculum were also flagged as limiting factors. One respondent (A1) remarked that *“the combination of curriculum learning objectives with the relevant technology tools to make its use better is a bit difficult.”* Other participants highlighted time pressures, noting that already congested teaching schedules leave little room for experimentation with ICT tools. As one participant emphasized, *“some teachers are bound by time as their calendar may already be packed, with no time left for scheduling and preparing classes, integrating technology as they ought to.”*

These accounts highlight a multifaceted set of barriers that collectively constrain ICT adoption. Resource inadequacies form the most visible impediment, but these are compounded by professional development gaps, negative teacher attitudes, and curriculum misalignment. The result is a fragmented landscape in which ICT adoption remains inconsistent, fragile, and often dependent on individual initiative rather than institutional support.

#### **Theme 5: Monitoring and Evaluation of Teachers’ ICT Integration**

Another major issue raised by participants concerned the absence of formal monitoring and evaluation (M&E) mechanisms for tracking ICT integration in teaching. Several respondents admitted that they were unaware of any systematic procedures established for this purpose. For example, participant A1 remarked: *“To my knowledge, there are no formally established procedures in tracking the progress of teachers in the integration of ICT.”* Similarly, participant

B1 emphasized: *“To the best of my knowledge, there is no formal system that supervises and evaluates teacher progression in its ICT integration.”* This absence of institutionalized M&E systems highlights a significant gap in policy implementation. Without structured mechanisms to assess progress, it becomes difficult for school leadership and educational authorities to track, evaluate, or provide feedback on teachers’ ICT practices.

Despite the absence of formal frameworks, several respondents acknowledged the potential of self-assessment as an informal mechanism for reflection and growth. One participant explained that *“practice of self-assessment will allow teachers to perceive fields for professional development in terms of ICT application.”* Another respondent observed that self-assessment will enable them to identify both strengths and weaknesses, thereby adjusting strategies to improve their ICT practices: *“...by self-assessment, they can find out what to improve and where they are strong and weak, so they can bend their strategies and keep on stirring their potential in ICT integration.”* In essence, even without the presence of formalized institutional frameworks, teachers recognized the inherent value of self-assessment as a driver of reflective practice. The responses indicate that self-assessment fosters greater professional awareness, enabling educators to pinpoint both strengths and areas needing development in ICT use.

### **Theme 6: Supports Required for Correct Implementation**

The final theme that emerged from the interview data relates to the support systems required to enable effective ICT integration. Across participants, there was a consensus that infrastructure improvement remains a critical prerequisite. One participant emphasized that *“if we increase the number of computers, tablets, projectors, and better internet available to schools, it*

*will be revolutionary*” (A1). Similarly, another participant stressed the importance of connectivity: *“Internet connections should be provided in school for access to diverse resources and tools on the web using assured connections and large bandwidth”* (B1). These responses indicate that adequate technological infrastructure is foundational to advancing ICT usage, and its absence continues to stall progress in teaching and learning practices.

In addition to infrastructure, respondents highlighted the importance of teacher motivation and recognition as a driver of ICT adoption. For instance, participant B2 recommended that *“there should be incentives or recognition packages for teachers about innovativeness in the use of ICT in teaching.”* Another dimension of support identified relates to mentorship and peer collaboration. Participant A6 underscored the value of mentorship programs and peer-sharing opportunities for best practices in ICT integration. This aligns with the understanding that sustainable ICT integration requires not only individual training but also collaborative learning ecosystems where teachers can share experiences, build confidence, and strengthen their capacity through collective practice.

The findings demonstrate that successful ICT integration is multi-dimensional. It is not merely a question of supplying hardware or connectivity; rather, it also involves creating motivational structures (incentives and recognition) and fostering professional learning communities (mentorship and peer collaboration). Without these holistic supports, even when resources are available, integration is likely to remain fragmented and underutilized.

#### **4.3.3.2.2 Open-ended Findings – Current State of ICT Integration Practices**

In addition to the structured items, teachers were asked an open-ended question: “What other additional information do you have on the current state of ICT integration practices in your school?” out of 335 responses to the questionnaire, 105 (31%) participants responded to this open-

ended question. A content analysis of these responses generated six key themes, together with their frequencies of occurrence and representative excerpts, which are summarized in Table 20.

**Table 20**

*Current state of ICT integration – (Open-ended Responses)*

<b>Theme</b>	<b>Frequency</b>	<b>Examples of Excerpts</b>
Lack of ICT Resources	42	...the school lacks the necessary technological resources to facilitate effective ICT education.
Need for Professional Development and Teacher Training	45	...teachers need to be comprehensively trained to acquire competencies to successfully infuse ICT in their teaching practice
Inadequate ICT Integration and Call for Action	72	"At the moment, ICT integration in our school is not adequate." "This is a critical situation that the school leadership must face up to immediately and urgently".
Digital Divide and Inequalities	30	"...it is worrying to note that the state of integration of ICTs in teaching of our school is quite poor." "... we do not have reliable internet connection, modern computer hardware, and much less updated software applications."
Resistance and Reluctance to Adopt ICT	25	"...while efforts to encourage ICT integration are made, there exists a huge difference between tech-embracing teachers who use ICT as a tool to improve teaching and learning and those who are hesitant or shy away from using technology, and therefore there is a need for constant support and encouragement."
Maintenance and Technical Support	12	".....acquiring some ICT equipment for the school has been a challenge but quality maintenance and upkeep have been a major challenge."

***Narrative Summary of Open-ended Findings from Table 20***

As presented in Table 20, several recurring themes emerged from the open-ended responses regarding the integration of ICT in the schools. The frequency of these themes highlights both the common barriers experienced across institutions and the strategic directions necessary to enhance ICT integration. Presentation of these themes are as follows:

**1. Lack of ICT Resources**

One of the most recurrent issues mentioned (n = 42) was the absence of adequate ICT resources. Respondents pointed to shortages in essential infrastructure, such as computers, projectors, and modern software applications. One respondent noted that “...*the school lacks the necessary technological resources to facilitate effective ICT education.*” This highlights a structural limitation that has consistently undermined the integration process.

## **2. Need for Professional Development and Teacher Training**

Professional development emerged as another prominent theme (n = 45). Respondents emphasized the urgent requirement for comprehensive training programs to equip teachers with the competencies required for ICT integration. As one participant reported, “...*teachers need to be comprehensively trained to acquire competencies to successfully infuse ICT in their teaching practice.*” This reinforces the gap already identified in interviews, where a lack of systematic professional training hinders pedagogical innovation.

## **3. Inadequate ICT Integration and Call for Action**

The most frequently cited theme (n = 72) was the overall inadequacy of ICT integration and the call for urgent intervention. Participants described the current state as insufficient, with statements such as “*At the moment, ICT integration in our school is not adequate*” and “*This is a critical situation that the school leadership has to face up to immediately and urgently.*” The urgency of these responses signals a strong demand for reform at both institutional and policy levels.

## **4. Digital Divide and Inequalities**

Concerns about digital inequalities were also identified (n = 30). Respondents stressed disparities between schools in terms of access to reliable internet and up-to-date ICT tools. For example, one participant commented: “...*we do not have reliable internet connection, modern*

*computer hardware, and much less updated software applications.*” This reflects not only infrastructural limitations but also systemic inequities across educational contexts, particularly between urban and rural schools.

### **5. Resistance and Reluctance to Adopt ICT**

Another theme related to teacher attitudes toward ICT adoption (n = 25). While some teachers embrace ICT as a transformative tool, others remain hesitant or reluctant to use technology in the classroom. As one participant put it:

*“...while efforts to encourage ICT integration are made, there exists a huge difference between tech-embracing teachers who use ICT as a tool to improve teaching and learning and those who are hesitant or shy away from using technology.”*

This points to cultural and psychological barriers that must be addressed through confidence-building initiatives and supportive leadership.

### **6. Maintenance and Technical Support**

The least frequent but still important theme (n = 12) concerned maintenance and technical support. Respondents noted that even when schools acquire ICT tools, upkeep and servicing remain a challenge. For instance, one participant remarked: *“...acquiring some ICT equipment for the school has been a challenge but quality maintenance and upkeep have been a major challenge.”* This underlines the necessity of sustainable support mechanisms, such as in-house technicians or reliable partnerships with ICT service providers. The analysis of the open-ended responses confirms that ICT integration in schools is still at an early stage, with systemic barriers spanning skills, resources, attitudes, and institutional support. The frequencies not only highlight the urgency of action but also provide a roadmap for interventions:

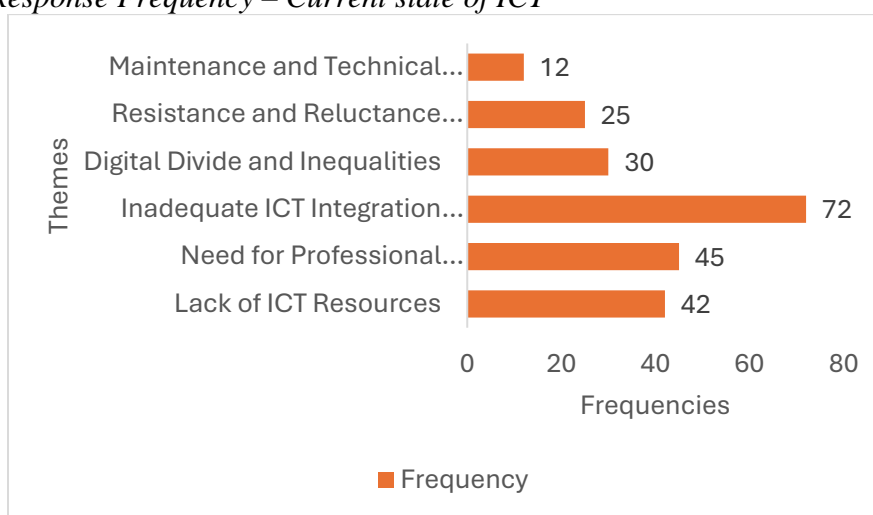
- i. Strengthening leadership action to enforce ICT policy implementation.
- ii. Expanding teacher training and professional development.

- iii. Investing in ICT resources and infrastructure.
- iv. Addressing inequalities to minimize the digital divide.
- v. Providing technical support and sustainable maintenance structures.

These findings, further illustrated in Figure 18, underline the critical need for a comprehensive and multifaceted strategy to ensure ICT integration is meaningful, equitable, and sustainable across schools.

**Figure 18**

*Open-ended Response Frequency – Current state of ICT*



#### ***4.3.3.3 Integration of Quantitative and Qualitative Datasets – Current state of ICT Integration Practices***

The integration of the quantitative and qualitative data, presented in the joint side-by-side matrix in Table 21, highlights both areas of convergence and divergence in ICT integration practices in primary schools. The quantitative strand identifies measurable trends in ICT usage, challenges, competencies, and professional development, while the qualitative strand provides contextual depth and explanatory insights. Taken together, the findings reveal a coherent picture

of minimal ICT integration, low teacher confidence, and the absence of strong systemic support structures.

**Table 21**

*Joint Display Matrix - ICT integration practices*

<b>Aspects</b>	<b>Quantitative Findings</b>	<b>Qualitative Findings</b>	<b>Integration Insight</b>
<b>ICT Tools Usage</b>	Low to very low usage across all ICT tools (M=1.28, SD=0.50). Video conferencing showed the lowest usage (M=1.08, SD=0.27). Digital evaluation tools rarely used (M=1.19, SD=0.39). All ICT tool categories showed well below neutral point	"Most teachers have historically relied on traditional methods" (A1). "Our teachers' level of ICT integration is at its lowest" (B1). Technology use was limited, mostly in the form of basic tools such as projectors used for presentations. 72 open responses indicated that there was inadequate ICT integration.	<b>Convergence:</b> The evidence from both data types is very strong in supporting extremely low levels of ICT integration. The quantitative finding that technology use was minimal is corroborated by qualitative data, with examples of the statistics that add qualitative meaning to the findings.
<b>Challenges to Integration</b>	High agreement with all challenge statements (M=4.16, SD=0.97). Insufficient technology/software rated highest (M=4.64, SD=0.59). Inadequate digital resources significant (M=4.56, SD=0.74). Time constraints substantial (M=4.07, SD=0.97)	"Lack of computers, projectors and reliable internet spells limitation on ICT integration" (A2). "The computer lab has a few outdated computers, and... internet connectivity is not reliable" (B1). 42 open-ended responses cited "lack of ICT resources". "Teachers, for instance, may feel pressured for time given that their schedules may be filled to the brim" (A4).	<b>Convergence and Enhancement:</b> Whereas quantitative data revealed the extent of challenges, qualitative data gave details on the challenges. The primary barrier found with both data findings was resource limitations, which were further elaborated on in qualitative data as to the specific nature of these limitations.

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<b>Teacher Confidence and Self-Efficacy</b>	Extremely low confidence across all measures (M=1.21, SD=0.45). Lowest confidence in effective integration (M=1.04, SD=0.20). Very low confidence in technical problem-solving (M=1.23, SD=0.46). Strong disagreement with qualification statements (M=1.26, SD=0.46)	"Some teachers are shy about using technology because of a lack of confidence" (B2). "Lack of confidence and fear of using technology among some teachers" (B3). 25 open-ended responses mentioned "resistance and reluctance to adopt ICT". "...there exists a huge difference between tech-embracing teachers...and those who are hesitant"	<b>Convergence and Enhancement:</b> The quantitative data revealed the extent of low confidence, while qualitative data provided contextual understanding of how this low confidence manifests as fear, shyness, and resistance to adoption.
<b>Competencies &amp; Skills</b>	Very low agreement with having required skills (M=1.21, SD=0.45). The most particularly low ratings were of specialized skills such as 'creating learning activities' (M = 1.30, SD = 0.50) and 'leading online research' (M = 1.29, SD = 0.53).	The 'range of competencies... differentiated support' (A1) is needed. "Teachers may lack the specific skills needed to effectively integrate ICT" (A3). "Some teachers have a basic foundation...but there is a gap in their knowledge of how to use the technology most effectively" (B4). "Many teachers have minimal training in technology skills for teaching strategies" (B1).	<b>Convergence and Enhancement:</b> The two datasets suggest there are competency deficits. Qualitative data helps to deepen perception by distinguishing between technical literacy and teaching pedagogy when it comes to the application of ICT.

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<b>Professional Development &amp; Support</b>	Very limited professional development reported (M=1.27, SD=0.47). Extremely low workshop participation opportunities (M=1.07, SD=0.26). Limited access to expert trainers (M=1.32, SD=0.48). Very low access to online resources (M=1.15, SD=0.38)	"There are no particular professional learning programs currently on offer" (A1). "Till date no professional development program has been designed" (A2). "Funding is 'very limited' and there are a 'number of competing priorities'" (A5). 45 open ended responses included 'professional development and teacher training."	<b>Convergence:</b> Both datasets show no programs that offer professional development for ICT integration. This finding is strengthened by qualitative data that shows that, in contrast to limited access, there literally are no formal programs.
<b>Evaluation &amp; Monitoring</b>	Although teachers agree that it is crucial to evaluate (C7 M = 4.20, SD = 0.94), they state they seldom use specific evaluation methods (M = 1.23, SD = 0.44). All specific evaluation approaches show minimal usage: student behavior observation (M=1.17, SD=0.38), surveys (M=1.17, SD=0.40)	"I am not aware of any procedures developed for the monitoring and evaluation of teachers' progress in ICT integration" (A1). "There is no formal system that supervises and evaluates teacher progression in its ICT integration" (B1). "Self-assessment assist teachers to realize on which aspects they require further professional development" (A1).	<b>Convergence and Enhancement</b> As a common feature, respondents affirmed that there is no monitoring and evaluation system. Qualitative data unearths why evaluation scores are low even though the importance of evaluation is recognized; there is no structural system for evaluation.

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<b>Beliefs &amp; Attitudes</b>	Regarding ICT's significance (M = 4.45, SD = 0.63) and the possible effects (M = 4.58, SD = 0.70).	"Some teachers believe rationally that technology would distract students" (A6). "Resistance to change and existing teaching methods also discourage the adoption" (B2). "This is a critical situation that the school leadership must face up to immediately and urgently." (open-ended response)	<b>Complementarity and Divergence:</b> A quantitative analysis was more optimistic about the importance of ICT where the qualitative data showed some level of opposition to its implementation. This points to the existence of other opinions that are not well expressed in the survey.
<b>Curriculum Alignment</b>	Finding suitable resources aligned with curriculum (M=4.14, SD=0.98). maintaining control over educational progress (M=3.67, SD=1.27)	"I think there is difficulty in finding technology tools that nicely fit with the curriculum's learning objectives and their assessment method." (A1). "Our performance reviews typically concentrate on curriculum delivery and teaching practices, without placing a strong emphasis on technology integration" (B4).	<b>Convergence and Enhancement:</b> Both datasets mentioned curriculum gap. Qualitative data helps in understanding in broader view with performance review systems.

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<b>Resource Inequities</b>	Strong disagreement that resources are easily available (M=1.16, SD=0.43).	"digital divide and inequalities" were mentioned in 30 of the open-ended responses. "It is worrying to note that the state of integration of ICTs in teaching of our school is quite poor." " We don't have available internet connection, modern computer hardware and hardly can speak of updated software applications."	<b>Enhancement:</b> Quantitative data revealed scarcity of resources in general, while qualitative data revealed concerns in relation to equity and the digital divide that were not questions in the questionnaire instruments.
<b>Maintenance &amp; Sustainability</b>	Concerns about reliability and safety of technology rated high (M=4.08, SD=0.97)	"Acquiring some ICT equipment for the school has been a challenge but quality maintenance and upkeep have been a major challenge." "Maintenance and technical support" issues (open-ended)	<b>Enhancement:</b> Some of the sustainability issues arose beyond what was captured by the questionnaire which enriched the reliability findings obtained.

### *Narrative Summary of Integrated Findings from Table 21*

As presented in Table 21, the findings show the extent at which the datasets overlap or differ in terms of quantity and quality from the emerging key aspects identified from both dataset findings.

**1. ICT Tools Usage and Practices:** Both datasets converged to reveal an alarmingly low level of ICT utilization across the schools. Quantitative survey results indicated that video conferencing tools were scarcely used (M = 1.08, SD = 0.27), with digital assessment tools also rarely employed (M = 1.19, SD = 0.39). This pattern of low engagement was echoed in the qualitative responses, where teachers reported relying predominantly on conventional

teaching methods with only sporadic ICT use. Open-ended responses—72 in total explicitly emphasized the inadequacy of ICT integration and called for immediate action. The convergence of evidence from both datasets highlights the reality that ICT remains peripheral rather than central to teaching practice.

- 2. Challenges to Integration:** The challenges associated with ICT integration emerged as one of the most pronounced findings. Survey data showed high levels of agreement on the presence of barriers ( $M = 4.16$ ,  $SD = 0.97$ ), with insufficiency of technology and software ( $M = 4.64$ ,  $SD = 0.59$ ), lack of digital resources ( $M = 4.56$ ,  $SD = 0.74$ ), and time limitations ( $M = 4.07$ ,  $SD = 0.97$ ) rated particularly highly. Qualitative responses provided vivid accounts of outdated equipment, unreliable internet connections, and insufficient funding. These complementary perspectives not only converge but also enhance understanding: the quantitative data quantified the extent of these challenges, while the qualitative responses offered grounded descriptions of how these barriers disrupt classroom practice.
- 3. Teacher Confidence and Competencies:** Teachers' self-efficacy in using ICT was consistently reported as low. Survey scores showed weak confidence in ICT for teaching ( $M = 1.21$ ,  $SD = 0.45$ ), integration into lessons ( $M = 1.04$ ,  $SD = 0.20$ ), and troubleshooting ( $M = 1.23$ ,  $SD = 0.46$ ). The interview data supported these findings, indicating that many teachers felt intimidated by ICT tools, describing themselves as reluctant, fearful, or hesitant to incorporate technology. This dual evidence confirms the existence of a confidence gap that extends beyond technical skills to attitudes and willingness. Similarly, ICT competency scores were uniformly low ( $M = 1.21$ ,  $SD = 0.45$ ), particularly for creating digital learning activities ( $M = 1.30$ ,  $SD = 0.50$ ) and guiding online research ( $M = 1.29$ ,  $SD = 0.53$ ). While surveys revealed competency deficits, qualitative data enriched this by distinguishing between basic

ICT literacy and the deeper pedagogical application required to embed ICT meaningfully in teaching.

- 4. Professional Development and Support:** Professional development emerged as a critical weakness in the data. The survey revealed very limited opportunities for training ( $M = 1.27$ ,  $SD = 0.47$ ), with workshops ( $M = 1.07$ ,  $SD = 0.26$ ) and access to trainers ( $M = 1.32$ ,  $SD = 0.48$ ) particularly scarce. Qualitative responses confirmed that formal training opportunities were largely absent, with lack of funding and competing administrative priorities frequently cited as barriers. These findings strongly converge that both datasets indicate lack of structured, ongoing professional development severely constrains teachers' ability to integrate ICT effectively.
- 5. Evaluation and Monitoring:** Another area of concern was the absence of evaluation and monitoring systems. Although teachers acknowledged the importance of evaluation in principle ( $M = 4.20$ ,  $SD = 0.94$ ), their actual practice was negligible, with very low usage of tools such as behavioral observation ( $M = 1.17$ ,  $SD = 0.38$ ) and surveys ( $M = 1.17$ ,  $SD = 0.40$ ). Interview data explained this discrepancy, confirming that no formal structures exist to assess ICT integration within schools. This finding illustrates convergence, while qualitative insights enhance understanding by showing that teachers are left to self-assess without institutional guidance or accountability.
- 6. Teacher Beliefs and Attitudes:** Perceptions of ICT integration produced mixed findings. Quantitatively, teachers reported strong agreement that ICT is important for teaching ( $M = 4.45$ ,  $SD = 0.63$ ) and beneficial for student learning ( $M = 4.58$ ,  $SD = 0.70$ ). In contrast, qualitative responses revealed resistance among some teachers, who viewed ICT as disruptive or unnecessary compared to traditional methods. This divergence suggests that while survey

data highlight a broad consensus on ICT's potential, interview accounts uncover underlying hesitation and reluctance that may hinder practical adoption.

- 7. Curriculum Alignment and Resource Inequities:** The issue of curriculum alignment presented further challenges. Survey results showed that many teachers struggled to align ICT tools with curriculum goals ( $M = 4.14$ ,  $SD = 0.98$ ) (Table 8) and reported difficulties in maintaining educational control ( $M = 3.67$ ,  $SD = 1.27$ ). Interview data supported this by noting limited availability of curriculum-relevant resources and performance review systems that prioritize curriculum coverage over ICT use. Similarly, disparities in ICT resources an expression of the digital divide were evident in survey results ( $M = 1.16$ ,  $SD = 0.43$ ) and elaborated in qualitative accounts. Respondents highlighted inequities between schools, obsolete technology, and inconsistent internet connectivity. Here, the datasets converged, with qualitative evidence enriching the quantitative findings by describing the inequities in more detail.
- 8. Maintenance and Sustainability:** Concerns about the sustainability of ICT integration also emerged. Quantitative findings indicated high levels of worry regarding the reliability and safety of ICT adoption ( $M = 4.08$ ,  $SD = 0.97$ ). Qualitative data reinforced this, describing persistent difficulties with equipment maintenance, lack of technical support, and the absence of long-term sustainability planning. This represents a clear case of enhancement, as interviews extended the survey findings beyond immediate reliability issues to systemic challenges of maintenance and resource upkeep.

Overall, the integration of data on the current state of ICT integration in primary schools depicts a landscape of severe constraints. Findings across all domains highlight inadequate infrastructure, limited teacher preparation, weak evaluation mechanisms, and unsustainable

resource provision. Convergence between the quantitative and qualitative strands was evident in most areas, with both confirming minimal ICT adoption. However, divergence emerged in relation to teacher attitudes: while quantitative results suggested optimism, qualitative accounts revealed resistance and skepticism. Notably, the qualitative findings consistently enriched the quantitative trends, providing contextual depth and illustrating the lived realities of teachers navigating the challenges of ICT integration.

#### **4.3.4: Determinant Factors that could influence Adoption of the DSAT**

This section reports findings for Research Question 2 (RQ2), which addresses Objective 2: to examine the factors that could influence teachers' perceptions and attitudes toward adopting a Digital Self-Assessment Tool (DSAT). The analysis considers both drivers and barriers across three dimensions: (a) infrastructural readiness and resourcing, (b) professional development and leadership support, and (c) individual-level motivations, including perceived usefulness, ease of use, and concerns about privacy and workload. Quantitative results establish prevalence patterns, while qualitative narratives provide contextual depth on how these factors manifest in practice. The integration of the two strands indicates that DSAT adoption depends not only on teacher willingness but also on the availability of systemic support and enabling conditions.

##### ***4.3.4.1 Quantitative Findings: Factors that could influence Adoption of the DSAT***

The quantitative analysis examined the key enablers that teachers perceive as essential to promote the adoption of a DSAT. Across all nine items, the results showed consistently high levels of agreement. These findings indicate a strong consensus among teachers regarding the critical conditions necessary to support the acceptance and sustained use of DSAT. Table 22 presents the detailed descriptive and normality statistics for each item.

**Table 22***Factors that could influence DSAT Adoption-Quantitative findings*

Items	N	Mean	SD	Skewness		Kurtosis		Shapiro-Wilk	
				Skewness	SE	Kurtosis	SE	W	p
RQ2 A1: Availability of adequate technological infrastructure could influence the tool's use.	335	4.68	0.576	-1.64	0.13	1.65	0.27	0.59	<.001
RQ2 A2: Adequate training could influence the tool's use	335	4.71	0.456	-0.92	0.13	-1.2	0.27	0.57	<.001
RQ2 A3: Provision of Customized components	335	4.54	0.608	-0.95	0.13	-0.1	0.27	0.7	<.001
RQ2 A4: The recognition and acknowledgement of one's efforts in integrating ICT could influence the use.	335	4.64	0.486	-0.69	0.13	-1.3	0.27	0.62	<.001
RQ2 A5: Inclusion of the provision of comprehensive and relevant self-assessment prompts	335	4.47	0.608	-0.71	0.13	-0.5	0.27	0.72	<.001
RQ2A6: Inclusion of individualized feedback	335	4.59	0.499	-0.42	0.13	-1.6	0.27	0.64	<.001
RQ2A7: The tool's user-friendliness and ease of navigation could influence one's willingness to use it.	335	4.64	0.48	-0.59	0.13	-1.7	0.27	0.61	<.001
RQ2 A8: Integration of interactive exercises or activities related to ICT integration could influence its use.	335	4.69	0.462	-0.84	0.13	-1.3	0.27	0.58	<.001
RQ2 A9: The inclusion of relevant resources and references to support my ICT integration could increase one's motivation to utilize tool.	335	4.64	0.479	-0.61	0.13	-1.6	0.27	0.61	<.001

### *Narrative Summary of Quantitative Findings from Table 22*

Teachers reported consistently high mean scores across all factors, indicating a broad consensus that multiple contextual and design-related elements influence their perceptions and willingness to adopt the DSAT. The highest-rated enablers were adequate training ( $M = 4.71$ ,  $SD = 0.456$ ) and the integration of interactive exercises ( $M = 4.69$ ,  $SD = 0.462$ ), underscoring the importance of practical, hands-on support for adoption. Strong agreement was also expressed regarding the availability of technological infrastructure ( $M = 4.68$ ,  $SD = 0.576$ ) and relevant instructional resources ( $M = 4.64$ ,  $SD = 0.479$ ), highlighting the role of technical readiness and content provision.

Design-related features, including user-friendliness and ease of navigation ( $M = 4.64$ ,  $SD = 0.480$ ), individualized feedback ( $M = 4.59$ ,  $SD = 0.499$ ), and customization ( $M = 4.54$ ,  $SD = 0.608$ ), were similarly valued, reflecting the significance of usability and personalization in fostering teacher engagement. Additionally, recognition of teachers' ICT integration efforts ( $M = 4.64$ ,  $SD = 0.486$ ) points to the influence of motivational and affective factors alongside technical and pedagogical supports. Across all items, the distribution of responses was negatively skewed (skewness ranging from  $-0.42$  to  $-1.64$ ), with values clustering at the upper end of the scale. This indicates that most participants rated the factors positively, with relatively low variability ( $SD = 0.456$ – $0.608$ ). Results from the Shapiro–Wilk test ( $p < .001$  for all items) further confirmed deviations from normality, consistent with the skewed distributions.

In summary, the findings suggest that teachers view adoption and utilization of the DSAT as strongly shaped by a combination of infrastructural readiness, training, embedded support, and motivational recognition mechanisms. The consistently high mean scores demonstrate broad consensus, underscoring the importance of addressing both technical and pedagogical ecosystems to foster effective adoption.'

