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Mathematics Teachers' Competencies in Designing Lessons that Foster 21st-Century Skills Acquisition Among Secondary School Students in Kwimba District, Tanzania

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Abstract

This quantitative study investigated mathematics teachers' competencies in designing lessons that foster 21st-century skills in Kwimba district, Tanzania. Data were collected from 100 teachers using a structured questionnaire and analyzed through descriptive statistics and cross-tabulations. Results indicated that 60% of teachers integrated critical thinking and 57% incorporated problem-solving, while fewer emphasized creativity (40%), collaboration (50%), communication (45%) and digital literacy (24%). These findings suggest that although teachers frequently embedded critical thinking and problem-solving in lesson plans, other essential skills considered in this study including creativity, collaboration, communication and digital literacy were less consistently addressed. The study recommends targeted professional development, curriculum revision and improved access to digital tools and resources to strengthen the integration of all 21st-century skills into mathematics lesson planning and delivery.

***Keywords*:** Mathematics teaching; teacher competencies; 21st-century skills; lesson planning

1. Introduction

1.1. Introducing the problem

The 21st century has been marked by rapid technological, economic and social transformations, requiring education systems to move beyond traditional literacy and numeracy toward equipping learners with broader competencies. These 21st-century skills include critical thinking, creativity, collaboration, communication, problem-solving and digital literacy (Trilling & Fadel, 2009; Redecker, 2020). They are increasingly recognized as essential for employment, civic participation and lifelong learning (Voogt & Roblin, 2012; Tienken, 2022). In mathematics education, often perceived as abstract and

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rigid, these skills can be nurtured through logic-based problem-solving, real-life applications and collaborative tasks (Boaler, 2016; Darragh & Radovic, 2022). Thus, mathematics teachers play a pivotal role in embedding 21st-century skills into lesson design and delivery (Care et al., 2023).

In line with global trends, the government of Tanzania has prioritized the integration of these competencies through educational reforms. The 2023 Education and Training Policy, to be implemented in 2024, emphasizes critical thinking, problem-solving, communication and digital literacy, alongside equitable access to education and improved teacher preparation (Policy Forum, 2024; UNESCO, 2023).

Despite such initiatives, research highlights persistent concerns regarding teachers' preparedness to effectively integrate 21st-century skills, especially in rural contexts where resources and professional development opportunities are limited (Komba & Nkumbi, 2019; Mcharo & Mligo, 2023). Kwimba district provides a relevant case as it reflects the broader realities of rural Tanzania, where limited infrastructure, scarce digital resources and uneven teacher training hinder the integration of competencies into classroom practice (URT, 2023).

While teachers are central to implementing the policy vision, little empirical evidence exists on mathematics teachers' competencies in lesson planning that explicitly fosters 21st-century skills in such rural settings. Addressing this gap, this paper investigates mathematics teachers' competencies in designing lessons that promote 21st-century skills among secondary school students in Kwimba district, Tanzania.

1.2. Review of past studies

Existing literature provides valuable insights into 21st-century skills education in Tanzania but reveals significant gaps in lesson planning research. Mkumbo and Komba (2018) and Mhando and Mtitu (2020) identified barriers such as inadequate resources, insufficient training and rigid curricula, yet they did not explore concrete strategies for integrating skills into lesson planning, particularly in under-resourced settings. Nyalusi and Rugambwa (2022) and Ndibalema and Mbelle (2023) emphasized the positive influence of professional development on teacher competencies but offered limited analysis of how such training translates into practical student-centered practices in mathematics classrooms. Similarly, Senjiro and Lupeja (2023) reported that even in urban Morogoro, many Geography teachers struggled to integrate 21st-century skills due to weak pedagogical preparation, suggesting that these challenges may be more acute in rural areas like Kwimba. Furthermore, there is little district-specific evidence on how teacher qualifications, professional development and resource availability influence mathematics teachers' lesson planning competencies. This study therefore addresses an important empirical gap by providing localized, quantitative insights into how mathematics teachers in a rural Tanzanian context prepare lessons that foster 21st-century skills.

1.3. Lesson planning and teachers' role in fostering 21st-century skills

Lesson planning is widely acknowledged as the backbone of effective teaching, shaping what is taught, how it is delivered and how learning is assessed (Marsh et al., 2023). Within the framework of 21st-century education, lesson planning requires teachers to embed opportunities for student-centered inquiry, real-world applications, cross-disciplinary connections and formative assessments (Brookhart, 2017; Care et al., 2023). For mathematics teachers, this means designing lessons that develop not only subject knowledge but also essential skills including critical thinking, creativity, collaboration, communication, problem-solving and digital literacy.

Research emphasizes that while critical thinking and problem-solving are often more visible in mathematics classrooms, creativity, collaboration, communication and digital literacy remain less consistently addressed (Goos, Geiger, & Dole, 2020; UNESCO, 2023). For example, creativity in mathematics instruction can be fostered through open-ended inquiry and project-based tasks (Beghetto, 2010), while collaboration and communication emerge when students work in groups to analyze and present problem solutions (Partnership for 21st Century Learning, 2023). Digital literacy, increasingly critical in mathematics, enables students to use digital tools for simulations, visualization and collaborative problem-solving (Zydney et al., 2020). Yet, studies across Sub-Saharan Africa, including Tanzania, highlight persistent challenges such as curriculum rigidity, inadequate professional development, overcrowded classrooms and limited access to technology (Mtika & Gates, 2021; UNESCO, 2023).

Teachers' ability to integrate these skills is closely linked to their mastery of Technological Pedagogical Content Knowledge (TPACK). Critical thinking and problem-solving align with content knowledge (CK), requiring deep subject mastery to design tasks that challenge reasoning (Schoenfeld, 2016). Creativity, collaboration and communication depend largely on pedagogical knowledge (PK), as teachers must select instructional strategies that foster inquiry, teamwork and dialogue. Digital literacy requires robust technological knowledge (TK), enabling teachers to embed tools that enhance exploration, visualization and interaction. Thus, effective integration of all six skills requires a balanced combination of CK, PK and TK.

