The Exploration of the Digital Literacy Development for Secondary School Teachers in Rwanda: A Review of Literature

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Abstract: **In the era of digital transformation, the development of digital literacy (DL) among secondary school teachers is crucial for fostering digitally skilled and talented students. While Rwanda has prioritized DL through policies such as Vision 2050 and the Smart Education Policy, little is known about digital literacy development among secondary school teachers. This systematic review explores the current state, challenges, and strategies for enhancing digital literacy development among secondary school teachers in Rwanda. Guided by a combination of TPACK and TAM frameworks and Digital Divide Theory. This review followed the guidelines of the Campbell Collaboration and synthesized literature published between 2016 and 2024. The findings indicate that many secondary school teachers in Rwanda have developed a basic foundation of technological knowledge (TK) and a growing awareness of digital skills. However, they remain at an early stage of integrating technology effectively into pedagogy to achieve Pedagogical Knowledge (PK) and Content Knowledge (CK) due to limited training, infrastructure, and socio-economic disparities. Key challenges include: (1) insufficient technological knowledge (TK) and inadequate professional training, (2) limited access to digital resources and infrastructures, (3) challenging working conditions, and (4) a persistent digital divide characterized by skill disparities, gender gaps, and resistance to technological change. The review concludes that effective strategies should involve strengthening digital training programs, fostering public-private partnerships, enhancing community involvement, international cooperation, and fully implementing Rwanda's SMART Education initiatives to improve teachers' digital literacy. Strengthening DL among secondary school teachers is essential for effective curriculum delivery and preparing Rwandan youth for a digital world.**

Keywords: **Digital literacy, Teacher Education, Digital Competence, Digital Divide, Supportive Strategies.**

1. INTRODUCTION

Since the 1980s, integrating technology into education has been a key reform, with educational computing preparing students with essential digital skills for their future jobs. DL has become a foundational competency in 21st-century education, shaping how teachers design instruction and how students engage with knowledge in increasingly technology-driven societies. The rapid advancement of digital technologies has transformed teaching and learning practices worldwide, positioning digital literacy as essential for educational innovation, workforce readiness, and sustainable development. The rapid evolution of 21st-century technological advancements has played an important role in the reform of education towards digital learning. The COVID-19 pandemic further exposed the critical role of digital competencies in ensuring continuity of education, as many education systems struggled to transition to remote and blended learning environments due to limited technological preparedness (Marioni et al., 2020). For instance, many African countries that were left behind in integrating digital literacy into their education systems have struggled to continue school operations online due to limited electricity

and digital resources (Marioni et al., 2020). These disruptions underscored the necessity of equipping teachers with not only basic technological skills but also the pedagogical capacity to integrate digital tools meaningfully into classroom instruction. This has shown most governments around the world the necessity to invest in digital technology within education settings to equip both teachers and students with the digital literacy required to survive in the workplace, during global emergencies, in global competitive markets, and cope with the rapid changes of the 21st-century technological advancement demand (UNESCO IITE, 2022). DL for teachers is seen as a cornerstone for achieving equitable, resilient, and future-oriented education systems.

In Rwanda, the government has prioritized DL integration through policies such as Vision 2050 and the SMART Education Policy, aiming to enhance teaching and learning through technology to achieve quality of education while preparing able and capable 21st-century students for the knowledge-based economy. Rwanda has been regarding digital literacy as a pivotal step to strengthen and equip both teachers and students with the necessary competencies to promote competence-based teaching and learning approaches that match international standards and the needs of society (Republic of Rwanda, 2020). DL was integrated into a competence-based curriculum as part of key performance in Rwanda's education system (MINEDUC, 2016). During the COVID-19 pandemic era, most schools in Rwanda were closed to avoid the spread of the pandemic (MINEDUC, 2020). Rwanda expanded digital learning platforms and broadcast-based education to mitigate school closures, further reinforcing the importance of teacher readiness to integrate digital technologies effectively. These initiatives demonstrate strong political commitment to digital education reform and teacher capacity development. Enhancing teachers' digital competencies to integrate digital literacy into pedagogy is a key to satisfy workforce demand and international education standards while promoting a knowledge-based economic growth (Republic of Rwanda Vision 2020). There has been a formulation of several education policies, such as Education for All, Girls' Education, the introduction of Competence-Based Curriculum, One Laptop per Child in 2008, One Laptop per Teacher, and the introduction of smart classrooms full of computers, projectors, and internet connectivity packages to improve education equity, access, and quality through technology within Rwanda's education system since the 2000s (MINEDUC, 2016).

The government has also been actively investing in digital technology programs and infrastructure in the workplace and is eager to provide training for 100,000 public servants by the end of 2024 (RDB, 2022)

In addition, the Ministry of Education (MINEDUC) and United Nations Children's Fund (UNICEF) have collaborated to develop digital literacy training programs for teachers and promote digital technology integration in education (UNICEF, 2024). Despite these policy commitments and infrastructural investments, evidence suggests that the development of digital literacy among secondary school teachers in Rwanda remains uneven across the districts, particularly within secondary education, where teachers play a critical role in shaping students' technological competencies and preparing them for higher education and future employment in a digital-driven society. While many teachers possess basic technological knowledge and awareness of digital tools, they often struggle to integrate technology effectively into pedagogical practice due to limited professional training, inadequate infrastructure, and persistent socio-economic disparities, particularly between urban and rural schools. According to the International Labor Organization (ILO, 2019), 56.4% of schools have digital access, but teacher training remains inadequate: only 26% have received basic training in digital technology, and 8% have received advanced training for using digital technology in pedagogy. Furthermore, infrastructure limitations such as limited internet connectivity and inadequate access to electricity, particularly in rural areas, significantly hindered effective digital technology integration in education (ILO, 2019).

The digital divide in digital resources and infrastructures underscores the need for purposeful and targeted interventions. Existing studies tend to focus on access to technology or isolated training programs, with limited synthesis of how teachers' technological, pedagogical, and content knowledge intersect in practice. Moreover, there is a lack of comprehensive reviews that integrate teacher attitudes toward technology adoption, structural digital divide factors, and pedagogical integration within the Rwandan secondary education context. This gap constrains evidence-based policymaking and limits the effectiveness of ongoing digital education reforms. To address this gap, this systematic literature review examines the development of digital literacy among secondary school teachers in Rwanda by synthesizing empirical and policy-based evidence published between 2016 and 2024. Guided by the Technological Pedagogical Content Knowledge (TPACK) framework, the Technology Acceptance Model (TAM), and Digital Divide Theory, the review explores three key dimensions: (1) the current state of digital literacy development among secondary school teachers, (2) the challenges teachers encounter in promoting and applying digital literacy in pedagogical practice, and (3) effective strategies for strengthening teacher digital literacy in alignment with Rwanda's national education goals. By consolidating existing

knowledge, this review aims to inform policymakers, educational leaders, and practitioners seeking to enhance digital teaching capacity and promote equitable, high-quality secondary education in Rwanda.

