Bridging the Digital Divide: Mathematics Teachers' Perceptions and Use of Information and Communication Technologies in the Classroom at Secondary Schools in Tanzania

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Abstract

This research investigated the perceptions of lower secondary school mathematics teachers regarding the use of Information and Communication Technology (ICT) in instruction. Ten ordinary secondary schools from Dar es Salaam and five from the Coastal regions were involved in the study. The schools were chosen based on their Mathematics Grade Point Average (GPA) from the 2021 Form Four National examinations. The research used a mixed methods approach whereby data were gathered through semi-structured interviews and questionnaires. Data were analysed using the SPSS IBM 25 software. Drawing upon the Technology Acceptance Model (TAM), it was deduced that teachers' perceptions of the usefulness and user-friendliness of ICT tools played a significant role in their adoption. Therefore, this study recommends collaborative efforts between policymakers and educators to fully leverage the benefits of integrating ICTs in mathematics education, ultimately serving both mathematics teachers and students for enhancing teaching and learning processes and quality of education.

Keywords: *ICT integration, teacher's perceptions, mathematics education, technology acceptance model (TAM), ordinary-level secondary schools, Tanzania*

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Introduction

While the Tanzanian government has made various efforts to improve the standard of Mathematics education, many students continue to struggle with underperformance in the subject. Recent data from the Basic Education Statistics-Tanzania (BEST) report of 2021 of the United Republic of Tanzania (URT) (URT, 2022) highlights this paradoxical trend; while Mathematics enjoys the most favourable

student-to-book ratio in Tanzanian schools. It concurrently reports the highest failure rate when juxtaposed against other subjects. National Examination Council of Tanzania (NECTA) results of the Certificate of Secondary Education Examination (CSEE), from 2019-2020 (URT, 2021) further substantiate this concern, revealing that while subjects like Kiswahili and Chemistry boasted pass rates of 94.8% and 87.1% respectively in 2020, Basic Mathematics lagged distressingly behind at a mere 20.1%. This discrepancy persists even though, as of 2021, Mathematics textbooks outnumbered those of any other subject across both lower and upper secondary school levels (URT, 2021). Moving forward to 2022, the trend remains worrisome. A staggering 84.4% of students who took the Form Two examinations in 2022 received an 'F' grade in Mathematics, with other science subjects similarly reflecting suboptimal performances (NECTA, 2023).

Among the reasons cited for these outcomes are insufficient teaching skills among Mathematics educators and a pervasive lack of student motivation in the subject (Mazana et. Al., 2020). In the context of Tanzanian secondary schools, especially within the subject of mathematics, the potential of Information and Communication Technology (ICT) to transform educational outcomes is substantial. Through visual aids and interactive platforms, ICT can significantly deepen students' understanding. However, this transformation's success largely hinges on the teachers. The way teachers perceive the use of ICT and their willingness to harness its capabilities in mathematics is vital in revitalizing the educational landscape and boosting student performance. In Tanzanian secondary schools, the integration of Information and Communication Technology (ICT) into mathematics education presents both opportunities and challenges. Teachers are at the forefront of determining how ICT aligns with the current curriculum and whether it complements the primary objectives of mathematics instruction. Their perceptions of ICT not only reflect their understanding of its advantages and drawbacks but also reveal their profound appreciation of its significant role in pedagogy (Adhikari, 2021, Kamau et al., 2016, Mwei, 2020).

Within the realm of mathematics education, ICT introduces a mix of hope and caution. While technology offers tools that can deepen understanding and enhance teaching methods, its adoption isn't automatic. The reservations stem from various concerns, making it essential to understand how mathematics teachers perceive and respond to the idea of integrating technology. A multitude of factors such as personal teaching experiences, professional development opportunities, familiarity with technology, and the unique nuances of the Tanzanian education system shape the perceptions of teachers towards integrating technology in mathematics instruction. The Technology Acceptance Model (TAM) postulates that the perceived usefulness and perceived ease of use are pivotal determinants in technology adoption within

educational settings (Davis, 1989). This means that for a country like Tanzania, where digital infrastructure is still evolving, the successful implementation of ICT in secondary school mathematics education hinges on understanding teachers' perceptions of usefulness and of easy to use. Understanding these perceptions is fundamental for its successful integration. As teachers continue to evolve through learning and exposure, too can their perceptions. The true success of integrating technology in the classroom depends not only on these evolving perceptions but also on a solid understanding of its educational value. Teachers' preparedness for ICT integration is pivotal for its successful implementation. Therefore, the transition towards using technology in the classroom must be anchored in a profound understanding of its educational potential, rather than being driven by fleeting trends.