#### 4.3.4.2 Qualitative Findings: Factors that could Influence Teachers' Perceptions and Attitudes towards Adoption and Utilization of the Tool – Interview Dataset

The qualitative component of the analysis, derived from semi-structured interviews, provided rich insights into the multidimensional factors shaping teachers' perceptions on the DSAT. Thematic analysis of the interview transcripts revealed four broad themes: (i) benefits of self-assessment, (ii) challenges and concerns, (iii) potential benefits of a DSAT, and (iv) external factors to impact the adoption of a DSAT. These themes, along with illustrative codes and excerpts, are summarized in Table 23.

**Table 23**

*Determinant factors that could influence DSAT Adoption - Interview findings*

<b>Theme</b>	<b>Codes</b>	<b>Excerpts</b>
<b>Benefits of Self-assessment</b>	Identify strengths and weaknesses	“Teachers' owns evaluation of ICT use in teaching and learning can be an important element in the establishment of their strengths and weaknesses”. (A1)
	Professional growth	“Teachers can determine how they are using technology to achieve instructional goals through regular self-assessment”. (A2)
	Improved teaching practices	Self-assessment enables teachers to gain insights into its effectiveness in engaging students in learning and achievement and identify the most suitable instructional strategies and technological instruments to use when teaching. (A3)
<b>Challenges and Concerns</b>	Access to resources	“The tool may not involve teachers in remote or resource-constrained regions if the tool is based on high-end devices or fast internet connections.” (A1)
	Time constraints	Challenges need to be addressed in time management as the teachers are already overburdened with a busy schedule." (A2)
	Usability and user-friendliness	“If the tool is difficult to use or if I cannot easily find my way around the tool, then I will quit using it.” (B1)

	Data privacy and security	It is also important to note that data privacy and security constitute vital facets of any business. Teachers must have confidence in the security of their inputs and the private information they supply during the reflection process.” (B1)
	Learning curve	“There may be a learning curve associated with “It might take some time for some educators to learn how to use the tool because most of them are not very tech-savvy, thus they could experience some difficulties at the beginning stages of using the tool.” (A5)
<b>Potential Benefits of a DSAT</b>	Tailored recommendations	It could also be useful for instructors to enhance their career progress by offering recommendations and other vital resources on current trends and proven strategies in educational technology to them. (A3) “Other benefits include possibilities for cooperation with other teachers and students.” (B1)
	Access to resources	Teachers may improve their ICT skills by setting goals and gaining access to resources. (B4)
	Collaboration and networking	“...ICT goals may help teachers to enhance their skills in the application of ICTs ...” (B4).
	Goal setting and tracking	
<b>External Factors that could impact the adoption of a DSAT</b>	Time constraints	Lack of time could be another factor; for instance, work overload or other commitments in the daily activities may limit the teachers’ ability to frequently incorporate the digital self-assessment tool. (B1)
	Lack of resources	“Some teachers may not be able to use the tool because they have poor access to computers or a stable internet connection.” (B2) “A lack of administrative support or encouragement could influence the willingness to apply the tool and use ICT in their teaching.” (B3)
	Unsupportive environment	“They also argued that where there is no incentive or any form of appreciation of self-reflection, then it may be hard to find reasons to engage in it.” (B4)
	Lack of recognition or incentives	“Use of the tool may be discouraged by limited technical assistance given to teachers.” (A4, A5, A6)
	Lack of technical support	

### ***Narrative Summary of Interview Findings from Table 23***

The interview data in Table 23 reveals a detailed picture of teachers' perceptions and attitudes toward the potential adoption and utilization of the digital self-assessment tool. Four overarching themes emerged: benefits of self-assessment, challenges and concerns, potential benefits of the digital tool, and external factors.

#### **Theme 1: Benefits of Self-Assessment**

Participants highlighted several intrinsic benefits of engaging with self-assessment practices. Teachers recognized that the tool could facilitate self-evaluation of strengths and weaknesses in ICT integration, which could in turn foster professional growth and continuous reflection on teaching practices. For instance, respondents noted that; *regular engagement with self-assessment could help educators track the effectiveness of their ICT use in achieving instructional goals* (A2). Furthermore, self-assessment was linked to improved teaching practices, enabling teachers to refine their instructional strategies and make more informed choices about digital tools (A3). Collectively, these findings underscore the role of self-assessment in cultivating reflective practitioners who can adapt to evolving educational technologies.

#### **Theme 2: Challenges and Concerns**

Despite acknowledging potential benefits, participants identified several barriers that could hinder adoption. Access to resources emerged as a critical concern, especially for *educators in rural or resource-constrained contexts, who may lack access to high-end devices or stable internet connectivity* (A1). Time constraints were also frequently cited, with participants noting that *teachers' heavy workloads may limit opportunities to engage with additional tools* (A2). Concerns about usability and user-friendliness were also voiced, as teachers emphasized that *overly complex interfaces could discourage sustained use* (B1). Another critical issue was *data privacy and security* (B1), with participants stressing that teachers must trust the confidentiality of their

personal reflections. Finally, participants highlighted on learning curve that might be associated with new technologies, *particularly for teachers with limited digital literacy* (A5), highlighting the need for ongoing support during the initial stages of tool use.

### **Theme 3: Potential Benefits of the Digital Tool**

Beyond the general value of self-assessment, participants anticipated that a well-designed digital tool could generate additional advantages. Teachers highlighted the potential for tailored recommendations and resource sharing, *which could support their professional development by providing updated strategies and access to relevant materials* (A3). *Opportunities for collaboration and networking* (B1, B4) were also viewed positively, with the tool seen as could be a platform for peer learning and professional dialogue. Additionally, the incorporation of goal setting and tracking mechanisms was mentioned, as these features could encourage teachers to *establish measurable ICT-related objectives and monitor progress over time* (B4). These insights indicate that participants expect the tool to go beyond evaluation and actively facilitate growth, collaboration, and sustained engagement with ICT.

### **Theme 4: External Factors**

Participants also identified external conditions that could shape the success of the tool's implementation. *Lack of resources* (B2) and *unsupportive school environments* (B3) were seen as structural barriers, with respondents stressing that without administrative backing and resource allocation, the tool's utility could be severely limited. Similarly, the *absence of recognition or incentives for engaging in self-assessment* (B4) was perceived as a potential deterrent that could hinder the consistent use. Respondents also noted the importance of technical support, emphasizing that *without timely assistance, teachers may become discouraged* (A4–A6). The recurring theme of time constraints also appeared here, reinforcing its significance as both an internal and external limiting factor (B1). The qualitative data reveals a comprehensive

perspective: while teachers are optimistic about the benefits of digital self-assessment for professional growth, they remain cautious about practical challenges such as time, usability, and support. Crucially, participants positioned the tool's success as contingent not only on individual motivation but also on systemic support, including administrative commitment, infrastructural provision, and recognition of teachers' efforts.

#### ***4.3.4.3 Integrated Findings: Factors that could Influence Adoption and Utilization of the DSAT***

The findings from both the quantitative and qualitative analyses show consistency in terms of the perceived factors that could influence the use of the DSAT. Table 24 presents the side-by-side joint display matrix of results from both strands of data and their integrated insights.

**Table 24**

*Integrated findings –Factors that could Influence the DSAT Adoption*

<b>Aspect</b>	<b>Quantitative Findings</b>	<b>Qualitative Findings</b>	<b>Integration Insight</b>
<b>Infrastructure and Resources</b>	Technological infrastructure (M = 4.68, SD = 0.576) had the highest ceiling effect (skewness = -1.64), which showed that there was general agreement among the respondents.	"The tool may not involve teachers in remote or resource-constrained regions if the tool is based on high-end devices or fast internet connections" (A1). Participant B2 mentioned that some teachers may be locked out from using it due to low access to computers or stable internet connection.	<b>Convergence:</b> Both sets of data reveal that technological infrastructures are seen as being of paramount importance; effectively, quantitative data place this factor as one of the highest priorities, while qualitative data gives certain details about the hardware and connectivity needs.

<b>Training and Technical Support</b>	Adequate training received the highest rating (M = 4.71, SD = 0.456) with very low variability.	"It might take some time for some educators to learn how to use the tool because most of them are not very tech-savvy, thus they could experience some difficulties at the beginning stages of using the tool." "Use of the tool may be discouraged by limited technical assistance given to teachers." (A4, A5, A6)	<b>Convergence:</b> Regarding importance, training and technical support are consequently perceived as critical factors in both datasets. The quantitative result shows it has the highest rank with the respondents, while the qualitative analysis provides detailed information about the issues around learning and the need for continuous help.
<b>User Experience and Design</b>	User-friendliness and ease of navigation were highly rated (M = 4.64, SD = 0.480) with low variability.	"If the tool is difficult to use or if I am not able to easily find my way around the tool, then I will quit using it." (B1)	<b>Convergence:</b> From both datasets it can be inferred that usability and ease to use are key aspects in usage and continued use. Qualitative data points out that a negative user experience could be a total showstopper.
<b>Customization and Personalization</b>	Provision of customized components (M = 4.54, SD = 0.608) and individualized feedback (M = 4.59, SD = 0.499) were rated highly but ranked in the middle of factors.	"It could also be useful for instructors to enhance their career progress by offering recommendations and other vital resources on current trends and proven strategies in educational technology to them" (A3).	<b>Enhancement:</b> Based on the two sets of data, it is evident that usability and intuitive design are valuable factors to facilitate the adoption as well as the utilization of technology products. Qualitative data supports the correlation, suggesting that the poor user experience could become the total inhibitor for adoption.

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<b>Interactive Features</b>	Integration of interactive exercises or activities was the second-highest rated factor (M = 4.69, SD = 0.462).	"Teachers may improve their ICT skills by setting goals and gaining access to resources" (B4). "Other benefits include possibilities for cooperation with other teachers and students" (B1).	<b>Enhancement:</b> Quantitative data suggests that the importance of interactive features is high, while qualitative data discusses general forms of interactivity that would be desired and beneficial, such as goal-setting aspects and peer-cooperation aspects.
<b>Resource Access</b>	Including appropriate resources and references was also appreciated highly (M = 4.64, SD = 0.479) with minimal variance.	"Teachers may improve their ICT skills by setting goals and gaining access to resources" (B4).	<b>Convergence:</b> From both data sets, it was established that the availability of resources was an important criterion for adoption.
<b>Time Constraints</b>	Not directly measured in the quantitative survey as a separate factor.	"Challenges need to be addressed in time management as the teachers are already overburdened with a busy schedule" (A2). "Lack of time could be another factor; for instance, work overload or other commitments in the daily activities may limit the teachers' ability to frequently incorporate the digital self-assessment tool." (B1)	<b>Expansion:</b> The qualitative data introduces a critical factor not explicitly measured in the quantitative data. Availability of time is also identified to be one of the potential challenges which should also be taken into consideration during the designing of the tools and their deployment.

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<b>Institutional Support</b>	Recognition and acknowledgement of one's efforts was highly rated (M = 4.64, SD = 0.486).	"A lack of administrative support or encouragement could influence the willingness to apply the tool and use ICT in their teaching" (B3). "They also argued that where there is no incentive or any form of appreciation of self-reflection, then it may be hard to find reasons to engage in it." (B4)	<b>Enhancement:</b> Whereas the quantitative analysis pointed to recognition as a factor of importance, the qualitative concept goes further to name institutional support as recognition, including encouragement by administrators and such tangible rewards as adoption.
<b>Data Privacy and Security</b>	Not directly measured in the quantitative survey as a separate factor.	"It is also important to note that data privacy and security constitute vital facets of any business. Teachers must have confidence in the security of their inputs and the private information they supply during the reflection process" (B1).	<b>Expansion:</b> This raises an important question about the measure and indicates a possible lack in this quantitative instrument, and it appears that there is another dimension that needs to be incorporated into tools.
<b>Perceived Benefits of Self-Assessment</b>	Comprehensive and relevant self-assessment prompts were rated the lowest (M = 4.47, SD = 0.608) but still highly on absolute scale.	"Teachers' own evaluation of ICT use in teaching and learning can be an important element in the establishment of their strengths and weaknesses" (A1). " It helps teachers to understand how well it fosters students' learning and performance as well as determine the instructional practices and technology tools to use in the classroom (A3).	<b>Enhancement:</b> Even though quantitative data presents self-assessment as less significant than other factors and yet relevant, qualitative data offers meaningful insights into perceived advantages of self-assessment on professional growth, as well as teaching performance among tutors.
<b>Goal setting and Tracking</b>	Not specifically measured as a distinct factor in the quantitative survey.	"Teachers may improve their ICT abilities by setting goals and	<b>Expansion:</b> The qualitative data presents goal setting and tracking of

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accessing resources."  
(B4)

progress as a new dimension not measured in the quantitative tool, recommending an approach that might further increase the usage and continuation of the tool.

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### *Narrative Summary of Integrated Findings in Table 24*

The integration of quantitative and qualitative data on factors influencing the uptake and use of the self-assessment tool, as summarized in Table 24, revealed patterns of convergence, enhancement, and expansion across the two strands.

#### **1. Convergence in Findings**

Several factors demonstrated strong alignment between the quantitative and qualitative datasets.

- a. Infrastructure and Resources were rated highly in the survey ( $M = 4.68$ ,  $SD = 0.576$ , skewness =  $-1.64$ ), while interviewees emphasized that limited access to computers and internet connectivity could impede effective use of the tool.
- b. Training and Technical Support received the highest mean score ( $M = 4.71$ ,  $SD = 0.456$ ), and participants similarly underscored the importance of continuous professional support, particularly for teachers with limited ICT skills.
- c. User Experience and Design also scored highly ( $M = 4.64$ ,  $SD = 0.480$ ). Qualitative accounts reinforced this finding, noting that difficulties in usability would discourage adoption.
- d. Resource Access ( $M = 4.64$ ,  $SD = 0.479$ ) was likewise seen as critical, with teachers confirming that the availability of relevant instructional materials would foster ICT skill development and integration.

## 2. Enhancement in Findings

In several areas, qualitative evidence elaborated on the quantitative trends, providing additional depth and specificity.

- a. Customization and Personalization ( $M = 4.54$ – $4.59$ ) were reinforced by interview accounts calling for recommendations tailored to teachers' instructional contexts and professional goals.
- b. Interactive Features ( $M = 4.69$ ,  $SD = 0.462$ ) were expanded by qualitative descriptions emphasizing desired functions such as goal setting and peer collaboration.
- c. Institutional Support, rated highly for recognition ( $M = 4.64$ ,  $SD = 0.486$ ), was further elaborated through participants' emphasis on the need for administrative encouragement and incentives to sustain adoption.
- d. Perceived Benefits of Self-Assessment, which recorded the lowest mean ( $M = 4.47$ ,  $SD = 0.608$ ), was nonetheless reinforced in the qualitative strand as valuable for identifying strengths, weaknesses, and instructional practices.

## 3. Expansion in Findings

The qualitative strand introduced additional considerations not captured in the quantitative analysis.

- a. Time Constraints were identified as a barrier, with heavy workloads limiting opportunities for teachers to engage with the tool.
- b. Data Privacy and Security emerged as a concern, as participants stressed the importance of trust and the protection of sensitive inputs.
- c. Goal Setting and Tracking, though not included in the survey, was highlighted as an important motivator for professional growth and sustained tool use.

Overall, no incongruence was observed between the two datasets. Instead, the integration demonstrated complementarity: qualitative evidence not only deepened the understanding of quantitative ratings but also introduced new factors for consideration in shaping teachers' adoption of the DSAT.

#### **4.3.5: Teacher-informed requirements for the Design of the DSAT**

This section presents findings on Research Question 3 (RQ3) aligned with Objective 3: To identify the teacher-informed requirements for a digital self-assessment tool. Results highlight requirements in four domains: (a) simple and intuitive user interface, (b) reflective and pedagogical features such as feedback and progress tracking, (c) collaborative options including peer-sharing and communities of practice, and (d) contextual adaptability, including offline functionality and curriculum alignment. Quantitative prioritization of these features is paired with qualitative explanations from teachers, ensuring that recommendations reflect both statistical trends and user narrative.

##### ***4.3.5.1 Quantitative Findings: Teacher-informed requirements for the DSAT***

Questionnaire responses from 335 participants indicated consistently high levels of support for all proposed features of the Digital Self-Assessment Tool (DSAT). As shown in Table 25, mean scores for every item exceeded 4.40 on a five-point scale, with negative skewness across items, reflecting a strong consensus on the importance of the proposed functional requirements for the tool.

**Table 25***Perceived Expected Features and Functionalities*

Item	N	Mean	Std. Deviation	Skewness		Kurtosis	
				Statistic	Std. Error	Statistic	Std. Error
RQ3 A1: The tool needs to have a self-evaluation feature.	335	4.62	.577	-1.224	.133	.510	.266
Q3 A2: The tool needs to offer guidance for teachers in the form of reflective prompts or questions.	335	4.67	.470	-.734	.133	-1.470	.266
RQ3 A3: Based on their self-assessment and objectives, teachers ought to be provided with individualized feedback and recommendations.	335	4.47	.664	-.871	.133	-.376	.266
RQ3 A4: The tool has the capacity to include interactive exercises or simulations that pertain to the integration of ICT.	335	4.59	.538	-.844	.133	-.406	.266
Q3 A5: The tool needs to offer entry to a variety of materials like articles, teaching strategies, instructional videos, and successful methods.	335	4.43	.661	-.739	.133	-.531	.266
RQ3 A6: The tool needs to enable teachers to monitor their progress over time.	335	4.53	.545	-.582	.133	-.804	.266
RQ3 A7: The tool needs to provide chances for teachers to engage and cooperate with colleagues, facilitating the exchange of experiences, ideas, and solutions regarding ICT integration challenges.	335	4.62	.486	-.501	.133	-1.760	.266

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RQ3 A8: The tool needs to possess a user-friendly and easy-to-use interface.	335	4.69	.465	-.808	.133	-1.355	.266
RQ3 A9: The tool needs to incorporate online courses that concentrate on utilizing ICT and implementing creative teaching techniques.	335	4.62	.487	-.488	.133	-1.773	.266

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### *Narrative Summary of Quantitative Findings from Table 25*

The results in Table 25 present teachers' perceptions of the expected features and functionalities of a digital self-assessment tool for ICT integration. Overall, the mean scores across all items are consistently high ( $M = 4.43$ – $4.69$  on a 5-point scale), with low standard deviations, indicating strong agreement and convergence of opinion among respondents.

#### **1. Core Functionalities**

Respondents rated self-evaluation ( $M = 4.62$ ,  $SD = .577$ ) and reflective prompts or guiding questions ( $M = 4.67$ ,  $SD = .470$ ) as highly essential. These findings emphasize the importance of reflection-oriented features that can help teachers critically assess their ICT practices and teaching strategies. Similarly, the inclusion of interactive exercises and simulations ( $M = 4.59$ ,  $SD = .538$ ) was rated strongly, reflecting teachers' recognition of the value of experiential and practice-based learning in ICT integration.

#### **2. Support for Professional Growth**

Teachers also expressed strong agreement that the tool should provide individualized feedback and recommendations ( $M = 4.47$ ,  $SD = .664$ ), as well as access to diverse resources such as articles, strategies, instructional videos, and best practices ( $M = 4.43$ ,  $SD = .661$ ). These responses suggest that teachers value tailored and resource-rich features that directly contribute to their professional learning and instructional improvement.

### **3. Monitoring and Collaboration**

There was a clear consensus on the need for progress tracking ( $M = 4.53$ ,  $SD = .545$ ) and collaborative opportunities with colleagues ( $M = 4.62$ ,  $SD = .486$ ). Teachers indicated that the ability to set goals, monitor growth, and share experiences is central to sustaining motivation and deepening ICT competencies over time.

### **4. Usability and Accessibility**

The highest mean score was recorded for the item on user-friendliness and ease of use ( $M = 4.69$ ,  $SD = .465$ ), underscoring that a simple and intuitive interface is a non-negotiable feature for adoption. Similarly, teachers agreed strongly that the tool should offer online courses and structured learning opportunities ( $M = 4.62$ ,  $SD = .487$ ) to support ongoing skill enhancement.

### **5. Distribution of Responses**

The skewness values across items were negative, suggesting that most responses were clustered at the higher end of the scale (agreement/strong agreement). Kurtosis values ranged from slightly negative to moderately positive, implying that while responses were generally concentrated, some items (e.g., collaboration, online courses) displayed higher peaks, reflecting very strong consensus.

In summary, the quantitative findings indicate that teachers have clear, consistent, and strongly positive expectations for the digital self-assessment tool. They prioritize reflection, tailored feedback, interactive learning, collaboration, and usability, highlighting that the tool must be designed to be both pedagogically supportive and practically accessible. These results provide a solid foundation for aligning the tool's design with teachers' professional needs and working conditions.

### 4.3.5.2 Qualitative Findings: Teacher-informed requirements for the DSAT

#### 4.3.5.2.1 Interview Data Analysis

Analysis of interviews revealed consistent agreement on several essential design considerations. Four major categories of features were emphasized, as presented in Table 26.

**Table 26**

*Interview Data Analysis: Perceived Expected Features and Functionalities*

Theme	Sub-themes	Examples of Excerpts
Essential Features and Functionalities	Guided prompts or questions for self-assessment	"The tool should provide guided questions or prompts to assist instructors in reflecting on their ICT integration methods" (B1). "It should include suggestions that urge people to think about their own strengths, problems, and places for progress" (A1, A2, A3, A4) "The tool should also be able to track progress towards set targets for targets over time" (A2, A5, A6).
	Tracking progress and setting goals	"The capacity to establish defined and quantifiable goals for ICT integration is also essential" (A4, A6)
	Integration with professional development programs	".....professional development programs or certification paths should be integrated in the tool" (A3).
	Peer collaboration and knowledge sharing	".....there should be discussion forums or communities where peers can collaborate and share their experiences" (B2, B3, B4, A1, A6)
	Customized recommendations and resources	"The tool should provide individualized recommendations or ideas based on the teacher's self-assessment" (B3). "Access needs to be given to appropriate educational resources, lesson plans and best practices for ICT integration" (B1, A1, A2)
	Scenario-based exercises and simulations	".... provide scenario-based simulations for implementing ICT ideas in real-world educational settings" (A5). "...interactive exercises allow instructors to experiment with ICT integration tactics and obtain feedback on their approach" (A3)
Interactive Exercises and Activities	Gamification and motivation	"Use gamification to enhance and motivate the reflection process" (A6)
	Continuous updates and user feedback	The participants B1, B2, B3, B4, A2, A3, and A5 noted that continuous updates and means for user feedback are necessary in order for the project to progress consistently.

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Training and support	<p>"Training sessions should be incorporated into the instrument to promote awareness and foster adoption" (A4).</p> <p>"Make available instructional videos that demonstrate the proper utilization of self-assessment tools" (A2).</p> <p>"Provide continuous technical support to remedy any challenges that educators may face while utilizing the tool" (A3)</p>
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### *Narrative Summary of Interview Findings from Table 26*

The qualitative interviews offered rich insights into participants' expectations regarding the essential features and functionalities of a proposed ICT self-assessment and development tool for primary education. Broadly, the findings clustered around two thematic areas: essential functionalities for effective ICT integration and interactive, supportive mechanisms to sustain teacher engagement.

#### **1. Essential Features and Functionalities**

Participants emphasized that the tool should include guided prompts and reflection questions to support teachers in evaluating their ICT integration practices. For example, one respondent explained: *"The tool should provide guided questions or prompts to assist instructors in reflecting on their ICT integration methods"* (B1). Another added: *"It should include suggestions that urge people to think about their own strengths, problems, and places for progress"* (A1, A2, A3, A4). Some respondents also highlighted the importance of goal setting and progress tracking. They stressed that clear objectives and monitoring mechanisms would help sustain professional growth: *"The tool should also be able to track progress towards set targets over time"* (A2, A5, A6). *"The capacity to establish defined and quantifiable goals for ICT integration is also essential"* (A4, A6).

Some participants suggested that the tool should be linked with professional development programs to extend its impact beyond individual reflection. As one teacher noted: “*Professional development programs or certification paths should be integrated in the tool*” (A3). Finally, peer collaboration and knowledge sharing were considered vital. Teachers emphasized the value of collective learning communities: “*There should be discussion forums or communities where peers can collaborate and share their experiences*” (B2, B3, B4, A1, A6).

## **2. Interactive Exercises and Activities**

Teachers also valued scenario-based simulations and interactive exercises that allow practical experimentation with ICT integration strategies:

- i. “*Provide scenario-based simulations for implementing ICT ideas in real-world educational settings*” (A5).
- ii. “*Interactive exercises allow instructors to experiment with ICT integration tactics and obtain feedback on their approach*” (A3).

Similarly, gamification elements were recommended to enhance motivation and sustain reflective engagement: “*Use gamification to enhance and motivate the reflection process*” (A6).

## **3. Personalization and Resources**

Respondents underlined the need for customized recommendations and resources based on self-assessment outcomes. This included access to lesson plans, strategies, and digital tools aligned with teachers’ needs:

- i. “*The tool should provide individualized recommendations or ideas based on the teacher’s self-assessment*” (B3).

- ii. *“Access needs to be given to appropriate educational resources, lesson plans, and best practices for ICT integration”* (B1, A1, A2).

While participants agreed strongly on most features, some pointed to additional motivational elements such as gamification, though these were not considered central. Overall, the data suggests that teachers see the tool not only as a mechanism for self-reflection but also as a comprehensive platform for professional growth, collaboration, and sustained ICT integration.

#### **4.3.5.2.2 Open-ended Data Analysis - Teacher-informed requirements for the DSAT**

Analysis of open-ended responses revealed several recurring themes concerning the expected features and functionalities of the self-assessment tool. In all 45 participants responded to this open-ended question. Table 27 summarizes these themes, their frequency of occurrence, and representative excerpts.

**Table 27***Open-ended Data Analysis: Perceived Expected Features and Functionalities*

<b>Theme</b>	<b>Frequency</b>	<b>Examples of Excerpts</b>
Comprehensive Assessment	30	"It should give a thorough coverage of teachers' digital competencies in the key areas."
Personalized feedback and recommendations	20	"Based on the teachers' self-assessment results, the tool should be able to issue individualized feedback and recommendations to teachers."
Reflective Prompts and Journaling	30	"Reflective prompts and journaling, for example, should be included in the tool so that teachers reflect deeply."
Peer-to-Peer Learning	22	The tool should promote peer-to-peer learning and collaboration opportunities for teachers to learn from one another."
Professional Development Tracking	34	"Provide functionality for setting professional development goals related to ICT integration and tracking progress over time." "Teachers' self-directed learning should be allowed; personal professional development goals for ICT integration should be set and means should be provided for tracking their ICT integration use over time."
Reporting and Analytics	20	"The reporting and analytics should be aggregated to school organization leaders and/or administrators."
Gamification and incentives	10	"While gamification elements and incentives can be included to motivate the teachers to engage with the tool, some other features can also be incorporated."

*Narrative Summary of Open-Ended Findings from Table 27*

The open-ended responses provide valuable insights into teachers' expectations of the essential features and functionalities of a digital self-assessment tool. Several key themes emerged, capturing both the practical requirements necessary for effective use and the broader aspirations teachers associate with professional growth. These themes are outlined as follows.

## 1. Dominant Themes

The most frequently highlighted theme was *Professional Development Tracking* (34 mentions). Teachers expressed a strong desire for functionality that would allow them to set personal ICT integration goals, monitor progress, and document their professional development journey. This indicates a recognition that self-assessment should not end with reflection but should extend into continuous growth and accountability. Closely aligned with this, *Comprehensive Assessment* (30 mentions) and *Reflective Prompts and Journaling* (30 mentions) were also highly emphasized. Teachers wanted the tool to offer thorough coverage of digital competencies while also prompting deep reflection through guided journaling and reflective questions.

## 2. Supporting Themes

Another prominent expectation was *Peer-to-Peer Learning* (22 mentions), where teachers highlighted the importance of collaboration and shared learning opportunities. This finding underscores the role of collegial networks in fostering ICT integration, suggesting that a collaborative dimension is vital for the tool's success. Similarly, *Personalized Feedback and Recommendations* (20 mentions) and *Reporting and Analytics* (20 mentions) were consistently noted, with respondents stressing the need for individualized guidance as well as system-level insights for administrators and school leaders.

## 3. Emerging Themes

Though mentioned less frequently, *Gamification and Incentives* (10 mentions) also appeared as a motivating factor, with some teachers suggesting that interactive features, rewards, or incentives could boost engagement with the tool. While this was not as dominant as other themes, it still points to the potential of motivational design in sustaining usage.