The Aim of the Review

This systematic review aimed to explore DL development among secondary school teachers in Rwanda since 2016 when the government decided to integrate DL in both primary and secondary education (MINEDUC,2016), guided by three research questions:

1. What is the current state of digital literacy development among secondary school teachers in Rwanda?

2. What challenges do secondary school teachers encounter while promoting digital literacy in Rwanda?

3. How can effective strategies be implemented to enhance digital literacy development among secondary school teachers in Rwanda?

2. DEVELOPMENT OF DIGITAL LITERACY IN RWANDA

Quality of education is one of the priorities for Rwanda's government as a means of preparing able and capable students for the knowledge-based economy and social development goals (Mugiraneza, 2021). The government has been integrating digital technology into its education system since 2008, starting with the project of One Laptop per Child (OLPC) as a pivot to improve quality education and equity with the purpose of transforming Rwanda into a knowledge-based economy by the end of 2050 (Republic of Rwanda, 2020). Since then, Rwanda has been launching different digital initiatives, such as smart classrooms with computers and internet connectivity and one-laptop-per-teacher initiatives, to promote digital literacy development among teachers and students to match the 21st-century technological advancement, workforce needs, and dynamic society's needs (REB, 2020). Through its Smart Classroom Initiative launch, the government was aiming to equip both teachers and students with the necessary digital competencies to access digital-driven learning materials by providing digital resources such as tablets, computers, and 4G internet connectivity access (Teta-Ufitiwabo, 2021).

This journey has made Rwanda an important player in the East African Community in promoting digital technologies in education, and it has also become an important example of how low-income countries could implement such a strategic policy in the education system. The government of Rwanda, under its Vision 2020 and 2050 planned development, prioritized the integration of DL in education for fostering economic development transformation and promote digitally competent youth (Republic of Rwanda, 2020). DL has gained momentum among secondary school teachers in Rwanda over the past decades. The government has focused its efforts on enhancing digital literacy development among teachers by providing regular digital training under partnerships with international organizations' efforts, such as the World Bank and UNICEF (REB, 2020). For instance, under the Ministry of Education (MINEDUC), the Rwanda Education Board (REB) designed digital information management systems for education personnel, such as the School Data Management System (SDMS), Comprehensive Assessment Management Information System (CAMIS), Teacher Management Information System (TMIS), Formative Assessment Management Information System (FAMIS), Learning and Teaching Materials Management System (LTMMIS), and Education Management Information System (EMIS), that were created through the partnership of the government of Rwanda and international partners like USAID for planning, monitoring, and evaluation. Similarly, there was an establishment of an e-assessment system in blended mode for delivery in both secondary and higher education. (UNESCO, 2021). Additionally, there was the development of online platforms such as E-Learning Rwanda, which aimed to provide access to digital content materials and offer an interactive learning environment in alignment with the national Competence-Based Curriculum (CBC) (Mugabo et al., 2021).

Despite these efforts, many teachers have shown dissatisfaction with the existing digital training that focuses on theory rather than providing enough practical experience and hands-on application in the classroom setting (Nsengiman et al., 2024). This has made most teachers lack confidence of integrating DL in a classroom setting. Furthermore, there is a lack of digital content that aligns with linguistic and cultural context, which hinders the effective development of digital literacy among teachers and students (KT Press, 2023). Additionally, there is limited access to digital resources, particularly in rural areas, such as limited access to computers and internet connectivity, which hindered effective teaching during emergencies, underscoring the impact of the digital divide on education equity (MINEDUC, 2020; Rudasingwa, 2021). The development of digital literacy is being hindered by insufficient training among teachers, shortages of electricity, and inadequate digital resources such as tablets, computers, and limited infrastructure, particularly in rural areas, which hinder the integration of DL in pedagogical instruction (Byura et al., 2016; Mugiraneza, 2021).

3. THEORETICAL BACKGROUND

Digital Literacy and Other Related Concepts

Digital literacy has a range of competencies that allow individuals to accomplish a task effectively and engage with digital technology critically. This is not merely a basic technical skill one can possess; it involves a deep understanding of digital technology utilization. According to BCS. (2025), digital literacy includes understanding digital technology, critical thinking, creative and effective use, and awareness of digital impact in a classroom setting. Digital literacy is the ability to use digital technology effectively, create, innovate, and communicate effectively in a classroom setting.

The National Literacy Trust (2025) highlighted that digital literacy involves digital skills usage, creativity production, collaboration and communication, evaluating critically, and actively participating responsibly and ethically in the digital environment. Digital literacy is beyond access; an individual must possess technical skills to navigate and assess digital content critically and its utilization. Additionally, digital literacy can be defined as a set of knowledge, skills, and attitudes to effectively utilize digital technologies in daily life, both in professional contexts and personal growth (OECD, 2023). Access to digital technology may not be translated into meaningful participation in a digital environment without possessing digital competencies (Hargittai, 2010).

Digital literacy can be defined as the ability to search, find, evaluate, share, and create content using the internet (Widana, 2020). Based on the above definition, this review defines digital literacy as the ability to understand and confidently apply or incorporate digital technology tools into pedagogy practices to navigate online platforms and education software, analyze online information critically, respect digital privacy, and consider the digital well-being of the students to foster more dynamic, collaborative, and active participation in a learning environment. Digital literacy gained momentum since the 1990s in the United States and started gaining traction around the world in the 21st century as a critical competency essential for students and teachers in the 21st-century rapid technological advancement in the modern education setting. This concept is not only possessing merely digital skills, but it encompasses the ability to use digital technology tools critically, evaluate, and create a variety of information (UNESCO, 2018). As the 21st-century technological advancement spread through the educational system globally, there has been growing emphasis on training teachers and equipping them with the necessary digital competencies to foster technological learning experiences for students to survive the 21st-century technological advancement societies (Koltay, 2011).

Digital technology tools have been increasingly incorporated in the education system worldwide to modernize education practices to fit the 21st-century technological advancements, aligned with modern societies and the workforce needs. Developed countries have led the way in integrating digital technologies in education by formulating national policies aimed at improving digital competencies among students and teachers. For instance, in the European Union (EU), digital literacy has been a core component of teachers' training programs and teacher education programs, guided by the EU Digital Competencies Framework for Education, which lists the specific digital competencies teachers need to integrate digital technology tools into pedagogical instruction (Redecker, 2017).

In North America, the introduction of blended learning and education tech platforms has accelerated the use of digital technology in pedagogical instruction. For example, in the USA, there has been the implementation of the National Education Technology Plan, which emphasized the use of digital literacy in equitable, inclusive, and innovative learning environments (U.S. Department of Education, 2017). In developing countries, the integration of digital technology into pedagogical instruction has been influenced by blended opportunities and different challenges. For instance, Sub-Saharan African countries have been facing problems related to poor internet connectivity and limited teacher readiness to integrate digital technologies in classrooms (Anasel & Swai, 2023; Ndulu et al., 2020; Pouezevara et al., 2013).