Systemic barriers remain significant. A rigid exam-oriented curriculum can limit teacher autonomy (Stacey, 2019), while inadequate infrastructure and professional development particularly in rural districts like Kwimba restrict access to innovative pedagogy and technology (Darling-Hammond, Hyler, & Gardner, 2017; URT, 2023). Previous studies by Mfaume and Bilinga (2017, 2019) further show that Tanzanian teachers often lack adequate preparation to apply competency-based approaches in lesson planning, with challenges exacerbated in rural areas where training and resources are scarce. These findings directly highlight the need for empirical evidence on mathematics teachers' lesson planning competencies in Kwimba.

1.4. Overview of the six 21st-century skills considered in the study

This study focused on six 21st-century skills emphasized in Tanzania's curriculum: critical thinking, creativity, collaboration, communication, problem-solving and digital literacy (MoEVT, 2007; Care et al., 2023). These skills were selected because they are central to both mathematics learning and broader educational outcomes. Critical thinking and problem-solving (CK) equip learners to analyze information and develop logical solutions (Saavedra & Opfer, 2012). Creativity (PK) encourages students to approach problems innovatively and flexibly (Beghetto, 2010). Collaboration and communication (PK) foster teamwork and the exchange of ideas essential for problem-solving contexts (Voogt & Roblin, 2012; Tienken, 2022). Digital literacy (TK) supports learning through technological tools, enabling students to access, evaluate and present mathematical ideas (Ananiadou & Claro, 2009; OECD, 2021). The integration of these skills in lesson planning requires teachers not only to understand their importance but also to possess the professional capacity and resources to implement them effectively. In rural contexts such as Kwimba, this remains a pressing challenge.

1.5. Theoretical Underpinnings of the study

This study was guided by Teacher Competency Framework and Technological Pedagogical Content Knowledge (TPACK) framework. The Teacher Competency Framework holds that to plan lessons that foster 21st-century skills, teachers must possess essential knowledge, skills and attitudes for effective teaching, including subject knowledge, pedagogical strategies and student engagement (König et al., 2021). It is particularly useful for assessing mathematics teachers' competencies in lesson planning aimed at enhancing students' 21st-century skills acquisition (Darling-Hammond et al., 2017; Kraft, Blazar & Hogan, 2021). It also provides a structured approach for identifying gaps in teachers' abilities and suggesting targeted interventions for professional development.

The Technological Pedagogical Content Knowledge (TPACK) Framework emphasizes that to effectively plan lessons that promote 21st-century skills, teachers must blend the three domains of Content Knowledge (CK), Pedagogical Knowledge (PK) and Technological Knowledge (TK) as essential for effective teaching in the 21st century to enhance learning and promote critical thinking, creativity, collaboration, communication, problem-solving and digital literacy (Koehler et al., 2013; Schmid, Brianza & Petko, 2021). The theory assumes these knowledge areas are interconnected and must work together to foster essential 21st-century skills (Voogt et al., 2013; Care et al., 2018). This framework is relevant to the study as it is essentially useful to evaluate how mathematics teachers in Kwimba district integrate technology with pedagogy and content to design lessons that support problem-solving and collaborative learning (Kimmons, 2015; Trust & Whalen, 2020).

1.7. Research question and its correspondence to the research design

The aim of this study was to investigate mathematics teachers' competencies in planning lessons that foster the acquisition of 21st-century skills among secondary school students. In this regard, the study was guided by a research question stated as; To what extent are secondary school mathematics teachers able to plan lessons that incorporate the development of the 21st-century skills? The descriptive survey design utilized in this study enabled for the usage of questionnaires which had closed-ended items in form of a test that prompted teachers to prove their competencies in planning such lessons. Therefore, this design ultimately, fostered obtaining results that answered the research question appropriately.

2. Method

2.1. Study area

The study was conducted in public secondary schools in Kwimba district, Mwanza region, Tanzania. The area was selected because mathematics teachers in the district face several persistent challenges, including inadequate access to professional development programs, insufficient teaching resources and limited exposure to innovative pedagogies that emphasize 21st-century skills (URT, 2020). Being a rural district, Kwimba represents the broader challenges of rural educational contexts in Tanzania, making the findings transferable to other similar settings.

2.2. Research approach and design

The study adopted a quantitative research approach, employing a descriptive survey design to investigate mathematics teachers' competencies in preparing lessons that foster 21st-century skills among secondary school students in Kwimba district, Tanzania. A quantitative approach was suitable as it allowed for the systematic collection of numerical data from a broad group, which could then be analyzed statistically to identify trends and patterns (Creswell & Creswell, 2023). Additionally, the descriptive survey design was particularly appropriate for measuring self-reported practices, perceptions and competencies of teachers across multiple schools without manipulating any variables (McMillan & Schumacher, 2022).

2.3. Sample size and sampling procedures

The study included all 81 officially employed mathematics teachers in Kwimba district, along with 19 volunteer professional mathematics teachers, making a total of 100 mathematics teachers. This sample size was considered adequate for providing reliable and generalizable results (Cochran 1977). Additionally, the sample included teachers from both lower forms (Form I–II) and upper forms (Form III–IV), ensuring representation across ordinary secondary education class levels.

2.4. Participants

Participants were 100 mathematics teachers, both male and female, teaching forms I–IV in public secondary schools across Kwimba district. Their demographic characteristics included gender, teaching class, age, academic qualifications and years of teaching experience.

2.5. Data collection technique

Data were collected using a structured questionnaire developed by the researcher based on existing validated instruments on teacher competencies and 21st-century skills integration (Voogt & Roblin, 2012; Tienken, 2022; Binkley et al., 2012; Care et al., 2023). Structured questionnaires were used in this study because they are widely used in similar educational settings for their efficiency in gathering standardized data from large samples (Aboagye et al., 2021; Kalinga et al., 2022). To improve clarity and ensure contextual appropriateness, the questionnaire was pilot-tested with a comparable non-sampled group of 15 mathematics teachers in the district. The feedback from the pilot informed minor revisions to item wording for clarity and cultural relevance.

2.6. Reliability and validity

The instrument's reliability was assessed using Cronbach's alpha, measured from the pilot data which produced an overall coefficient of 0.82, indicating high internal consistency. Content validity was established through expert review by experienced mathematics educators and research experts at Sokoine University of Agriculture, who confirmed the alignment of questionnaire items with the study objective and the 21st-century skills constructs.