Background to the Study

In the evolving realm of education, teachers' attitudes toward technology play a crucial role in its successful integration (Teo et al., 2016). While there is a significant potential in integrating ICT into mathematics education, the success of such initiatives depends on the perceptions, training, and support provided to teachers. For optimal outcomes, a balanced approach, combining the strengths of traditional methods with the advantages of technology, is often recommended. Several researchers have previously embarked on the exploration of teachers' attitudes toward technology integration, each with distinct facets and approaches. Teo et al. (2016), Venkatesh et al. (2016), and Schlebusch (2018), for instance, have their unique methodologies and focal points in examining this phenomenon. Tuncer (2012) offers valuable insights into the integration of technology in classrooms, emphasizing the pivotal role of teachers' attitudes in this process. Despite positive attitudes toward technology, some teachers restrict students' access to it, even when they show strong motivation for its use. This disparity between attitude and practice presents a significant ongoing challenge in education as evidenced by comprehensive studies by Bamigboye et al. (2013), Chou (1997), and Christensen (2002), it's crucial to discern the nuances in each study.

Several assessment scales have also been curated to evaluate these attitudes, as seen in the works of Agyei and Voogt (2010) and Christensen and Knezek (2009). Yet, these scales are not monolithic. Some lean heavily into dissecting elements such as enjoyment and anxiety, while others might prioritise different criteria. The range in the number of criteria further accentuates the variability among studies. For instance, while Christensen (2002) delves deep with nine criteria, both Bamigboye et al. (2013) and Chou (1997) streamline their approaches with just four. Within the Tanzanian educational framework, various studies have also illuminated distinct

facets of ICT integration. For instance, Kafyulilo (2014) delved into the specific realm of mobile phones, focusing on their access, usage, and implications as learning tools in teaching. Kisanga and Ireson (2016), on the other hand, concentrated on the development of a scale assessing e-learning-related attitudes, gravitating more towards the online educational sphere. Building on these foundational studies, Njiku (2022) offers a novel perspective by examining the perceptions related to the application of ICT explicitly in mathematics teaching at the secondary level. The study done by Mwalongo (2011) adopted a more encompassing approach, exploring teachers' perceptions of ICT not just in teaching, but also for professional development and administrative purposes. Contrasting these works, Njiku et al. (2019) probed into the emotional and behavioural intricacies of teachers' attitudes toward ICT. Each of these investigations offers valuable insights, shedding light on different components of the ICT mosaic in Tanzanian education.

Contrary to the studies mentioned earlier, our current research distinctively focuses on the cognitive dimension of teachers' engagement with ICT, emphasizing their perceptions. However, focusing solely on attitudes may overlook deeper cognitive processes. While attitudes represent emotional inclinations, perceptions encompass an informed awareness of a subject. Perception encompasses how teachers interpret and understand the role of technology, providing a richer understanding of their receptivity to it (Tuncer, 2012). For instance, a teacher's scepticism about technological tools might stem from past failures or a lack of awareness of their benefits. Addressing these perceptions through training and exposure ensures that technology adoption is based on informed choices, rather than transient emotions. In essence, for robust technological integration in education, especially in Tanzanian mathematics classrooms, it is crucial to align positive attitudes with well-informed perceptions.

While earlier research provides critical insights into attitudes and related metrics, this study explores perception, primarily how these teachers cognitively grasp the potential benefits, challenges, or significance of ICT and its implications within their unique teaching contexts. Significantly, this research differentiates itself by enhancing perceptions linked to ICT use in the specific context of secondary school mathematics. Hence, despite the invaluable insights of previous studies, this research distinguishes itself by blending a focus on both perception and mathematics, adding a refined perspective to the dialogue on ICT in Tanzanian education (Kayombo and Mlyakado, 2016; Mwila, 2018).

Research questions

The study was guided by four research questions:

i. How do mathematics teachers perceive their ability to use ICT tools in teaching Mathematical concepts in the classroom setting?
ii. To what extent do teachers use ICT to achieve Secondary school mathematics objectives?
iii. Which learning objectives do Mathematics teachers believe are the best achieved with the use of ICT tools?
iv. What challenges do teachers face in integrating ICT tools into their mathematics instruction?