In Rwanda, the effort of promoting digital literacy in pedagogical instruction has been hampered by a shortage of infrastructure, lack of digital technology resources, and insufficient digital training programs for teachers (MINEDUC, 2020). Digital literacy for teachers can be explained as the possession of technical skills that involve the use of digital technology devices and proficiency in educational software. This allows teachers to incorporate digital technology tools into pedagogical instruction to enhance teaching strategies and improve students' learning outcomes. Teacher digital literacy may also include the ability to apply and integrate digital tools into a classroom practice in the process of supporting learning and students (Liu et al., 2020). Similarly, teacher digital literacy may also include the practical ability to absorb knowledge from text and online reading with practical inquiry (Leu et al., 2019; Kimani & Onyancha, 2015). In this context, teachers' digital literacy is vital to enhance education quality and equip students with the 21st-century digital competencies needed to solve complex problems within their daily life situations.

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Digital Competence

Digital competence is defined as the critical use of technologies for tasks and the confidence to communicate and learn in the digital world. It encompasses a set of competencies that enable teachers and students to navigate digital education effectively. According to Antonior-Manuel et al. (2022), digital competence is a multifaceted concept that encompasses competencies and abilities to critically and creatively use technology tools professionally. Digital competence is referred to as the confident, critical, and responsible use and engagement with digital technology tools for work, learning, and participation in modern society (Vuorikari et al., 2022, p. 10). Teachers' responsibility has been to enhance students' performance and digital competencies by incorporating digital technology tools in a classroom setting to create an interactive and collaborative learning environment (Khatamova & Sayfiddinova, 2023).

Digital competencies have also been proven to go beyond formal education and enter industrial sectors for entrepreneurs who have embraced technology and leverage digital technology skills in their businesses to prosper in the digital environment (Santos et al., 2023). In addition, teachers who demonstrated the highest digital competencies had confidence and are more likely to integrate digital technology tools in a classroom setting and adapt quickly to use new innovative digital technology tools that emerged in a classroom setting inclusively (Tondeur et al., 2021).

Digital Divide

Digital divide refers to the inequalities that appear in access to digital technology resources, digital infrastructure, and digital skills among teachers (Van Dijk, 2020). This term was initially introduced in 1990 to highlight the gap between those with access to digital technology resources and those without, to bridge the gap between them (Srinuan & Bohlin, 2011). This concept has been there since not only talking about physical access but also the competencies one holds and open opportunities to effectively use digital technology tools in a classroom setting. The digital competencies an individual possesses to use digital technology tools in education vary widely, leading to different outcomes, which reinforced the existing inequalities (Cheah et al, 2022; Robinson et al., 2015).

Method

This systematic review followed the guidelines of Campbell Collaboration (2013) to explore digital literacy development among secondary school teachers and was informed by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) approach to ensure transparency, rigor, and replicability. We followed a) a predetermined set of inclusion and exclusion criteria, b) screened and extracted secondary data, c) examined the relevance of the reviewed data from different published studies, and d) synthesized the findings. The review utilized existing academic and grey literature to answer these questions. According to Gough et al. (2017), a systematic literature review has an ''explicit rigorous methodology,'' making the review findings ''accountable and open to criticism.'' (p. 9). This type of review can offer a complementary mechanism for analyzing and mapping the information; it is possible to gain insights into certain aspects of digital literacy development while having a general overview of digital literacy practice across countries over a time span. Indeed, we considered systematic review a useful and reliable methodology, if conducted rigorously, in delivering evidence for policy makers and practitioners in both policy maker and secondary education fields.

Searching Strategy

In consultation with two references, including an expert in systematic review and another in digital technology, a comprehensive search was conducted across electronic databases, including ERIC, Scopus, Web of Science, Google Scholar, as well as institutional repositories and official reports from the MINEDUC, UNICEF, UNESCO, REB, and the government of Rwanda

### Inclusion/Exclusion Criteria

We developed four inclusion criteria to determine the relevant studies from our preliminary search, studies: (1) published between 2016 and 2024; (2) contained in the abstracts all three keywords or synonyms, as determined from an electronic thesaurus: (a) digital literacy or digital competencies or ICT skills or teacher education (b) were conducted in Rwanda or included Rwandan participants, (c) secondary education; 3) written in English, and 4) originality of reported data or reviewed. A figure based on these criteria was designed to screen the studies and synthesize the relevant findings. Studies that were excluded were solely based on higher education or primary education and were not peer reviewed unless official government or NGO reports, and lacked a clear methodological description.

Data Screening and Extraction

The initial database search yielded 1,000 records. After removing 2 duplicate records, 998 records remained for title and abstract screening. During the first screening stage 646 abstracts were excluded because they were unrelated to digital literacy. Of the remaining 352 records, 245 studies were excluded for not focusing in secondary education. Full-text screening was conducted for 107 studies, of which 51 were excluded for being non-reviewed or lacking sufficient methodological detail. The final review included 56 studies that met all inclusion criteria for independent, detailed evaluation. Data from the included studies were then extracted onto a matrix (in Microsoft Excel), covering author, year, study design, sample, key findings, and containing four relevant categories drawn from the research questions, including country. The extracted data were organized according to the review's research questions to facilitate thematic synthesis. To enhance reliability data extraction was cross-checked a second time by reviewers

Study Relevance Assessment

The reviewers assessed the 56 articles in terms of their relevance to the current review's objectives. We followed:
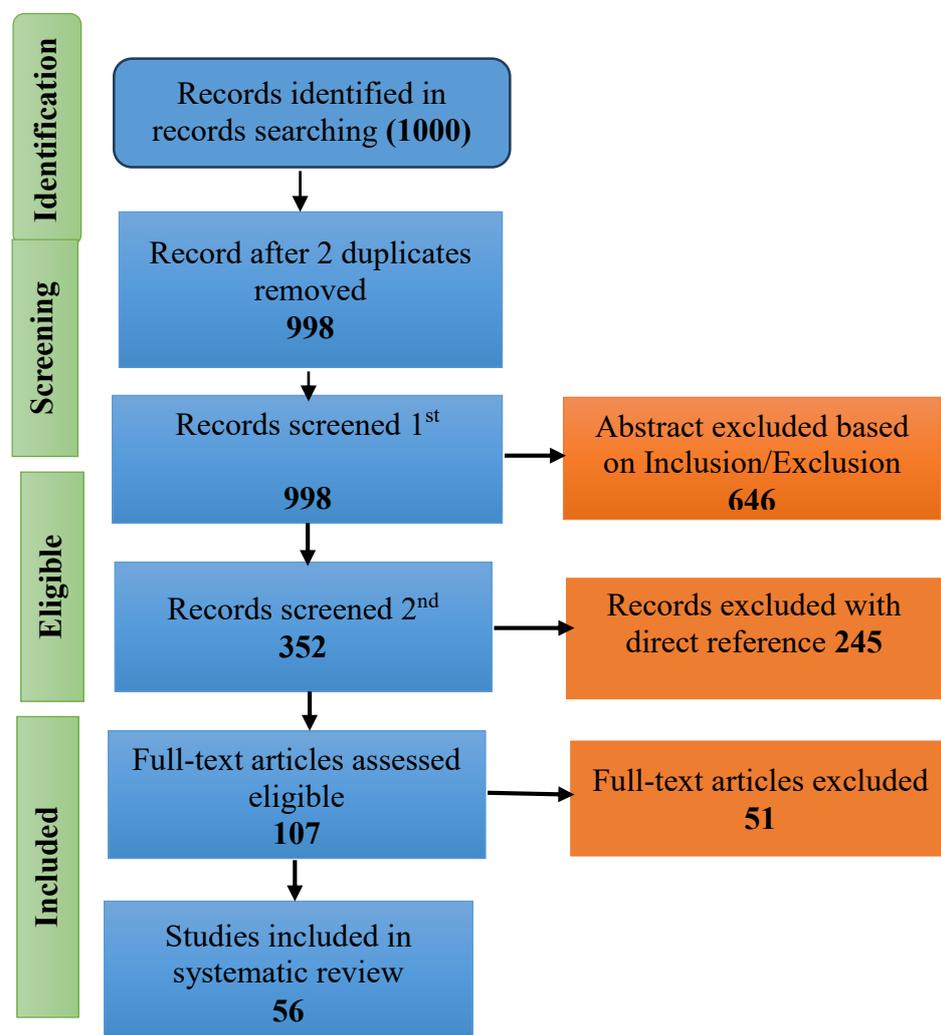
Fig1. Process of Selecting Article for Review (Adopted from PRISMA Flow Diagram)