2.7. Data analysis

Data collected from the questionnaires were coded and entered into Statistical Package for Social Sciences (SPSS) version 26 for analysis. Descriptive statistics, including percentages, means and standard deviations, were used to summarize teachers' responses regarding their competencies in lesson planning, while cross-tabulations were conducted to explore relationships between teachers' qualifications and their competency levels. Descriptive statistics were employed in this study as they are essential in educational research to capture the scope and nature of teaching practices (McMillan &

Schumacher, 2022), while cross-tabulations help reveal potential disparities among teacher subgroups (Masanja & Mkoma, 2023). To classify competency, mean scores were categorized into four levels: Mean>4 "High competency", mean 3.3-4 "Moderate competency", mean 2.5-3.2 "Low competency" and mean<2.5 "Very low competency". This cut-off was adapted from educational measurement literature to reflect teachers' relative strengths and weaknesses in planning for 21st-century skills.

2.8. Ethical considerations

The study adhered to ethical standards in educational research. Ethical clearance was granted by Sokoine University of Agriculture on behalf of the Tanzania Commission for Science and Technology. Permission to conduct the study was also obtained from the District Education Office. Informed consent was sought from all participants and anonymity was ensured by omitting names from questionnaires. Finally, data were analyzed and presented objectively to safeguard integrity and avoid bias.

3. Results and Discussion

The study intended to investigate mathematics teachers' competencies in preparing lessons that foster 21st-century skills acquisition among secondary school students. It sought to investigate teachers' ability in planning lessons that develop 21st-century skills. The 21st-century skills investigated by the study were critical thinking, creativity, collaboration, communication, problem-solving and digital literacy. The study findings are presented based on the specific objective.

3.1. Teachers' familiarity with 21st - century skills

Table 1: Teachers' familiarity with 21st-century skills

Familiarity Level	Frequency (%)
Very Familiar	36 (36%)
Familiar	52 (52%)
Somewhat Familiar	12 (12%)
Total	100 (100%)

Table 1 shows that 36% of teachers reported being very familiar with 21st-century skills, 52% were familiar and 12% were somewhat familiar. While a majority indicated some level of familiarity, the relatively low percentage of those who are very familiar suggests a gap in deep understanding and practical application of these skills in lesson planning. This aligns with findings by Voogt and Roblin (2012), who reported that although many teachers recognize the importance of 21st-century competencies, few feel adequately prepared to implement them effectively. Similarly, a study by UNESCO

(2023) in Sub-Saharan Africa highlighted that limited exposure to competency-based education and insufficient teacher training often hinder the integration of these skills into classroom practices. As a result, many teachers may find it challenging to create meaningful learning experiences that nurture critical thinking, creativity, collaboration, communication, problem-solving and digital literacy among students. This finding reflects the dimensions of the Teacher Competency Framework, which emphasizes not only teachers' knowledge but also their ability to apply pedagogical skills, professional values and reflective practices in fostering student learning. Teachers who only report general familiarity may lack the pedagogical and professional depth required to embed these competencies meaningfully in lesson plans. Furthermore, from the Technological Pedagogical Content Knowledge (TPACK) framework, the results highlight that familiarity alone is insufficient without the integration of technological, pedagogical and content knowledge in lesson planning. Strengthening professional development and curriculum support is essential to address this shortfall and enhance holistic lesson planning competencies that reflect 21st-century learning goals.

3.2. Teachers' integration of 21st-century skills in lesson planning

Effective lesson planning that incorporates 21st-century skills plays a pivotal role in fostering students' readiness for the demands of the modern world, especially in science and mathematics education (Anderson & Anderson, 2023). Integration of competencies such as critical thinking, creativity, collaboration, communication, problem-solving and digital literacy ensures that learners are equipped not only with content knowledge but also with adaptable skills for lifelong learning. Nevertheless, existing literature reports persistent challenges among teachers in embedding these skills into lessons, especially in under-resourced and rural contexts (UNESCO, 2019; Ng, 2022). These challenges often stem from limited access to instructional resources, digital tools and contextualized professional development. In light of this, Figure 1 presents data on how mathematics teachers in Kwimba district incorporate specific 21st-century skills in their lesson planning, offering insight into current instructional practices and the extent of skill-based, particularly in rural contexts Tanzania.