Literature Review and Theoretical Framework

Literature review

The role of teacher perception in ICT integration in Mathematics education

The fusion of ICT into mathematics potentially simplifies complex concepts, engages students more deeply, and caters to diverse learning needs, ensuring a more holistic and effective educational experience (Das, 2019; Mistretta, 2005; Mwaniki et al. 2024). The confluence of perception, ICT, and mathematics forms a dynamic triad in the educational landscape. Perception, in this context, refers to the way teachers interpret, understand, and feel about the role of ICT in teaching mathematics. Teacher's perception encompasses both their cognitive understanding and emotional response to the integration of technology into their teaching practices (Das, 2019; Shar 2022; Mwaniki, 2024). Understanding teachers' perspectives and addressing systemic issues are crucial for ensuring that ICT realises its full potential in enhancing mathematics education. For successful integration, fostering positive perceptions among educators is crucial, as their attitudes will significantly influence the acceptance and effectiveness of ICT tools in the mathematics classroom.

Determinants and factors shaping teachers' perceptions

Understanding the determinants that shape an educator's stance on ICT in mathematics is crucial. At its core, the perception of ICT doesn't solely rest on its educational merits. Some view it as a combination of elements such as liking technology, feeling its importance, and having comfort using it (Njiku et al., 2019). An educator's perspective on the role of ICT in teaching mathematics is influenced by various factors. Training and exposure to ICT play a major role in shaping these perceptions. According to Wong and Li (2008) and Mwei (2020), younger educators who are familiar with the digital environment might be more

inclined to incorporate technology compared to their older peers. The support from educational institutions, both in terms of resources and training can also impact the integration of ICT. Additionally, personal teaching philosophies, whether traditional or more modern, can influence an educator's stance on ICT. The environment within an educational institution is another pivotal determinant. If there is robust infrastructural and pedagogical support, educators are more likely to be receptive to the use of ICT in their classrooms (Wong, 2008). On the flip side, a lack of resources or support might deter its adoption. Additionally, the integration of ICT in mathematics teaching offers several potential benefits yet its effectiveness largely depends on how educators perceive its role, the support they receive, and the broader teaching environment (Davis, 1989).

The benefits of ICT integration in Mathematics instruction

Educators acknowledge the numerous advantages of integrating ICT into mathematics instruction. Tools such as graphing calculators and specialised software simplify complex mathematical concepts for students, while interactive tools and educational games enhance student engagement in learning (Wong, 2008, Bingimlas, 2015). Moreover, some ICT tools adjust according to individual student needs, ensuring more tailored learning experiences by enabling instant feedback, and helping students understand and adjust their learning process (Miima, 2013).

Challenges and concerns in the integration of ICTs

The integration of ICT in Mathematics education is not without its challenges. Some educators express concerns over students becoming too reliant on technology, possibly undermining their foundational mathematical skills. Unequal access to technology among students might lead to disparities in learning opportunities. Not all educators are well-versed in technology, indicating a need for consistent training (Maja 2023; Abel, Tondeur and Sang 2022; Ndume, Kisanga, and Majige 2021; Malekani 2018; Kisanga 2016). There's also the financial aspect to consider, as obtaining the necessary technological tools can be expensive. Furthermore, the potential for distractions in the online realm can divert students from their primary learning goals (Vimbai, Kennedy, and Tendayi, 2013).

Theoretical framework: Technology Acceptance Model (TAM)

The digital era's evolving landscape of mathematics education necessitates a profound theoretical foundation to decipher teacher perceptions and inclinations towards ICTs. The TAM, devised by Davis in 1986, serves as an apt lens to illuminate these dimensions, especially in the context of mathematics educators (Hsu et al., 2013; Mugo et al., 2017). TAM suggests that an individual's intention to use technology

is shaped by its perceived usefulness and ease of use, which subsequently affects the actual system use. This model is ideal for examining teachers' readiness to incorporate ICT tools into their teaching, reflecting on their perceptions of these tools' usefulness and user-friendliness. TAM provides a framework for analysing teachers' perceptions, challenges, and motivations regarding ICT tool utilisation in Tanzanian secondary school mathematics classrooms (Mugo et al., 2017).

At the heart of TAM, there are two pivotal constructs: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). PU gauges users' belief that using a specific technology will enhance their performance. In the context of this study, this aligns with the first research question inquiring how mathematics teachers perceive the potential of ICT tools in enhancing student understanding and engagement. As the study delves into the question of ICT's role in simplifying the teaching of intricate mathematical concepts, TAM steers the inquiry towards the PU construct. A heightened PU indicates that teachers discern a notable advantage in student outcomes due to ICT integration. Yet, recognizing a tool's potential doesn't always lead to its adoption. Here, PEOU comes to the fore, assessing the anticipated ease or complexity of using the technology.