Data Synthesis and Analysis

As mentioned earlier, we tabulated all relevant information of the included studies on a matrix with categories corresponding to different aspects of the research questions. A thematic synthesis approach was applied to analyze the extracted data. The reviewers together went through the information under each category and unanimously synthesized the results across the studies. Findings were categorized according to the three research questions and interpreted using an integrated theoretical lens combining TPACK, TAM, and Digital Divide Theory

The main aim of this cross-study synthesis was to seek common overall trends and explore potential emerging comparisons in Rwanda's digital literacy among secondary school teachers on the basis of available evidence collected across the country. The synthesis focused on identifying convergent evidence rather than quantifying effect sizes, consistent with systematic review methodology in education research (Gough et al., 2017).

Findings

This section presents the synthesized findings from 56 studies included in this review, organized according to three research questions:

Conceptual Frameworks Guided this Review

This systematic review is guided by an integrated theoretical framework combining the Technological Pedagogical Content Knowledge (TPACK) framework, the Technology Acceptance Model (TAM), and Digital Divide Theory. The integration of these three frameworks provides a comprehensive lens for examining digital literacy development among secondary school teachers in Rwanda by capturing pedagogical competence, individual technology adoption behavior, and structural inequalities influencing digital education.

Technological Pedagogical Content Knowledge (TPACK)

The TPACK framework serves as the essential framework for evaluating teachers' competencies to integrate digital technology in pedagogy and content knowledge (Mishra & Koehler, 2006). This evaluation focuses mainly on the practical application of TPACK by examining teachers' ability to use technology tools (TK) effectively, combined with pedagogical approaches (PK) and subject expertise (CK) in their teaching practice. For example, if a biology teacher can effectively use interactive simulations to enhance biology instruction, he/she is considered to show a strong demonstration of TPACK alignment. Specifically, TPACK informs Research Question 1, which examines the current state of digital literacy development among secondary school teachers in Rwanda. By drawing on TPACK, this review evaluates whether teachers' digital literacy reflects isolated technological knowledge or integrated pedagogical practice. Empirical evidence synthesized in this review suggests that while many teachers demonstrate basic TK, the integration of technology with pedagogy and content knowledge remains limited, indicating incomplete TPACK development (Mishra & Koehler, 2006; Koehler & Mishra, 2009).

Technology Acceptance Model (TAM)

On the other hand, while TPACK explains how teachers integrate technology pedagogically, it does not fully account for why teachers choose to adopt or resist digital technologies. To address this limitation, this review incorporates the Technology Acceptance Model (TAM), defined by Fred Davis in 1986 as the theoretical behavior to explain and predict the adoption and use of technology based on users' perception, was later redefined by Davis in 1989 based on two primary beliefs that determine an individual's intention to use technology: a) Perceived Usefulness (PU), which deals with the degree to which a person believes that using a particular technology will enhance their job performance or productivity, and b) Perceived Ease of Use (PEOU), which deals with the degree to which a person believes that using a system can be free of effort. These perceptions shape teachers' attitudes toward technology and their behavioral intention to use digital tools in professional practice. In the context of this review, TAM is used to interpret teachers' attitudinal and motivational factors influencing digital literacy development, particularly in relation to Research Question 2, which explores the challenges secondary school teachers encounter in promoting digital literacy. Limited training opportunities, lack of technical support, and high workload negatively affect teachers' perceptions of usefulness and ease of use, thereby constraining technology adoption even when digital resources are available (Davis, 1989; Teo, 2011). TAM thus provides a behavioral explanation for uneven digital technology integration across secondary schools in Rwanda.

Digital Divide Theory

To complement the individual-level perspectives offered by TPACK and TAM, this review also draws on Digital Divide Theory, which addresses structural and socio-economic inequalities in access to digital technologies and digital skills. Initially conceptualized as disparities in physical access to technology, the digital divide has evolved to include differences in skills, usage, and outcomes (Van Dijk, 2006, 2020). In educational contexts, the digital divide manifests through unequal access to infrastructure, connectivity, training opportunities, and institutional support.

Digital Divide Theory is particularly relevant to Research Question 2 and Research Question 3, as it explains how disparities between urban and rural schools, gender inequalities, and socio-economic constraints limit teachers' opportunities to develop and apply digital literacy. In Rwanda, persistent gaps in electricity access, internet connectivity, and availability of digital devices continue to shape teachers' capacity to engage with technology-enhanced pedagogy, regardless of individual motivation or policy intentions (Van Dijk, 2020; UNICEF, 2021).

Integrated Frameworks

The integration of TPACK, TAM, and Digital Divide Theory enables a multidimensional understanding of digital literacy development among secondary school teachers in Rwanda. TPACK captures teachers' pedagogical competence in integrating technology, TAM explains teachers' attitudes and adoption behavior, and Digital Divide Theory situates these processes within broader structural and socio-economic contexts. Together, these frameworks align directly with the review's research questions by examining the current state of teacher digital literacy (RQ1), identifying barriers to digital integration (RQ2), and informing strategies to enhance digital literacy development through professional training, institutional support, and equitable infrastructure investment (RQ3).