Overall, the open-ended findings highlight that teachers expect the tool to balance comprehensive self-assessment and deep reflection with professional growth tracking and collaborative learning opportunities. While personalization and analytics are valued for individual and institutional use, the inclusion of motivational elements like gamification could further enhance engagement. The frequency distribution indicates that while certain features are core expectations (e.g., tracking, assessment, and reflection), others like gamification are complementary but still noteworthy.

#### 4.3.4.3 Integrated Findings: Perceived Expected Features and Functionalities

The integration of quantitative and qualitative findings provides a comprehensive understanding of the key features and functionalities teachers expect in a self-assessment tool for ICT integration. The summary is presented in Table 28.

**Table 28**

*Joint Display Matrix: Perceived Expected Features and Functionalities*

Aspect	Quantitative Findings	Qualitative Findings	Integration Insight
User Interface Design	User-friendly interface (M = 4.69, SD = 0.465)	"Training sessions should be incorporated into the instrument to promote awareness and foster adoption" (A4). "Make available instructional videos that demonstrate the proper utilization of self-assessment tools" (A2)	<b>Convergence:</b> the two datasets underline the values of accessibility and usability. Qualitative data goes further to give an insight of how this can be implemented through training and/or instructional resources, while information derived from quantitative data shows this as the most highly rated feature.
Guidance and Reflection	Guidance through reflective prompts (M = 4.67, SD = 0.47)	"The tool should provide guided questions or prompts to assist instructors in reflecting on their ICT integration methods" (B1). "Reflective prompts and journaling,	<b>Convergence:</b> Strong agreement between quantitative and qualitative data on the importance of guided reflection. This seems to be a very basic/general

		for example, should be included in the tool so that teachers reflect deeply" (n=30)	requirement that is present in both datasets.
Self-Assessment Capabilities	Self-evaluation feature (M = 4.62, SD = 0.577)	"It should include suggestions that urge people to think about their own strengths, problems, and places for progress" (A1, A2, A3, A4). "It should give a thorough coverage of teachers' digital competencies in the key areas" (n=30)	<b>Convergence with Enhancement:</b> Qualitative data enhances the quantitative findings by specifying that self-assessment should be comprehensive and focus on strengths, challenges, and growth areas.
Collaboration Features	Teacher collaboration opportunities (M = 4.62, SD = 0.486)	"...there should be discussion forums or communities where peers can collaborate and share their experiences" (B2, B3, B4, A1, A6). "The tool should promote peer-to-peer learning and collaboration opportunities for teachers to learn from one another" (n=22)	<b>Convergence:</b> Both data sources highlight the importance of peer collaboration. Qualitative data specifies implementation through discussion forums and communities of practice.
Progress Tracking	Progress monitoring (M = 4.53, SD = 0.545)	"The tool should also be able to track progress towards set targets for targets over time" (A2, A5, A6). "Offer functionality for creating professional development goals pertaining to the use of ICT and monitoring personal development over time" (34).	<b>Convergence with Enhancement:</b> In both datasets, progress tracking is mentioned; from the qualitative data, it emerges as the most frequently mentioned theme in open-ended responses (34), thus possibly more valued than the ranking indicates.

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Personalized Feedback	Individualized feedback (M = 4.47, SD = 0.664)	"The tool should provide individualized recommendations or ideas based on the teacher's self-assessment" (B3). "Based on the teachers' self-assessment results, the tool should be able to issue individualized feedback and recommendations to teachers" (n=20)	<b>Partial Divergence:</b> While still rated positively in quantitative data, personalized feedback ranked relatively lower compared to other features. However, there is more significant qualitative evidence of this feature, and its importance may depend on the context in which it is used.
Learning Resources	Access to resources (M = 4.43, SD = 0.661)	"Access needs to be given to appropriate educational resources, lesson plans and best practices for ICT integration" (B1, A1, A2)	<b>Convergence:</b> Both data sources rate this feature as relatively lower priority, though still important.
Interactive Learning	Interactive exercises (M = 4.59, SD = 0.538)	"...provide scenario-based simulations for implementing ICT ideas in real-world educational settings" (A5), "...interactive exercises allow instructors to experiment with ICT integration tactics and obtain feedback on their approach" (A3)	<b>Convergence with Enhancement:</b> Qualitative data elaborates on the nature of interactive exercises as scenario-based and simulation-oriented, providing context for implementation.
Online Courses	Online courses (M = 4.62, SD = 0.487)	"...professional development programs or certification paths should be integrated in the tool" (A3)	<b>Convergence:</b> Both datasets indicate the importance of structured learning opportunities integrated within the tool.
Gamification Elements	Not directly measured in quantitative survey	"Use gamification to enhance and motivate the reflection process" (A6). "While gamification elements and incentives can be included to motivate the teachers to engage with the tool, some other features can also be incorporated" (n=10)	<b>Complementarity:</b> Qualitative data introduces gamification as an additional feature not captured in the quantitative instrument, though with relatively lower frequency (n=10), suggesting it may be considered supplementary rather than essential.
Administrative Features	Not mentioned in quantitative	"The reporting and analytics should be aggregated to school	<b>Complementarity:</b> Qualitative data identifies an organizational dimension not addressed in the quantitative

		organization leaders and/or administrators" (n=20)	survey, highlighting the tool's potential value beyond individual teacher development.
Continuous Improvement	Not mentioned in quantitative	"Continuous updates and means for user feedback are necessary in order for the project to progress consistently" (B1, B2, B3, B4, A2, A3, A5)	<b>Complementarity:</b> Qualitative data reveals an important meta-feature the tool's ability to evolve and improve based on user feedback not captured in the quantitative instrument.

### *Narrative Summary of Integrated Findings from Table 24*

The joint display analysis (Table 24) reveals a strong convergence between the quantitative survey results and qualitative interview insights, with some areas of complementarity and partial divergence that provide a richer understanding of participants' expectations for the ICT self-assessment and development tool.

#### **1. Convergence on Core Features**

Both data strands emphasized the importance of core functionalities such as a user-friendly interface, guided reflection, self-assessment capabilities, collaboration features, progress tracking, interactive exercises, and integration with online courses. Quantitative findings rated these features highly, with mean scores ranging from 4.47 to 4.69, while qualitative responses provided practical suggestions for their implementation. For instance, usability received the highest quantitative endorsement ( $M = 4.69$ ), and interview participants recommended complementary training sessions and instructional videos to support adoption. Similarly, reflective prompts were strongly endorsed in the survey ( $M = 4.67$ ), with teachers adding that journaling activities would help deepen engagement.

#### **2. Convergence with Enhancement**

Some features, while already highly rated in the survey, were further elaborated in the interviews. Self-assessment capabilities ( $M = 4.62$ ) were expanded by qualitative calls for a comprehensive approach that captures teachers' strengths, challenges, and areas for growth. Progress tracking ( $M = 4.53$ ), strongly supported in the survey, also emerged as the most frequently cited theme in open-ended responses, underscoring its importance for ongoing professional development. Likewise, interactive learning activities were described in interviews as scenario-based simulations, offering a more concrete vision of their practical application.

### **3. Partial Divergence**

A slight but significant divergence was evident in the case of personalized feedback. Although quantitatively valued ( $M = 4.47$ ), it ranked lower compared to other features. However, qualitative findings strongly emphasized individualized recommendations and feedback, suggesting that while teachers see it as vital in practice, its importance may not have been fully captured by the survey ranking. This indicates contextual dependency and potential underestimation in quantitative scoring.

### **4. Complementarity**

The qualitative dataset contributed additional perspectives not addressed in the quantitative instrument. These included the importance of gamification elements to motivate engagement, administrative features such as reporting and analytics for school leaders, and continuous improvement mechanisms like user feedback loops and regular updates. While these features were not measured quantitatively, they expand the overall understanding of the tool's potential scope—beyond individual teacher development to institutional and systemic utility.

Overall, the integrated findings provide a clear response to the study's research objectives, particularly regarding teachers' expectations for a digital self-assessment tool to support ICT

integration. By combining quantitative ratings with qualitative insights, the analysis demonstrates that usability, guided reflection, comprehensive self-assessment, collaboration, progress tracking, and personalization constitute the core foundation of the tool. At the same time, complementary suggestions such as incorporating gamification, administrative reporting, and mechanisms for continuous improvement extend its potential value beyond individual users to professional communities and institutions. Collectively, these results affirm that the tool should function not only as a reflective instrument for teachers' personal growth but also as a dynamic platform that promotes long-term professional development and systemic advancement in ICT integration practices.

#### **4.3.6: Design recommendation of the DSAT Prototype**

This section synthesizes findings for Research Question 4 which addresses Objective 4. Drawing on both empirical evidence and theoretical guidance, the section outlines key design recommendations from the findings. These include principles of interface design, personalization, integration into professional development structures, and institutional support for sustainability.

##### ***4.3.6.1 Quantitative Findings: Design Recommendations for the DSAT***

Table 29 presents the descriptive statistics. All items received high approval, with mean scores ranging from 4.41 to 4.67 and standard deviations between 0.477 and 0.664, showing strong consensus across respondents (n = 335).

**Table 29***Descriptive Statistics: Design Recommendations for the DSAT Adoption*

Items	N	Mean	Std. Deviation	Skewness		Kurtosis	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
RQ4 A1: The tool should have a clean and straightforward user interface	335	4.64	.571	-1.348	.133	.835	.266
RQ4 A2: The tool should incorporate multimedia elements.	335	4.67	.477	-.818	.133	-1.113	.266
RQ4 A3: The tool should have responsive design interface and adapts to various screen sizes and devices.	335	4.46	.664	-.850	.133	-.403	.266
RQ4 A4: The tool should include an offline mode.	335	4.62	.534	-.958	.133	-.179	.266
RQ4 A5: The tool should provide clear and concise instructions or tooltips to guide teachers.	335	4.41	.659	-.672	.133	-.592	.266
Valid N (listwise)	335						

***Narrative Summary of Table 29: Design Recommendations of the DSAT***

The descriptive statistics presented in Table 29 provide insights into teachers' perceptions of user-friendliness and accessibility features of the proposed tool. Across all five items, the responses demonstrate consistently high mean scores, with values ranging from 4.41 to 4.67 on a five-point Likert scale, suggesting that participants strongly endorsed the importance of these features. Specifically, the highest-rated item was the incorporation of multimedia elements ( $M = 4.67$ ,  $SD = 0.477$ ), indicating that participants placed particular emphasis on the inclusion of

diverse media resources within the tool. Similarly, the requirement for a clean and straightforward user interface also received a high mean rating ( $M = 4.64$ ,  $SD = 0.571$ ), reflecting strong agreement that ease of navigation is an essential usability factor.

Other features were also rated positively, with the provision of an offline mode ( $M = 4.62$ ,  $SD = 0.534$ ) emerging as a crucial accessibility requirement, particularly relevant in contexts where internet connectivity may be limited. The expectation for a responsive design that adapts to different devices and screen sizes was moderately high ( $M = 4.46$ ,  $SD = 0.664$ ), further reinforcing the importance of cross-platform usability. The lowest mean was observed for the provision of clear and concise instructions or tooltips ( $M = 4.41$ ,  $SD = 0.659$ ), though still well above the midpoint, showing that participants nonetheless recognized guidance as a valuable component of the tool's design.

The distributional properties of the data also suggest a strong clustering of responses toward agreement. Skewness values for all items were negative, ranging from  $-0.672$  to  $-1.348$ , indicating that many respondents leaned toward the higher end of the scale, with relatively fewer low ratings. Similarly, kurtosis values were generally close to zero, with slight variations in positive and negative directions, reflecting moderate peakedness and confirming that responses were tightly concentrated around the mean values. In whole, these results demonstrate that teachers overwhelmingly favored features that enhance usability and accessibility, with particular importance placed on multimedia integration, intuitive design, and offline availability.

#### ***4.3.6.2 Qualitative Findings – Design Recommendations for the DSAT***

Semi-structured interviews with selected participants (A1–A6 and B1–B4) provided insights into teachers' views and experiences with ICT in schools. Data were analyzed using the six-phase thematic analysis framework (Brown, 2018). Table 30 presents the emergent themes, sub-themes, and illustrative excerpts.

**Table 30***Thematic Analysis: Design Recommendations of the DSAT*

Theme	Sub-themes	Examples of Excerpts
Platform Preferences	Multiple platforms for accessibility and flexibility	Offering the tool on different platforms, the mobile and web, means increased accessibility and flexibility for educators' (A1). A2 also points out that the tool's provision across multiple platforms can meet the heterogeneous preferences and requirements of various educators."
	Contrasting views on single vs. multiple platforms	"Standardized interface and data security may be easier to guarantee on a single platform" (B3, B4).
	Tracking progress and setting goals	"It should include suggestions that urge people to think about their own strengths, problems, and places for progress" (A1, A2, A3, A4) "The tool should also be able to track progress towards set targets for targets over time" (A2, A5, A6). "The capacity to establish defined and quantifiable goals for ICT integration is also essential" (A4, A6)
	Integration with professional development programs	"...professional development programs or certification paths should be integrated in the tool" (A3).
	Peer collaboration and knowledge sharing	"...there should be discussion forums or communities where peers can collaborate and share their experiences" (B2, B3, B4, A1, A6)
	Customized recommendations and resources	"The tool should provide individualized recommendations or ideas based on the teacher's self-assessment" (B3). "Access needs to be given to appropriate educational resources, lesson plans and best practices for ICT integration" (B1, A1, A2)
	Gamification and motivation	"...interactive exercises allow instructors to experiment with ICT integration tactics and obtain feedback on their approach" (A3) "Use gamification to enhance and motivate the reflection process" (A6)
Resource Integration	Access to up-to-date resources and references	"...incorporating relevant references, connections, or resources into the tool may facilitate educators' professional development in the domain of ICT integration" (B1). The B3 says that "the application can include a collection of reviewed, updated resources to provide teachers with the best and latest information."

	Professional development opportunities	“Connections to other professional development resources focused on the integration of ICT are required” (A5).
Accessibility and Usability	User-friendly interface and clear instructions	"To improve the tool's accessibility and efficacy for educators, it should include a user-friendly interface and plain, concise instructions for its operation" (B1). “The instrument should be user-friendly and easy to understand” (B1, B2, B3, A3).
	Offline functionality	"Offline functionality should be provided" (B1). “Thus, it should include offline functionality to cover areas where internet connectivity is unstable.” (B2, B3, B4, A6) “Introducing gamification elements or rewards of usage of a gamified tool consistently may assist to sustain the engagement and motivation of a teacher over a longer time” (B2, B3).
	Gamification and incentives for engagement	"An example of possible strategies involves the implementation of incentives or acknowledgement initiatives for educators who actively use the tool" (B1, A3).
	Continuous updates and user feedback	The participants B1, B2, B3, B4, A2, A3, and A5 noted that continuous updates and means for user feedback are necessary for the project to progress consistently. "Training sessions should be incorporated into the instrument to promote awareness and foster adoption" (A4).
	Training and support	"Make available instructional videos that demonstrate the proper utilization of self-assessment tools" (A2). "Technical support should be provided to address all the difficulties that a teacher may encounter in using the tool" (A3).

### ***Narrative Summary of Table 30 - Interview Findings***

Educators emphasized the importance of accessibility by noting the value of providing the tool across multiple platforms to maximize flexibility and inclusiveness. As one participant explained, “*Offering the tool on different platforms, the mobile and web, means increased accessibility and flexibility for educators*” (A1). Another added, “*the tool's provision across multiple platforms can meet the heterogeneous preferences and requirements of various educators*” (A2). Yet, some participants voiced caution, highlighting that a single, standardized platform might better ensure consistency and data security: “*Standardized interface and data*

*security may be easier to guarantee on a single platform*” (B3, B4). This reflects a balance between broad accessibility and controlled uniformity.

Beyond platform availability, teachers highlighted the importance of goal setting and monitoring progress. For example, one noted, *“The tool should also be able to track progress towards set targets over time”* (A2, A5, A6), while others emphasized measurability: *“The capacity to establish defined and quantifiable goals for ICT integration is also essential”* (A4, A6). This reinforced the perception that accountability and reflective practice would be strengthened by structured tracking mechanisms.

Integration with professional development opportunities was also stressed. One participant suggested, *“...professional development programs or certification paths should be integrated in the tool”* (A3), illustrating how educators expected the tool not only to support reflection but also to contribute to formal growth pathways. In addition, collaboration and peer learning emerged as recurring priorities. As one excerpt indicates, *“...there should be discussion forums or communities where peers can collaborate and share their experiences”* (B2, B3, B4, A1, A6), reinforcing the role of collegial exchange in strengthening ICT integration.

Personalization was also deemed crucial, with calls for customized recommendations and resources. For instance, a participant explained, *“The tool should provide individualized recommendations or ideas based on the teacher's self-assessment”* (B3). Similarly, the provision of relevant resources was highlighted: *“Access needs to be given to appropriate educational resources, lesson plans and best practices for ICT integration”* (B1, A1, A2). This points to a demand for adaptability that goes beyond generic support, offering tailored strategies.

Several educators proposed that gamification would sustain engagement, noting statements such as, *“Use gamification to enhance and motivate the reflection process”* (A6) and *“Introducing*

*gamification elements or rewards ... may assist to sustain the engagement and motivation of a teacher over a longer time*” (B2, B3). These perspectives indicate that playful, motivational design could facilitate long-term adoption.

The integration of relevant, updated references was also discussed, as participants underscored the need for current resources: “...*incorporating relevant references, connections, or resources into the tool may facilitate educators' professional development in the domain of ICT integration*” (B1). This was reinforced by another comment: “*The application can include a collection of reviewed, updated resources to provide teachers with the best and latest information*” (B3).

Finally, issues of accessibility and usability dominated the discussion. Teachers strongly emphasized that the tool should be intuitive, with a participant remarking, “*To improve the tool's accessibility and efficacy for educators, it should include a user-friendly interface and plain, concise instructions for its operation*” (B1). This was echoed by others who stated, “The instrument should be user-friendly and easy to understand” (B1, B2, B3, A3). Connectivity challenges also prompted calls for offline functionality: “Offline functionality should be provided” (B1) and “it should include offline functionality to cover areas where internet connectivity is unstable” (B2, B3, B4, A6). Sustainability through continuous improvement was also stressed, with excerpts noting, “*Continuous updates and means for user feedback are necessary in order for the project to progress consistently*” (B1, B2, B3, B4, A2, A3, A5). Others added that training and technical support would be indispensable: “*Training sessions should be incorporated ... to promote awareness and foster adoption*” (A4) and “*Technical support should be provided to address all the difficulties that a teacher may encounter in using the tool*” (A3).

### 4.3.6.3 Integrated Findings – Design Recommendations for the DSAT

Table 31 presents a joint display matrix combining quantitative and qualitative findings related to user recommendations on the tool’s design, perceived user-friendliness and accessibility issues of the tool. This integrated analysis highlights both areas of convergence (where survey results and interview feedback align) and complementarity (where qualitative data adds new dimensions not captured in the quantitative items). Together, the findings provide a more comprehensive understanding of educators’ needs, covering usability, guidance, adaptability, and broader professional development features.

**Table 31**

*Joint Display Matrix: – Design Recommendations of the DSAT for Adoption*

<b>Key Aspects</b>	<b>Quantitative Findings</b>	<b>Qualitative Findings</b>	<b>Integration Insight</b>
<b>User Interface</b>	RQ4 A1: The tool needs to have a user interface that is clear and easy to navigate (Mean=4.64, SD=0.571)	"To improve the tool's accessibility and efficacy for educators, it should include a user-friendly interface and plain, concise instructions for its operation" (B1). "The instrument should be user-friendly and easy to understand" (B1, B2, B3, A3).	<b>Convergence:</b> User Interface: Both quantitative and qualitative findings reveal a high significance for easy understanding of the interface as a major design consideration.
<b>Guidance and Instructions</b>	RQ4 A5: The tool needs to offer teachers clear and concise guidance through instructions or tooltips (Mean=4.41, SD=0.659)	"To improve the tool's accessibility and efficacy for educators, it should include a user-friendly interface and plain, concise instructions for its operation" (B1). "Make available instructional videos that demonstrate the proper utilization of self-assessment tools" (A2). "Technical support should be provided to	<b>Enhancement:</b> Whereas quantitative evidence shows the significance of guidance, qualitative evidence on the same suggests possible ways in which this could be provided (through instructional videos or technical support), with added implementation best practices.

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		address all the difficulties that a teacher may encounter in using the tool (A3)" (A3).	
<b>Multimedia Features</b>	RQ4 A2: It is necessary for the tool to include multimedia features (Mean=4.67, SD=0.477)	Limited direct discussion of multimedia features in qualitative data, though implied in reference to instructional videos and interactive exercises	<b>Complementarity:</b> Quantitative data highlights the importance of multimedia features, while qualitative data suggests specific applications (instructional videos, interactive exercises) without explicitly naming them as multimedia.
<b>Responsive Design</b>	RQ4 A3: The tool needs to have a responsive design interface that adjusts to different screen sizes and devices (Mean=4.46, SD=0.664)	"Offering the tool on different platforms, the mobile and web, means increased accessibility and flexibility for educators" (A1). "A2 also points out that the tool's provision across multiple platforms can meet the heterogeneous preferences and requirements of various educators."	<b>Enhancement:</b> Qualitative data complements quantitative finding by making it explicit that multiple interfaces (mobile and web) are important.
<b>Offline Functionality</b>	RQ4A4: It is necessary for the tool to have a mode that can be used without an internet connection (Mean=4.62, SD=0.534)	"Offline functionality should be provided" (B1). "Thus, it should include offline functionality to cover areas where internet connectivity is unstable." (B2, B3, B4, A6)	<b>Convergence:</b> When it comes to offline functionality there is high level of consensus between the quantitative and qualitative surveys for areas with weak connections.
<b>Platform Integration</b>	Not directly addressed in quantitative items	"Standardized interface and data security may be easier to guarantee on a single platform" (B3, B4). Some disparities concerning single and multiple platforms are	<b>Complementarity:</b> Qualitative data adds a factor that is not considered in the quantitative survey: the comparison of single and multiple platforms use as

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<b>Progress Tracking</b>	Not directly addressed in quantitative items	<p>captured in the qualitative findings.</p> <p>"The tool should also be able to track progress towards set targets for targets over time" (A2, A5, A6). "The capacity to establish defined and quantifiable goals for ICT integration is also essential" (A4, A6)</p>	<p>well as the security implications.</p> <p><b>Complementarity:</b> Qualitative data introduces functionality requirements not captured in the quantitative survey items - specifically the need for progress tracking and goal-setting features.</p>
<b>Professional Development Integration</b>	Not directly addressed in quantitative items	<p>".....professional development programs or certification paths should be integrated in the tool" (A3). "Connections to other professional development resources focused on the integration of ICT are required" (A5).</p>	<p><b>Complementarity:</b> This qualitative data discloses an important feature, a professional development resource, which is not addressed by a quantitative survey.</p>
<b>Peer Collaboration</b>	Not directly addressed in quantitative items	<p>".....there should be discussion forums or communities where peers can collaborate and share their experiences" (B2, B3, B4, A1, A6)</p>	<p><b>Complementarity:</b> Qualitative data introduces social and collaborative aspects not explored in the quantitative items.</p>
<b>Resource Access</b>	Not directly addressed in quantitative items	<p>".... incorporating relevant references, connections, or resources into the tool may facilitate educators' professional development in the domain of ICT integration" (B1). "The B3 says that "the application can include a collection of reviewed, updated resources to provide teachers with the best and latest information." "Access needs to be given to appropriate educational resources, lesson plans and</p>	<p><b>Complementarity:</b> Qualitative data highlights resource integration features not captured in the quantitative survey.</p>

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<b>Personalization</b>	Not directly addressed in quantitative items	<p>best practices for ICT integration" (B1, A1, A2)</p> <p>"The tool should provide individualized recommendations or ideas based on the teacher's self-assessment" (B3). "It should include suggestions that urge people to think about their own strengths, problems, and places for progress" (A1, A2, A3, A4)</p>	<p><b>Complementarity:</b> Qualitative data introduces personalization as an important feature not addressed in the quantitative items.</p>
<b>Engagement Strategies</b>	Not directly addressed in quantitative items	<p>"Use gamification to enhance and motivate the reflection process" (A6). "Introducing gamification elements or rewards of usage of a gamified tool consistently may assist to sustain the engagement and motivation of a teacher over a longer time" (B2, B3). "An example of possible strategies involves the implementation of incentives or acknowledgement initiatives for educators who actively use the tool" (B1, A3).</p>	<p><b>Complementarity:</b> Whereas engagement strategies such as gamification and incentives are expressed and uncovered by the qualitative data, the quantitative data does not detail this aspect.</p>
<b>Continuous Improvement</b>	Not directly addressed in quantitative items	<p>"The participants B1, B2, B3, B4, A2, A3, and A5 noted that continuous updates and means for user feedback are necessary in order for the project to progress consistently."</p>	<p><b>Complementarity:</b> Qualitative data introduces the concept of ongoing tool improvement and feedback mechanisms not captured in the quantitative items.</p>

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*Narrative summary of Findings on Integrated Insights from Table 31*

The integrated analysis on the *Design Recommendations of the DSAT for Adoption* revealed strong convergence between survey results and interview data on core usability features, particularly regarding interface clarity, guidance, and accessibility. Quantitative findings demonstrated consistently high agreement on the importance of a clear and intuitive interface (M=4.64, SD=0.571), responsive design (M=4.46, SD=0.664), multimedia features (M=4.67, SD=0.477), and offline functionality (M=4.62, SD=0.534). These priorities were reinforced by qualitative accounts such as, “*The instrument should be user-friendly and easy to understand*” (B1, B2, B3, A3) and “*Offline functionality should be provided to cover areas where internet connectivity is unstable*” (B2, B3, B4, A6). This convergence underscores that educators regard usability not simply as a matter of convenience but as a prerequisite for equitable access and sustained adoption.

Beyond this alignment, the qualitative evidence also broadened the scope of usability considerations, offering insights into how these features should be operationalized. Participants emphasized the value of practical guidance mechanisms such as instructional videos (A2), technical support (A3), and interactive exercises (A3), which extend beyond the survey’s broad emphasis on guidance and tooltips (M=4.41, SD=0.659). Moreover, educators stressed the importance of platform integration and flexibility, with some favoring multiple platforms for accessibility (A1, A2) while others cautioned that a single platform may better safeguard data security (B3, B4).

Crucially, several themes emerged exclusively from the qualitative strand, enriching the quantitative profile by pointing to broader pedagogical and professional dimensions. These included the *integration of professional development programs* (A3), *mechanisms for peer collaboration* (B2, B3, A1, A6), *access to curated educational resources* (B1, A1, A2),

personalization through tailored recommendations (B3), and *motivational strategies such as gamification* (A6). Participants also highlighted the necessity of *continuous updates and user feedback* (B1, B2, B3, B4, A2, A3, A5), signaling that tool effectiveness depends not only on initial usability but on long-term responsiveness to evolving educator needs. Taken together, these insights position usability as both a technical and pedagogical construct, encompassing interface design, accessibility, and integration with broader ecosystems of professional learning and collaboration.

#### **4.4 Evaluation of Findings**

This section evaluates the study's findings in relation to the guiding research objectives/questions, and the conceptual frameworks underpinning the study. While Section 4.3 presented the statistical, narrative, and integrated results, this section interprets these findings considering grounded theories and prior empirical works. This structure facilitates a systematic interpretation of how quantitative and qualitative strands converge, diverge, or complement each other. Following Creswell and Clark (2017), the emphasis lies in drawing inferences from mixed methods results while avoiding conclusions that exceed the strength of the evidence. Three overarching patterns emerged. First, both surveys and interviews showed that teachers valued ICT integration in principle but faced structural and pedagogical barriers that constrained actual classroom practice. This reflects earlier studies in sub-Saharan Africa (Tondeur et al., 2018; Buabeng-Andoh, 2019), which highlight the persistent gap between positive ICT attitudes and systemic limitations. Second, user-friendliness, accessibility, and contextual adaptability emerged as critical design priorities for the adoption of the DSAT. This aligns with HCI knowledge emphasizing teacher-centered approaches as prerequisites for adoption (Luckin & Cukurova, 2019). Third, the integration of datasets revealed that while there was broad consensus on

requirements such as offline functionality and clear guidance, the qualitative strand added further depth, highlighting needs in professional development, personalization, and teacher engagement strategies that were not fully captured in the survey items.

At the same time, divergences emerged that merit reflection. For example, while some teachers supported a standardized DSAT platform to ensure uniformity and security, others advocated for multiple access points to enhance reach and flexibility. This tension illustrates that ICT integration cannot be reduced to a one-size-fits-all solution but instead requires balancing competing priorities: simplicity versus adaptability, centralization versus decentralization, and efficiency versus inclusivity. In general, the analysis confirms the applicability of the selected frameworks while extending them by demonstrating how contextual mediators such as infrastructural shortages, cultural attitudes, and inadequate professional development can shape adoption processes in Ghanaian primary schools. The following subsections evaluate the findings based on the study's objectives in turn.