The second research question, probing the relationship between teaching experience and ICT tool adoption, interacts with both PU and PEOU. Newer teachers, even when recognizing ICT's benefits (elevated PU), might hesitate if they anticipate a steep learning curve, suggesting a lowered PEOU. In contrast, experienced educators might be sceptical about ICT's advantages, reflecting a subdued PU. However, if the tools appear user-friendly, even those with traditional pedagogical approaches might be swayed, highlighting PEOU's role. The third research question, which zeroes in on the challenges that hamper the seamless integration of mathematics teaching with ICT tools, positions PEOU as a focal construct. If educators, despite seeing the myriad benefits of ICT (robust PU), are restrained by challenges like insufficient training, limited resources, or the inherent complexity of some tools, it underscores a subdued PEOU. In summary, the Technology Acceptance Model provides an insightful framework to unravel the complex dynamics of mathematics teachers' perceptions and behaviours towards ICT tools. TAM's core constructs – PU and PEOU – offer valuable perspectives that enrich the research questions, facilitating a deeper dive into the motivators and barriers influencing ICT adoption in the mathematics realm.

Research Methodology

A case study design was adopted to investigate the teachers' perceptions of the use of ICT tools during teaching. The section elucidates the strategies and procedures that were used to gather and analyse the data pertinent to the research

questions, grounded in TAM that offers a holistic view of the factors influencing the acceptance and integration of ICT. The mixed-methods approach ensures that both statistical data and in-depth perspectives are harnessed for a comprehensive analysis (Leavy, 2022, Weyant, 2022)**.** To serve this purpose, the study employed a mixed-methods approach, combining both quantitative and qualitative data to gain a comprehensive understanding of the topic. This method is beneficial as it triangulates data sources, ensuring the reliability and validity of the results.

Due to financial constraints, the population for this study comprised secondary school teachers from two regions, Dar es Salaam and the Coastal region. The schools were selected based on two criteria, the grade point average (GPA) on basic mathematics for the national certificate of secondary education examination results of the year 2021 that ranged from 1.3 to 3.5 inclusively and the type of schools. Using a stratified random sampling based on the criteria set to ensure a representative sample that considers two regions, only 10 secondary schools from Dar es Salaam and 5 from the Coastal region met the selection criteria. A total of 57 mathematics teachers from those schools participated in the study. However, due to the lack of a considered GPA range, not all districts had schools qualified to be in the sample. Among the selected secondary schools, 2 were girls' secondary schools, 3 boys' secondary schools and 10 were co-education secondary schools. The chosen Secondary schools from Dar es Salaam that met a GPA of 1.3 to 3.5 were Bright Future (co), Chang'ombe Demonstrations (co), Helasita (co), Feza Boys, Feza Girls, Kibasila (co), Canosa (co), Liberman (boys' school), St. Augustine Tagaste (co) and Shamsiye (boys' school). Secondary schools in the Coastal region were Baobab Secondary School (co), Kibaha (boys' school), Marian boys, Marian girls, and Gili (girls' school). During data collection, it was noted that out of 57 participant teachers, four (4) were female lower secondary school teachers and fifty-three (53) were male lower secondary school teachers, aged between 23 and 51 years. At a minimum, each teacher had two years of experience teaching mathematics, and the majority held a bachelor's degree. Among the selected secondary schools, eleven (11) reported the presence of computer labs whilst projectors were commonly found as ICT tools across all of the selected schools. Table 1 shows the sample of the schools qualified for the study with their respective GPA obtained in national form four, certificate of secondary education examination results in the year 2020.

Table 1

Mathematics Grade Point Average of The Schools at the National Examination (CSEE Results, 2020).

S/No.	Name of School	GPA	Subject rank	Region
1,	Bright future	1.3789	6	Dar es Salaam
2	Canosa	1.4831	9	Dar es Salaam
3	Chang'ombe	2.9	130	Dar es Salaam
4	Feza girls	1.6667	11	Dar es Salaam
5	Feza boys	1.46	8	Dar es Salaam
6	Helasita	2.8222	105	Dar es Salaam
7	Kibasila	2.8341	108	Dar es Salaam
8	St. Augustine Tagaste	2.1887	33	Dar es Salaam
9	Liberman Boys	3.1395	172	Dar es Salaam
10	Shamsiye	1.8	18	Dar es Salaam
11	Baobao	3.5147	317	Coastal Region
12	Gili	2.4666	57	Coastal Region
13	Kibaha boys	2.0667	26	Coastal Region
14	Marian girls	2.5472	67	Coastal Region
15	Marian boys	1.4532	7	Coastal Region