Figure 2. Conceptual Framework of this Review
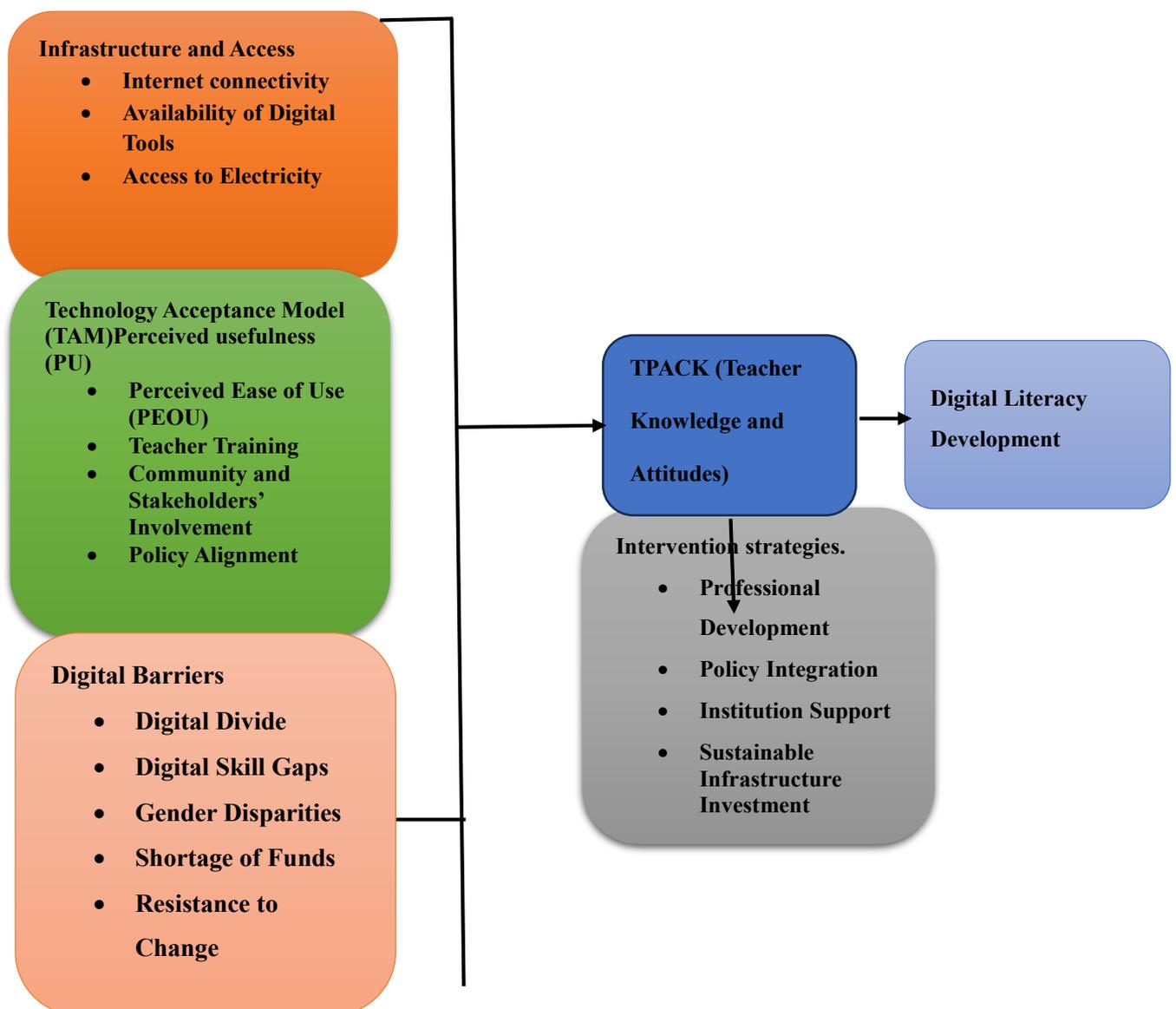
Figure 2 illustrates the conceptual framework guiding this review. The framework demonstrates the interaction between infrastructure and access conditions, teachers' technology acceptance (TAM), and contextual digital barriers in shaping

teachers' Technological Pedagogical Content Knowledge (TPACK). TPACK is understood as the intermediary framework through which these elements influence the development of digital literacy in secondary school educators. Effective measures, such as professional development, institutional support, policy integration, and sustainable infrastructure investment, serve as intervention mechanisms to enhance TPACK and mitigate digital divide limitations.

RQ 1: Current State of Digital Literacy Development Among Secondary School Teachers

The review indicates that many secondary school teachers demonstrate the basic foundation of technological knowledge (TK), including the ability to operate computers, use word processing software, and access online platforms. However, evidence consistently shows that they are still in the early stage of integrating technology effectively into pedagogy, as they still lack strong application of Pedagogical Knowledge (PK) and Content Knowledge with technology to form complete TPACK. The majority of studies report limited application of digital tools to support instructional strategies aligned with curriculum objectives (ILO, 2019; Nsengimana et al., 2022).

This highlighted the digital skills gap among secondary school teachers across schools, with teachers in urban areas demonstrating higher exposure to digital tools than those in rural schools

For instance, urban teachers are capable of using digital technology tools, while many of their counterparts in rural schools still struggle to integrate these digital technology tools meaningfully into pedagogical instruction (Nsengimana et al., 2022). Access to infrastructure such as electricity, internet connectivity, and digital devices was frequently identified as uneven, influencing teachers' opportunities to practice and develop digital competencies (MINEDUC, 2020; UNICEF, 2021). Teachers without proper training cannot progress beyond access to actual usage. Therefore, interventions must focus on skilled capacity-building that addresses all three frameworks.

RQ2: Challenges Encountered by Secondary School Teachers in Promotion of Digital Literacy

The most frequently reported challenges include limited professional training, inadequate infrastructure, and persistent digital divide factors. The infrastructure and access continue to pose a challenge to the full integration of digital technology tools in the classroom setting. There is a significant digital divide in digital infrastructure; for instance, urban schools benefit more from internet connectivity and basic digital technology tools, while their counterparts in rural areas have inconsistent availability of electricity, poor internet connectivity, and inadequate digital technology tools (MINEDUC, 2020; UNICEF, 2021). This creates digital skills inequalities among teachers between urban and secondary schools. Additionally, many teachers reported receiving short, theory-oriented training sessions that did not adequately prepare them for classroom application, and some highlighted that they have never received formal digital training, leading to limited confidence to use digital technology tools in their daily teaching instruction (Mugiraneza, 2021; Nsengimana et al., 2022). Without access to professional training and digital resources, teachers cannot practice or integrate digital literacy meaningfully into pedagogy. Additionally, unreliable electricity, weak internet connectivity, and limited access to devices were commonly reported, particularly in rural secondary schools (Byura et al., 2016; Rudasingwa, 2021). As TAM demonstrates, unreliable access reduces teachers' perceived usefulness of digital tools and perceived ease of use. If teachers perceive technology as cumbersome or irrelevant due to a lack of contextualized training, their motivation to integrate it into pedagogical instruction diminishes. Unequal access to training leads to widening gaps in usage and benefits. These disparities directly affect teachers' opportunities to practice and integrate digital tools, leading to unequal development of digital skills. TAM also underscores the role of institutional support in shaping user perceptions. Teachers who receive consistent technical assistance, mentorship, and recognition for technology integration are more likely to view digital tools as beneficial and easy to use (Teo, 2011). Socio-economic constraints, including low income, heavy workload, and limited institutional support, were also identified as barriers to digital literacy development. Several studies reported gender-based disparities, with female teachers experiencing reduced access to training opportunities and digital resources, especially in rural contexts (CONTRAF, 2025; New Times, 2023; UNESCO, 2025).