#### **4.4.1 Current State of ICT Integration Practices in Ghana's Primary Schools**

The findings of this study revealed a striking inconsistency in the current state of ICT integration in Ghana's primary schools. On one hand, teachers expressed overwhelmingly express positive awareness of the usefulness of ICT in teaching and learning, as reflected in a high mean score ( $M = 4.45$ ,  $SD = 0.63$ ) (Table 16). On the other hand, their reported use of ICT tools was very low ( $M = 1.28$ ,  $SD = 0.50$ ) (Table 14). This gap between attitudes and practice echoes what is described in the TAM, which emphasizes perceived usefulness and ease of use as key drivers of adoption (Venkatesh et al., 2022). However, this study results indicate that in the contexts where structural and systemic barriers are severe, positive attitudes alone are insufficient to guarantee adoption. This was indicative, as one participant explained (Table 19); "*most teachers largely*

*relied on classic methods*” (A1), despite recognizing the importance of technology. Such insights highlight that integration cannot be understood purely through the lens of individual attitudes but must also be examined within the broader material, institutional, and policy environment.

Resource constraints emerged as the most consistent barriers in both the quantitative ratings and in qualitative statements. The barrier of inadequate resources and insufficient financial support was rated extremely high ( $M = 4.64$ ,  $SD = 0.59$ ) (Table 12), suggesting that teachers felt fundamentally under-equipped to implement ICT. Participants described in the interview response that; *“currently there are not enough computers that are suitable to be used in the computer lab, some of them are old... and there is poor internet connectivity”* (B1), these concerns are not unique to this study. Prior research by Quaicoe and Pata (2020) similarly found that weak infrastructure constituted the most significant barrier to ICT adoption in classrooms. The present findings thus reinforce the observation that infrastructure investment is a necessary condition for any meaningful ICT integration.

Beyond resources, teacher knowledge and professional development were also found to be limited to support effective integration. The study recorded a low mean score for teacher confidence in the TPACK domains ( $M = 1.21$ ,  $SD = 0.45$ ) (Table 14), which suggests that technological knowledge (TK), technological pedagogical knowledge (TPK), and related intersections are not adequately developed among primary school teachers. This was supported by comments such as *“teachers may lack the specific skills needed to effectively integrate ICTs”* (A3) and *“many teachers lack training in technology skills in pedagogical strategies”* (B1), (Table 19). According to Mishra and Koehler’s TPACK framework, meaningful technology integration requires a balanced and dynamic interplay between content, pedagogy, and technology (Hebert,

2024). Yet this study's findings suggest that these domains are fragmented, leaving teachers without the confidence to implement ICT in ways that could truly enhance teaching and learning.

The absence of structured professional development opportunities recorded very low mean scores ( $M = 1.27$ ,  $SD = 0.47$ ), this indicates that teachers have limited opportunities to build or update their technological competencies. Interview responses confirmed this pattern, with one noting that “*no ICT integration professional development program has been designed*” (A1). This finding aligns with Goka et al. (2023), who observed that professional development opportunities in Ghana are often ad hoc and fragmented, lacking the subject-specific focus required to enhance practice. Given that Ghana's Education Strategic Plan (2018–2030) identifies continuous professional development as a national priority, the present results point to a significant gap between policy commitments and classroom realities.

Equally striking is the misalignment between Ghana's ICT in Education Policy and actual classroom practices. While the policy frameworks encourage learner-centered technology-enhanced learning, classrooms remain dominated by traditional teacher-centered methods. This disjunction reflected in the high rating for curriculum–technology misalignment ( $M = 4.14$ ,  $SD = 0.98$ ). An interview response cited, “*performance evaluations favor the spread of instructional content... rather than technological use*” (B4), suggesting that the systemic assessment frameworks privilege rote learning and coverage over innovation and digital integration. Abedi (2024) similarly reported that Ghana's evaluation systems reinforce traditional pedagogies and thereby create disincentives for teachers to adopt ICT.

In addition, teacher perceptions revealed underlying skepticism and resistance to change. While many acknowledged ICT's potential, some feared it might “*distract students*” (A6), and 25 respondents to the open-ended questions (Table 20), reported *general reluctance to alter*

*entrenched practices*. Such attitudes echo the findings of Ayebi-Arthur and Owusu (2015), who noted that although pre-service teachers in Ghana valued ICT, their classroom practices were inconsistent and shaped by cautious or resistant dispositions.

Another critical gap identified concerns the absence of monitoring and supervisory structures for ICT integration. The mean score for assessment/evaluation was only 1.23 (SD = 0.44), reflecting the lack of mechanisms in schools and education authorities to systematically track or evaluate the extent and quality of ICT use in classrooms. Qualitative findings corroborated this weakness, with one remarking; “*there are no supervisory structures for ICT implementation*” (B1). The absence of supervisory structures not only prevents schools from tracking progress but also leaves critical gaps in ICT integration unaddressed, reinforcing what Asare et al. (2023) highlighted on that, without robust evaluation and accountability mechanisms, ICT policies are unlikely to achieve long-term impact.

Overall, the findings present a complex picture of ICT integration in Ghana’s primary schools. On one level, teachers express strong appreciation for the value of ICT and broadly align with policy rhetoric that emphasizes its importance. On another, structural barriers, including limited resources, insufficient professional development, and weak monitoring systems significantly constrain their capacity to translate positive attitudes into practice. The outcome is a system where aspirations remain high but implementation lags.

#### **4.4.2 Factors that could influence Teachers’ attitudes towards adopting the DSAT**

The evaluation of findings related to the second research objective reveals range of factors combined to shape teachers’ attitudes towards the adoption of the digital self-assessment tool. The analysis underscores the complex interplay of infrastructural, pedagogical, organizational, and personal considerations, each of which directly influences whether teachers view such tool as

beneficial and feasible for use in their classrooms. This resonates strongly with the Technology Acceptance Model (TAM), which posits that technology adoption is driven by perceived usefulness and ease of use, but also mediated by external conditions and facilitating supports (Venkatesh et al., 2022). The evidence from this study shows that without supportive conditions, even favourable perceptions may not translate into actual adoption.

A primary influence identified on attitudes was the availability of technological infrastructure. Both quantitative and qualitative findings converged on the point that inadequate access to computers, weak internet connectivity, and limited financial investment remain significant obstacles. This is consistent with prior studies indicating that poor infrastructure is among the greatest barriers to educational technology adoption in low-resource environments (Burns, 2023; Chuaungo et al., 2022). In this study, participants emphasized that while they may value the tool, its use could be heavily constrained by unreliable resources. Thus, infrastructural readiness becomes a precondition that could shape whether the tool is perceived as practical. This finding reinforces TAM's emphasis on external variables and supports earlier Ghanaian studies that highlight infrastructure gaps as decisive in ICT adoption (Quaicoe & Pata, 2020).

Alongside infrastructure, teachers highlighted the importance of training and technical support. The findings revealed that perceived ease of use one of TAM's central constructs was strongly influenced by whether teachers had access to capacity-building opportunities. Many respondents indicated that without sustained training, the DSAT could be perceived as difficult to navigate or incompatible with their existing practices. This confirms Howard et al. (2021) and Falloon (2020), who emphasize that educators' digital skills and pedagogical orientations directly affect readiness to integrate new technologies. Contemporary TPACK scholars highlight that meaningful technology integration is achieved through the dynamic interplay of technological,

pedagogical, and content knowledge, rather than through tool knowledge in isolation (Petko et al., 2024). More recent updates to the framework also emphasize the importance of contextual factors, situating TPACK within the broader realities of teachers' practice and institutional environments (Petko et al., 2025). Teachers' limited exposure to structured training suggests that they may lack the technological-pedagogical knowledge needed to adapt the DSAT effectively to their teaching contexts.

Another important factor emerging from the study is the design of the tool itself. Teachers valued the tool's capacity to foster active engagement, set learning objectives, and support self-reflection, all of which are consistent with constructivist learning principles. This finding supports Ruijuan et al. (2023), who argue that collaborative and goal-oriented environments enhance attention, motivation, and learning outcomes. Furthermore, the emphasis on customization and personalized feedback resonates with Rogers' Diffusion of Innovation (DOI) theory, particularly the attributes of compatibility and complexity (Alamri et al., 2021). Teachers are more likely to adopt technologies that align with their teaching values and that can be adjusted to meet diverse classroom needs.

Workload conflict was raised in interviews as a significant issue, despite not being captured in the quantitative data. Participants emphasized that teachers are already burdened with responsibilities beyond instruction, and that the additional time demands for adopting a digital self-assessment tool may act as a deterrent. This finding is consistent with Creagh et al. (2025) and Stacey et al. (2022), who show that time constraints and workload stress are recurring obstacles in teachers' willingness to engage with new technologies. Similarly, issues of data privacy and security, also absent from the questionnaires but present in the interviews, highlight the extent to which teachers' trust in data management systems could affect adoption decisions. Torres-

Hernández and Gallego-Arrufat (2023) confirm that concerns over privacy can significantly reduce teachers' willingness to engage with digital tools, especially when sensitive data is involved.

Institutional and organizational support also emerged as a decisive factor. Teachers consistently pointed to the role of school leadership, motivation, and recognition in shaping their willingness to adopt new tools. This observation strongly aligned with the DOI theory, which emphasizes the organizational environment as a major determinant of innovation adoption (García-Avilés, 2020). In the current study, participants suggested that formal institutional backing through policies, recognition, or rewards would make them more inclined to adopt the DSAT. This finding is further reinforced by Abdekhoda and Dehnad (2023), who identified organizational infrastructure and support as strong predictors of technology acceptance among teachers.

Theoretically, these results strongly confirm the centrality of perceived usefulness and perceived ease of use. Furthermore, the findings successfully extend the theoretical discussion by integrating contextual insights from the TPACK framework, the DOI theory, and constructivist perspectives. Practically, the findings underscore the importance of implementing holistic and integrated strategies: without concurrent improvements in infrastructure, relevant training, sustained institutional support, and meticulous tool design, widespread and sustainable adoption is unlikely. Conversely, systematic attention to these identified factors could significantly enhance teachers' willingness to embrace digital self-assessment, thereby fostering a culture of reflective practice and contributing directly to improved teaching quality within Ghana's primary schools.

#### **4.4.3 Teacher-informed requirements for the Design of the DSAT**

The findings regarding the desired features of the digital self-assessment tool reveal a strong alignment with contemporary literature on technology integration for teacher professional development. A recurring emphasis was placed on usability and user experience, consistent with

the TAM. Participants underscored the importance of a clear, intuitive interface, noting that an overly complex design would present barriers to consistent use. Such emphasis echoes the broader discourse in technology adoption research, which cautions that even well-designed pedagogical tools risk underutilization if they are not user-friendly (Mlekus et al., 2020).

Equally prominent in the findings was the expressed demand for guided reflection and self-assessment functionalities, which directly align with the core principles of the TPACK framework. Contemporary studies demonstrate that embedding reflective scaffolds within professional development programs significantly strengthens teachers' capacity to integrate technology effectively across pedagogy and subject matter. For example, Rahayu et al. (2024) found that reflective, collaborative, and practice-oriented training designs demonstrably enhanced elementary school teachers' TPACK competencies. The participants' strong preference for reflective prompts and comprehensive self-evaluation features within the proposed tool directly corroborates the argument that sustained reflection is indispensable for building digital literacy and pedagogical adaptability (Prestridge & de Aldama, 2016). Ultimately, embedding such features moves the tool beyond mere assessment, establishing a mechanism for ongoing professional and pedagogical growth.

Beyond individual reflection, the study identified collaborative functionalities as vital design requirements. Teachers consistently expressed interest in features such as discussion forums and peer-feedback channels, which strongly resonate with social constructivist learning theories. Research has demonstrated that established communities of practice effectively foster shared knowledge construction and lead to positive professional outcomes (Trust & Horrocks, 2017).

The findings also indicate a clear alignment with Self-Regulated Learning (SRL) frameworks, specifically through the pronounced desire for progress tracking and monitoring

features. SRL scholars emphasize that effective learning is facilitated when individuals can systematically set goals, monitor their progress, and adapt strategies in response to feedback (Rodriguez-Gomez et al., 2024). Features enabling teachers to track their longitudinal development, reflect on their strategic utilization of ICT, and identify precise areas for growth, thus positioning the tool not merely as an assessment mechanism but as a structured professional development pathway (Faza & Lestari, 2025).

Additional functionalities, such as administrative reporting and continuous improvement capabilities, were not captured in the quantitative instrument but emerged strongly in the qualitative analysis. These features if considered could extend the tool's utility beyond individual self-assessment, creating opportunities for schools and educational systems to use aggregated data to inform professional development planning. This finding resonates with ecological systems perspectives on educational change, which argue that transformation requires interventions at multiple levels of the system individual, organizational, and policy (Zhao & Zhong, 2025). By integrating administrative dashboards and reporting mechanisms, the tool could serve not only teachers but also institutions, thereby linking micro-level practices with macro-level decision-making.

Collectively, these findings affirm that the effectiveness of the digital self-assessment tool hinges on a multidimensional design: one that is demonstrably easy to use (TAM), promotes rigorous reflective practice (TPACK), effectively supports collaboration (Social Constructivism), enables systematic progress tracking (SRL), and explicitly connects individual growth to broader institutional systems (Ecological Systems Theory). Notably, studies underscore that effective EdTech in low-resource contexts must adopt this holistic approach, accounting for implementation context, equity, and alignment with system needs (Nicolai, 2023). At the same time, subtle

discrepancies such as the moderate quantitative rating versus the deeper qualitative appreciation for progress tracking, and the ambivalence around collaboration, underscore the critical need for iterative testing and contextual adaptation of the tool in real-world settings to ensure it meets the diverse and evolving needs of educators (Alwashmi, 2019; Peters et al., 2024).

#### **4.4.4 Design recommendations of the Prototype DSAT**

The preceding section established that adoption of digital self-assessment tools is not merely a matter of individual teacher willingness, but a systemic process shaped by institutional support, professional development opportunities, and infrastructural readiness. Building on this foundation, the objective four shifts to a more practical and design-oriented focus: how the tool itself should be conceptualized and constructed to encourage uptake among primary school teachers. This represents a transition from examining why adoption may occur to interrogating how it can be most effectively facilitated. The evaluation of findings based on the objective/research question four, emphasizes user-centered design principles, including interface simplicity, offline functionality, personalization, and engagement strategies. Together, these findings highlight a multidimensional set of requirements that extend beyond conventional usability checklists and move into the deeper domain of teacher-centered design philosophy. These design recommendations from the findings are elaborated as follows:

##### **a. Teacher-Centered Design**

A central pattern emerging from both the quantitative and qualitative strands of data is that teachers overwhelmingly value design decisions that are responsive to their professional realities. This resonates with contemporary studies on human-computer interaction (HCI) and educational technology, which stresses that technologies cannot be separated from the context of their use (Tondeur et al., 2021). For primary school teachers, whose workload is typically fragmented across

lesson planning, classroom management, and administrative tasks, an overly complex or unintuitive digital tool risks becoming an additional burden rather than a supportive resource. In this respect, the respondents underscored that design features must not only be functional but also directly supportive of teaching practice.

### **b. User Interfaces**

Quantitative data strongly highlights the importance of simple, intuitive interfaces, while qualitative reflections added depth by linking interface design with time constraints and cognitive load. Contemporary extensions of TAM have confirmed that when educational technologies are perceived as overly complex, teachers often abandon them despite recognizing their pedagogical potential (Kelly et al., 2023; Mlekus et al., 2020). The findings here are therefore consistent with global patterns: teachers prefer tools that minimize unnecessary steps, reduce redundancy, and present information in clean, accessible formats. Vlasenko et al. (2023) reinforce this, by emphasizing that interface simplicity is particularly critical for time-pressured teachers who must manage simultaneous demands in their daily practice.

### **c. Offline Functionality and Digital Equity**

A second recurrent theme is the need for offline functionality. Despite broad improvements in connectivity worldwide, unreliable or unstable internet access remains a barrier in many primary schools. Respondents in this study voiced concerns about the feasibility of relying solely on online systems, particularly when connectivity disruptions could undermine lesson continuity or access to assessment data. These concerns echo Akmad and Abatayo's (2024) findings, which documented persistent infrastructural inequalities that hinder EdTech adoption, even in regions with overall high levels of connectivity. The emphasis on offline features thus speaks not only to

convenience but also to issues of digital equity, ensuring that teachers in less-resourced contexts are not disadvantaged in their professional development.

#### **d. Beyond Basic Functionality: Instructional Support**

While intuitive interface design and offline accessibility establish baseline usability, the integrated findings underscore educators' desire for more sophisticated internal support features such as embedded guidance, instructional videos, and learning aids to ease navigation and reduce reliance on external training. These design principles reflect a broader shift toward systems that provide just-in-time instructional support offering contextual cues and assistance as users gain familiarity and competence thus enhancing usability and supporting sustained adoption (Kaldaras et al., 2024).

#### **e. Fit-for-Purpose and Contextual Relevance**

The findings also highlight that digital self-assessment tools must be designed with responsiveness to teachers' working contexts. Børte and Lillejord (2024) highlight that digital learning design tools are most effectively integrated when they cohere with existing pedagogical and technological ecosystems in schools. In the present study, teachers articulated a preference for designs that allowed flexibility, such as customizable dashboards, adaptable assessment criteria, and settings that reflect the rhythms of the school calendar. This aligns with research on contextual adaptation, which demonstrates that technologies that are too rigidly standardized often face resistance at the implementation stage (Petko et al., 2024).

#### **f. Emergent Findings from Qualitative Data**

Perhaps most enlightening are the additional design considerations revealed only in the qualitative strand, underscoring the value of a mixed-methods approach. Eight factors not covered

by the quantitative survey emerged, pointing to novel requirements beyond standard usability. These included:

- a. **Progress Tracking and Personalization:** Educators wanted the tool to facilitate not just assessment but also longitudinal tracking of growth, with adaptive features that tailor recommendations based on individual needs. This corresponds with Zhang et al. (2022), who stresses the pedagogical value of adaptive learning systems.
- b. **Peer Collaboration Features:** A recurrent theme was the inclusion of options for collaborative use, such as peer benchmarking or community discussion spaces. This reflects the growing recognition that teacher professional learning communities are critical for sustaining technology adoption (Thomas, 2019).
- c. **Gamification Elements:** The introduction of motivational features, such as progress badges or recognition milestones, was identified to maintain teacher engagement. Pozzi et al. (2016) provide evidence that gamification can enhance motivation and persistence in professional learning, even among adult users.
- d. **Aesthetic and Emotional Appeal:** Recent User Experience (UX) studies substantiate that aesthetics in interface design play a critical role in shaping emotional engagement and shaping users' intentions toward both initial adoption and sustained use. For example, Peng et al. (2021) demonstrated through eye-tracking experiments that positively designed emotional interfaces enhance learners' emotional states, cognitive focus, and overall usability perceptions. Similarly, Ruf et al. (2022), found that aesthetic appeal in educational interfaces fosters user interest, enthusiasm, and sustains interaction revealing that aesthetics not only affect how users feel but also how persistently they engage.

### **g. Platform Approaches and Adaptive Interfaces**

A more contested design issue concerned the platform approach. While some respondents advocated for a single, unified platform to ensure consistency, others preferred multi-platform adaptability to accommodate diverse contexts. Garrett (2022) provides UX guidelines emphasizing consistency across platforms; however, the qualitative evidence from this study suggests that strict adherence to such principles may not always align with teachers' practical needs. Recent advances in adaptive user interface (UI) research highlight the importance of context-awareness in enhancing usability and personalization. For example, Williams et al. (2025) demonstrated that adaptive accessibility interfaces incorporating situational variables such as user location and preferences significantly improved satisfaction and efficiency. Similarly, Carrera-Rivera et al. (2024) proposed a framework for context-aware adaptive interfaces that integrate user interactions with ontological modeling to tailor recommendations across varied contexts. Collectively, these studies reinforce the argument that UI design should balance consistency with flexibility, creating environments where diverse user profiles and teaching settings are dynamically accommodated without undermining clarity or control.

### **h. Design Theory and Practice**

The findings collectively advance the understanding of teacher-centered design. They demonstrate that successful adoption is not merely about producing a technically functional tool but about embedding features that align with teachers' pedagogical practices, professional growth needs, and motivational drivers (Luckin & Cukurova, 2019; Kaliisa et al., 2022). The results move beyond generic usability principles toward a more contextually grounded framework, one that situates digital self-assessment tools within the lived realities of primary school teaching. Importantly, the identification of features not anticipated in the quantitative phase underscores the

methodological value of triangulation: without a mixed-methods approach, such innovative requirements would likely have remained obscured (Creswell & Clark, 2017).

In summary, the findings reveals that the design of a digital self-assessment tool for primary school teachers must extend beyond basic technical efficiency. The findings resonate with established theoretical frameworks such as the Technology Acceptance Model (TAM) and adaptive learning systems, while also extending them through the principle of fit-for-purpose design, that is, ensuring educational technologies are developed in direct response to pedagogical goals, contextual realities, and professional growth needs of teachers (Luckin & Cukurova, 2019; Nicolai et al., 2023).

#### **4.5 Empirically Based Design Implications**

Both quantitative and qualitative outcomes were discussed and summarized in the preceding sections of this chapter; the aim of this sub-section is, thus, to explicitly outline how the presented empirical results guide the design considerations and requirements of the proposed Digital Self-Assessment Tool (DSAT) prototype. It is essential to make this connection because the DSAT is supposed to directly respond to the contextual realities, constraints, and demands defined by the educators. As a result, the design suggestions presented in this paper are based on the evidence results of the research conducted, thus making sure that the tool is not perceived as a generalized self-evaluation tool but a context-specific tool that is correlated with the lived experiences of the educators and the conditions in the institutions.

##### **4.5.1 Implications on Tool Purpose and Scope**

Quantitative results showed very low scores on the ICT integration in classroom practice ( $M = 2.11$ ), although the teachers have strong positive views on the importance and possibilities of ICT in teaching and learning ( $M = 4.45-4.58$ ). This gap was supported by qualitative data where

teachers and education authorities were repeatedly reporting a dependence on conventional didactical approaches and the insignificant use of digital resources. This overlap between statistical patterns and narrative descriptions suggests that the DSAT cannot be used as an evaluator or benchmarking tool only. Rather, the findings suggest that the tool should assume a more developmental and reflective stance and assist teachers who are largely at early or emerging phases of ICT integration. The DSAT, therefore, is supposed to be designed in such a way that it:

- i. Support reflective awareness of existing ICT practices,
- ii. Focus more on formative self-evaluation, instead of summative evaluation, and
- iii. Promote slow, gradual development, as opposed to presumed high-level ICT expertise.

#### **4.5.2 Usability and Accessibility Implications**

The results of the survey show that the confidence and ICT experience of teachers are significantly low, with an average score of about 1.21. The participants indicated limited ability to incorporate ICT tools, troubleshoot technical problems or develop technology-enhanced learning activities. Qualitative data further expounded these results, highlighting the dominant fears, anxiety, and apprehension to interact with technology that can be explained by the lack of skills and previous exposure. These results have direct implications for the usability and accessibility of the DSAT. On this basis, therefore, the instrument ought to be such that it neutralizes technical and cognitive barriers, thus ensuring that low ICT confidence does not translate into disengagement during the self-assessment. The empirical data, thus, indicate that the DSAT should:

- i. Emphasize simplicity and clarity in interaction design,
- ii. Use non-technical and teacher-friendly language,
- iii. Navigate users through the evaluation procedure through systematic inquiries and easy navigation.

### **4.5.3 Feedback and Reflective Support**

The quantitative data indicated a very low level of participation in both formal and informal self-evaluation patterns (mean scores of 1.17-1.32 in all methods of evaluation), as well as a high level of agreement that teachers do not systematically evaluate their ICT integration ( $M = 4.20$ ) (Table 13). Qualitative analyses explained this trend by mentioning the lack of formal monitoring and evaluation systems in schools. Taken together, these results suggest that the DSAT should mitigate the lack of institutional feedback mechanisms by instantiating automated formative reflective support. The design implication is not just a teacher practice assessment but also entails the development of reflective practice and professional development. As a result, the DSAT is to be designed to:

- i. Promote reflective thinking by identifying areas of strength and possibilities for progress;
- ii. Present results in a supportive and non-punitive manner; and
- iii. Provide prompt, individualized feedback following self-assessment.

### **4.5.4 Professional Development**

The results of both data strands showed high consistency in terms of extremely weak access to ICT-related professional development ( $M 1.27$ ), and the respondents of the interviews affirmed that there were no structured training programmes. However, educators were very unanimous that training and encouragement are necessary in enhancing ICT integration. These results suggest that the DSAT cannot be used independently of professional learning. Instead, it is supposed to be made to correspond with and facilitate professional growth, especially in those situations where formal training opportunities are limited. Therefore, the DSAT must:

- i. Promote self-directed professional learning,
- ii. Signpost appropriate learning resources in accordance with measured needs,

- iii. Be used as a supplementary strategy that aids in progressive growth, but not to substitute official training programs.

#### **4.5.5 Context Sensitivity and Customization Implications**

The empirical evidence highlights a significant contextual limitation, which includes the poor infrastructure, intermittent internet access, and the high level of inequality in the distribution of resources amongst schools. These barriers were indicated in the high levels of challenge ( $M = 4.16$  to  $4.64$ ) and confirmed by the qualitative accounts of outdated equipment and a strong sense of digital divide. These results imply that the DSAT should be contextually sensitive, that is, it needs to take into consideration systemic constraints instead of comparing educators to idealized and rich standards. As a result, the design must be sensitive to the heterogeneity within dissimilar school settings. Accordingly, the DSAT should:

- i. Offer the flexibility of the assessment items to support different access to ICT.
- ii. Do not assume the existence of high-bandwidth and advanced technologies.
- iii. Underline reflective practice in the given contextual limitations without using deficit-based assessments.

#### **4.5.6 Ethical and Teacher Trust Implications**

The qualitative results suggest that a substantial number of teachers show interest in practicing reflective self-assessment; however, simultaneously, they are also concerned with the practices in evaluation, surveillance, and the risks of misusing the collected information by the institution. The ethical implications of such concerns on the design of the DSAT are very profound, especially concerning protecting autonomy, guaranteeing confidentiality, and professional trust. Empirical results, hence, require that the ethical aspect should be intrinsically incorporated in the

design rationale of the DSAT. The tool needs to be clearly positioned as a teacher-centered and ethically based tool to foster trust and free will to participate. Implications for design include:

- i. The need for the DSAT to clearly state its purpose and who owns/controls self-assessment data collected through the tool,
- ii. The need for the DSAT to protect the autonomy of teachers and avoid using self-assessment data for punitive or evaluative purposes that may be imposed upon them by external parties,
- iii. Adhere to ethical codes of transparency, confidentiality and professional respect.

Together, the design implications that have been obtained through empirical research define the key demands that the DSAT should achieve contextual relevance, usability, and ethical suitability among primary-school teachers. Notably, this section is not about the technical implementation or realization of the DSAT; instead, it provides an evidence-based rationale wherein the results of the study assist in the design requirement formulation. These requirements are then translated into system architecture, platform directions, and functional units, as found in Chapter 5.

#### **4.6 Integrative Synthesis - Translating Research Findings into DSAT Design Requirements**

The synthesis of the results of all four research questions brings four general principles:

1. Contextual Responsiveness: DSAT should be able to operate in settings where there is a dearth of infrastructure.
2. Pedagogical Relevance: The tool should aid significant reflection in relation to teaching practice.
3. User-Centered Design: Usability and personalization are the major drivers of adoption.
4. Ethical and Reliable Analytics: Data processing should be open, safe and favorable to teacher autonomy.

Table 32 provides a Combined integrated view of Quantitative and Qualitative Results on DSAT Design Requirement.