After obtaining the necessary permissions from the University of Dar es Salaam, districts (Ilala, Temake and Kinondoni) and Coastal region authorities, questionnaires were then distributed to the sampled schools using KOBO. A structured questionnaire based on the TAM was administered to all mathematics teachers in schools under a controlled environment to ensure the reliability of responses. The questionnaire comprised demographic details, ICT attitudes and perceptions, and perceived ease of use and perceived usefulness of ICT. Thereafter, the semi-structured interviews were conducted with teachers to gain in-depth insights into their experiences and perspectives on ICT integration while teaching mathematics lessons. The interviews revolved around the challenges faced, the perceived benefits of ICT, and the factors influencing their adoption of ICT in teaching mathematics. The instruments were piloted and tested on a smaller sample before the main survey. Cronbach's alpha was used to measure the reliability of the questionnaires, ensuring internal consistency. The feedback from the pilot study was used to refine and improve the instrument for data collection.

Data Analysis

Quantitative data from the questionnaires were analysed using SPSS IBM 25 software. Descriptive statistics, correlation and regression analyses were used to interpret the data concerning the research objectives. Qualitative data from the

interviews were transcribed and then subjected to thematic analysis. This allowed the identification of key themes and patterns regarding teachers' experiences and perceptions towards ICT integration. The qualitative and quantitative data are presented in Table 2, Table 3, Table 4 and Figure 1.

Ethical Considerations

Researchers obtained research clearance from the University of Dar es Salaam, which introduced them to the relevant local education authorities, including regional and district education officers in Ilala, Kinondoni, and Temeke, as well as Heads of Secondary Schools. The permits granted by regional and district authorities allowed researchers to conduct the study in selected secondary schools. Informed consent was obtained from all participants before data collection, ensuring they were aware of the voluntary nature of participation and the confidentiality of their responses. All data were anonymised during analysis to protect participants' privacy.

Findings

Perception of mathematics teachers on the ability to use ICT tools in teaching mathematical concepts in the classroom setting

In light of the TAM theory, understanding users' perceptions, particularly educators in this instance is paramount to predicting and explaining system usage. The findings in Table 2 highlighted in this research accentuate distinct patterns and tendencies in teachers' perceptions towards employing ICT tools to convey various mathematical topics.

Table 2

Means, Standard Deviations, and Percentages Showing the Extent of Teachers on the Use of ICT Tools on the Subject Emphasis

No	Item	Mean	Std. Deviation	Per cent	Rank	Extent
	Computational techniques	2.68	1.212	53.60	8	Fairly
	Specific mathematics or definitions	3.14	1.109	62.80	5	Fairly
	Broad mathematics concepts	3.16	1.162	63.20	4	Fairly
	Problem-solving/inquiry skills	3.11	1.080	62.20	7	Fairly

	Skill in communicating in speech or writing about mathematical ideas or applications	3.12	1.166	62.40	6	Fairly
	Importance of mathematics in daily life	3.81	1.093	76.20	1	Frequently
	Applications of mathematics in science	3.79	0.977	75.80	2	Frequently
	Applications of mathematics in business and industry	3.63	1.080	72.60	3	Frequently

Relevance of mathematics in real-world contexts

Teachers feel particularly confident and inclined to utilise ICT tools when elucidating the real-world importance and applications of mathematics. This is evident from the high percentages (above 70%) corresponding to topics like the significance of mathematics in daily life, its applications in science, and its use in business and industry. This might be attributed to the inherent interactive and illustrative nature of digital tools, which can effectively contextualise mathematical concepts in real-life scenarios. Such content often requires visual aids, simulations, or practical examples, all of which can be efficiently provided by ICT. This correlation supports the TAM's "Perceived Usefulness" (PU) construct, suggesting that teachers see a tangible benefit in leveraging ICT tools for these specific topics.

Fundamental mathematical concepts and techniques

There's a noticeable dip in confidence when it comes to deploying ICT for more foundational aspects of mathematics. As observed, only around 53% to 63% of teachers believe they can use ICT tools effectively to teach computational techniques, broad mathematical concepts, problem-solving skills, and skills in communicating mathematical ideas. These findings resonate with the "Perceived Ease of Use" (PEOU) construct in TAM. It suggests that while teachers may recognise the potential benefits of integrating ICT tools (PU), they might perceive foundational topics as being more challenging to teach through digital platforms or feel less equipped or trained to do so effectively. The standard deviation values, especially the 1.212 for computational techniques, further reinforce this notion, indicating a larger variance in teachers' perceptions regarding the ease of use of ICT tools for such topics. Furthermore, the rankings can be interpreted as a direct reflection of teachers' comfort levels, with foundational topics ranking lower (items 1 to 5) and application-based topics securing the top ranks (items 6 to 8). The rankings underscore the areas where potential interventions like targeted ICT training, could be most beneficial for educators.