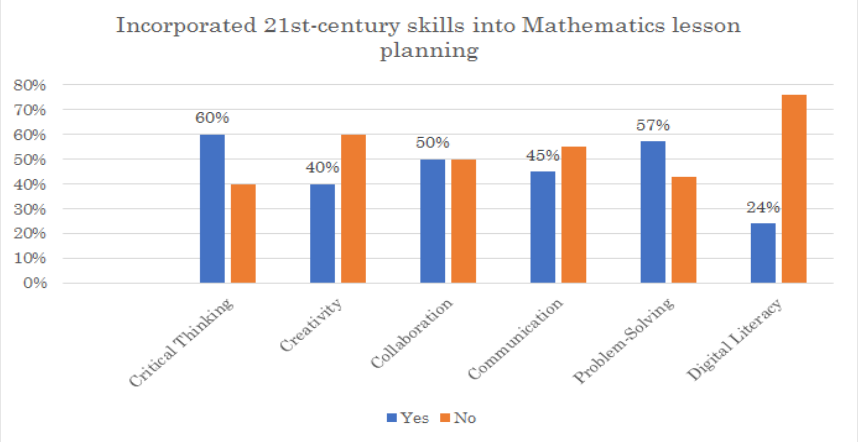

Figure 1: Teachers' integration of 21st-century skills in lesson planning

Figure 1 illustrates that while 60% of teachers consistently integrate critical thinking tasks and 57% include problem-solving activities in their lesson plans, only 24% reported using digital tools, making digital literacy the least implemented 21st-century skill. These results reflect a partial but uneven adoption of essential skills, suggesting that although some cognitive competencies are addressed, digital literacy remains notably underdeveloped. This finding aligns with UNESCO (2019), which identified limited use of technology, especially in rural contexts as a key challenge to achieving quality education. Trilling and Fadel (2021) also stress that the effective use of digital tools is central to preparing learners for modern challenges, yet barriers such as insufficient access and limited teacher confidence persist. Ng (2022) supports this view, pointing out that without appropriate infrastructure and training, rural teachers struggle to integrate ICT effectively. Furthermore, Anderson and Anderson (2023) highlight the value of focused professional development in equipping teachers with strategies to embed digital and higher-order skills into instruction. From the Teacher Competency Framework, these results show that teachers demonstrated strength in the pedagogical competency domain, particularly in designing learning experiences that develop students' analytical and reasoning skills. However, from the TPACK framework, although critical thinking and problem-solving were integrated, they mainly reflect Pedagogical Knowledge (PK) and Content Knowledge (CK), with less evidence of integration with Technological Knowledge (TK), indicating teachers relied on traditional lesson planning strategies rather than technology-enhanced problem-solving planning approaches. These findings suggest an urgent need to support teachers through context-specific solutions, investments in educational technology and training programs that ensure comprehensive skill integration across all aspects of lesson planning.

3.3. Parts of lesson plan in which 21st-century skills are incorporated by teachers

Understanding where in the lesson structure teachers integrate 21st-century skills is essential for evaluating the depth and intentionality of skill-based instruction. A well-structured mathematics lesson plan typically includes components such as objectives, instructional strategies, learning activities, assessment methods, and reflections, all of which offer opportunities for embedding competencies like critical thinking, creativity, collaboration, communication, problem-solving and digital literacy (OECD, 2018; Tienken, 2022). Research indicates that purposeful integration of these skills throughout various stages of lesson planning enhances student engagement and better prepares learners for real-world challenges (Darling-Hammond et al., 2020). However, in many classrooms, particularly in under-resourced settings, teachers may focus on only certain sections of the lesson plan, limiting the holistic development of these competencies. To explore how teachers in Kwimba District approach this, participants were asked to indicate the specific parts of their mathematics lesson plans in which they incorporate 21st-century skills. Their responses are summarized in Figure 2

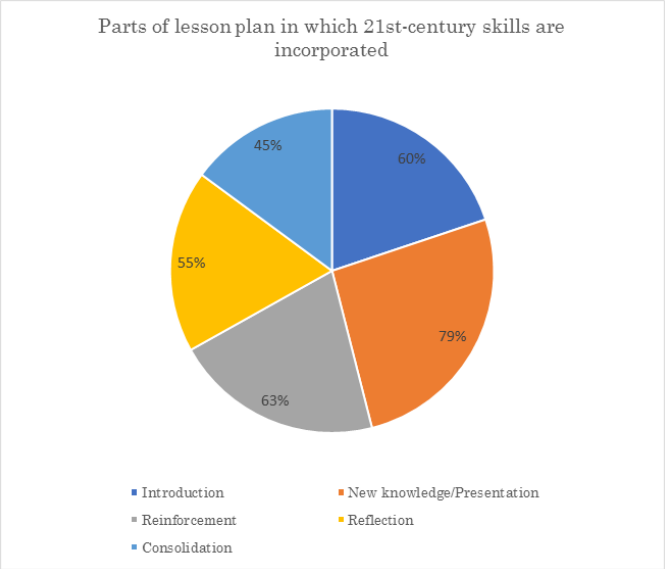

Figure 2: Teachers' 21st-century skills integration competencies in the parts of the lesson plan

Figure 2 shows that a majority of teachers (79%) integrate 21st-century skills primarily in the new knowledge/presentation stage of their lesson plans, followed by 63% during the reinforcement stage, while only 45% incorporate such skills during the consolidation phase. This uneven distribution suggests that teachers tend to prioritize skill integration during content delivery but neglect its continuity across other critical instructional stages. According to the OECD (2018), effective development of 21st-century competencies requires consistent embedding across all lesson components ranging from lesson introduction to assessment and reflection to ensure learners are continuously engaged in higher-order thinking and collaborative activities. Studies by Makunja (2020) and Hemed and Mafwimbo (2022) similarly report that Tanzanian teachers often demonstrate partial engagement with competency-based practices, largely due to inadequate professional training and lack of clarity on curriculum expectations. Moreover, Voogt and Roblin (2012) argue that for skill acquisition to be sustainable, integration must be intentional and balanced throughout lesson delivery, not confined to a single segment. From the Teacher Competency Framework, this finding highlight limited instructional design competency, as teachers' planning fails to demonstrate a balanced integration of professional, pedagogical and reflective dimensions across all lesson parts. Similarly, from the TPACK perspective, the neglect of certain lesson components reveals an underdeveloped capacity to blend pedagogical strategies with content and technology across the full instructional planning sequence. These findings highlight a pressing need to enhance teachers' instructional design capacities, with a focus on applying competency-based strategies across all stages of the teaching and learning process to support holistic student development.

3.4. Teachers' frequency of integrating 21st- century skills in lesson planning

Effective lesson planning for 21st-century skills requires consistent integration of key competencies such as critical thinking, creativity, collaboration, communication, problem-solving and digital literacy. The frequency with which these skills are embedded in teachers' planning provides insight into both their pedagogical priorities and the practical constraints they encounter. Literature emphasizes that frequent and balanced incorporation of these skills is essential to prepare students for future societal and workforce demands (Trilling & Fadel, 2009; Voogt & Roblin, 2012; Tienken, 2022). Therefore, understanding how regularly mathematics teachers integrate these competencies is crucial in evaluating instructional readiness and areas needing targeted support. Respondents were asked about their frequency extent of incorporating 21st-century skills in their lesson planning with responses ranging from "always" to "never" and that various choices were provided by respondents as descriptively summarized in figure 3.