**Table 32**

*Translating Research Findings into DSAT Design Requirements*

<b>Quantitative Evidence</b>	<b>Qualitative Evidence</b>	<b>Synthesized Insight</b>	<b>Resulting DSAT Design Requirement</b>
Teachers report moderate ICT competence but positive attitudes toward ICT integration (RQ1)	Teachers describe enthusiasm but also uncertainty and limited digital practice due to contextual constraints	Teachers are willing to use technology but require scaffolds that accommodate varying readiness levels	Simple, low-cognitive-load interface; guided developmental progression; offline and low-bandwidth functionality (Tondeur et al., 2018)
High endorsement of ease of navigation, clarity, and intuitive UI (RQ3)	Participants emphasize desire for simplicity, tooltips, and clear task sequences	Usability is a pre-condition for adoption, particularly in high-workload settings	Minimalist interface, embedded help prompts, consistent navigation

High agreement on the need for structured reflection and comprehensive ICT self-assessment (RQ3)	Participants highlight need for contextual reflective prompts and pedagogical relevance	Reflection is a valued component of ICT professional learning	Guided reflection engine aligned with TPACK. scenario-based prompts (Mamakli et al., 2023)
Teachers value progress tracking and goal-setting features (RQ3)	Participants describe desire for monitoring growth over time and identifying strengths	Longitudinal development motivates engagement and reinforces ICT integration	Progress dashboard, competency mapping, goal-setting functions (Ifenthaler & Yau, 2020)
High endorsement of personalized feedback (RQ3 & RQ4)	Respondents request actionable, context-tailored recommendations	Personalization increases perceived usefulness and adoption	Recommendation engine that produces personal feedback (Khalil & Yousuf, 2020)
Strong support for peer learning and collaboration (RQ3)	Participants value shared practice, benchmarking, and collegial reflection	Collaboration enhances teacher motivation and knowledge exchange	Desirable community functionalities, peer-sharing, and anonymized benchmarking.
Need for offline access, due to infrastructure challenges (RQ1 & RQ2)	Participants describe unreliable connectivity, device limitations, and power issues	Digital tools must adapt to low-resource realities	Offline mode, local caching, low-data design
Teachers express privacy concerns regarding digital tools (RQ4)	Participants request transparency, data control, and trust safeguards	Trust and ethical data use shape perceptions of digital tools	Privacy-first architecture, consent management, role-based data access (Slade & Prinsloo, 2019)
Teachers note value of school-level reporting (RQ4)	Participants require aggregated insights for planning	DSAT must support multi-level use cases	Anonymous analytics administrative dashboard.

The combined integrated view presented in Table 32 gives an integrated view of the use of the mixed-method research results to inform the conceptualization and architecture of the DSAT.

This visual combination reinforces the methodological clarity of the research and shows that the requirements of the DSAT are deeply rooted in the empirical data instead of being based on presumed design inclinations.

#### **4.7 Summary of Chapter Four - Findings**

Chapter Four outlines the empirical results of the research and demonstrates how these findings are used to design the Digital Self-Assessment Tool (DSAT). The chapter starts with outlining the quantitative and qualitative analytical procedures and the credibility of the mixed-methods design. The findings that relate to the specific research questions are then provided in detail, with the results providing information on what is currently being done by teachers to integrate ICT into their professional practice, how they perceive and feel about digital self-assessment, and what characteristics they consider to be required of an effective DSAT design. To provide a balance of the two strands of data, the chapter gave a broader quantitative narrative and then proceeded to a qualitative interpretation of the data that identified the contextual realities, practical constraints, and expectations of digital professional development tools as perceived by teachers.

To provide a visual representation of the points of overlap and divergence between the datasets, as well as explain how integrated information was applied to the design logic, a mixed-method joint display was provided. The addition of a synthesis section called Translating Research Findings into DSAT Design Requirements was a major contribution to this chapter. This part clearly shows how empirical results are used to make decisions on usability, reflective scaffold, personalization, progress tracking, collaboration, accessibility in low-resource settings, privacy needs, and administrative functionality. The synthesis also describes the general design principles that arise from the findings, including contextual responsiveness, pedagogical relevance, user-centered design, and ethical data utilization. Subsequent amendments reinforce the argument on

the issue of data privacy and connect them to tangible design solutions to protect the information of teachers. A brief overview of the technical specification explains how the DSAT might translate the design requirements that were identified by the teachers, with an understanding that more detailed architectural elaboration will be given in the next chapter.

In general, Chapter Four connects the empirical data to the research design goals, providing a strong evidence basis for the DSAT prototype presented in the following chapter. The chapter explains how the needs of teachers are linked to contextual limitations and the theoretical basis that informed the development of the tool. This is then extended in the next chapter to give the full prototype architecture, its implications and future refinement and research directions.

## CHAPTER FIVE: DSAT DESIGN, IMPLICATIONS, RECOMMENDATIONS, AND CONCLUSIONS

### 5.0 Overview

Expanding on the empirical findings and design implications outlined in Chapter Four, the current chapter summarizes the findings of the study into general implications, recommendations and reflective conclusions that address the longstanding challenges to ICT integration in Ghanaian primary schools. As the previous chapters have demonstrated, despite the constant policy attention, ICT integration is still hindered by infrastructural limitations, inconsistent Internet access, a limited amount of professional growth opportunities, and the inability to introduce systematic measures to evaluate and nurture the digital skills of teachers. These challenges still limit the professional growth of teachers and the successful development of 21st-century skills in learners. The research had two intersecting aims: to investigate the present state of ICT integration practices and the contextual factors influencing the perception and willingness of teachers; and to develop a situational-specific prototype of a Digital Self-Assessment Tool based on the results of empirical research and guided by the conceptual frameworks. Notably, the DSAT depicted in this dissertation is a conceptual and functional prototype, designed to provide an illustration of how the empirically derived design requirements can be operationalized. The research has not gone to pilot, validate, or assess the DSAT across real-world classroom environments; this assessment is strategically placed as a future research agenda.

The DSAT prototype design is directly grounded on the empirically based design implications, which are clearly spelt out in Section 4.5, and which converted the quantitative and qualitative results into evidence-based design requirements. These requirements shaped the structure, elements and desired functionality of the prototype, making the artefact remain traceable

to the needs and stated requirements of the teachers, their contextual constraints and institutional realities, instead of an arbitrarily designed system. As a result, the work is consistent with the postulates of the design science and design-based research framework (Hevner et al., 2004; McKenney & Reeves, 2018), where the development of a prototype artefact is considered a valid contribution to scholarly knowledge and can be used as a starting point for further iterative development and testing. In this regard, this chapter does not provide a technical evaluation of the system and claims empirical efficacy of the DSAT. Rather, it is a reflection on the implications of the findings and prototype design on theory, practice, policy, and future research.

The chapter is organized into two main parts to make a clear distinction between the design-seeking outputs of the research and the wider scholarly considerations that ensue. In the first section, the focus is on the conceptualization and development of the prototype of DSAT. Based on the empirical evidence in Chapter Four, this section explains the theoretical framework on which the tool is based, outlines its architecture and main characteristics, explains its logical workflow and user experience, and explains the state of the prototype, as far as evaluation is concerned. It shows how teacher-driven requirements, which were identified in the previous phases of the study, were converted into a defensible design in a systematic manner.

The second part is the discussion of the broader implications, limitations, and the overall conclusion of the study. It integrates the theoretical, methodological, and policy implications of the findings; speculates on the intrinsic limitations connected with the design and scope of the study; establishes future research directions; defines the originality of the DSAT; and finally, concludes by stating the epistemic contributions of the study. Collectively, the two sections are a disposition of the research cycle wherein the empirically informed design is transferred to rigorous

interpretation and critical reflection. The chapter begins with a detailed description of the DSAT prototype.

## **SECTION ONE: 5.1 Design and Development of DSAT Prototype**

This section gives the design, structure, and logical operation of the Digital Self-Assessment Tool (DSAT) created. It elaborated on how the conceptualization and development of the DSAT was informed by empirical findings and theoretical considerations. It also explains the extent of the prototype and describes the state of its assessment, understanding that the tool is a preliminary design product that is to be refined.

### **5.1.1 DSAT Framework and Rationale**

The Digital Self-Assessment Tool (DSAT) design was driven by a need to create a contextually relevant, pedagogically based, and simple tool, hence supporting teachers in their own professional growth of integrating information and communication technologies (ICT). The rationale of the DSAT came directly out of the empirical results reported in Chapter Four, wherein instructors described a need to have structured self-assessment, personalized feedback, progress monitoring, group learning, and digital resources that can be used even under low-resource settings. These results explained functional and contextual requirements that the DSAT had to fulfill. The DSAT conceptual framework is a synthesis of three major models, including Technological Pedagogical Content Knowledge (TPACK) framework, Technology Acceptance Model (TAM), and Diffusion of innovations (DOI). The rationale behind the selection of these models is that, collectively, they focus on (a) the complexity of teacher ICT competence, (b) the drivers of user adoption of digital tools, and (c) the antecedents that support the adoption of an educational innovation.

The TPACK framework informed the design of the self-assessment component by making sure that the instrument systematically assessed the teachers in terms of their knowledge in all three areas of technological, pedagogical, and content domains. This enabled the DSAT to diagnose the strengths and gaps in a way that would be consistent with the realities of the classroom practice. The design guidance provided by TAM paid attention to usability, perceived usefulness, and easy navigation- variables that the participants included in this study defined as critical. Lastly, DOI provided a theoretical foundation to ensure that the DSAT was manifestly representative of relative advantage, compatibility with teacher practice, and a possibility of gradual adoption, which is considered paramount to the Ghanaian environment.

Together, these models offer a logical explanation of the design rationale that makes the DSAT consistent with the theoretical framework as well as the practical demands of the teachers. This framework is designed to make sure that the system encourages reflective practice, creates meaningful interaction and adapts to contextual limitations. The next section explains how this conceptual base was applied in the design and characteristics of the prototype.

### **5.1.2 DSAT Prototype Architecture and Features**

The Digital Self-Assessment Tool (DSAT) was designed in accordance with the functional requirements, contextual limitations and pedagogical demands outlined in Chapter Four. Based on the empirically drawn design implications, the DSAT is introduced as a conceptual prototype to depict the operationalization of the requirements and not as a fully implemented or empirically tested system. In line with suggestions on the design of educational technologies in resource-constrained contexts, the prototype uses a lightweight, modular, web-based architectural paradigm with a focus on usability, adaptability and reliability (Tondeur et al., 2018). The prototype of the DSAT is designed with four overlapping layers which include presentation, application, data and

security layers that perform a different role but are mutually supportive in terms of providing an intuitive and ethically sound user experience.

### **1. Presentation Layer: User Interface and Interaction Structure**

The presentation layer has been conceptualized to reflect the visual and interactive elements in terms of which users will interact with the tool. This is the main interface, and it interacts with the rest of the system functionalities with the teacher. The results obtained during the investigation show that educators attach much significance to the existence of clear navigation, low interface complexity, and intuitive interaction schemes. These implications are reminiscent of available evidence that perceived ease of use has a severe effect on technology adoption among teachers (Scherer et al., 2019). Based on these empirical findings, the interface utilizes the following design features:

- a. Minimal and uncomplicated designs
- b. Standardized icons and legible labels
- c. Directive navigation between major tasks and activities
- d. Context-sensitive languages and tooltips, and compatibility with mobile and desktop devices.

Collectively these features act to reduce cognitive load and ease learning across educators with varied levels of ICT proficiency, so as to be consistent with established principles of usability that are prevalent in the extant literature on teacher technology adoption research.

### **2. Application Layer: Core Functional Modules**

The application layer has been designed in such a way that it can accommodate the central functional modules that operationalize teacher-informed requirements. Each of the modules is conceptually a response to empirical evidence provided in Chapter Four, and theoretical

considerations based on TPACK, TAM, reflective practice models, and self-regulated literature on learning.

- a. **Diagnostic Self-Assessment Module.** This module is aimed at assisting teachers in self-assessment on the TPACK domains. The educators of the study expressed the necessity to have systematic self-assessment tools that would reflect the authentic classroom behaviors. The design purpose is harmonious with the literature that highlights the importance of diagnostic feedback in the development of the teacher (Ifenthaler and Yau, 2020).
- b. **Individualized Recommendations and Feedback System.** The feedback engine is envisioned to make sense of the assessment responses and produce specific recommendations, edited materials, and next steps to take. Previous studies demonstrate that self-directed learning settings may be improved with personalized digital feedback (Khalil & Yousuf, 2020).
- c. **Goal setting and Tracking Module.** The module itself is expected to allow a teacher to create professional objectives, visualize progress, and catalogue growth over time. This functionality is consistent with self-regulated learning theories, where goal setting and monitoring are the most important processes (Panadero, 2017).
- d. **Resource Repository of Learning.** The repository aims at offering access to curated resources that are consistent with assessment profiles of teachers. Teachers emphasized the necessity of practical and conveniently available materials that would support the process of ICT integration, which is consistent with empirical evidence that adequately aligned digital resources and systematic feedback are indispensable elements of the teacher professional development tools (Fisher et al., 2023).
- e. **Peer-learning and Collaboration Module.** The optional module is designed in a way that will support collaborative reflection, shared practice, and anonymized peer learning. Studies

indicate that the use of collaborative digital spaces can help in the motivation of teachers and in the creation of communities of practice (Trust & Prestridge, 2021).

- f. **Administrative Dashboard Module.** The administrative dashboard is designed in such a way that the school leaders will be shown anonymized and aggregated data to make decisions about planning and professional development. Anonymization and role-based access were also informed by the privacy concerns raised by the educators, adhering to the ethics of learning analytics (Slade et al., 2019).

### **3. Data Layer: Storage and Retrieval Mechanisms**

The data layer is envisioned to support user profile, assessment response, progress indicators and system activity log management. To address the issue raised by educators concerning unstable connectivity, this layer is meant to include:

- i. Local caching,
- ii. Low-bandwidth optimization, and
- iii. Effective data access to generate feedback.

These design factors are to aid reliability and usability in the low-resource settings, which are in line with the ICT4D system design principles and educational technology design to constrained settings (Heeks, 2017; Walsham, 2017).

### **4. Security and Privacy Layer**

In the results of Research Question 4, the issue of privacy was raised. Based on this, the security and privacy layer was designed to include consent-based data sharing; role-based access control; sensitive data encryption; analytics anonymization; and secure password management. These steps are the design intentions in accordance with guidelines that allow ethical learning analytics and responsible data stewardship (Slade et al., 2019).

### *DSAT Architectural Summary*

The prototype architecture of the DSAT is based on a conscious set of requirements informed by educators, a set of theoretical frameworks, and design tenets that are suitable for the low-resource educational setting and teacher-driven requirements. Individual constituent modules are conceptually linked to discrete requirements based on empirical observations, and the architecture demonstrates how reflective, personalized, and ethically oriented professional development can be supported with the help of a digital self-assessment tool. Figure 19 outlines the main functional elements of the DSAT prototype and explains the systemic structure that is planned to support the process of teacher-centered professional growth. The authentication and data security features concerned with the issues of privacy and ethical use of data by participants. The goal setting and progress monitoring segment realizes the stated need of educators to have a structured reflection and longitudinal tracking of ICT integration development.

The integrated learning resources provide context-specific support in line with the competency gaps identified, and the community forums and peer collaboration element react to the desire by educators toward collaborative professional learning. The administrative dashboard allows school-level management by providing anonymized analytics, thus making sure that the institutional planning requirements are addressed without interfering with the privacy of individual teachers. Together, these elements represent the teacher-informed design requirements outlined in Chapter Four and form the functional basis of the DSAT. The next section outlines the planned logical flow of the prototype and the user journey that it is supposed to cover.

**Figure 19***Core Functional Components of the DSAT*

*Image Source: Researcher's Construct (2025)*

### 5.1.3 Logic Flow and Intended Functionality of the DSAT prototype

The logic flow of the Digital Self-Assessment Tool shows what the user should expect in terms of interaction, starting with first access, continuing with self-assessment, feedback, and further professional development planning. This procedural framework is not a description of the observed system behavior, but a conceptual model that should be developed to support structured reflection, personalized learning and ethical data use in low-resource educational environments. This section consists of the interface representations presented in screenshot in Appendix 3.

#### 1. System Access and User Authentications

The launching of the DSAT interaction is given based on a solid authentication protocol in which the users authenticate themselves using encrypted credentials. The verification leads to the assignment of access permissions, which depend on a user-assigned role, which is teacher or administrator. As a result, teachers can receive personalized self-assessment and professional

growth capabilities, and administrators are limited to anonymized and aggregate analytical boards. This access scheme is specifically coordinated with the expressed interests of teachers in the areas of data privacy and professional autonomy.

## **2. Dashboard Navigation and User Orientation**

Once they have passed the authentication, they will be redirected to a personalized dashboard, which will act as the main navigation point of the DSAT. In the case of teachers, the dashboard will provide a summary of assessment statuses, program progress, suggested steps, and system messages. The dashboard layout focuses on the clarity and ease of navigation and, thus, allows users to quickly find the pending tasks and resources available without excessive complexity. The administrators, conversely, have a different dashboard, which only shows summaries at the school or district level, and, thus, there remains an ethical boundary between the individual and institutional data perspectives.

## **3. Self-Assessment Process**

The initial main task of the DSAT is the completion of a structured self-assessment that the teacher completes in accordance with the TPACK framework. The presentation and arrangement of assessment items are in a sequential order and by domain so that one can reflect on them specifically. The answers are captured with the help of scaled indices, which allow teachers to describe the degrees of confidence or mastery instead of making binary decisions. The selected methodology reduces anxiety in assessment and promotes open self-reflection.

## **4. Automated Analysis and Generating Feedback**

In response to the submission of the self-assessment, the system will run the responses through an automated feedback engine. The scores of individual items are added together within domains to create a competency profile that highlights the strengths and the areas of development.

Based on this profile, the DSAT would produce individual feedback in the form of interpretive summaries, recommendations on improvement areas, and recommended actions. This instant feedback system is aimed to transform self-evaluation information into workable professional information.

### **5. Goal Setting and Progress Monitoring**

The goal-setting module would allow teachers to convert feedback into specific objectives of professional development. The goals are entered into the system, planned, and associated with progress indicators. As one constantly has access to the platform, every update is recorded and presented in the dashboard, which allows a user to track progress over the long term. This characteristic would lead to the development of long-term involvement and also encourage self-guided professional learning.

### **6. Access to Learning Resources**

The resource repository is made accessible after one has gone through the goal setting and assessment processes. Digital resources are offered to teachers based on their needs and goals identified and demonstrate strategies of teaching, reports on the use of ICT integration, external educational resource links and additional materials. This system interconnects these resources to the results of the assessment in a dynamic way, which makes them relevant and effective in practice.

### **7. Cooperation and Peer Learning**

A shared optional platform is offered where teachers can learn together via discussion and idea sharing. The engagement in this space is voluntary, which acknowledges the levels of comfort with the open discussion of professional issues. The system also allows anonymized

benchmarking, which allows educators to view trends in aggregate form without compromising on individual anonymity.

## **8. Reporting and Administrative Analytics**

The administrators are also empowered to communicate with the Tool via an analytics dashboard where aggregate information is displayed based on educator interactions and assessment data. On an institutional level, reports outline the patterns of ICT competence, patterns of participation, and developmental requirements. Notably, the data on personal information of teachers is anonymous to protect confidentiality and build trust. Export summaries can be used to enlighten specific professional development efforts and interventions in policy.

## **9. Data Management and Privacy Logic**

The DSAT uses data acquisition, which is a consent-based data acquisition, encryption of acquired and transmitted data, and role-based access control within its logical structure. The logging of user activities is only done to facilitate the functionality of the system and not to monitor them. These processes guarantee that ethical data operations are integrated during the interaction phases in the system.

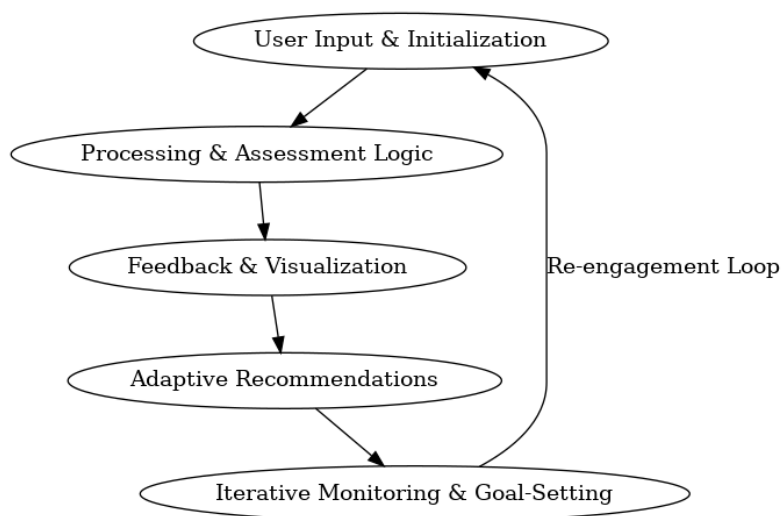
### ***DSAT Logic Flow Summary***

Figure 20 shows the logic flow conceptualization of the Digital Self-Assessment Tool (DSAT) prototype. The sequence starts with user input and system startup which is equivalent to the authentication and self-assessment modules outlined in Section 5.1. This analysis is input into the feedback and visualization stage where the assessment results are converted to interpretable competency profiles. The adaptive recommendations utilize individual feedback and learning resource modules to create context-specific recommendations and recommended actions that correspond to the needs identified. It is concluded by the process of iterative monitoring and goal setting, which facilitates the longitudinal professional development by allowing teachers to

monitor their progress along the way. The re-engagement loop shown in Figure 20 brings out the reflective and cyclical nature of the DSAT, which is designed as a continuous self-improvement process as opposed to a diagnostic tool. The phases are presented in interface mock-ups and screenshots, which are provided in Appendix 3, thus providing a better level of transparency and understandability.

### Figure 20

*Conceptual logic flow of the DSAT prototype*



*Image Source: Researcher's Construct, (2025)*

#### 5.1.4 Prototype Evaluation Status and Design Completeness

The DSAT is a research prototype, and it is not a fully developed or empirically tested system. The main objective of the DSAT on the boundaries of this thesis was to operationalize empirically sound design requirements into a congruent artefact that demonstrates feasibility, conceptual and contextual relevance. In this regard, a complete end-user-based empirical assessment was not conducted as part of this study. Such a conscious stance is in line with well-known design science research (DSR) principles, which see artefact creation and testing as processes of continuous, repeated development and analysis as opposed to discrete events (Hevner et al., 2004; Hevner, 2007). In this paradigm, initial artefacts are often created in a way that helps

to prove the idea of conceptual completeness and relevance before a serious assessment is carried out during later research cycles.

#### ***5.1.4a. Rationale for the Absence of Empirical Evaluation on the DSAT***

The absence of empirical assessment of the DSAT in this thesis cannot be interpreted as a methodological flaw, but it is a necessary constraint related to the scope of the study. The two-fold purpose of this study was to (a) examine the ICT integration practices and (b) develop a contextually relevant prototype of DSAT based on these empirical results and grounded on conceptual frames. Such a stringent assessment would have required prolonged implementation, numerous design cycles, ethical approval of school-based application, and longitudinal data gathering procedures that would not only exceed the timeframes of the study but also the approach methodology of the current study. The scholars of design science point out that the evaluation plans in both artefacts and research goals need to be proportionate to the maturity of the artefact and the research goals at a specific stage of development (Hevner et al., 2004; Peffers et al., 2007). The prototype stage is concerned with showing relevance, logical coherence, and design ability and does not give empirical evidence of functionality.

#### ***5.1.4b. Defining “Completeness” at the Prototype Stage***

The DSAT is viewed as full prototype of the requirements of Design Science Research (DSR) and tradition of designing-based research within the context of this study (Hevner, 2007; McKenney & Reeves, 2018). The completeness in prototype is established by the following criteria:

1. Problem–Solution Alignment: The DSAT deals with the empirically determined issues related to ICT integration, teacher reflection, limitations of usability and data privacy.

2. **Theoretical Grounding:** The artefact is placed with popular conceptual frameworks, including TPACK, principles of technology-adoption and reflective practice; thus, maintaining conceptual and pedagogical consistency.
3. **Functional Coverage:** The entire essential functional requirements identified by the educators that need to be present within the DSAT, including self-assessment, feedback, goal setting, progress tracking, learning materials, collaboration, and administrative analytics, are intuitively modelled and integrated.
4. **Operational Logic:** The logical flow of the system states how users will engage with the DSAT through the iterations of reflective and professional development.
5. **Responsiveness to Ethics and the Context:** Privacy, data security and low-resource constraints are explicitly considered using design decisions, which are considered in responsible educational technology design practices.

#### ***5.1.4c. Planned Approaches for Future Evaluation***

Following the principles of design science and design-based research, additional research is needed on iterative analysis and improvement of the DSAT through user-centered approaches (Hevner et al., 2004; McKenney & Reeves, 2018). The following strategies of evaluation can be embraced:

1. To determine the interface clarity and usability, a usability assessment, including heuristic evaluation and cognitive walkthroughs.
2. Preliminary studies in a sample of primary schools to check the viability and teacher involvement.
3. Design-based research cycles with ongoing redesign through practitioner feedback.

4. Qualitative user research, such as interviews and focus groups, to determine perceived usefulness and contextual relevance.
5. Usage data analytics, to analyze patterns of engagement and trends of longitudinal interaction.

These methods will enable the implementation of an intensive assessment of the usability, relevance, and practical usefulness of the DSAT, which will promote continuous improvement.

### **5.1.5 DSAT Validity and Generalizability**

Since no empirical analysis has been performed, the results related to the DSAT prototype should be interpreted as hypothetical design suggestions, as opposed to empirically tested results. At this point, the prototype is not making claims that it has predictive generalizability or that it is demonstrably effective. Rather, it provides a conceptually based and empirically supported premise on which further assessment and improvement can be built.

#### ***Section Summary***

This section explains the evaluations of the DSAT status and defines the criteria of completeness of the prototype stage. The study maintains methodological transparency and explicitly situates the discussion in the principles of design-science research, as well as directly raises questions of artefact evaluation and relevance by acknowledging that the DSAT prototype designed in this study has not been empirically validated.

## **SECTION TWO: IMPLICATIONS, RECOMMENDATIONS, AND CONCLUSIONS**

Section Two of this chapter provides an interpretive and reflective synthesis of the study that combines the empirical findings registered in Chapter Four with the design and development of the Digital Self-Assessment Tool (DSAT) as reported in Section One of the chapter. Whereas in Section 1, the emphasis was on translating research into a design artifact, Section 2 is an evaluation of the greater importance, limits, and contribution of the research. Particularly, the section

discusses the implications of the findings on theory, methodology and policy/practice and connects the implications to the research questions set by the study. It subsequently addresses shortcomings of the study and outlines future research directions, including those that are related to the prototype nature of the DSAT. The section also explains the novelty and originality of the study, putting the DSAT in the context of the current teacher self-evaluation systems, and the work ends by briefly summarizing the contribution of the study to the field of knowledge and practice.

### **5.2.1 Implications of the Study**

This study has tremendous implications in understanding and enriching the ICT integration in primary schools in Ghana. These implications are discussed with reference to the research questions of the study and are expressed on three complementary levels: theoretical, methodological, and policy-practice. This type of structure allows a systematic understanding of how the results can be extrapolated to the existing theoretical frameworks, guide research methods, and guide action plans in the educational contexts. In this organizational structure, specific attention is paid to the implications of the DSAT as one of the main design products of the study. The implications of DSAT are implicit in the research questions and conceptual lenses are presented with the recognition of the Tool as a research-based prototype. As a result, the discussion does not make any firm statements about the impact or effectiveness but highlights possible contributions to reflective practice and professional development.

#### ***5.2.1a. Implications of Results Related to Research Question 1***

**Research Question 1:** *What is the current state of ICT integration practices in Ghana's primary schools?*

Findings associated with Research Question 1 indicate that ICT integration in primary schools in Ghana is a slow but ongoing process that is limited by the infrastructural means and

availability of digital resources, as well as insufficient prospects of sustained professional growth. Although some teachers acknowledge their basic knowledge of ICT use, the level of integration was not high at pedagogically meaningful levels. These findings coincide with some of the concerns voiced by the literature about the consistent discrepancies between ICT policy intentions and classroom realities in low-resource educational settings (Tondeur et al., 2017). The implications of these findings are discussed below.

### **a. Theoretical Implications**

The results of Research Question 1 indicate that prevailing models of ICT integration and teachers' digital competence need to be more concerned with contextual and systemic limitations. Although integration of ICT in education has been conceptualized through frameworks like Technological Pedagogical Content Knowledge (TPACK) where the conceptualization focuses on the technological, pedagogical and content knowledge of teachers, the findings of this study show that technological, pedagogical and content knowledge are mediated by the availability of infrastructure, institutional support and school-level conditions (Herring et al., 2016). The weak penetration of ICT integration is in line with the literature arguments suggesting that access to technology cannot lead to meaningful pedagogic utilization (Tondeur et al., 2019). This paper, thus, supports the argument that ICT integration theories should be viewed through the lens of context, especially in primary education institutions in developing nations, where structural limits play a crucial role in defining the ability of teachers to implement theoretically optimal actions.