How does teaching experience influence the choice and use of ICT tools and mathematical packages among mathematics teachers?

Table 3 shows the perception of mathematics teachers on their ability to use ICT tools and mathematical packages among the teachers based on their teaching experience. Given the findings presented in Table 3, which details the use of ICT tools and mathematical packages among teachers based on their teaching experience, several insights emerge in line with the Technology Acceptance Model (TAM). The findings show that novice teachers use more technological software followed by experienced teachers. The intermediate teachers are the least users of the technology in teaching different concepts of mathematics in the classroom.

Table 3

ICT Tools and Mathematical Packages Usage Against Teachers' Experience

Percentages and Totals are Based on Respondents in a Dichotomy Group Tabulated at Value 1.						
Novice Intermediate			**Experience Groups**			**Total**
			Experienced/ Expert			
Tools/ Mathematical Package	Matlab	Count	4	1	5	10
	Graphing Calculator 3D	Count	4	0	3	7
	SPSS	Count	2	2	2	6
	Geogebra	Count	5	1	3	9
	Graph Sketch	Count	6	4	4	14
	Microsoft Mathematics	Count	5	6	2	13
	Maths Editor	Count	3	1	3	7
	Graph Maker	Count	2	2	3	7
	Internet Archive	Count	3	1	1	5
	None	Count	6	7	7	20
	Others	Count	21	2	5	28
Total		Respondents	61	27	38	126

Perceived usefulness and teaching experience

There is a diverse use of technological tools among mathematics teachers. Notably, Graph Sketch (11%), Microsoft Mathematics (10%), and Matlab (7.9%) are the most popular among teachers, highlighting the perceived usefulness of these tools in their teaching regimen. Yet, a significant 16% reported not using any tool. This

absence, especially when juxtaposed with the prominence of certain tools, signals the possibility that there may be varying levels of perceived usefulness across the faculty – an essential construct of TAM.

Perceived ease of use versus experience

Delving deeper into the experience-wise breakdown, novice teachers seem to have a broader spread in their tool adoption, from the use of GeoGebra, and Graph Sketch, to Microsoft Mathematics. This suggests that newer entrants to the teaching profession might be more open to experimenting with diverse tools, likely due to their recent exposure to these during their training or their inherent comfort with technology. However, the fact that even among the novice group, there's a noticeable percentage that hasn't adopted any tool indicates potential challenges in perceived ease of use or perhaps lack of access and training.

Experienced teachers and tool adoption

The expert or experienced teacher group demonstrates a preference for tools like Graph Sketch but shows less inclination toward Microsoft Mathematics. This suggests that entrenched teaching habits or a perceived lack of added value may influence their adoption patterns.

Diverse tools and potential barriers

The 'Others' category, which stands at 22%, points towards a plethora of other tools that haven't been specified. This indicates that while there's a wide range of tools available, there might be barriers (either in terms of ease of use or perceived utility) preventing a more uniform adoption across the board. In light of the TAM theory, these findings underscore the pivotal role that both perceived usefulness and perceived ease of use play in the adoption of ICT tools among mathematics teachers. Further, the dichotomy based on teaching experience accentuates that these perceptions are dynamic and can evolve based on the teacher's tenure and the evolving technological landscape. Consequently, targeted interventions, perhaps in the form of training or workshops, might be needed to bridge these perception gaps and foster a more inclusive adoption of ICT tools across all experience levels.

The extent to which teachers use ICT tools to achieve various mathematical packages

Considering the Technology Acceptance Model (TAM) in the interpretation of the data concerning the research question, "How extensively do teachers use ICT tools to achieve various mathematical packages?" it is clear that the two primary

determinants of TAM, namely Perceived Usefulness (PU) and Perceived Ease of Use (PEOU), manifest differently across experience levels in teachers' recognition and potential application of ICT tools.

Given the data from Table 4 and Figure 1, teachers have demonstrated a clear inclination toward using ICT tools when explaining the real-world significance of mathematics. The importance of mathematics in daily life is ranked first with a high mean of 3.81 and 76.2% of teachers emphasizing its use. Similarly, applications of mathematics in science, business, and industry are highlighted by over 70% of teachers, further underscoring the perceived usefulness of ICT tools in these areas. Among universally acknowledged tools like Matlab, Mathematica, and Microsoft Mathematics, usage rates stand at 11%, 10%, and 9.4%, respectively. This suggests that these tools are perceived as useful (PU) across all experience groups. Their widespread recognition indicates that they offer essential functionalities for mathematics teaching, making them indispensable for many educators.