RQ3: Strategies for Enhancing Digital Literacy Development Among Secondary School Teachers

The reviewed literature identifies several strategies to strengthen teachers' digital literacy development. These include continuous professional development programs, peer mentoring, hands-on training approaches, and sustained investment in digital infrastructure. TAM-driven intervention by Davis (1989), which emphasizes the perceived usefulness and ease of use, would play a significant role in shaping a positive attitude towards digital technology integration in education by ensuring that user-friendliness and clearly demonstrating educational value together with effective Professional

Development (PD) which is iterative, collaborative, and situated within teachers' own classrooms can help increase teachers' adoption of digital technology tools in teaching and learning process (Staverma, 2025). Studies also emphasize the importance of aligning teacher training initiatives with national education policies and fostering partnerships between government institutions, public-private collaboration, international organizations, and local communities to improve access to digital resources (MINEDUC, 2016; UNICEF, 2024).

4. DISCUSSION AND RECOMMENDATIONS

This systematic review offers a nuanced understanding of digital literacy development among Rwandan secondary school teachers by interpreting the synthesized findings through the lenses of the Technological Pedagogical Content Knowledge (TPACK) framework, the Technology Acceptance Model (TAM), and Digital Divide Theory. The discussion situates these findings within Rwanda's larger education digitalization strategy and compares them to evidence from previous national and international studies.

State of Digital Literacy and TPACK Integration

The findings show that, while many Rwandan secondary school teachers have basic Technological Knowledge (TK), such as computer operation and use of educational software. This is consistent with national infrastructure investments such as the One Laptop per Teacher initiative and represents a successful first step toward technological exposure, but their capacity to integrate digital literacy into instructional practices and subject content is limited. This shows that teachers' digital literacy development in Rwanda is at the tool operation level rather than developing toward pedagogically transformative technology use. Similar tendencies have been documented globally, with teachers acquiring fundamental digital abilities but unable to integrate them meaningfully into instructional design and Content delivery (Koehler & Mishra, 2009; Tondeur et al., 2022). Insufficient TPACK development is linked to the structure of existing teacher training and professional development programs, which frequently prioritize technical expertise over pedagogical application. In Rwanda, this gap can be linked to short-term, theoretical training and professional development initiatives that lack persistent focus on hands-on application, subject-specific mentoring on incorporating digital literacy into daily instruction (Nsengimana et al., 2022; ILO, 2019). As a result, digital tools are frequently employed for administrative or presentation purposes rather than to enhance learner-centered, competency-based instruction, as envisaged under Rwanda's Competence-Based Curriculum (MINEDUC, 2016).

Structural Inequalities and the Digital Divide

Differences in infrastructure and access continue to be defining features of secondary school teachers' digital literacy development. According to Digital Divide Theory, secondary school teachers in urban schools have better access to electricity, internet connectivity, and digital gadgets than their rural counterparts, who confront ongoing infrastructure constraints. The gap in reliable electricity, internet connectivity, and device access between urban and rural schools creates a gap in digital skills across the regions (MINEDUC, 2020; UNICEF, 2021). This access gap directly affects teachers' ability to practice and enhance their digital skills, particularly in rural schools, resulting in a skills and usage split (Van Dijk, 2020). These structural inequalities limit teachers' ability to practice, experiment with, and enhance digital pedagogies, perpetuating competence disparities across districts. This finding aligns with broader evidence from Sub-Saharan Africa, where access-based inequalities continue to shape educational technology outcomes (Ndulu et al., 2020; Mutula, 2021). Importantly, the review demonstrates that access alone does not guarantee effective digital literacy development. Teachers who lack consistent access to infrastructure are unable to move beyond basic exposure to sustained and meaningful use, reinforcing Van Dijk's (2020) argument that digital divides evolve from access gaps into skills and usage inequalities. In Rwanda, these dynamic risks are undermining national efforts to promote equitable, technology-enhanced education across all regions.

Teacher Motivation and Technology Acceptance (TAM)

Beyond structural hindrance, the findings emphasize the importance of teachers' attitudes and perspectives that contribute greatly to digital literacy development. TAM analysis shows that limited access to training, unreliable infrastructure, and heavy workloads hinder teachers' perceived usefulness (PU) and perceived ease of use (PEOU) of digital technologies. When digital technologies are difficult to use, or mismatched with classroom reality, teachers are less likely to see them as valuable, beneficial or worth the extra effort required for integrating DL in their daily practices (Davis, 1989; Teo, 2011). As a result, even when resources are available, low motivation and confidence prevent adoption. This review builds on

previous TAM-based research by demonstrating that positive attitudes alone are insufficient in environments characterized by structural constraints. Even when teachers see the potential benefits of digital technology, a lack of institutional support and difficult working conditions limit their capacity to put their intentions into practice. This finding is consistent with previous research showing that organizational and contextual factors impact technological acceptability, particularly in low-resource contexts (Liu et al., 2020; Tondeur et al., 2022).

Gender and Socio-Economic Dimensions of Digital Literacy

The analysis also highlights gender and socioeconomic gaps in digital literacy development, notably among female teachers in rural areas. These inequities reflect broader tendencies observed in developing countries, where women frequently face additional challenges due to access, cultural expectations, and workload (UNESCO, 2025). These findings highlight that digital exclusion is not only technological but also social and economic in character, as stated in the digital divide theory (Van Dijk, 2020). Such inequities limit teachers' participation in professional development opportunities and reduce their exposure to digital tools, resulting in skill gaps. Addressing digital literacy development, therefore, involves gender-responsive and context-sensitive interventions that address the interaction of technology, socio-economic conditions, and cultural norms.

Implications for Digital Literacy Enhancement Strategies

The strategies outlined in the examined literature indicate that effective digital literacy development must be multifaceted and ongoing. In terms of TPACK, professional development programs should highlight the integration of technology with pedagogy and content, allowing teachers to design lesson plans, create subject-specific, learner-centered digital activities. TAM-driven interventions emphasize the need to design training that displays clear instructional value and usability, which increases teachers' enthusiasm and confidence in using digital resources (Davis, 1989; Stavermann, 2025). Digital Divide Theory highlights the importance of ongoing investment in inclusive and equitable infrastructure, especially in rural schools. Aligning teacher training initiatives with national policies like the SMART Education Policy, as well as fostering partnerships between government agencies, private sector actors, and international organizations, can help ensure that policy intentions match classroom realities (MINEDUC, 2016; UNICEF, 2024).

Synthesis of Frameworks

The combination of TPACK, TAM, and Digital Divide Theory provides a comprehensive explanation for the observed patterns in Rwanda's secondary school system. TPACK shows which competences are lacking, TAM clarifies why teachers may resist or struggle with technology adoption, and Digital Divide Theory identifies where and for whom inequalities exist. This integrated perspective strengthens the claim that digital literacy development is a pedagogical, behavioral, and structural process that must be approached holistically.