### **b. Methodological Implications**

In its methodological perspective, the results reveal the importance of the mixed-method approach in exploring the practice of ICT integration. The quantitative measures have given general access and frequency of use, but the qualitative data played a critical role in uncovering

how the teachers construct, adapt, and restrain their ICT practices based on contextual pressures. This reinforces methodological claims that ICT integration research gains advantage of triangulation to embrace both measurable trends and lived experiences (Creswell & Clark, 2017). The results also underscore the weakness of using self-reported survey data to determine ICT integration. Such data may overestimate meaningful ICT use unless they are followed qualitatively. This implies that any future research studying ICT integration, especially in low-resource settings, must include qualitative inquiry to provide interpretive richness and validity of contexts.

### **c. Policy and Practice Implications**

Results on Research Question 1 further showcase important educational policy and classroom practice implications pertaining to the Ghana's primary schools. At the policy level, the underwhelming state of ICT integration highlights the necessity to find solutions to underpinning infrastructural issues such as stable electricity, working devices, and connectivity. These results are consistent with national and international reports, which identify infrastructure as a hub of successful ICT integration (Ministry of Education, 2019; Burns, 2023). At the practice level, the results suggest that teacher professional development programmes of short-term ICT training programmes should be replaced with long term practice-based support. The educators need persistent access to pedagogical strategies that allow them to incorporate ICT into curriculum and assessment limitations in meaningful ways (Tondeur et al., 2017). Leadership in schools is also vital in creating environments that promote experimentation, collaboration and reflective practice regarding the use of ICT. All these implications indicate that to enhance ICT integration in primary education, a coordinated strategy to integrate infrastructure, professional growth, and institutional support is necessary instead of holding responsibility on individual teachers.

### ***5.2.1b. Implications of Results Related to Research Question 2***

**Research Question 2:** *What factors could influence teachers' perceptions and attitudes toward adopting a digital self-assessment tool (DSAT)?*

The results related to Research Question 2 prove that the willingness of teachers to use a digital self-assessment tool depends on the interdependence of the perceived usefulness, perceived ease of use, the relevance of the situation, workload considerations, and trust regarding the use of data. Teachers showed a tendency to use the tools that support professional growth and simultaneously expressed concerns about the increased working load, data privacy, and the potential abuse of self-evaluation data. The findings fit with the available academic literature on the use of technology in education, especially where institutional trust and resource constraints are relevant (Davis, 1989; Rogers, 2003).

#### **a. Theoretical Implications**

The results further justify the relevance of the theoretical conceptions of technology adoption among teachers by validating the relevance of the constructs of perceived usefulness, perceived ease of use and compatibility with the existing practices. Although Technological Acceptance Models have analytically largely focused on personal perceptions, this exploration makes it critical to establish these constructs with wider institutional and socio-cultural contexts. The fears expressed by teachers about the workload, accountability, and the use of data show that the choice of adoption is determined not only by the characteristics of the systems but also by the existence of organizational norms and power hierarchies. In addition, the evidence suggests that trust and perceived purpose are the determinants that are critical in the attitude of adoption. Engagement with the digital self-assessment tool (DSAT) would be preferable when the tool is framed as a developmental and reflective tool, but not an assessment or surveillance tool. This

highlights the need to make adoption theories more explicitly include constructs of professional autonomy, trust, and ethical use of data, especially in educational settings.

### **b. Methodological Implications**

Methodologically, the results in connection with Research Question 2 illustrate the worth of integrating quantitative indicators of attitudes with qualitative investigation of the perceptions and concerns of teachers. Although the survey data gave us a broad view of general receptiveness toward the DSAT, qualitative data were crucial to showcase finer aspects, including the fear of data misuse, the pressure of the institution, and the amplification of workload. This sustains methodological claims that the adoption of technology is a field of research in which mixed-methods research designs can be adopted to both identify attitudinal patterns and the rationales behind these patterns (Creswell & Clark, 2017). There are also limitations identified by the findings on self-reported measures of attitudes. The willingness of teachers to accept a tool does not always mean their continued use when implementation pressures are experienced. This indicates that any future study conducted on the adoption of digital tools needs to include longitudinal designs or post-studies to capture the change in perceptions across time.

### **c. Policy and Practice Implications**

The implications associated with the insights related to Research Question 2 have a profound impact on the introduction and application of digital professional development tools in primary education. The policy level requires a clear statement on the use and purpose of self-assessment data. Policies should clearly place tools like the DSAT as a means of professional learning, but not performance, and hence reduce resistance and build trust. At the practice level, policymakers and school leaders ought to come up with strategies to minimize the perceived workload burden with digital tools. Adoption can be promoted by integrating the DSAT into the

existing system of professional development instead of introducing it as an extra burden. Assurances related to privacy and transparency of the data, as well as the agency of the teachers regarding the self-assessment outputs, are important in enhancing meaningful engagement too. All these implications together indicate that the key determinants of successful adoption of a DSAT would be found in the quality of technical design and in supportive institutional cultures, ethical practices in data and agreement with the professional realities of teachers.

### ***5.2.1c. Implications of Results Related to Research Question 3***

**Research Question 3:** *What teacher-informed requirements should guide the design of the Digital Self-Assessment Tool (DSAT), specifically regarding pedagogical and technological features, usability, and accessibility in low-resource primary schools?*

The results associated with Research Question 3 show that teachers value design requirements that include classroom reality, aid reflective practice, are user-friendly, and can be used in low-resource settings. Ease of use, meaningful feedback, privacy of data, relevance in a context, and simplicity of the interface were stressed by teachers. These results support the importance of basing educational technology design on practitioner views and have important theoretical, methodological, and policy consequences.

#### **a. Theoretical Implications**

The findings have a theoretical impact by showing how abstract conceptual frameworks could be operationalized by teacher-informed design. Although models like TPACK and reflective practice frameworks explain the elements of a successful ICT integration process, this paper demonstrates how the theoretical constructs can be transformed into tangible design elements in a digital artefact. The focus on feedback, goal-setting, and iterative reflection by the teachers helps to justify theoretical views on professional learning as a cyclical, self-regulative process rather

than a cumulative skill acquisition (Panadero, 2017; Korthagen, 2017). Furthermore, the results support literature claims that educational technologies should be context-sensitive to be considered theoretically significant. The emphasis of the teachers on usability, accessibility and low-band operation features demonstrates the shortcomings of the technology-focused design framework that presupposes a stable infrastructure and a high level of digital preparedness. This implies that contextual constraints and user agencies, which are mainly present in primary education in developing countries, need to be considered more explicitly in theories of ICT integration and digital professional growth.

### **b. Methodological Implications**

On a methodological level, the results reaffirm the usefulness of participatory and user-centered methods in educational technology research. The study illustrates how empirical information can be used to design artefacts in a systematic and defensible way by foregrounding the voice of the teachers in specifying the design requirements. This reinforces methodological arguments that design-oriented research has the advantage of working in close collaboration with end users to make it relevant and usable (McKenney & Reeves, 2018). The results further demonstrate the methodological power of incorporating insights gained in qualitative research decisions in design. The narratives of the teachers included a different interpretation of the need to have such features like simplified interfaces, optional collaboration, and privacy controls. This implies that future design studies must consider the importance of a qualitative approach where eliciting the design requirements, especially in situations where standardized design assumptions are not necessarily the case.

### **c. Policy and Practice Implications**

The results also have serious implications for policy and practice in terms of teacher professional development and the use of digital tools. The excessive focus on data privacy and non-punitive use of the results of self-assessment, as highlighted by the teachers at the policy level, suggest that clear guidelines that will ensure professional autonomy should be provided. In turn, the policies of digital professional development tools must clearly identify self-assessment information as developmental and not evaluative purposes. Practically, the findings indicate that digital tools that should be used by teachers should be designed with a high level of usability and flexibility rather than being overly technical. Professional development programmes incorporating technology like the DSAT should offer teachers guidance that leads to a reflective engagement and not prescriptive teaching. The integration of principles of teacher-informed design on the levels of professional learning systems can contribute to improved engagement, trust, and continued use. Overall, these implications emphasize the necessity of the digital tool design that can be determined in accordance with the lived experiences and professional requirements of the teacher, thereby supporting the role of the practitioner in the definition of successful educational technology adoption.

#### ***5.2.1d. Implications of Results Related to Research Question 4***

**Research Question 4:** *How could the prototype Digital Self-Assessment Tool (DSAT) be designed to reflect Ghana's educational realities while drawing on empirical and established conceptual frameworks (TPACK, TAM, and DOI)?*

The results concerning Research Question 4 indicate how empirical knowledge, contextual limitations, and theoretical framework can be integrated into the construction of a contextually meaningful digital artefact. The DSAT prototype can be interpreted as a deliberate trade-off between conceptualization and practicality, and it suggests key implications in terms of theory,

methodology, and policy on designing educational technologies to be used in low-resource primary education environments.

### **a. Theoretical Implications**

The findings are relevant to theory by demonstrating the ability to integrate and operationalize various conceptual approaches into a single design artefact. Although models like TPACK, the Technology Acceptance Model (TAM), and Diffusion of innovations (DOI) are mostly used separately to discuss and analyze teacher behaviour or technology adoption, this research illustrates the complementary nature of these models when employed as joint design prisms. The prototype of the DSAT demonstrates that TPACK can be used to inform the domains of competencies, TAM can be incorporated to develop usability and perceived usefulness factors, and DOI can be utilized to make compatibility and adoption-related design choices. Moreover, the construction of the DSAT supports theoretical views which consider artefacts as carriers of theoretical knowledge, instead of neutral technological instruments. The DSAT is also an operationalization of theory in that theoretical assumptions have been directly inserted into system logic, feedback, and interface design. This justifies design science research arguments that the artefacts themselves can be useful as contributions to theory when they operationalize and realize conceptual principles (Hevner et al., 2004; Hevner, 2007).

### **b. Methodological Implications**

Methodologically, the results emphasize the usefulness of design-oriented research methodologies that extend beyond the analysis of a problem to the creation of artefacts. The progressive design of the DSAT prototype is the embodiment of the sequential transfer of empirical result into the explicit design specifications, structural choices, and functional elements. The use of such an approach is compatible with the traditional design-based and design science research

paradigm that predicts a reciprocal relationship between the theory, empirical evidence, and artefact creation (Peppers et al., 2007; McKenney & Reeves, 2018). Another issue raised by the study is the need to define the scope of design research clearly. This paper proves transparency in methodology and does not overstate claims by explicitly stating that the DSAT is a prototype project and not a proven system. This has future research implications, indicating that initial artefact development could be a valid contribution to research in cases where this contribution is clearly justified, documented design logic, and future evaluation is planned.

### **c. Policy and Practice Implications**

The policy and practice implications of the findings can also be explained regarding the implementation of digital tools of professional development in primary education in Ghana. On the policy level, the DSAT prototype explains how digital tools may be adjusted to the national priorities of ICT integration and teacher development without becoming insensitive to the contextual limitations. Placing the DSAT in a self-reflective and developmental practice can help to advance policy objectives associated with teacher capacity building without fostering high-stakes accountability expectations. At the practice level, the DSAT shows that it is possible to initiate low-cost, scalable digital technologies that can help teachers reflect and develop. The prototype can form the basis of pilot reflective self-assessment programs that school leaders and education authorities can implement to supplement their current professional development systems. The results also reveal that successful implementation will rely on institutional support, purpose communication, and protective measures to guarantee ethical use of data. In general, these implications emphasize the possibility of designing contextually based design solutions to fill the gap between educational theory, research findings, and practice.

### **Summary of Implications**

The section concludes by synthesizing the implications of the study findings in terms of the four research questions, and highlighting their importance to theory, methodology and policy and practice in the context of integrating ICT in Ghanaian primary schools. Altogether, the implications emphasize that ICT integration must be viewed not only as a question of personal teacher competence, but it is a process that takes place within a context and is influenced by infrastructural conditions, institutional support, and professional cultures.

Theoretically, the findings support the need to apply existing frameworks contextually concerning ICT integration, technology adoption, and reflective professional learning. The paper shows how conceptual frameworks like TPACK and technology adoption models can be operationalized with a teacher-centered digital artefact and indicates the constraints of using these two models without reference to local constraints. In line with this, the implications enhance theoretical knowledge by demonstrating the way in which theory can be used to make practical design choices in low-resource educational environments. Methodologically, the implications emphasize the usefulness of mixed methods and design-based research methods to deal with complex educational issues. Combining quantitative and qualitative data helped to gain a subtle insight into ICT practices and teacher perceptions, whereas the dynamic evolution of empirical results to prototype design demonstrates how research can go beyond analysis and generate solution-focused results. At the same time, the research provides evidence of the necessity of a clear definition of the limits of design research, especially when artefact evaluation is not in the focus of the study. Regarding policy and practice, implications have been placed on the necessity of coordinated strategies to match infrastructure provision, professional development and institutional leadership. The results indicate that the digital tools that can aid teachers in their development must focus on usability, trust and ethical data practice, and be framed as

developmental, but not evaluative processes. The prototype of the DSAT is a demonstration of how these principles may be incorporated into the design of professional learning tools, which are responsive to the needs of teachers and contextual realities.

In general, the implications of the study refer to the possibility of supporting reflective teacher professional development with the help of empirically based, theory-inspired digital instruments. These insights are used as the basis of further sections of this chapter, where the study limitations are discussed and future research directions are outlined.

### **5.2.2 Study Limitations and Directions for Future Research**

In this section, the paper identifies the main constraints of the current study and then outlines relevant areas of further research. These limitations are analyzed to define the limits of the interpretation and position the findings within the methodological, contextual and design-related parameters of the study. Expanding these limitations, the section then suggests the future research directions that would continue the empirical and design-oriented work of the study, including further explorations of the ICT integration and the iterative design and testing of the DSAT prototype. Together, these reflections provide a clear description of the limitations of the study and, at the same time, outline possible directions for research and practice in the field of context-sensitive educational technology creation.

#### ***5.2.2a Limitations of the Study***

Despite the significant input of the study to understanding the process of ICT integration and the creation of a prototype Digital Self-Assessment Tool (DSAT) that could be used by Ghanaian teachers, a few limitations are to be mentioned. Understanding these constraints is essential to put the findings into context, defining the scope of interpretation, and future studies that will help draw a stronger empirical base to the DSAT and similar educational technology.

## **1. Contextual Limitations**

The research was carried out in a limited geographic unit where a purposive sample of public primary schools in Ghana was considered. Although this close-ended scope enabled a comprehensive study of the practice of integrating ICT and teacher perceptions, it also restricts the extrapolation ability of the results. The ICT inequality between districts in terms of infrastructure, policy adoption, leadership support, and resource allocation can facilitate different experiences of ICT integration in other Ghanaian regions or in similar low- and middle-income country (LMIC) environments (Adarkwah, 2021; Osei, 2024). Another contextual constraint is associated with the policy and governance setting in which the research was undertaken. Even though the Ministry of Education in Ghana has developed national strategies to facilitate the integration of ICT, the paper did not explore mechanisms of policy implementation and institutional enforcement processes in detail. Consequently, although the views of teachers regarding the integration of ICT and adoption of DSAT were elicited, the study did not fully consider the influence of systemic impacts on implementation on a large scale, e.g. funding flows, administrative accountability and incentive structures. This restricts the scope of how the research can account for the variation in ICT adoption outside the classroom and highlights the necessity to conduct future research that considers multi-level policy implementation and teacher practices.

## **2. Methodological Limitations**

This study was largely based on self-reported tools, that are questionnaires and interviews, which are prone to biases in response. The teachers were more likely to inflate their ICT competencies to fit socially desirable standards, and they may also under-report difficulties due to fears of professional assessment. These biases are inevitable, although strict ethical measures were applied to prevent them, including informed consent, voluntary participation, and confidentiality

guarantees. Additionally, cross-sectional design only measured teachers' practices and perceptions at one point in time, and thus, the study did not help to understand how ICT use and attitudes change. Previous studies show that observational and digital trace data have the potential to identify technology use patterns that are significantly different from self-reported ones (Lee & Kizilcec, 2020). Although the convergent mixed-method design enhanced interpretation by making the mixed-method design stronger using the concept of triangulation, there were still some variations in focus between the quantitative and qualitative results. This difference is an inherent trade-off of incorporating various sources of data into a convergent mixed method framework and is not due to the absence of methodological rigor.

### **3. limitations of the DSAT Prototype**

The DSAT was co-designed with teacher and stakeholder input, yet not all suggested features may be technically feasible in resource-limited contexts. As technology adoption research cautions, stated preferences do not always translate into sustained usage. Importantly, within this study, the DSAT remains at the prototype stage. It has not been piloted or validated; its primary contribution lies in offering a theoretically grounded, empirically informed blueprint for further development. This aligns with principles of Design-Based Research (DBR), which emphasize iterative cycles of prototyping, piloting, and refinement in authentic classroom settings rather than expecting comprehensive validation at the first stage (McKenney & Reeves, 2018). Furthermore, since the DSAT is in its prototype form and has not undergone any empirical pilot studies or user-based tests, its results cannot be translated as predictive or generalizable outcomes of teacher competence or professional development. The existing design is conceptually and contextually relevant, but it is yet to prove validated effectiveness. Therefore, any conclusion that can be made

about the effects of the DSAT should be considered as tentative until a systematic assessment is carried out in a variety of educational environments.

#### **4. Limited Qualitative Sample**

Though the qualitative component results in rich, contextually grounded data, the sample size is relatively small and therefore limits the possibility of generalizability of the results to the whole population of teachers in Ghana. The qualitative strand was deliberately planned to provide depth of experience instead of statistical representativeness in compliance with the methodological suggestions of Creswell and Poth (2016) and Given (2015). Transparency in coding steps and reflexivity in interpretation help to ensure the trustworthiness of the study (Nowell et al., 2017), but the limited size of the sample restricts the generalizability of the discovered themes to other regions and institutional settings. In turn, further validation of these themes would require larger-scale surveys, country-level needs assessment, or multi-site case studies that can be employed to measure regional and systemic variation.

#### **5. Framework Limitation**

While the research was carried out within the frames of established theoretical frameworks, including the TPACK, the TAM, and the DOI, the empirical data reveal that the operationalization and application of these frameworks to the study was limited by structural and contextual factors that are inherent to primary education systems in the low- and middle-income countries (LMICs). More recent work has suggested that TPACK, specifically, could be improved with a clearer incorporation of the contextual knowledge to capture the infrastructural constraints, cultural processes, and institutional environments that inform the use of technology (Petko et al., 2018;

Tondeur et al., 2020). Equally, the adoption models like TAM and DOI could also poorly represent the structural barriers and equity factors that are particularly imperative within resource-constrained settings (Baran et al., 2019). To this end, this limitation does not in itself dispute the validity of these frameworks as such but instead underscores the limitations related to their use in this research study, devoid of contextual elaboration. The results, hence, justify the need to have hybrid or modified frameworks that incorporate feasibility, equity, and contextual sensitivity on top of conventional predictors of technology adoption.

### ***5.2.2b Directions for Future Research***

Based on the limitations and the scope of the current study, several research opportunities emerge that can expand and deepen the body of empirical evidence regarding ICT integration and teacher-centered digital self-assessment in Ghanaian primary schools and similar settings.

One of the key avenues of investigation is geographical expansion. Future research ought to go beyond the few locations explored in this study to various districts in Ghana and other Sub-Saharan African education systems. This would facilitate the systematic discussion of regional, institutional, and infrastructural differences in ICT access, policy implementation and pedagogical activities. Previous studies suggest that cross-regional research in low- and middle-income nations frequently indicates the unequal ICT adoption that stays hidden in localized studies (Hennessy et al., 2022). Equity-related aspects of ICT integration would also be enlightened further through comparative studies between rural and urban schools, and between public and private institutions.

Another significant area of research in future is methodological diversification. Although self-reported data were useful in the current study, future studies may enhance empirical validity with the help of classroom observations, digital-trace analytics, and longitudinal designs. These would enable triangulation of reported practice and observed behaviour, leading to a stronger

interpretive development (Creswell & Clark, 2017; Lee & Kizilcec, 2020). Specifically, longitudinal designs would allow analyzing how the practices and attitudes of teachers towards ICT would change with time due to ongoing exposure to digital tools (Tondeur et al., 2017).

More advanced integration of mixed methods could be pursued in future studies as well. The qualitative themes revealed in this research, including the issues of data privacy, workload, and goal-setting choices, may be used to create more sophisticated quantitative tools and digital design solutions. Mixed methods designs that are iterative in nature, whereby qualitative results are directly used to drive the subsequent quantitative stages, have been demonstrated to increase the level of explanatory depth and construct validity (Creswell & Clark, 2023).

Another area of focus of future research includes the iterative testing and refinement of the prototype of the DSAT. Since the DSAT is based on research-informed design as a formative prototype, further research must make use of design-based research (DBR) cycles involving piloting, usability testing, participatory design workshops, and staged implementation of the prototype in various school settings. The use of user-centered design methodologies has been demonstrated to make educational technologies seem more relevant and acceptable, especially when end users participate in the development process (Luckin & Cukurova, 2019). This type of iterative testing would allow empirical evaluation of usability and contextual fit to be done without undermining the exploratory nature of the prototype.

Lastly, theoretical development is another significant direction of future research. As TPACK, TAM, and DOI offered sound conceptual frameworks to this study, the results indicate that this set of models needs to be refined even further to capture the contextual and structural elements that may drive ICT adoption in resource-intensive environments. Emerging research has emphasized the role of organizational culture, infrastructural capacity, and institutional support

coupled with individual attitudes and intentions (Venkatesh et al., 2016). Future studies would thus help to establish and confirm hybrid or context-dependent models which better reflect the dynamics of ICT integration in education systems in Sub-Saharan Africa (Hennessy et al., 2022).

Collectively, these recommendations present a consistent research agenda in the future that revolves around multi-contextual scaling, methodological creativity, prototype development, and theory optimization. To demonstrate how the limitations of the study fit within these suggested directions, Table 29 cross-tabulates each of the limitations identified with the nature of the avenue that may be pursued further into the research.

**Table 33***Mapping Study Limitations to Future Research Directions*

<b>Limitation</b>	<b>Implication</b>	<b>Future Research Direction</b>
Contextual scope – Study focused on a limited geographic area within Ghana, with variation likely across districts and school types.	Limits generalizability and masks regional inequities in ICT adoption.	Conduct multi-district and cross-country studies (urban vs. rural; public vs. private) to capture variations and equity issues (Hennessy et al., 2022).
Policy–practice gap – Inconsistent translation of ICT policies into classroom practice.	Teachers’ willingness to adopt DSAT may not be sufficient without systemic support.	Comparative policy–practice analyses to examine alignment between national ICT strategies and classroom realities.
Self-reported data reliance – Questionnaires and interviews subject to bias (social desirability, under-reporting).	Risks misrepresenting actual ICT use and attitudes.	Triangulate with classroom observations, digital-trace data, and mixed-methods designs (Lee & Kizilcec, 2020).
Cross-sectional design – Data captured at one time point only.	Limits understanding of how ICT practices evolve.	Employ longitudinal designs to examine changes in teacher practice and attitudes over time (Tondeur et al., 2017).
Discrepancies between data strands – Some themes (privacy, workload) appeared in interviews but not in surveys.	Indicates limited complementarity between methods.	Strengthen mixed-methods integration through iterative loops between qualitative and quantitative phases (Creswell & Clark, 2023).
Prototype stage of DSAT – Not piloted or validated; some features aspirational.	Current contribution is conceptual, not yet practical validation.	Undertake iterative DBR cycles: prototyping, piloting, usability testing, and scaling (Luckin & Cukurova, 2019).
Small qualitative sample – Rich insights but limited representativeness.	Restricts transferability across Ghana’s diverse teaching population.	Expand to multi-site qualitative case studies and national surveys to validate and broaden findings.
Framework adaptation – TPACK, TAM, and DOI insufficiently capture LMIC-specific constraints.	Classical models miss contextual, infrastructural, and socio-cultural realities.	Develop hybrid or context-specific theoretical models incorporating equity, feasibility, and institutional support (Venkatesh et al., 2016; Hennessy et al., 2022).

### 5.2.3 Innovation

The main innovation of this study is the creation of the Prototype Digital Self-Assessment Tool (DSAT) which is based directly on the opinions and concerns of Ghanaian primary-school educators and representatives of the Ghana Education Service (GES). Unlike the traditional top-down, externally imposed design of the conventional professional-development interventions, the DSAT is a bottom-up design, which is based on the realities of professional practice by practitioners. Such a direction can be connected to a growing body of literature on educational design in low- and middle-income nations (LMICs) that promotes co-design and contextual responsiveness as the fundamental conditions of digital innovation sustainability (Jita, 2024). The DSAT integrates the knowledge of three complementary models, including:

- a. TPACK (Mishra & Koehler, 2006) with emphasis on the interaction between areas of teacher knowledge;
- b. TAM (Davis, 1989), the theory of the influence of perceived usefulness and ease of use on adoption; and
- c. DOI (Rogers, 2003), which puts technology adoption in larger institutional and social contexts (García-Avilés, 2020).

The DSAT builds on a multidimensional approach towards conceptualizing ICT adoption in primary schools by integrating these models. The novelty of the Digital Self-Assessment Tool is particularly noticeable in the context of comparison with the long-standing teacher competency and self-assessment models like the DigCompEdu provided by the European Union and the ICT Competency Framework of Teachers (ICTCFT) offered by UNESCO. Although these frameworks offer holistic, standardized reference points of what teacher digital competence is, they are largely intended as a policy and assessment reference tool, as opposed to a reflective, practitioner-focused

system. In comparison, the DSAT is conceived as a prototype of formative, self-diagnostic translation of competency frameworks that transforms them into an interactive and teacher-centered reflective process. Instead of comparing teachers with externally set standards of proficiency, the DSAT focuses on self-awareness, individual goal-setting, and professional development in contextually limited settings.

Furthermore, unlike DigCompEdu and ICT-CFT developed with a large-scale international applicability in mind, the DSAT is specifically situated within the infrastructural, pedagogical, and institutional realities of the Ghanaian primary schools. This contextual basis allows the tool to operationalize the global competency expectations in ways that are significant as well as practical to teachers working in low-resource environments. Based on this, it is posited that the DSAT is complementary to international frameworks and not competing with them, as it offers a way by which such standards can be interpreted and implemented locally.

The innovation of the DSAT can be interpreted to be working on two complementary planes. On the micro level, the tool is designed to help teachers explore their ICT competencies and develop individualized learning goals and self-guided professional growth. The design is based on the adult learning theories that emphasize the autonomy, relevancy, and applicability in real world (Rajput & Sharma, 2025). On the macro level, the DSAT would potentially provide school leaders, policymakers, and ministries of education with a diagnostic platform that would help them to determine gaps in competencies, support targeted professional development programs, and make evidence-based decisions. These system level functions are conceptually aligned with the digital maturity models that are used in global educational reform (Michel & Pierrot, 2024). The conceptualization of the DSAT, which is a teacher-informed and evidence-based prototype, is also a form of design innovation, though the prototype has not been piloted or refined yet. The

instrument is placed in the context of design-based research (DBR) to illustrate how theory, empirical evidence, and contextual realities could be combined to shape the creation of educational technologies that are responsive to local demands (Scott et al., 2020). The DBR is of specific relevance in West African contexts in the attempt to match the innovation with the complex educational realities (Akindele, 2025).

In general, the innovation explored in this paper is not confined to the development of the DSAT prototype; it is also in its potential as a model that can be replicated and customized to suit other education systems that face similar challenges. The research adds to the theoretical literature on educational technology development and proposes recommendations related to the development of effective strategies to assist in the implementation of ICT integration in resource-limited schools by advancing a teacher-driven, theoretically based, and contextually relevant tool (El-Hamamsy et al., 2024).

#### **5.2.4 Recommendations**

Directly based on the empirical results of the study, as well as on the implications presented earlier in this chapter, this section outlines a set of recommendations, which are structured to enhance the ICT integration in Ghana's primary schools and enable the responsible development of the Digital Self-Assessment Tool (DSAT). The recommendations are structured into two domains, which are interrelated. The first is more practical and policy-based in its applications, providing a working solution to infrastructural, professional, and institutional challenges developed during the study. The second area is the theory-driven hypothesis and future research plan needed to test and generalize the findings of the study. The key to these recommendations is the DSAT, which is proposed as a research-based prototype that aims to explain how teacher self-assessment can be used to facilitate reflective professional practice in low-resource settings. Since

the tool is yet to be piloted or empirically tested, suggestions regarding the DSAT focus on iterative testing, context refinement, and policy alignment as opposed to scale testing.

#### ***5.2.4.1 Recommendations for Application***

The present subsection outlines practice- and policy-based recommendations that are the direct results of the empirical data of the current research. The recommendations are presented within the context of major stakeholders, such as policymakers, school leadership, teacher educators and development partners, and structured around important areas that regulate the incorporation of information and communication technology (ICT) in primary education. Such areas include infrastructural capacity, professional development of teachers, institutional support, data governance, and responsible development of the Digital Self-Assessment Tool (DSAT) as a research-based prototype. The recommendations in general aim to alleviate the short-term systemic limitations and promote sustainable context-based solutions to digital innovation in Ghana's primary schools.