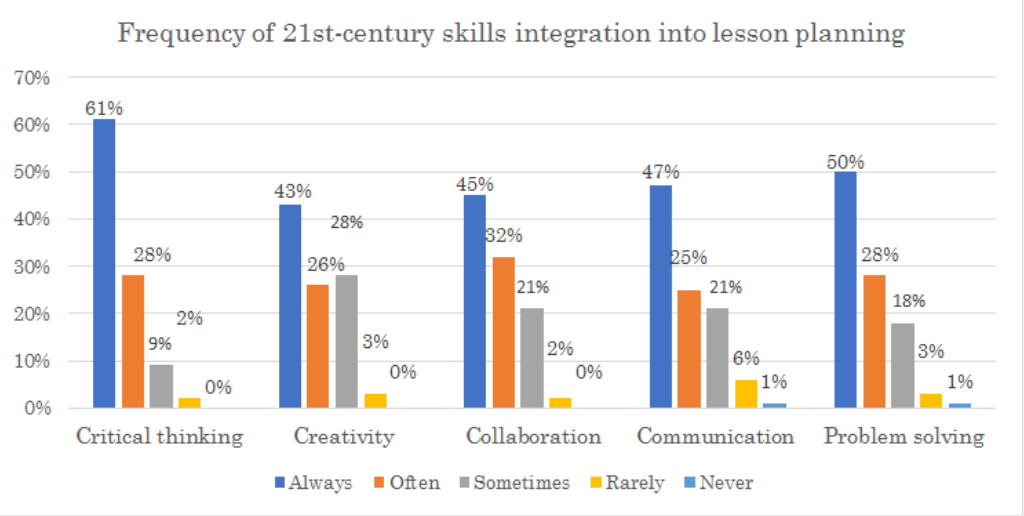

Figure 3: Teachers' frequency of integrating 21st-century skills in lesson planning

Figure 3 indicates that critical thinking (61% "always") and problem-solving (50% "always") were the most frequently integrated 21st-century skills in lesson planning among mathematics teachers. In contrast, creativity, collaboration, communication and digital literacy were less frequently embedded, suggesting that teachers may favor cognitive-oriented competencies while neglecting interpersonal and innovative dimensions. This pattern aligns with findings by Kafyulilo et al. (2015) and Mosha (2012), who noted discrepancies between curricular intentions and actual classroom practices across Sub-Saharan Africa due to resource constraints and pedagogical gaps. Brookhart (2017) emphasizes that robust 21st-century lesson planning should include opportunities for creativity, collaboration, communication and inquiry to support diverse skill acquisition. Through the Teacher Competency Framework, these results point to strengths in content and pedagogical knowledge but weaknesses in professional and

adaptive competency, as teachers underemphasize social and digital skills critical to modern learning. From a TPACK standpoint, the imbalance reflects insufficient pedagogical and technological integration, where teachers rely primarily on traditional mathematics problem-solving without leveraging technology or collaborative pedagogies. The imbalance in skill integration reveals potential weaknesses in professional development and highlights the need for more inclusive instructional frameworks that promote all dimensions of 21st-century skills.

3.5. The extent of mathematics teachers to integrate digital literacy in lesson planning

Digital literacy is increasingly considered a foundational 21st-century skill necessary for learners to thrive in a technology-driven world. For mathematics education, integrating technology into lesson planning enhances visualization, real-world problem-solving, and interactive learning (NCTM, 2020). However, studies have shown that teachers in under-resourced regions often face barriers to integrating digital tools effectively (World Bank, 2020). This section explores the extent to which mathematics teachers incorporate digital literacy into their planning to support student engagement with technology. Respondents of the study provided various responses regarding the question on the extent to which they incorporate digital literacy/technology skills in their lesson planning practices and that the results regarding the responses were presented as shown in figure 4.

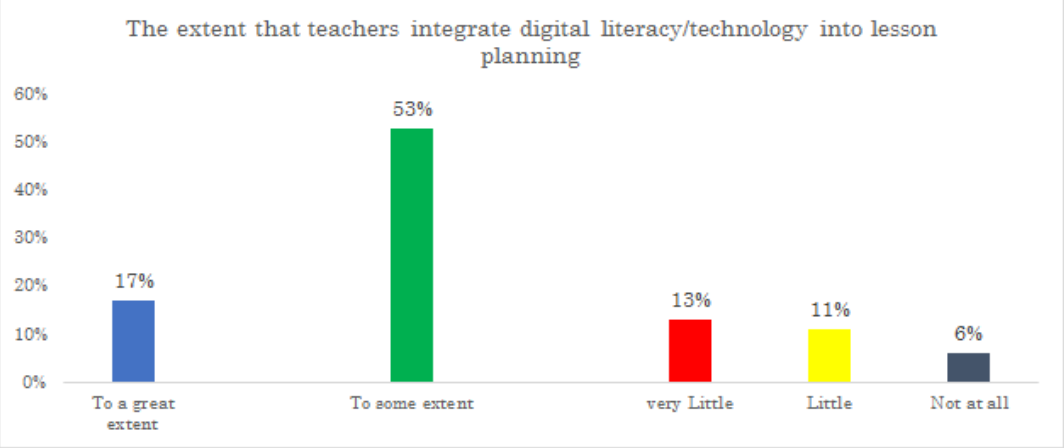

Figure 4: The extent of mathematics teachers to integrate digital literacy in lesson planning

Results in Figure 4 reveal that only 17% of mathematics teachers incorporate digital literacy "to a great extent" in their lesson planning, while 53% do so only "to some extent." This limited engagement suggests persistent challenges in integrating technology, potentially linked to infrastructure gaps and insufficient training. Langoi and Deogratias (2024) similarly found that only 24.3% out of the sampled 70 mathematics and science teachers in Morogoro Municipality, Tanzania, regularly use ICT tools, reflecting systemic barriers to digital literacy education. From the Teacher Competency

Framework, the results highlight deficiencies in professional competency and contextual adaptability, as teachers lack the capacity to navigate the infrastructural challenges and integrate digital tools into lesson planning and delivery. Through the lens of TPACK framework, these findings reflect underdeveloped intersection of technological knowledge with pedagogy and mathematics content, constraining teachers' ability to design lessons that cultivate digital literacy alongside core mathematics concepts. These findings illustrate that without enhanced access to digital resources and sustained training, efforts to foster digital competencies in mathematics classrooms may remain superficial and uneven. Thus, while some effort exists, the results confirm a pressing need for capacity building initiatives that develop teachers' professional competencies and strengthen their digital literacy integration particularly in rural Tanzania contexts.