Conversely, computational techniques, despite being a core component of mathematics, are ranked the lowest with a mean of 2.68. Only 53.6% of teachers believe they can effectively employ ICT tools for this foundational topic. This suggests a potential gap in either available ICT resources for these topics or teachers' comfort and training in applying them. Other foundational topics, including specific mathematics definitions and broad mathematics concepts, hover in the 60% range, reflecting moderate confidence in using ICT tools. Furthermore, the standard deviation values, especially the higher value of 1.212 for computational techniques, indicate a greater variance in teachers' perceptions. This implies that while some educators might be adept at using ICT tools for these foundational aspects, a significant portion may feel unsure or untrained. Incorporating these specific data points into our interpretation, it becomes evident that while teachers value the potential of ICT tools, especially for real-world contextual teaching, there's a palpable need for enhanced training and resources focused on foundational mathematical aspects. Addressing these gaps can catalyze a more comprehensive and effective integration of ICT tools in mathematics instruction.

Table 4

ICT Tools Used by Teachers in Teaching Various Mathematical Packages Knowledge and Experience Groups Crosstabulation

Novice Intermediate			experience groups			Total
			Experience/ Expert			
ICT tools used for teaching Mathematics	Matlab	Count	9	9	10	28
	Maple	Count	5	6	3	14
	Mathematica	Count	6	9	11	26
	Graphing Calculator 3D	Count	11	5	7	23
	Geogebra	Count	7	5	8	20
	Graph Sketch	Count	9	7	6	22
	Microsoft Mathematics	Count	7	11	6	24
	Maths Editor	Count	6	7	8	21
	Graph Maker	Count	3	6	5	14
	Others	count	10	31	23	64
Total		Count	73	96	87	256

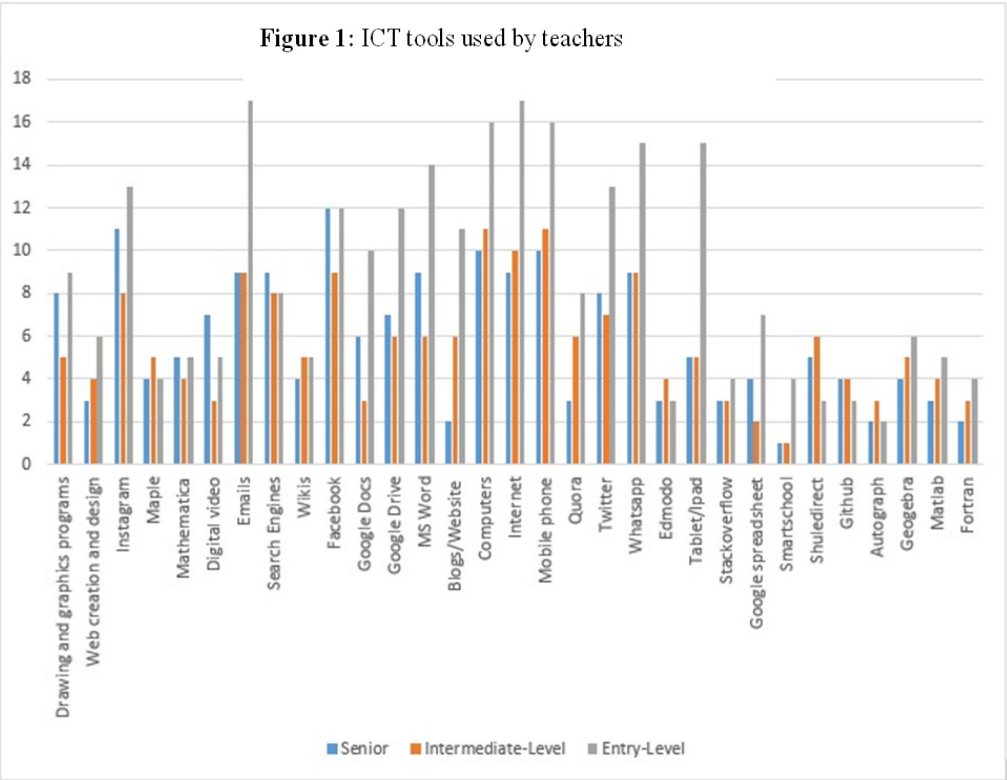

Figure 1: *ICT tools used by teachers*

Challenges teachers face in integrating ICT tools into their mathematics instruction