#### **1. Enhancing ICT Infrastructure as an Enabling Environment**

The results confirm that poor ICT infrastructure has continued to be a significant impediment to teacher adoption of digital tools in teaching. Inconsistent power supply, low internet connectivity, and access to ineffective devices were repeatedly cited as a hindrance to the use of ICT. These findings support the wider findings of Sub-Saharan Africa, where the infrastructural fragility is emphasized as a key factor of digital adoption in education systems (Adarkwah, 2021). Policy and development processes must therefore focus on systemic infrastructural development as opposed to individual hardware supply. It is necessary to invest strategically in stable power solutions, low-cost connectivity, and locally available locally. Contextually relevant options to minimize inter-school disparities in the Ghanaian setting may involve collaborating with

telecommunication companies and energy agencies, such as solar-powered solutions to schools in rural and peri-urban areas (Mustafa et al., 2024).

## **2. Teacher Capacity of Sustained Professional Learning**

The results reveal that the lack of digital skills and the lack of pedagogical readiness remain an obstacle to ICT-based integration among primary school teachers. This aligns with previous studies in similar settings (Kafyulilo et al., 2016; Boateng, 2022), which posit the need to have continuous, contextually specific professional development, instead of brief trainings. Professional Learning Communities (PLCs) represent a rather promising tool in entrenching ICT-related professional development into the daily practice of teachers. PLCs facilitate collaborative learning, peer mentoring, and working together on the same problem, thus contributing to the sustainability of professional development initiatives (Darling-Hammond et al., 2017). These programs must be supplemented by the introduction of ICT-oriented courses into preservice teacher training and organized mentoring and coaching of in-service teachers.

## **3. Piloting and Refinement of DSAT Prototype**

The DSAT is a key design product of this study, but it is a formative prototype and not a tested intervention. In line with this, structured piloting and iteration refinement should precede any action that may lead to increased adoption. An appropriate methodological framework, which would allow this process to be implemented, is design-based research (DBR), which allows implementation, feedback, analysis, and redesign cycles in real school settings (Ifenthaler & Yau, 2020). The usability, clear navigation, perceived relevance and the workload implications on teachers should be the areas of initial pilot studies. Future versions can experiment with sustained engagement patterns and the possibility of incorporating reflective capabilities (e.g. goal-setting and feedback) in the long-term.

#### **4. Usability and Accessibility in Refining DSAT**

To ensure the prototype of the DSAT can remain responsive to the needs of teachers, its constant improvement should focus on its usability and accessibility. Studies have proven that perceived ease of use and relevance are powerful factors that determine teacher use of digital tools (Teo, 2019). The design solutions must focus on mobile-first and offline-capability, as smartphone access is common in most schools in Ghana, and internet connectivity is widely unstable (World Bank, 2021). Onboarding can be structured with embedded guidance and reduce user anxiety, as well as increase uptake (Kemp et al., 2022). Individual teacher motivation and reflective practice can also be supported by personalization features that are aligned with personal professional goals (Panadero, 2017).

#### **5. Fostering Teacher Motivation with Institutional Culture and Recognition**

The paper identifies teacher motivation as one of the most important variables affecting ICT adoption. Digital badges, certificates, or professional recognition are among other recognition mechanisms that could strengthen engagement when integrated into an institutional culture that is supportive (Ryan & Deci, 2021). Nonetheless, these incentives must be used to supplement, and not substitute, collaborative learning networks like mentoring and PLCs. Schools' ought to create cultures that promote the exploration of ICT, and professional learning should be based more on a continuous process than on a measure of performance.

#### **6. Developing Data Literacy to make Informed Decisions**

Lack of knowledge about the use of data-driven decision-making has become one of the hindrances to the successful use of digital tools. To achieve the optimal value of DSAT-generated knowledge, school and system-level data literacy development is required (Mandinach & Gummer, 2016). The teachers and leaders of schools should be trained in how to interpret simple

analytics, make patterns, and use feedback to develop professionally. More complex data skills are needed at district and policy levels to incorporate the insights into the planning of professional development and ICT policy implementation.

## **7. Data Security and Transparency**

Issues of data privacy and security were evident among participants and were possible barriers to adoption. The future implementation of the DSAT prototype should then entail clear and transparent data governance policies. The process of data collection, data storage, data access, and data anonymization should be clearly communicated to the teachers. It is necessary to align data practices with the established international standards and place them in the context of the Ghanaian regulatory framework to gain trust and legitimacy (Livingstone & Stoilova, 2021).

## **8. Reducing the Gap between National Education Policies and DSAT Development**

To have institutional legitimacy, the further development of the DSAT prototype should be associated with national policy on digital education and the professional growth of teachers. Consistency with schemes like the ICT in Education Policy and Continuous Professional Development schemes in Ghana would aid in coherence and persistence (Tondeur et al., 2021). The Ghana Education Service (GES) and the National Council for Curriculum and Assessment (NaCCA) are good examples of important institutional players that can take the role of strategic champions by assisting in agency integration, curriculum alignment, and coordination. Policies may also help to access funding, technical assistance, and scalability in the long term and reduce the risk of the so-called pilot project syndrome (Trucano, 2019).

### ***5.2.4.2 Discussion of Hypotheses and Future Research Directions***

The current study was designed in the form of research questions, in place of formal hypotheses, which was a choice and a purposeful decision in terms of the exploratory nature of the

study. The exploratory and descriptive methodological paradigms are especially suitable in those environments where the available empirical data is minimal, since they allow mapping the variables, interconnections, and the surrounding conditions, which later are then followed by the hypothesis-based analysis (Creswell & Creswell, 2017). Regarding the incorporation of information and communication technology (ICT) and digital self-assessment into Ghanaian primary schools, the lack of previous empirical studies on the use of instruments like the DSAT made research-question-focused a necessity. This position is consistent with the stance by Ifenthaler and Yau (2020), who argue that new educational technologies tend to be exploratory in nature before engaging in the actual causal analysis. Nonetheless, the findings of the current study form a substantive empirical framework for subsequent hypothesis-led research. Strictly recording the current state of ICT integration, examining the perceptions and attitudes of teachers, and outlining design-relevant determinants, the research produces a range of theoretically resonant propositions, which can be further empirically validated in future study.

Future research has the potential, e.g., to focus on the causal relationships between ICT integration and student learning outcomes. This study placed more emphasis on teacher readiness and design-related aspects, but experimental or quasi-experimental designs would enable researchers to determine whether systematically implemented ICT use leads to a quantifiable increase in literacy, numeracy or problem-solving skills (Cheung et al., 2021). Further assumptions can be built related to teacher motivation and the adoption of technology. Based on the self-determination theory, future studies might consider the idea of whether intrinsic motivators (autonomy and mastery) or extrinsic motivators (recognition and certification) have a stronger impact on continued use of digital self-assessment tools (Ryan & Deci, 2024).

Leadership and organizational capacity also present possible points of testing a hypothesis. Future research can identify whether data-sophisticated school leadership mediates the relationship between the use of digital self-assessment and the planning of professional development. As an example, the schools in which leaders actively utilize the analytics based on DSAT seem to implement more focused strategies of resource allocation and professional development.

Equity-based hypotheses are also justified. Future studies might consider assessing whether specific infrastructural interventions, including solar-powered ICT facilities in rural schools, can mitigate differences in the adoption and use of ICT and, thus, promote the goal of inclusive education in line with SDG 4 (Antoninis et al., 2023).

Lastly, design-oriented hypotheses can also examine the influence of specific technical features on adoption and continued usage. Comparative studies would be able to establish whether mobile-first or offline-capable designs have better uptake in comparison to traditional web-based platforms in low-resource settings. Despite the literature confirming usability as a reasonable predictor of adoption (Davoodi et al., 2020; Kemp et al., 2022), it is still essential to empirically support the prediction under local conditions. By distinguishing between exploratory research and hypothesis-driven inquiry, future research can be more than descriptive mapping, but it should eventually develop into the framework of explanatory and predictive model building. This methodological advancement is essential to the development of theory, the development of a policy based on evidence, and the subsequent scaffolding of digital self-assessment instruments based on sound empirical data.

#### ***5.2.4.3 Summation of Recommendations***

Overall, the recommendations in this section are structured in two mutually reinforcing areas: recommendations for application, and discussion of hypotheses and future research

directions. Collectively, these areas would bring the empirical results of the study to the level of practical advice and a prospective agenda of academic research.

The application recommendations underscore the need to have a well-coordinated system-wide solution to enhance ICT integration within Ghanaian primary schools. Among the top priorities are the advancement of basic infrastructure, long-term and collaborative professional development of teachers, data literacy, and the development of explicit data governance patterns to promote the development of trust in digital tools. The Digital Self-Assessment Tool (DSAT) will fall under the category of a research-based form tool within this domain. The recommendations associated with the DSAT are not based on the implementation of the DSAT at scale but on careful piloting, gradual refinement, improvement of usability and accessibility, and relating it to national policies on education. These applied recommendations are further elaborated in the discussion of hypotheses and future research directions, which present the avenues for further development of empirical and theoretical knowledge. This latter area establishes the extent of the exploratory findings of the study to be used in constructing hypothesis-based research, such as the establishment of causal links between ICT adoption and other factors, such as teacher motivation, leadership practices, equity, and design characteristics of digital self-assessment tools. Through these differentiations between exploratory inquiry on one hand and explanatory and predictive research on the other, this part gives a systematic transition between the already present prototype phase and the subsequent validation and proof of theory. Collectively, the two domains of recommendations provide a balanced roadmap, which can support the immediate enhancement initiatives at the same time, establishing the groundwork for conducting highly grounded research in the future. This dual emphasis makes sure that ICT integration efforts and further elaboration of

the DSAT would be context-driven and accountable empirically, hence leading to sustainable digital transformation in the primary education system of Ghana.

### **5.2.5 Conclusions**

This study examined the current state of ICT integration practices in Ghana's primary schools and developed an empirically supported and theoretically based prototype of a Digital Self-Assessment Tool that aimed at assisting teachers in assessing and enhancing their technology-enhanced teaching competencies. The study was guided by four research questions that sought to explore current ICT practices, the perceived factors that could influence teacher perceptions and attitudes towards adopting a DSAT, teacher-informed design requirements of a DSAT, and processes by which a DSAT prototype could be created to align with the educational context of Ghana, but informed by the established conceptual frameworks. By answering these questions, the research generated an empirically based understanding of the disproportionality of ICT integration in primary schools and, at the same time, created a context-sensitive DSAT prototype based on the professional needs of teachers.

The DSAT design, based directly on the study findings, presents how the systematic use of empirical evidence in the development of digital tools can help to better match classroom realities and increase the chances of contextual relevance and uptake. Although there is a growing importance on information and communication technology in the educational policy framework in Ghana, the dissemination of the policy guidelines to the classroom is disproportionate. Systemic infrastructural shortcomings, lack of equal opportunities to professional growth, and sociocultural contingencies continue to influence the real implementation of ICT.

Despite the existing body of literature focusing on the potential of ICT to help enhance learner engagement, curriculum differentiation and higher-order thinking capabilities, this benefit

depends on teacher preparedness, institutional support, and long-term capacity-building programmes. It is in this dual context of opportunity and restraint that the present study provides empirically informed perspectives on the role of ICT integration in the context of primary-education and suggests a new, teacher-centered way of digital engagement improvement using the DSAT prototype.

Three complementary models: TPACK, TAM, and DOI were used as theoretical frameworks in the study. All the frameworks provided useful insights into the exploration of different dimensions of adoption: TPACK explains the interplay between content, pedagogy, and technological knowledge; TAM explores the perceived ease of use and perceived usefulness; and DOI explores the social diffusion of innovation. However, the findings revealed that even though the analytical strength of these frameworks is significant, their application requires contextualization to achieve a sufficiently high degree of representational fidelity that has the potential to capture the realities of Ghanaian classroom environments. Structural barriers, the existing cultural values of technology, and gaps between policy mandates and practice made a difference in adoption patterns in ways that the original constructs could not well capture.

#### ***5.2.5.1 Contribution to Knowledge***

The study provides three main contributions to academic literature in the areas of educational technology, information and communication technology integration, and teacher professional development in resource-limited contexts. These contributions are theoretical, methodological, and empirical, all of which are based on the mixed-methods design and design-focused approach of the study.

### **1. Theoretical Contributions**

The research contributes to theory by placing existing theories of technology adoption and integration, TPACK, TAM, and DOI, in the context of Ghanaian primary education, an environment with infrastructural limitations, institutional inequities in support, and relatively few opportunities to enhance professional development. Although these frameworks are widely used in scholarly research on educational technology, they have been studied largely in high-resource settings. The present analysis shows that:

1. TPACK operationalization is mediated by institutional and structural constraints,
2. Positive attitudes measured by TAM do not lead to adoption in the case of non-enabling conditions, and
3. Diffusion patterns that could be related to DOI are conditional on the presence of institutional support in limited resource systems.

Instead of overlooking these frameworks, the current research proves the argument that these can be recalibrated and viewed in the relational context, thus reaffirming the idea of advocating theoretical pluralism and situational specifics in educational research that are undertaken in lower- and middle-income countries. In that way, the research contributes to the body of literature that emphasizes the limitations of context-neutral theoretical frameworks when trying to explain the integration of information and communication technologies in the context of foundational education.

## **2. Methodological Contributions**

The study contributes in the methodological sense that convergent mixed-methods research can be synergized with design-oriented inquiry to transform empirical results into a research-informed prototype. The methodology offers a feasible methodological way through which

solution-based research can be conducted in resource-limited contexts, whereby full design-based research cycles might not be feasible. The study also contributes by:

1. Conforming data collection instruments to realities of infrastructures and contexts without loss of rigour, and
2. Integrating theoretical models at instrument design and analysis levels.

This approach to methodological integration demonstrates that empirical inquiry and formative design may be programmatically integrated to provide a model that is transferable to educational technology research in other low-resource settings.

### **3. Practical Contributions**

Empirically, the study provides context-specific information about ICT integration practice, teacher perception, and professional development requirements in Ghanaian primary schools, which have been very limited in terms of empirical research. These results fill a reported gap in ICT adoption research in low-resource primary education. In practice, the study presents the Digital Self-Assessment Tool (DSAT) as a research-driven prototype to demonstrate the ways through which teacher self-assessment and reflective practice may be incorporated into the more general ICT integration work. The DSAT has not been piloted or validated, but its conceptual design illustrates how empirical evidence, as well as theory, can be translated into a formative artefact that can help educators to act as agents and reflect on their practice.

Collectively, these contributions enhance the knowledge on the concept of ICT integration in low-resource primary education systems and give new conceptual and methodological background to future research, piloting, and development according to policy. By extension, the study not only adds to the body of knowledge but also to the contextual-response design of enhancing digital transformation in primary school education.

### *5.2.5.2 Final Wrap-up*

This research touched on a crucial problem in the basic education system in Ghana related to the continuous lack of congruency between the national ICT policy goals and objectives and the realities of ICT empowerment in the classroom setting in primary schools. Based on this, the study had two aims: firstly, to examine the current situation regarding the use of ICT in Ghanaian primary schools; secondly, to develop a conceptually informed Digital Self-Assessment Tool (DSAT) prototype, based on factual evidence and existing theoretical models. The pursuit of empirical inquiry and design-oriented inquiry allowed the researcher to provide systematic data in addition to formative responses to the issues that surround teacher ICT adoption in low-resource learning environments.

The study used a convergent mixed-methods design, which merged quantitative and qualitative data to study the ICT practices, perceptions, and the conditions of professional development among teachers. The findings show that though the teachers usually saw the instructional potential of ICT, their integration was limited by infrastructural barriers, intermittent access to long-term professional development opportunities, and institutional and workload requirements often hindered effective integration. Although the Technological Pedagogical Content Knowledge framework, the Technology Acceptance Model, and the Diffusion of Innovations theory offered significant analytical perspectives, the research showed that those frameworks need to be interpreted within contexts to explain the structural and organizational variables affecting adoption in practice. These findings informed the study to proceed with the design of a teacher-informed DSAT prototype based on empirical evidence and guided by theory. The prototype explains how research outcomes can be translated into design requirements that

consider the classroom realities, professional learning requirements, and design contextual constraints.

In line with the extent of the study, the DSAT is shown as a proof of concept instead of a validated intervention. It intends to illustrate and prove the effectiveness of a reflective, self-assessment-based strategy in supporting teacher ICT competence, and to offer grounds by which further piloting, refining, and assessment may be established. The study is thus multi-layered in terms of its contributions. It empirically buttresses the scanty evidence on the integration of ICT in primary education in Ghana. In theory, it justifies the necessity of contextual application of formal ICT adoption frameworks. In terms of methodology, it also shows how design-oriented outputs can be integrated with mixed-methods research to produce knowledge that is relevance to practice. In practice, it suggests a teacher-oriented design model that focuses on the area of professional development on contextual realities as opposed to prescriptive methods.

To sum up, this research does not purport to address the challenges of ICT integration in primary educational settings. Instead, it offers an empirically based background to further research, policy formulation, and design-based research. Focusing on teacher experience, systemic constraints, and contextually responsive DSAT prototype development, the current study is a contribution to the ongoing attempts of enhancing the sustainability and meaningfulness of digital transformation in the primary education system in Ghana and other contexts of low resource availability.

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## APPENDICES

## Appendix 1: UREC Final Approval



UREC Decision, Version 2.0

**Unicaf University Research Ethics Committee  
Decision****Student's Name: Bernice Yawa Tsitsia****Student's ID #: R1703D2510866****Supervisor's Name: Dr Joyce Wangui Gitau****Program of Study: UU-PhD-INTEC-900-3****Offer ID /Group ID: O59686G61158****Dissertation Stage: DS3****Research Project Title:****Digital Self-Assessment Tool for Promoting Teachers' TPACK and its Influence on ICT  
Integration in Teaching in the Ghanaian Primary Schools****Comments: No comments.****Decision\*: A. Approved without revision or comments****Date: 23 May 2023**

\*Provisional approval provided at the Dissertation Stage 1, whereas the final approval is provided at the Dissertation stage 3.  
The student is allowed to proceed to data collection following the final approval.

## Appendix 2: GES Approval Letter

### GHANA EDUCATION SERVICE

*In case of reply the number and date of this letter should be quoted.*

My Ref. GES/VR/TJ30  
Your Ref. No.....



REPUBLIC OF GHANA

REGIONAL EDUCATION OFFICE  
P. O. BOX 46,  
HO,  
VOLTA REGION

18<sup>th</sup> July, 2023

#### **RE: PERSONNEL RECRUITMENT FOR A STUDY**

Management of the Volta Regional Directorate of Education writes to permit **Miss. Bernice Yawa Tsitsia** of Peki College of Education to involve some Selected GES Personnel in conducting a PhD Research.

The research topic is: **Digital Self-Reflection Tool for Promoting ICT Integration in Teaching in the Ghanaian Primary Schools.**

The Selected GES Personnel to assist in the Research Work are:

1. Professional Teachers/Headteachers
2. HR Managers
3. SISOs
4. IT Officers/Coordinators
5. ICT Teachers

It is the expectation of Management that the Researcher will be given the necessary assistance to ensure the success of the research.

It is also expected that the research will be conducted within the approved guidelines of the Ghana Education Service.

Thank you.

  
**FRANCIS YAW AGBEMADI**  
REGIONAL DIRECTOR  
VOLTA

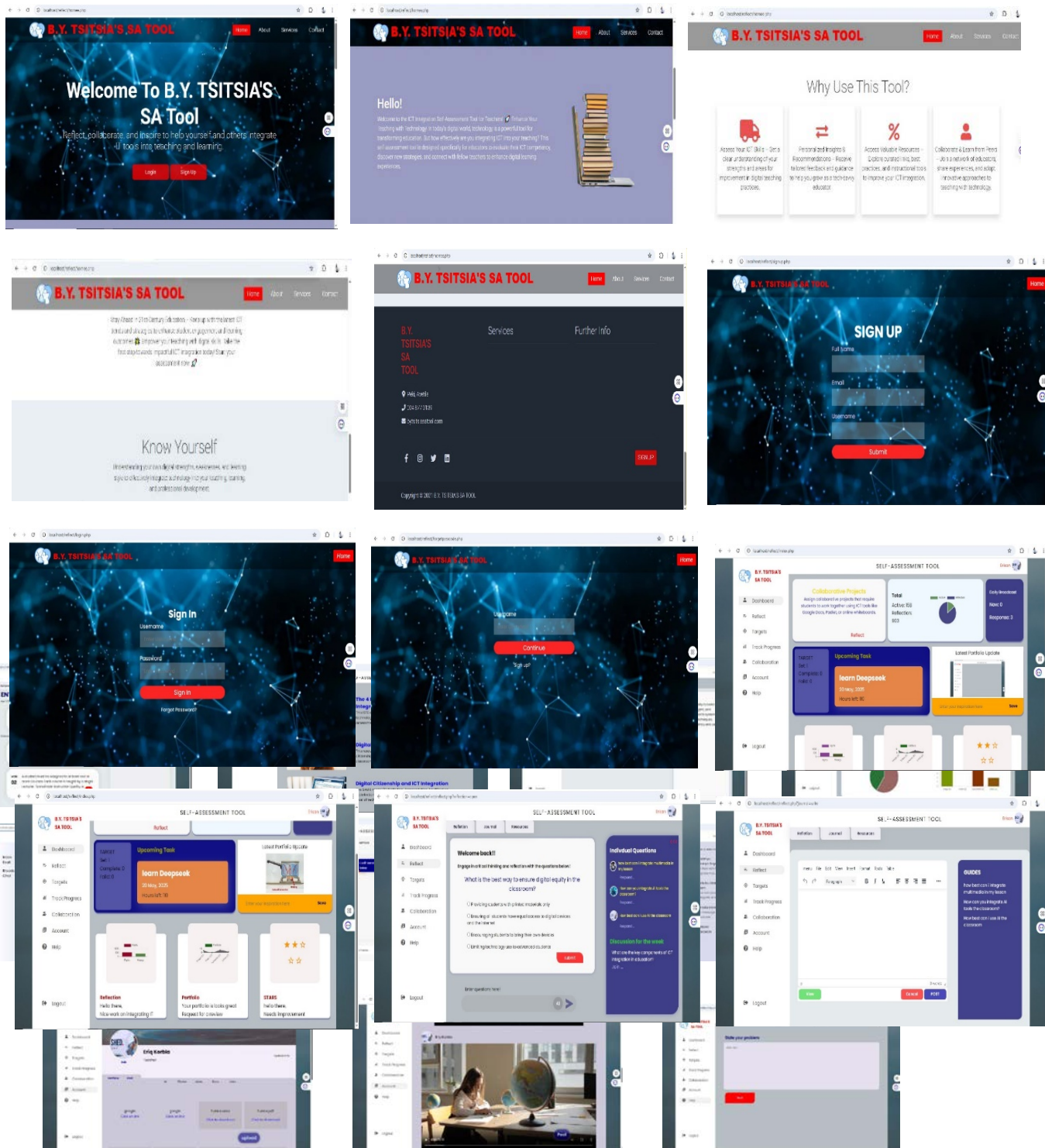
MISS BERNICE YAWA TSITSIA  
PEKI COLLEGE OF EDUCATION  
PEKI

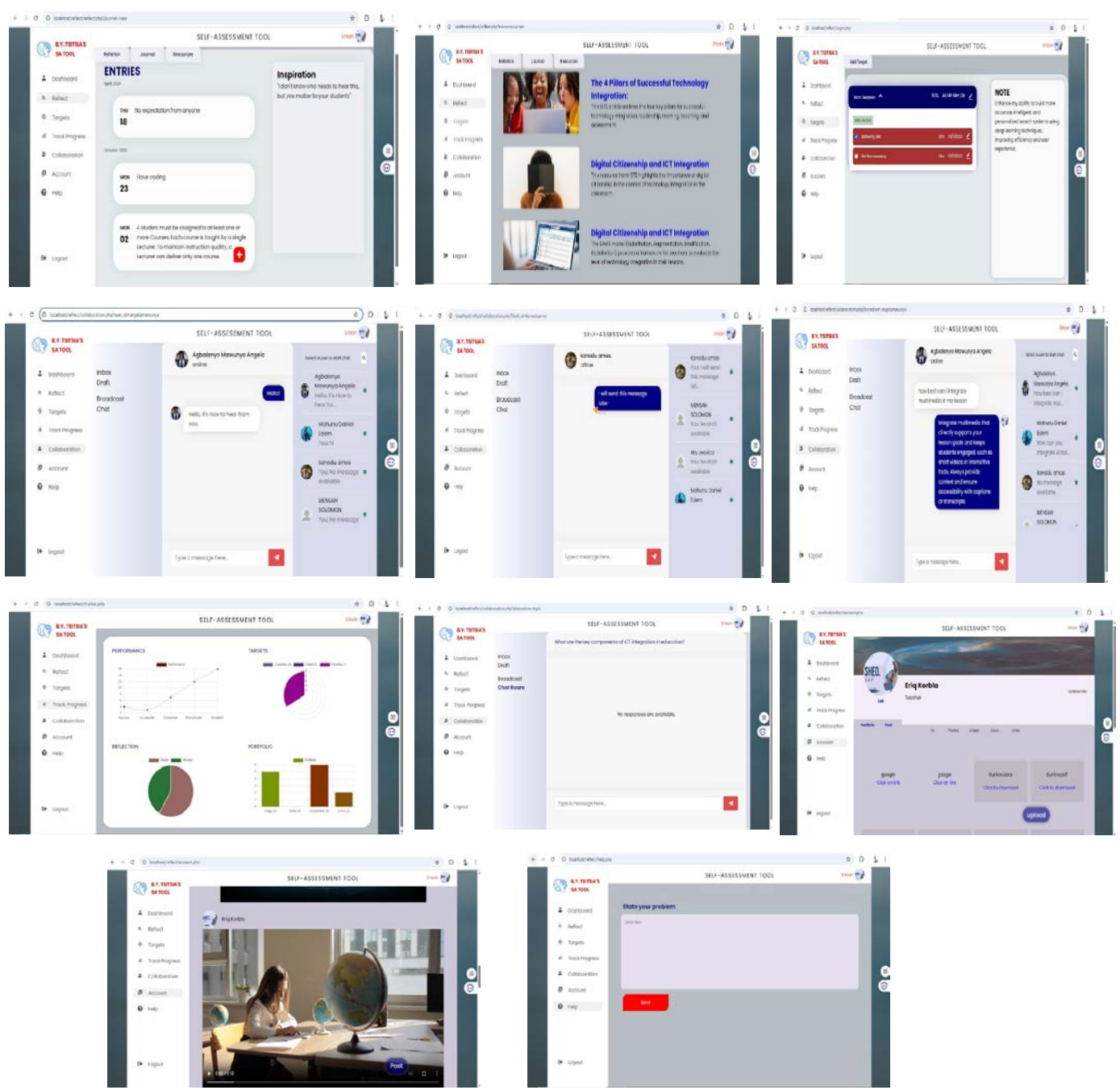
cc: Municipal/District Directors, GES, Volta