Recommendations

Theory

Several researchers and scholars should conduct longitudinal studies to investigate the long-term impact of TPACK proficiency intervention and examine the students' outcomes as a function of teacher digital literacy in different levels of the education sector while considering cultural, political and historical context, and socio-economic conditions. These approaches will provide deep insights into the durability and sustainability of digital literacy development over time, contributing to theoretical frameworks on technology in instruction changes within educational institutions. In addition, they should also examine how technology can be applied in education where there are limited resources and insufficient infrastructures, and still positively affect teaching practice and students' outcomes within the primary education context in the perspective of new curriculum (CBC), as much research and studies focus mostly on secondary education.

Practices

Rwanda should invest more in digital infrastructure development programs and professional development for teachers, by prioritizing the integration of DL in pedagogical practices, which are proven to align with the Competence-Based Curriculum teaching approach and the 21st century student-centered learning that allows student to personalize and customize their way of learning basing on their pace and interest, hence contribute to the overall success of education policies and national educational goals to improve quality of education which is still issue in Rwanda's education sector. These digital training programs should also include training modules on Pedagogical Knowledge and Content Knowledge,

how to involve teachers in cyber security, analyzing online information critically as the 21st century had proven to be full of misinformation, and other training modules on intellectual stimulation, peer mentoring support, and how to develop and improve the DL level of students.

Policy

Rwanda's government should shift from theoretical workshops to sustained, structured hands-on application practice such as peer mentoring and classroom simulation as digital competencies require more practice and updated workshops, due to the dynamic of the 21st-century technology advancements evolution. This should be taken seriously to achieve education technology reform, hence contributing to the national development strategy that prioritize education technology as a pivot to achieve the national agenda of 2050 to turn Rwanda into a knowledge-based economy.

5. CONCLUSIONS AND FUTURE RESEARCH

This systematic review examined the complex landscape of digital literacy (DL) development among secondary school teachers in Rwanda. The analysis was guided by an integrated theoretical framework that combine Technology Pedagogical Content Knowledge (TPACK) and Technology Acceptance Model (TAM), and Digital divide theory that revealed an environment of substantial policy ambition confronted with complex on-the-ground reality. The findings confirm that, while national initiatives have successfully developed a basic level of technological knowledge (TK) among secondary school teachers, the ultimate goal of deep, pedagogically sound technology integration is still in the early stage to completely form TPACK. due to inadequate infrastructure, gaps in digital training, poor internet connectivity, inadequate devices, lack of electricity, and socio-economic factors that hindered the effective implementation of education technology reform in Rwanda (MINEDUC,2020; Nsengimana et al, 2022; UNICEF, 2021). The fundamental conclusion is that DL development in Rwandan secondary education is a systemic challenge that necessitates coordinated interventions at different levels. This constraint is worsened by ongoing structural inequalities such as the digital divide in infrastructure and access that unequally distribute opportunity and maintain skill disparities, notably between urban and rural areas. Furthermore, these external restrictions have a detrimental impact on teacher motivation and acceptance, as stated by TAM, where perceived utility and simplicity of use are low due to unreliable materials, digital resources, and inadequately contextualized training. Therefore, developing teacher digital literacy requires a holistic, synergistic strategy. Effective advancement requires moving beyond isolated workshops and implementing continuous, practice-oriented professional development that actively integrates DL into pedagogy, and specific subject-content. Furthermore, policy initiatives like SMART Education and GIGA are crucial and promising, but they need to be complemented by continuous professional development, infrastructure investment, community involvement, and collaboration of educational stakeholders such as police makers, parents, teachers, students, international partnerships, NGOs, and private investors to bridge the digital divide and gender disparities. Investing in sustainable infrastructure, such as solar-powered devices and reliable internet connectivity, is essential for bridging rural–urban disparities and promoting inclusive digital access.

Future Research

First, future studies should employ longitudinal and mixed-methods designs to capture changes in rural secondary and primary school teachers' digital competencies, attitudes, and pedagogical practices over time. Secondly, researchers should explore the perspectives of multiple stakeholders, including students, parents, policymakers, and school leaders, to understand how collective beliefs, social expectations, and community contexts influence technology adoption. Finally, future research should also examine the digital literacy development among rural primary school teachers as the primary agents to promote digital literacy among young children

REFERENCES

[1] Akomolafe, M. J. (2016). Big Five personality traits influencing secondary students' environmental literacy in Ondo State, Nigeria. *Journal of Teaching and Teacher Education*, *5*(1), 27-31

[2] Anasel, M. G., & Swai, I. L. (2023). Factors to determine the adoption of online teaching in Tanzania's Universities during the COVID-19 pandemic. *PLOS ONE, 18(10), e0292065.* https://doi.org/10.1371/journal.pone.0292065

[3] Antonio-Manuel R.G, Manuel-Jesús CP, Juan-Carlos De la CC, et al. (2022). Communicating and collaborating with others through digital competence: A self-perception study based on teacher trainees' gender. *Education Sciences 12(8): 534.*

[4] BCS (2025). Digital literacy: Preparing young people for the digital society.

[5] Byungura, JC, Hansson, H., Mazimpaka, O., & Thashmee, K. (2016, May). Exploring teacher adoption and use of an upgraded eLearning platform for ICT capacity building at University of Rwanda. In *2016 IST-Africa Week Conference* (pp. 1-11). IEEE.

[6] Campbell Collaboration. (2013). Retrieved November 2, 2013, from

[7] Cheah, Y. H., Oliveri, A. R., & Hughes, J. E. (2023). Unpacking K-12 teachers' technology-supported, equitable practices: A mixed-methods systematic review. *Teaching and Teacher Education, 125*, 103984. https://doi.org/ 10.1016/j.tate.2023.103984

[8] COTRAF. (2025). Study on living and working conditions of workers in the education sector in Karongi, Kicukiro and Rulindo districts. *Confederation of Trade Unions of Rwanda. https://cotrafrwanda.org/wp-content/uploads/ 2025/01/Study-on-Living-and-Working-Conditions-of-Workers-in-Education-Sector-in-Karongi-Kicukiro-and-Rulindo-Dis.pdf*

[9] Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, 319-340.

[10] European Union (2022). Digital Competence Framework for Citizens (DigComp)

[11] Gough, D., Thomas, J., & Oliver, S. (2017). An introduction to systematic reviews.

[12] Hargittai, E. (2010). Digital na(t)ives? Variation in internet skills and uses among members of the "net generation". *Socius: Sociological Research for a Dynamic World, 6, 1-20.* http://www.campbellcollaboration.org/what_is_a_ systematic_review/index.php

[13] International Labour Organization. (2019). Digitalization in teaching and education in Rwanda

[14] Khatamova O and Sayfiddinova N (2023) The role of digital competence in ELT. *Central Asian Journal of Literature, Philosophy and Culture 4(6): 232–235.* Available at: https:// cajlpc.centralasianstudies.org/index.php/CAJLPC/ article/ view/929

[15] Kimani, H.N., & Onyancha, O.B. (2015). Information literacy Skills among Incoming First-Year Undergraduate Students at the Catholic University of Eastern Africa in Kenya. Innovation, 2015(51), 22–45.

[16] Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge (TPACK)?. *Contemporary issues in technology and teacher education*, *9*(1), 60-70.