3.6. Teachers' abilities in lesson planning for 21st-century skills

Assessing the specific instructional strategies teachers use to foster 21st-century skills offers critical insight into their pedagogical abilities and readiness for competency-based education. A detailed analysis of the activities used to promote critical thinking, creativity, collaboration, communication, problem-solving and digital literacy skills reveals strengths and gaps in lesson planning. The capacity to embed these skills effectively into learning objectives aligns with curriculum reforms promoting student-centered and inquiry-based learning (Voogt & Roblin, 2012; NCTM, 2020). Respondents provided various responses regarding varieties of activities they address in each of the six (6), 21st-century skills of critical thinking, creativity, collaboration, communication, problem-solving and digital literacy to foster skills development among secondary school students. Each of the 21st-century skills considered in this study had four key activities for teachers to incorporate in their lesson plans to ensure effective development of these skills among students. Teachers' responses were summarized and descriptively presented in table 2.

Table 2: Teachers' abilities in lesson planning for 21st-century skills

Teachers' Abilities in Lesson Planning for 21st-Century Skills	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Critical Thinking					
I design tasks that require students to analyze, evaluate and interpret mathematical data	1(1%)	2(2%)	3(3%)	72(72%)	22(22%)
I encourage students to explore multiple solutions to mathematical problem	2(2%)	2(2%)	3(3%)	57(57%)	36(36%)
My lesson plans include activities that require logical reasoning	0(0%)	1(1%)	1(1%)	68(68%)	30(30%)
I incorporate real-world mathematical problems that require in-depth analysis	1(1%)	2(2%)	5(5%)	67(67%)	25(25%)
Creativity					
I encourage students to create their own mathematical models or representations	10(10%)	6(6%)	15(15%)	50(50%)	19(19%)
I use open-ended questions to promote innovative thinking	1(1%)	2(2%)	25(25%)	58(58%)	14(14%)
I include tasks that allow students to develop unique solutions	1(1%)	3(3%)	16(16%)	52(52%)	28(28%)
My lesson plans allow room for creative exploration of mathematical concepts	5(5%)	8(8%)	12(12%)	50(50%)	25(25%)
Collaboration:					
I organize group-based mathematical tasks in my lessons	2(2%)	5(5%)	9(9%)	52(52%)	32(32%)
I assign roles to students during collaborative activities to enhance group dynamics	0(0%)	4(4%)	8(8%)	59(59%)	29(29%)
I assess students based on their contributions to group projects	0(0%)	9(9%)	19(19%)	46(46%)	26(26%)
My lesson plans include cooperative learning strategies	5(5%)	3(3%)	11(11%)	56(56%)	25-(25%)
Communication:					
I plan activities that require students to explain mathematical reasoning verbally	1(1%)	3(3%)	16(16%)	52(52%)	28(28%)
I include written assignments that require clear expression of mathematical ideas	1(1%)	1(1%)	15(15%)	57(57%)	26(26%)
My students present solutions to their peers in class	0(0%)	2(2%)	12(12%)	61(61%)	25(25%)
My lesson plans encourage active participation through classroom discussions	0(0%)	1(1%)	11(11%)	52(52%)	36(36%)
Problem-Solving:					
I use real-world problem problems that require mathematical modeling	1(1%)	3(3%)	6(6%)	72(72%)	18(18%)
I incorporate inquiry-based learning into my lesson plans	2(2%)	3(3%)	5(5%)	66(66%)	24(24%)
I plan tasks that involve multi-step problem-solving	3(3%)	5(5%)	8(8%)	64(64%)	20(20%)
I challenge students with problems requiring innovative thinking and solutions	3(3%)	3(3%)	5(5%)	61(61%)	28(28%)
Digital Literacy:					
I incorporate digital tools such as graphing software, calculators, or online platforms	19(19%)	22(22%)	14(14%)	25(25%)	20(20%)
I use technology to enhance students learning experiences	17(17%)	20(20%)	17(17%)	27(27%)	19(19%)
My students use digital tools for collaborative projects and presentations	24(24%)	31(31%)	20(20%)	10(10%)	15(15%)
I provide online resources to support independent learning	16(16%)	12(12%)	26(26%)	36(36%)	10(10%)

Results from table 2 indicate that majority of the teachers incorporated critical thinking and problem-solving skills at relatively high levels compared to other skills. Teachers foster critical thinking skills by incorporating tasks that require students to analyze, evaluate and interpret mathematical data in their lesson planning by 72% "Agree" and 22% "Strongly Agree"; problem-solving skills by incorporating real-world problems that require mathematical modelling (72% "Agree" and 18% "Strongly agree"), communication skills through students presentation of solutions to their peers in class (61% "Agree" and 25% "Strongly Agree") collaboration skills through assigning roles to students during collaborative activities to enhance group dynamics (59% "Agree" and 29% "Strongly Agree"), creativity skills by using open-ended questions to promote innovative thinking (58% "Agree" and 14% "Strongly Agree) and digital literacy skills entirely through providing online resources to support independent learning (36% 'Agree" and 10% "Strongly Agree"). These findings reflect the inherent nature of mathematics as a discipline that supports logical reasoning and analysis, as highlighted by Arthur et al. (2018) and NCTM (2020). However, the less frequent inclusion of digital and creative tasks suggests that while cognitive competencies are prioritized, teachers may lack the confidence or tools to facilitate holistic skill development. From the Teacher Competency Framework, this trend shows that teachers demonstrate subject matter and pedagogical competency but are weaker in fostering transversal skills such as creativity and digital competency. From a TPACK perspective, the imbalance indicates teachers' ability to integrate pedagogy and content knowledge effectively but difficulty incorporating technological knowledge, resulting in uneven lesson designs. These findings emphasize the need for professional development grounded in both frameworks to cultivate balanced abilities in lesson planning that extend beyond mathematics cognitive focus to embrace creativity, collaboration, communication and technology-driven learning.