\*\*LJ\*\*/BJ

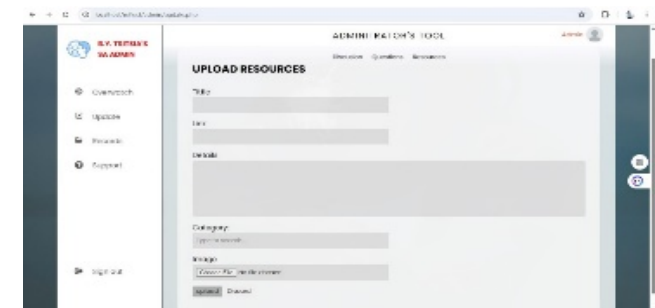
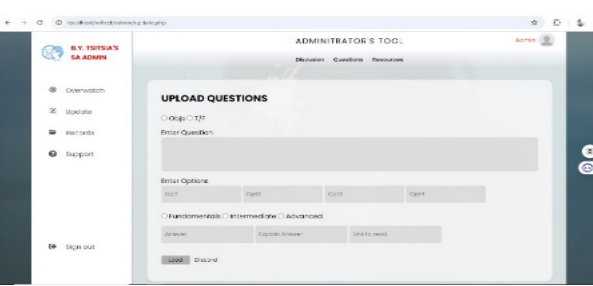
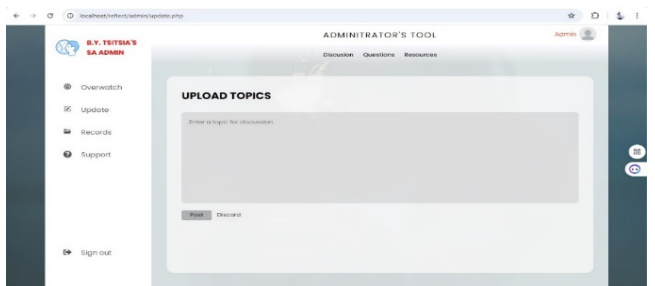
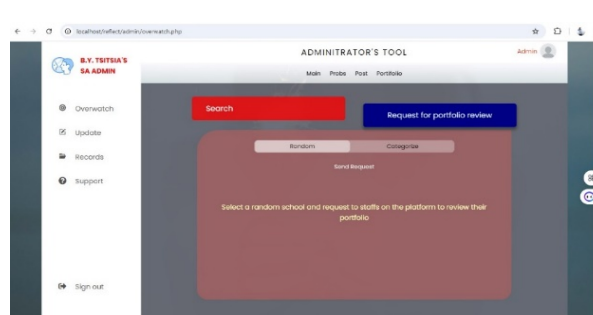
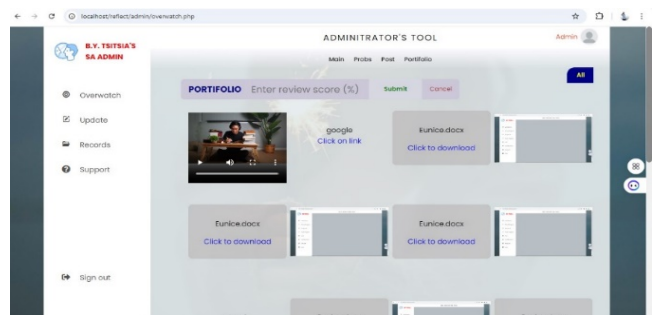
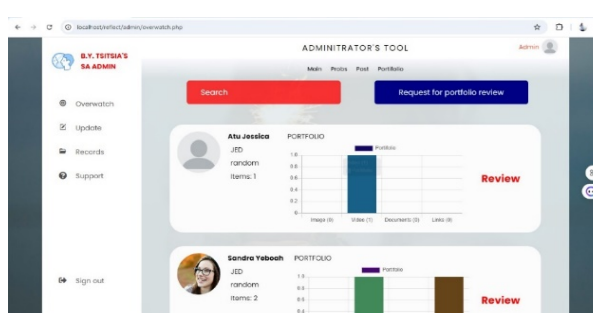
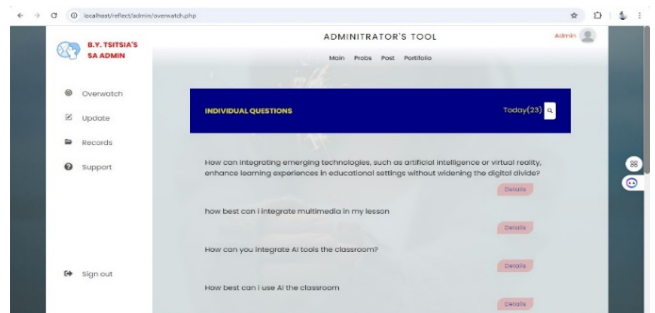
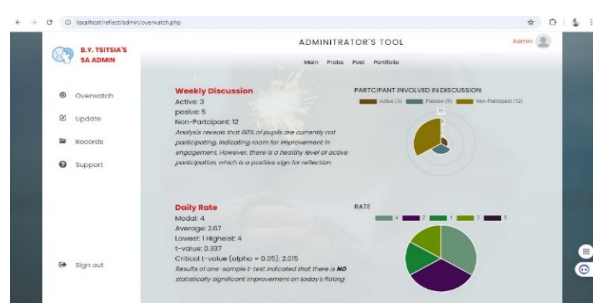
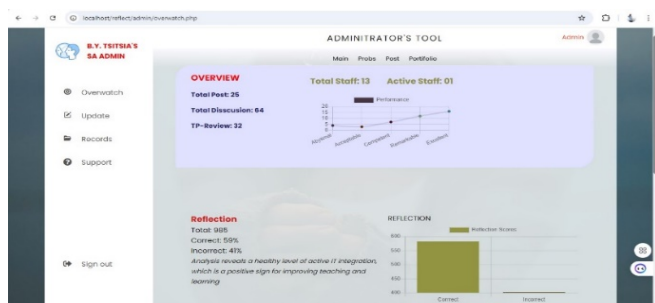
# Appendix 3: DSAT Prototype UI Surface

## B. Interface of DSAT Developed - USER





### C. Interface of DSAT Developed - ADMINISTRATORS



### **DSAT Usability Considerations and Future Evaluation**

The Digital Self-Assessment Tool (DSAT) that is introduced in the current appendix is a prototype interface that was created to demonstrate a flow, layout, and user interaction, but not a fully validated system. Based on this, no formal usability testing with end users was conducted in the context of this study, which can be explained by the fact that the study design is based on the design-oriented research paradigm, where conceptual design and contextual relevance are more important than summative assessment at this point. The iterative design-based research process with prospective users might be conducted to determine the usability of the DSAT in the future. These assessments can include task-based usability testing to evaluate how easy to use the navigation and the prompt clarity and time-up, think-aloud studies to obtain the reasoning of the users during the interactions, and post-use surveys to understand the perceived usability, usefulness, and satisfaction. Qualitative feedback might be further enhanced by usage analytics: completion rates and interaction patterns. These techniques would result in the systematic optimization of the DSAT interface and user experience (when incorporated in piloting) to make sure that the tool is user-friendly, convenient, and adaptable to the requirements of the teachers who will work in the low-resource environments of the primary-school setting.

## Appendix 4: Data collection Tools

### 1. QUESTIONNAIRE

#### QUESTIONNAIRE

You are invited to complete the following questionnaire on the topic: **Digital self-assessment tool for promoting ICT integration in Ghana's Primary Schools**. The study is being conducted by BERNICE YAWA TSITSIA, A PhD. Doctor of Philosophy - Information Technology student, at the UNICAF University Malawi (UUM). E-mail Address: berniceyawa@rocketmail.com. Supervisor's Name: DR. JOYCE GIKANDI-GITAU. The purpose of this study is to provide insights into the current level of ICT integration in the primary schools of Ghana and to develop a digital self-reflection tool to enable the teachers' evaluate their progress and use of technology in teaching.

The significance of the study lies in its potential to enhance ICT integration, empower teachers, support professional development, contribute to educational research, support policy making, contribute to the broader research landscape in the field of ICT integration in Ghanaian primary schools and bridge the digital divide in Ghanaian primary schools. Ultimately, it aims to improve the quality of education by leveraging technology effectively in the teaching and learning process.

The potential participants for the study are classified into two categories these are: Ghanaian primary school teachers and head teachers who have experience integrating ICT into their teaching as well as those who may face challenges in doing so, and the GES personnel from the district/municipal offices including: HRM, IT coordinator, and the SISOs. The informed consent of participants will be obtained before they are enrolled in the study.

The researcher (named above) is committed to ensuring participant's voluntarily participation in the research project and guaranteeing there are no potential risks and/or harms to any of the participants. Participants have the right to withdraw at any stage (prior or post the completion) of the research without any consequences and without providing any explanation. In these cases, data collected will be deleted. All data and information collected will be coded and will not be accessible to anyone outside this research. Data described and included in dissemination activities will only refer to coded information ensuring beyond the bounds of possibility participant identification.

#### **Participants Certificate of Consent:**

I have read the foregoing information about this study, or it has been read to me. I have had the opportunity to ask questions and discuss about it. I have received satisfactory answers to all my questions and I have received enough information about this study. I understand that I am free to withdraw from this study at any time without giving a reason for withdrawing and without negative consequences. I consent to the use of multimedia (e.g. audio recordings, video recordings) for the purposes of my participation in this study. I understand that my data will remain anonymous and confidential, unless stated otherwise. I consent voluntarily to be a participant in this study.

I accept to take part in this study.

Tick [] the box inside to indicate your Consent. [  ]

**SECTION A: Respondents Background Information (Select only one option in each case from this section by ticking [√]).**

1. Indicate your Gender:
  - a. Female [ ]
  - b. Male [ ]
  - c. Other [ ]
  - d. Prefer not mention [ ]
2. Select the right box to specify your age range:
  - a. Below 30 years old [ ]
  - b. 31-40 years old [ ]
  - c. 41-50 years old d. [ ]
  - d. 51 years old and above [ ]
3. Number of years working as a teacher. Choose only one option.
  - a. Less than 5 years [ ]
  - b. 5 to 10 years [ ]
  - c. 11 to 20 years [ ]
  - d. 21 and above years [ ]
4. Indicate the level of class you are currently teaching
  - a. Lower Primary [ ]
  - b. Upper Primary [ ]
5. What is your position at your school now?
  - a. Class teacher [ ]
  - b. Subject teacher [ ]
  - c. Head teacher [ ]
6. Indicate your highest qualification
  - a. Cert "A" (3 or 4 year) [ ]
  - b. Diploma in Education [ ]
  - c. First Degree in Education [ ]
  - d. Master's in Education [ ]
  - e. Other (Please Indicate): .....

**SECTION B: THE CURRENT LEVEL OF ICT INTEGRATION AMONG TEACHERS IN GHANAIAN PRIMARY SCHOOLS.**

**RQ1:** What is the current state of ICT integration practices in Ghanaian primary schools?

This section examines the current level of teachers' ICTs integration in Ghana's primary schools. It covers six key thematic areas including: *[ICT Tools used in teaching; challenges in ICT integration; assessment of ICT integration; confidence and expertise with ICT; professional development and support; and teachers beliefs and perspectives on ICT integration.]*

Please rate the following statement under each key area by selecting either: Strongly Agree (SA), Agree (A), Undecided (UN), Disagree (D) or Strongly Disagree (SD).

<b>A. ICT Tools Used in Teaching: I use ..... in teaching.</b>	<b>SA</b>	<b>A</b>	<b>UN</b>	<b>D</b>	<b>SD</b>
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<b>RQ1 A1</b> 1. Learning management systems (e.g., Moodle, Canvas, Blackboard).					
<b>RQ1 A2</b> 2. Presentation software (e.g., PowerPoint, Prezi, Google Slides).					
<b>RQ1 A3</b> 3. Video conferencing tools (e.g., Zoom, Skype, Google Meet).					
<b>RQ1 A4</b> 4. Interactive whiteboards (e.g., Smart Board, Promethean Board).					
<b>RQ1 A5</b> 5. Social media platforms (e.g., Twitter, Facebook, Instagram).					
<b>RQ1 A6</b> 6. Digital assessment tools (e.g. Quizlet, Google Forms)					
<b>B. Challenges in ICT Integration:</b> What are the main challenges you face when integrating ICT into your teaching practices?	<b>SA</b>	<b>A</b>	<b>UN</b>	<b>D</b>	<b>SD</b>
<b>RQ1 B1</b> 1. Lack of access to appropriate technology or software.					
<b>RQ1 B2</b> 2. Limited technical support or training.					
<b>RQ1 B3</b> 3. Limited time to plan and implement technology-rich lessons					
<b>RQ1 B4</b> 4. Concerns about learners' digital literacy and ability to effectively use technology.					
<b>RQ1 B5</b> 5. Limited availability of digital resources and materials.					
<b>RQ1 B6</b> 6. Concerns about the reliability and security of technology.					
<b>RQ1 B7</b> 7. Difficulty in finding appropriate and engaging digital tools that align with the curriculum and learning goals.					
<b>RQ1 B8</b> 8. Resistance to change from learners or colleagues					
<b>RQ1 B9</b> 9. Fear of losing control of the classroom dynamic or the learning process.					
<b>C. Assessment of ICT Integration</b>	<b>SA</b>	<b>A</b>	<b>UN</b>	<b>D</b>	<b>SD</b>
<b>RQ1 C1</b> 1. I assess my ICT integration competency through learners' performances.					
<b>RQ1 C2</b> 2. I assess my ICT integration competency through observing learners' behavior during class.					
<b>RQ1 C3</b> 3. I assess my ICT integration competency through feedback from learners.					

<b>RQ1 C4</b> 4. I assess my ICT integration competency through feedback from my colleagues.					
<b>RQ1 C5</b> 5. I assess my ICT integration competency through analysis of learners' work.					
<b>RQ1 C6</b> 6. I assess my ICT integration competency through surveys and questionnaires.					
<b>RQ1 C7</b> 7. I do not assess myself on ICT integration competency in teaching.					
<b>D. Teacher's Confidence and Experience with ICT:</b>	<b>SA</b>	<b>A</b>	<b>UN</b>	<b>D</b>	<b>SD</b>
1. RQ1 D1: I feel confident in my ability to effectively integrate ICT tools (e.g. computers, tablets, software) into my instruction.					
2. RQ1 D2: I am confident in using basic technology tools (e.g., word processors, presentation software) in my teaching.					
3. RQ1 D3: I feel comfortable troubleshooting technical difficulties when using technology in my lessons.					
4. RQ1 D4: I have sufficient previous experience using ICT for instruction to feel qualified integrating technology.					
5. RQ1 D5: I am confident guiding learners through appropriate online research, evaluation of digital sources, and citation of resources.					
6. RQ1 D6: I am knowledgeable about a variety of educational websites, apps, and platforms that align to my subject area.					
7. RQ1 D7: I am confident in my ability to develop well-designed technology-enhanced learning activities.					
8. RQ1 D8: I actively use online platforms and resources to supplement my classroom instruction.					
9. RQ1 D9: I feel comfortable incorporating multimedia elements (e.g., videos, images) into my lesson plans.					
10. RQ1 D10: I am confident in integrating educational software and apps to enhance my teaching methods.					
<b>E. Level of Professional Development and Support:</b>	<b>SA</b>	<b>A</b>	<b>UN</b>	<b>D</b>	<b>SD</b>
1. RQ1 E1: My school/district regularly offers professional development opportunities on effectively integrating ICT into teaching"					
2. RQ1 E2: I have sufficient opportunities to attend workshops to improve my technology integration skills.					
3. RQ1 E3: Expert trainers have been brought into my school occasionally to provide hands-on ICT integration coaching and development.					

4. RQ1 E4: My school has implemented collaborative initiatives like professional learning communities to foster discussion around ICT teaching practices.					
5. RQ1 E5: My school/district frequently surveys teachers to identify high priority areas for ICT integration training based on needs.					
6. RQ1 E6: My professional development includes hands-on exploration of new education technologies and digital platforms.					
7. RQ1 E7: I have access to an online repository of ICT integration resources and best practices for reference.					
8. RQ1 E8: My school/district covers travel or other costs associated with external ICT integration training programs and workshops.					
<b>F. Teacher's Beliefs and Perspectives on ICT Integration:</b>	<b>SA</b>	<b>A</b>	<b>UN</b>	<b>D</b>	<b>SD</b>
<b>RQ1 F1</b>					
1. ICT integration is important to me in my teaching.					
<b>RQ1 F2</b>					
2. I believe ICT integration positively impacts learners learning outcomes at the primary school level.					
<b>RQ1 F3</b>					
3. I believe the current level of ICT integration in Ghanaian primary schools adequately prepares learners for the digital age.					
<b>RQ1 F4</b>					
4. There are readily accessibility of ICT tools and resources in my school for both teachers and learners.					
<b>RQ1 F5</b>					
5. I believe increased ICT integration in Ghanaian primary schools would require additional investment in infrastructure and resources.					

**Open Ended:**

1. What other additional information do you have on the current level of ICTs integration in teaching in your school?

.....

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.....

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**SECTION C: Design of the Digital Self-Reflection Tool**

This section explores teachers' expectations of the digital self-reflective tool, and the perceived factors that could affect the adoption of the digital tool.

On a scale of 1 to 5, where; 1 is “Strongly Disagree” 2 Disagree” 3 is “Moderately Agree” 4 is “Agree” 5 is “Strongly Agree”, indicate how you would agree on the following statements for the digital self-reflection tool be designed to be user-friendly and accessible for the teachers.

<b>A. RQ 2.</b> How could the digital self-reflection tool be designed to be user-friendly and accessible for Ghanaian primary school teachers?					
To design the digital self-reflection tool to be user-friendly and accessible for teachers in Ghanaian schools:	<b>SA</b>	<b>A</b>	<b>UN</b>	<b>D</b>	<b>SD</b>
<b>RQ2 A1</b> 1. The tool should have a clean and straightforward user interface with clear navigation, making it easy for teachers to access different features of the tool without confusion.					
<b>RQ2 A2</b> 2. The tool should incorporate multimedia elements like images, videos, and audio to cater to different learning preferences and literacy levels.					
<b>RQ2 A3</b> 3. The tool should have responsive design interface and adapts to various screen sizes and devices, including smartphones, tablets, and laptops.					
<b>RQ2 A4</b> 4. The tool should include an offline mode, allowing teachers to use the tool even without an internet connection.					
<b>RQ2 A5</b> 5. The tool should provide clear and concise instructions or tooltips to guide teachers through using the tool effectively, especially for those who may be less familiar with technology.					
<b>B. RQ 3:</b> What features or functionalities should the digital self-reflection tool have to effectively enhance teachers' ICT integration skills?					
Please indicate your level of agreement, on a scale of 1 to 5, where 1 is “strongly disagreed” 2 Disagreed” 3 is “Moderately agreed” 4 is “Agreed” 5 is “Strongly Agreed”, for the digital self-reflection tool to have the following features or functionalities to effectively enhance teachers' ICT integration skills:	<b>SA</b>	<b>A</b>	<b>UN</b>	<b>D</b>	<b>SD</b>
<b>RQ3 A1</b> 1. The tool should include a self-assessment component where teachers can evaluate their current ICT integration skills and identify areas for improvement.					
<b>RQ3 A2</b> 2. The tool should provide reflective prompts or questions to guide teachers in reflecting on their ICT integration practices, challenges, and successes.					

<b>RQ3 A3</b> 3. Teachers should receive personalized feedback and suggestions based on their self-reflection and goals. This feedback could include recommendations for resources, strategies, or professional development opportunities to enhance their ICT integration skills.					
<b>RQ3 A4</b> 4. The tool can incorporate interactive activities or simulations related to ICT integration, allowing teachers to practice and apply their skills in a virtual environment.					
<b>RQ3 A5</b> 5. The tool should provide access to a collection of resources, such as articles, lesson plans, video tutorials, and best practices, to support teachers' professional development in ICT integration.					
<b>RQ3 A6</b> 6. Teachers should be able to track their progress over time, visualizing their growth and improvement in ICT integration skills.					
<b>RQ3 A7</b> 7. The tool should offer opportunities for teachers to connect and collaborate with peers, enabling the sharing of experiences, ideas, and solutions related to ICT integration challenges.					
<b>RQ3 A8</b> 8. The tool should have an intuitive and user-friendly interface, making it easy for teachers to navigate, access features, and engage with the self-reflection process.					
<b>RQ3 A9</b> 9. The tool should integrate online courses focused on ICT usage and innovative teaching methods, helping teachers continuously develop their skills.					
<b>C. RQ4.</b> What are the factors that could influence teachers' perceptions and attitudes towards using the digital self-reflection tool for ICT integration?	<b>SA</b>	<b>A</b>	<b>UN</b>	<b>D</b>	<b>SD</b>
<b>RQ4 A1</b> 1. The availability of adequate technological infrastructure in my school would positively influence my perception of using the digital self-reflection tool for ICT integration.					
<b>RQ4 A2</b> 2. If I receive training or professional development on how to effectively use the digital self-reflection tool, I would be more likely to have a positive attitude towards using it for ICT integration.					
<b>RQ4 A3</b> 3. If the digital self-reflection tool allows for customization and adaptability to my specific teaching context, it would positively impact my attitude towards using it for ICT integration.					

<b>RQ4 A4</b> 4. The recognition and acknowledgement of my efforts in integrating ICT through the use of the digital self-reflection tool would motivate me to continue using it.					
<b>RQ4 A5</b> 5. The availability of comprehensive and relevant self-assessment prompts in the digital self-reflection tool would positively impacts my perception of its usefulness for improving my ICT integration skills.					
<b>RQ4 A6</b> 6. If the digital self-reflection tool provides personalized feedback on my ICT integration progress, I am more likely to have a positive attitude towards its adoption.					
<b>RQ4 A7</b> 7. The user-friendliness and ease of navigation within the digital self-reflection tool would influence my willingness to use it.					
<b>RQ4 A8</b> 8. Having interactive exercises or activities related to ICT integration in the self-reflection tool would enhance my interest in using it for professional development.					
<b>RQ4 A9</b> 9. The inclusion of relevant resources and references to support my ICT integration skill development would increases my motivation to utilize the digital self-reflection tool.					

**Open Ended:**

1. What other suggestion (s) will you provide to aid the development of the digital self-reflection tool?

.....

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**Thank you for Responding to this Survey**

## 2. Interview Questions

### DATA COLLECTION TOOLS

#### GES' INTERVIEW QUESTIONS

You are invited to complete the following questionnaire on the topic: “Digital self-assessment tool for promoting ICT integration in Ghana’s Primary Schools.”

This study is being conducted by BERNICE YAWA TSITSIA. A PhD Doctor of Philosophy - Information Technology student, at the UNICAF University Malawi (UUM). E-mail Address: berniceyawa@rocketmail.com. Supervisor’s Name: DR. JOYCE GIKANDI-GITAU.

The purpose of this study is to examine the current state of ICT integration practices in Ghana’s primary schools and to develop a digital self-assessment tool that could aid the teachers in evaluating their progress and use of technology in teaching.

This study’s contribution to the effective integration of technology into teaching and learning in primary schools in Ghana is significant because it can improve the quality of education and better prepare learners for the digitalization age. The potential participants for the study are classified into two categories these are: Ghanaian primary school teachers who have experience integrating ICT into their teaching as well as those who may face challenges in doing so, and the GES personnel from the district office including: HRM, IT coordinator, and the SISOs. The informed consent of participants will be obtained before they are enrolled in the study.

The researcher (named above) is committed to ensuring participant’s voluntarily participation in the research project and guaranteeing there are no potential risks and/or harms to any of the participants. Participants have the right to withdraw at any stage (prior or post the completion) of the research without any consequences and without providing any explanation. In these cases, data collected will be deleted. All data and information collected will be coded and will not be accessible to anyone outside this research. Data described and included in dissemination activities will only refer to coded information ensuring beyond the bounds of possibility participant identification.

#### **Participants Certificate of Consent:**

I have read the foregoing information about this study, or it has been read to me. I have had the opportunity to ask questions and discuss about it. I have received satisfactory answers to all my questions and I have received enough information about this study. I understand that I am free to withdraw from this study at any time without giving a reason for withdrawing and without negative consequences. I consent to the use of multimedia (e.g. audio recordings, video recordings) for the purposes of my participation in this study. I understand that my data will remain anonymous and confidential, unless stated otherwise. I consent voluntarily to be a participant in this study.

Tick [] the box inside to indicate your Consent.

I accept to take part in this study. [  ]

### SECTION A

### Section A

1. Indicate your Gender:
  - a. Female [ ]
  - b. Male [ ]
  - c. Other [ ]
  - d. Prefer not mention [ ]
2. What is your position in GES?
  - a. HRM [ ]
  - b. Head teacher [ ]
  - c. SISO [ ]
  - d. IT coordinator [ ]
3. How long have you being in that position?
  - a. 0 – 3 years [ ]
  - b. 4 – 6 years [ ]
  - c. Beyond 6 years [ ]

### Section B

1. In your opinion, do you think that the primary school teachers are well equipped with the needed competencies (in terms of technology, pedagogy, content knowledge) to promote effective ICT integration in their classrooms? Explain your view.
2. In your opinion do you believe the teachers' competency and skills in technology, teaching methods, and subject matter can promote effective integration of ICT in teaching? How?
3. Generally, how will you rate the Ghanaian primary school teachers' ICT integration in teaching and learning? (Either: very high, high, low, or very low). Why?
4. In your opinion, what are the factors influencing the teachers' effective ICT integration into teaching and learning in the Ghana's primary schools?
5. Is there any method employed by GES for evaluating the teacher's Level of ICT integration into the teaching and learning? If yes, how is it done?
6. Do you believe that teachers' self-assessment on their own use of ICT to enhance teaching and learning can help them identify their areas of strengths and weaknesses? Why?
7. What other factors do you believe influence the level of ICT integration among primary school teachers in Ghana?

8. How can the government and educational institutions better support teachers in improving their ICT integration skills?
9. On a scale of 1 to 10, where 1 is considered very low and 10 as very high, how will you rate the impact of these factors on the level of ICT integration among primary school teachers in Ghana? Also give a short explanation for your valuation:
  - a. Access to digital technology resources
  - b. Teacher technological knowledge and digital literacy
  - c. Teachers pedagogical/subject methods knowledge
  - d. Teacher content knowledge and mastery in their subject areas
  - e. Teacher training and professional development
  - f. Availability of technical support
  - g. Teacher attitudes and beliefs towards technology
  - h. School leadership support and encouragement
  - i. Collaboration of teachers and sharing of ideas and resources
10. What other thing(s) would you like to suggest that will promote teachers' effective ICT integration in the classroom?

### **Interview Questions (Teachers)**

## **DATA COLLECTION TOOLS**

### **TEACHERS' INTERVIEW QUESTIONS**

You are invited to complete the following questionnaire on the topic: "Digital self-assessment tool for promoting ICT integration in Ghana's Primary Schools."

This study is being conducted by BERNICE YAWA TSITSIA. A PhD Doctorate of Philosophy - Information Technology student, at the UNICAF University Malawi (UUM). E-mail Address: berniceyawa@rocketmail.com. Supervisor's Name: DR. JOYCE GIKANDI-GITAU.

The purpose of this study is to examine the current state of ICT integration practices in Ghana's primary schools and to develop a digital self-assessment tool that could aid the teachers in evaluating their progress and use of technology in teaching.

This study's contribution to the effective integration of technology into teaching and learning in primary schools in Ghana is significant because it can improve the quality of education and better prepare learners for the digitalization age. The potential participants for the study are classified into two categories these are: Ghanaian primary school teachers who have experience integrating ICT into their teaching as well as those who may face challenges in doing so, and the GES

personnel from the district office including: HRM, IT coordinator, and the SISOs. The informed consent of participants will be obtained before they are enrolled in the study.

The researcher (named above) is committed to ensuring participant's voluntarily participation in the research project and guaranteeing there are no potential risks and/or harms to any of the participants. Participants have the right to withdraw at any stage (prior or post the completion) of the research without any consequences and without providing any explanation. In these cases, data collected will be deleted. All data and information collected will be coded and will not be accessible to anyone outside this research. Data described and included in dissemination activities will only refer to coded information ensuring beyond the bounds of possibility participant identification.

**Participants Certificate of Consent:**

I have read the foregoing information about this study, or it has been read to me. I have had the opportunity to ask questions and discuss about it. I have received satisfactory answers to all my questions and I have received enough information about this study. I understand that I am free to withdraw from this study at any time without giving a reason for withdrawing and without negative consequences. I consent to the use of multimedia (e.g. audio recordings, video recordings) for the purposes of my participation in this study. I understand that my data will remain anonymous and confidential, unless stated otherwise. I consent voluntarily to be a participant in this study.

Tick  the box inside to indicate your Consent.

I accept to take part in this study.

**SECTION A**

2. Indicate your Gender:
  - a. Female
  - b. Male
  - c. Other
  - d. Prefer not mention
3. Select the right box to specify your age range
  - a. Below 30 years old
  - b. 31-40 years old
  - c. 41-50 years old d.
  - d. 51 years old and above
4. What is your position at your school now?
  - a. Class teacher
  - b. Subject teacher
5. Number of years working as a teacher. Choose only one option.

- a. Less than 5 years [ ]
- b. 5 to 10 years [ ]
- c. 11 to 20 years [ ]
- d. 21 and above years [ ]

### **SECTION B**

1. What types of digital technology tools do you use in your classroom? And how often do you use these tools?
2. In your opinion, what are the biggest barriers affecting the integration of ICT into teaching in Ghanaian primary schools? What do you suggest will curb the situation?
3. What types of support would you need to improve your knowledge and skills in ICT integration?
4. What do you think are the benefits of using technology in teaching, and in which ways have you seen these benefits in your own teaching?
5. In your opinion, how can the government and school administration better support teachers in improving ICT integration in their teaching?
6. In what ways does your knowledge and competence in teaching methods affect your ICT integration in teaching?
7. In what way does your mastery of the technology have influence on the extent of ICT use in teaching and learning?
8. How does your technology skill either improve or hinder your use of ICT to teach?
9. Do you believe that a teacher's self-assessment on their own use of technology to enhance teaching and learning could help them identify their areas of strengths and weaknesses? Why?
10. What other factors do you believe influence the level of ICT integration among primary school teachers in Ghana?

**Thank you for your time!**