[17] Koltay (2011). The media and the literacies: media literacy, information literacy, digital literacy. Media, Culture & Society 33(2) 211–221. sagepub.co.uk/journals Permissions.nav. DOI: 10.1177/0163443710393382

[18] KT Press. (2023, October 9). EdTech Monday: On access to digital literacy in Rwanda. KT Press.

[19] Leu, D.J., Kinzer, C.K., Coiro, J., Castek, J., & Henry, L.A. (2019). New literacies: A dual-level theory of the changing nature of literacy, instruction, and assessment. In D.E. Alvermann, N.J. Unrau, M.

[20] Liu, Q., Geertshuis, S., & Grainger, R. (2020). Understanding academics' adoption of learning technologies: A systematic review. *Computers & Education, 151*, 103857. https://doi.org/10.1016/j.compedu.2020.103857

[21] MINEDUC. (2016). ICT in Education Policy. Ministry of Education.

[22] Ministry of Education. (2020). Smart Education Master Plan 2020–2024. Republic of Rwanda.

[23] Mugabo, L., Tugirinshiti,J,B., & Banuza, A. (2021). Integrating Video-Based Multimedia in Teaching Physics in Context of Covid-19 in Rwandan Secondary Schools. *International Journal of Learning, Teaching and Educational* Research Vol. 20, No. 12, pp. 49-63, Received Sep 25, 2021; Revised Nov 30, 2021; Accepted Dec 05, 2021. https://doi.org/10.26803/ijlter.20.12.4

[24] Mugiraneza, J.P. (2021). Digital in Teaching and Education in Rwanda: Digitalization, the Future of Work and Teaching Professional Project. *International Labor Office. Geneve, Switzerland. The report 28.*

[25] National Literacy Trust (2025). What is digital literacy and technology?

[26] Ndulu, B., Ngwenya, N. & Setlhalogile, M. (2020). The digital divide in South Africa: Insights from the Covid-19 experience and beyond, *University of Witwatersrand*.

[27] New Times. https://www.newtimes.co.rw/article/12111/news/technology/inside-rwandas-plan-to-digitise-all-irembo-services-by-2024

[28] Nsengimana, T., Nsengimana, V., Nkundabakura, P. *et al.* Exploring the skills acquired by mathematics and science teachers through the development of scripted lessons for continuous professional development. *Educ Inf Technol* **29**, 22681–22698 (2024). https://doi.org/10.1007/s10639-024-12753-5

[29] OECD (2023). Shaping digital education: Enabling factors for quality, equity and efficiency, *OECD Publishing, Paris: https://doi.org/10.1787/bac4dc9f-en*.

[30] Pouezevara, S., Dinçer, A., Kipp, S., & Sariisik, Y. (2013). Turkey's FATIH project: A plan to conquer the digital divide or a technological leap of faith. *Turkey: RTI International & Education Reform Initiative (ERI)*.

[31] Ramchand, M. (2022). Pedagogic content knowledge of science: A framework for practice and construct for understanding teacher preparation. *Contemporary Education Dialogue, 19*(2), 168–195. https://doi.org/10.1177/09731849221083063

[32] REB (2020). ICT in Education. Retrieved from [Reb.rw]

[33] Redecker, C. (2017). European framework for the digital competence of educators: DigCompEdu. Publications Office of the European Union. https://doi.org/10.2760/159770

[34] Republic of Rwanda. (2020). *Vision 2050*. Retrieved from https://www.minecofin.gov.rw/

[35] Rudasingwa, A. (2021). Diffusion of innovations. Free Press, New York.

[36] Rwanda Development Board. (2022). ICT skills snapshot. *Rwanda Development Board*.

[37] Santoso B, Hufad A, Wahyudin U, et al. (2023). The Effect of digital literacy competence toward the income of home industry entrepreneurs. *Lembaran Ilmu Kependidikan 52(1): 36–42.*

[38] Srinuan, C., & Bohlin, E. (2011). Understanding the digital divide: A literature survey and ways forward. *Telecommunications Policy, 35(8), 654-664.*

[39] Stavermann, K. Online Teacher Professional Development: A Research Synthesis on Effectiveness and Evaluation. *Tech Know Learn 30, 203–240 (2025). https://doi.org/10.1007/s10758-024-09792-9*

[40] Stephen M. Mutula (2021). Bridging the digital divide through schools: Develops in Sub-Saharan Africa.

[41] Teta Ufitiwabo, A., (2021). Rwanda: Over 1,800 Science Teachers to Be Given Laptops in August 2021. Retrieved on April 6th, 2022 from www. allafrica.com/stories/202108030506.html.

[42] Teo, T. (2011). Factors influencing teachers' intention to use technology: Model development and test. *Computers & Education*, *57*(4), 2432-2440.

[43] Tondeur, J., van Braak, J., Ertmer, P. A., & Ottenbreit-Leftwich, A. (2022). Understanding the relationship between teachers' pedagogical beliefs and technology use in education: A systematic review of qualitative evidence. *Educational Technology Research and Development, 69, 293–314.* https://doi.org/10.1007/s11423-021-09998-z

[44] U.S. Department of Education, National Center for Education Statistics. (2019). Characteristics of public and private elementary and secondary schools in the United States: Results from the 2017–18 National Teacher and Principal Survey First Look (NCES 2019-140).

[45] UNESCO IITE (2022). Global Smart Education Conference on Intelligent Technology and Digital Transformation in Education held in Beijing

[46] UNESCO. (2021). ICT transforming education in Africa: ICT transforming education in Africa-UNESCO-KFIT project

[47] UNESCO. (2022). Global Education Monitoring Report. UNESCO.

[48] UNESCO. (2023). Technology in education: A tool on whose terms? Global Education Monitoring Report. https://unesdoc.unesco.org/ark:/48223.

[49] UNESCO. (2025). *Closing the digital divide for women and girls in Africa through education.* UNESCO. https://www.unesco.org/en/gender-equality/education/digital-divide

[50] UNICEF (2018). Digital literacy for children: Exploring definitions and frameworks. UNICEF Publishing

[51] UNICEF (2021). Digital Transformation in the East Asia and Pacific Region

[52] UNICEF (2024). Digital Literacy. UNICEF RWANDA

[53] Van Dijk, J. (2020). The Digital Divide: Tapping the Potential of the Internet for All. *Social Inclusion Journal, 8(3),* 42-58. http://dx.doi.org/10.1002/asi.24355

[54] Van Dijk, J. (2020). The Digital Divide: Tapping the Potential of the Internet for All. *Social Inclusion Journal, 8(3),* 42-58. http://dx.doi.org/10.1002/asi.24355

[55] Vuorikari, R., Kluzer, S., & Punie, Y. (2022). DigComp 2.2: The Digital competence framework for citizens - With new examples of knowledge, skills and attitudes. Publications Office of the European Union. https://doi.org/10.2760/115376

[56] Widana, I. W. (2020, July). The effect of digital literacy on the ability of teachers to develop HOTS-based assessment. In *Journal of Physics: Conference Series* (Vol. 1503, No. 1, p. 012045). *IOP Publishing*.