3.7. Competency levels in 21st-century skills integration in lesson planning

3.7.1. Mean scores and standard deviations of competency levels

Quantitative metrics such as mean scores and standard deviations offer a clearer view of mathematics teachers' perceived competencies in integrating 21st-century skills. These measures help evaluate whether teachers feel confident embedding skills like creativity, digital literacy, and collaboration, which are essential for effective 21st-century education (Trilling & Fadel, 2009; Tienken, 2022). By identifying competency trends across different skills, targeted support strategies can be developed to enhance instructional planning effectiveness. The mean scores and standard deviations of teachers' responses were calculated using SPSS to assess their competency levels across various skills in planning for 21st-century skills. Competency was categorized as moderate, low, or very low based on the Likert scale values as presented in table 3.

Table 3: Mean scores and standard deviations of competency levels for 21st- century skills lesson planning

Skill area	Mean score (out of 5)	Std. Deviation	Competency level
Critical thinking	4.2	0.7	High
Creativity	3.8	0.9	Moderate
Collaboration	4.0	0.9	Moderate
Communication	4.0	0.8	Moderate
Problem-solving	4.1	0.7	High
Digital literacy	3.0	1.4	Low

Note: Mean above 4 "High", 3.3 - 4 "Moderate", 2.5 - 3.2 "Low", Below 2.5 "Very Low"

From table 3 teachers reported high competency levels in critical thinking (mean 4.2, standard deviation 0.7) and Problem-solving (mean 4.1, standard deviation 0.7), While creativity (mean 3.8, standard deviation 0.9), collaboration (mean 4.0, standard deviation 0.9) and communication (mean 4.0, standard deviation 0.8) moderate competency levels. Digital literacy (mean 3.0, standard deviation 1.4) was reported the low competency level area. These findings suggest that teachers demonstrate limited competency in integrating 21st-century skills, particularly digital literacy, into lesson planning. Additionally, the findings reflect a persistent imbalance in the integration of 21st-century skills, with teachers placing greater emphasis on cognitive and problem-oriented aspects of mathematics while undervaluing socio-emotional and technological competencies. This is consistent with recent studies such as Kivunja (2023), who noted that many teachers in Sub-Saharan Africa struggle to incorporate soft skills and digital literacy due to limited training and infrastructural barriers. Similarly, research by Agyei and Voogt (2022) found that despite curriculum reforms promoting ICT integration, practical implementation remains low in many African classrooms. Furthermore, the prominence of critical thinking and problem-solving aligns with the discipline's inherent focus on logical reasoning and analytical thinking, as emphasized by the National Council of Teachers of Mathematics (NCTM, 2020), which underscores mathematics' natural alignment with these skills when applied in inquiry-based instruction. Within the Teacher Competency Framework, these findings demonstrate partial competency, as teachers excel in subject content and pedagogical knowledge but lack full professional, digital and adaptive capacities. From the TPACK perspective, the results highlight incomplete intersections between technology, pedagogy and content, limiting teachers' ability to plan lessons that holistically integrate 21st-century skills. These findings suggest the need for more comprehensive and balanced professional development that supports teachers in planning for the full spectrum of 21st-century skills, especially in rural and resource-constrained settings.

3.7.2. Cross-tabulation of teacher qualifications and competency levels

Teacher qualifications play a crucial role in shaping their competencies in curriculum implementation and instructional innovation. Highly qualified teachers often possess deeper pedagogical content knowledge and are more likely to integrate a range of 21st-century skills in their teaching (Komba & Nkumbi, 2008). A cross-tabulation analysis

was conducted to examine the relationship between teachers' qualification levels and their competencies in integrating 21st-century skills as presented in figure 5

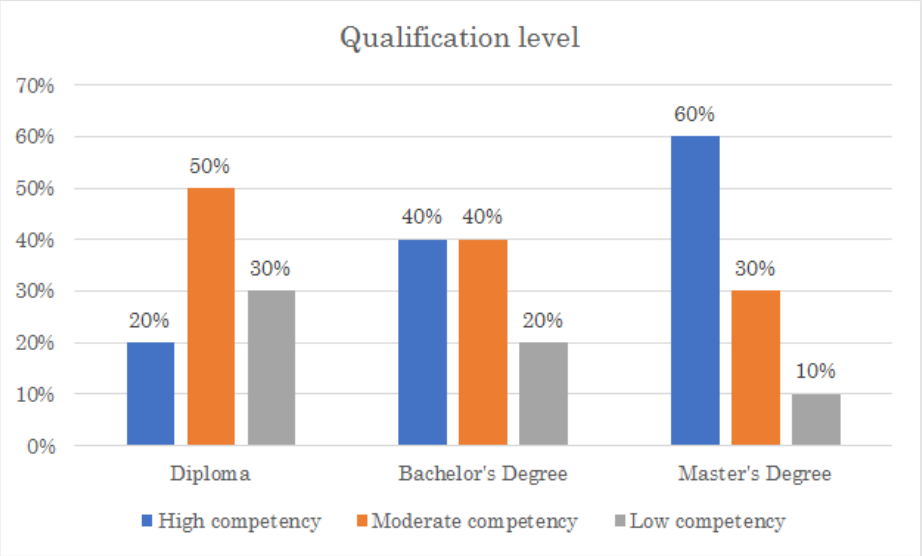

Figure 5: Cross-tabulation of teacher qualification levels and competency in integrating 21st-century skills

From figure 5 results indicate that teachers with postgraduate qualifications demonstrated higher competency levels (60% "High competency") in integrating 21st-century skills compared to those with bachelor's degrees (40% "High competency") or diplomas (20% "High competency"). These findings support earlier work by Komba and Nkumbi (2008), who emphasized that professional growth through in-service training and advanced academic qualifications significantly contribute to improved teaching competencies. This underscores the importance of incentivizing continuous academic advancement among teachers to support the effective integration of 21st-century skills in lesson planning. From the Teacher Competency Framework, this finding highlights the critical role of academic growth in enhancing professional, pedagogical and reflective competencies for effective 21st-century skills integration. Through the TPACK framework, higher qualifications may enhance teachers' ability to connect content, pedagogy and technology, explaining their stronger competencies in lesson planning. The linkage between qualification level and competency underscores the need for policy frameworks that promote access to postgraduate teacher education and continuous professional development for teachers in Tanzania, particularly in subjects like mathematics, where integrating higher-order skills is essential.

3.8. Professional development focused on integrating 21st-century skills into teaching and learning

Professional development is a cornerstone for equipping teachers with the knowledge, skills, and pedagogical strategies required to implement 21st-century competencies effectively. Focused in-service training programs can significantly enhance teachers'

ability to integrate skills such as critical thinking, creativity, collaboration, communication, problem-solving and digital literacy into lesson planning and classroom practice (Darling-Hammond et al., 2017). In contexts like Kwimba District, where systemic challenges may limit access to modern teaching tools and methodologies, the quality and focus of professional development become even more critical. Table 4 presents teachers' responses regarding their participation in professional development programs and the perceived effectiveness of such training in fostering the integration of 21st-century skills into mathematics instruction.

Table 4: Effectiveness of professional development received by mathematics teachers in Kwimba district

Professional Development Effectiveness	Frequency (%)
Very effective	31(31%)
Effective	43(43%)
Moderate effective	15 (15%)
Not effective	1(1%)
Undecided	10(10%)
Total	100(100%)

Table 4 shows that while a substantial majority (90%) of mathematics teachers in Kwimba district had received some form of professional development, the content primarily addressed general pedagogical practices rather than specific strategies for integrating 21st-century skills. Only 15% of teachers rated the training they received as "moderately effective", while 43% considered it "effective" and 31% rated it as "very effective". Although most teachers found the training beneficial, the limited focus on 21st-century skill integration reveals a gap in content specificity. These findings suggest that although training is relatively accessible, its content may not adequately address the demands of competency-based instruction. This aligns with the World Bank (2020) report, which emphasizes that teacher training programs must be context-specific and skill-focused to improve instructional planning and delivery effectiveness. Furthermore, research by Nyalusi and Rugambwa (2022) and Ndibalema and Mbelle (2023) found that well-targeted professional development significantly improves teacher confidence and instructional innovation. From the Teacher Competency Framework, this indicates the professional development that strengthens general pedagogy but does not adequately support the development of the 21st-century competencies. Similarly, from the TPACK framework, the training appears to reinforce pedagogical and content knowledge but fails to sufficiently build technological knowledge or its integration with other domains. As a result, teachers remain underprepared to translate 21st-century competencies into classroom lesson planning and delivery. Therefore, to strengthen 21st-century skills integration, future training initiatives should explicitly focus on practical methods, digital pedagogy and collaborative instructional design tailored to rural settings.

In summary, the findings reveal that while mathematics teachers in Kwimba district demonstrate relatively high familiarity and competency in critical thinking and problem-solving, they face significant challenges in integrating creativity, collaboration,

communication and digital literacy. These disparities stem from limitations in infrastructure, targeted training and curriculum clarity. Addressing these challenges requires systemic investment in context-specific professional development and the provision of digital resources to enhance holistic 21st-century learning outcomes.

4. Conclusions

This study investigated mathematics teachers' competencies in preparing lessons that foster 21st-century skills among secondary school students in Kwimba district, Tanzania. While teachers showed awareness of critical thinking and problem-solving, the integration of other essential skills such as creativity, collaboration, communication and digital literacy was less consistent. These findings highlight the need to strengthen teachers' capacity to design comprehensive lesson plans that reflect the demands of the competency-based curriculum. Beyond reporting uneven competencies, the results emphasize the importance of addressing systemic barriers such as limited resources, large class sizes and insufficient digital infrastructure. By enhancing teachers' lesson planning competencies, Tanzania's education system can be better positioned to equip students with the skills needed for a rapidly changing world.

4.1. Implications for teacher professional development

The study underscores the importance of sustained professional development tailored to the integration of 21st-century skills in mathematics instruction. Rather than focusing solely on generic pedagogy, training should include practical workshops on designing creative mathematical tasks, embedding collaboration and communication strategies, and effectively using digital tools for instruction and assessment. Since teachers with higher academic qualifications demonstrated greater confidence in fostering these skills, professional development initiatives should be coupled with policies that encourage teachers to pursue advanced studies. Strengthening in-service training and mentorship programs could provide teachers with both theoretical grounding and practical competencies to meet the demands of curriculum reforms.

4.2. Implications for curriculum and instructional planning

The findings suggest a need for curriculum guidelines that explicitly promote learner-centered methodologies to complement teachers' reliance on critical thinking and problem-solving. Strategies such as project-based learning, inquiry-based tasks and group problem-solving activities can enhance collaboration, creativity and communication in mathematics classrooms. In addition, integrating digital literacy requires deliberate curriculum alignment with Tanzania's vision for digital competency development. Equipping schools with accessible technologies and embedding digital tasks into lesson planning will ensure mathematics instruction remains relevant to 21st-century educational goals.

4.3. Implications for policy and educational reform

At the policy level, the study reinforces the urgency of aligning Tanzania's ongoing competency-based curriculum reforms with the realities of classroom practice. While policy mandates highlight 21st-century skills, successful implementation depends on creating enabling conditions for teachers through adequate infrastructure, smaller class sizes and consistent resource provision. Addressing these systemic challenges is essential if reforms are to achieve their intended impact. Policymakers must therefore move beyond prescriptive frameworks to actionable support mechanisms that empower teachers to implement student-centered, skill-oriented lesson planning.

4.4. Recommendations for practice

The most urgent priority is strengthening in-service training for secondary school mathematics teachers, focusing on practical strategies for integrating 21st-century skills into lesson planning and classroom instruction. Equally critical is expanding access to digital tools and improving school infrastructure, as effective planning for creativity, collaboration, communication and digital literacy cannot be realized in resource-constrained environments. Schools should create peer-learning communities where teachers can share best lesson planning competencies and collaboratively design inquiry-based lesson plans to promote student engagement and higher-order skills. Curriculum revisions should deliberately embed these skills supported by learner-centered pedagogies such as project-based learning. Teacher education institutions, including universities and colleges, should restructure their programs to equip pre-service teachers with competencies aligned to 21st-century demands. At the same time, the School Quality Assurance Department (SQAD) should intensify monitoring and feedback on teachers' incorporation of 21st-century skills during school visits to ensure sustained accountability. Finally, teachers themselves must embrace continuous self-improvement and modern pedagogical practices with professional pride, thereby modeling and facilitating the acquisition of these essential skills among their students.

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