In addition to quantitative findings, a second set of results was obtained from the focused group, which helped to contextualise and interpret the quantitative results. Firstly, the majority of users believe that ICT can simplify delivering a lesson to students, help to explain complex ideas and mathematics topics, reduce the time taken to deliver a lesson, and can also allow for flexibility during teaching. For example, a teacher from one school pointed out:

> "… We plan to build a digital centre because the current computer lab offers limited access to students…" another said:

> "… What we are supposed to do is to cope, adapt and use technology for us to reach to do better. And for our school, we have to provide more than two computers to our teachers…"

Secondly, teachers think the use of ICT to teach mathematics may affect the ability of students to solve mathematics problems as well as reduce the performance of students in examinations. The following were the main challenges explained by the respondents:

Inconsistent internet connectivity

Reliable internet bandwidth remains an issue, particularly outside the Dar es Salaam region. For instance, a respondent said:

> "…I believe that using ICT tools to teach mathematics, especially the challenging topics like Three Dimension and Sphere can enhance the understanding of students for with computer becomes very easy and flexible to teach, but the internet connectivity in peripheral parts of the country is still a challenging phenomenon …"

Limited technical support

While students are acquainted with the use of ICT tools in the classroom, the absence of immediate technical assistance when issues arise poses a problem. Teachers often find themselves tasked with troubleshooting during lesson hours. Another said:

> "…when I taught using ICT the students were interested and reduced the time I used to explain and still students understood the lesson very well, but very small part of the content can be effectively covered…"

Unavailability of essential mathematical software

Many computers lack the necessary mathematical packages installed, hindering effective ICT integration in mathematics teaching. The majority of the teachers thought it entails training students on how to use the ICT tools to participate in the lesson. For example, a teacher said:

> "… Mathematics is among challenging subjects that are very cumbersome to teach using ICT tools as teachers are not computer speciality…"

Time constraints versus ICT utilisation

Despite possessing the skills to use ICT tools, their integration can be time-intensive. Given the stringent syllabus timelines and no provision for extra hours, many educators find it challenging to incorporate these tools efficiently. For instance, one respondent said:

> "…I imagine the use of ICT going to inhibit the ability of students in solving present solution of questions and hence reducing the number of students passing mathematics in the national examination…"

Another said:

> "…when I taught using ICT the students were interested and reduced the time I used to explain and still students understood the lesson very well, but very small part of the content can be effectively covered…"

A mismatch between student enthusiasm and curriculum rigidity

While students exhibit a keen interest in ICT-driven learning, the current curriculum offers limited flexibility. There's a distinct lack of training tailored for the application of ICT in mathematics teaching, and the curriculum doesn't explicitly outline mandatory ICT-based learning modules for students. Moreover, the results from the discussion show that teachers need software tools for teaching mathematics, training on how to construct content and use software, as well as support. Several respondents said:

> "…The computer lab with working computers is available, but not enough software for teaching mathematics installed…"

In addition, there was a misconception of the meaning of "to use ICT tools to teach mathematics".

The majority of the teachers thought it entails training students on how to use the ICT tools to participate in the lesson. For example, a teacher said:

> "…Mathematics is among challenging subjects that are very cumbersome to teach using ICT tools as teachers are not computer speciality…"

Discussion of the Findings

The integration of tools in mathematics instruction within Tanzania's secondary schools stands as a testament to the evolving landscape of modern education (Das, 2019; Josh, 2017; Sawyerr A, Agyei D, 2022). This study underscored the vibrant potential of ICT tools in enriching the teaching and learning experience, especially in making mathematical concepts more relatable and applicable to real-world scenarios. However, alongside the promise lies a gamut of challenges, from infrastructural limitations to discrepancies in teaching methodologies rooted in experience. The TAM aptly frames these findings, suggesting that perceptions of usefulness and ease of use are pivotal in determining ICT adoption. The disparity in tool utilisation among educators, based on tenure, underscores the pressing need for a unified approach to professional development and resource allocation. Moreover, the challenges spotlighted, notably the lack of consistent internet connectivity, absence of vital mathematical software, and curriculum rigidity, necessitate immediate and concerted efforts from educational stakeholders. Collaborative endeavours that bridge the gaps between policymakers, educators, and technical experts could usher in a new era of ICT-integrated mathematics instruction in Tanzania. As we forge ahead into an increasingly digital future, ensuring that our educators are well-equipped and our curriculum is adaptive remains paramount. Only then can we truly harness the transformative power of ICT for the benefit of our students and the broader educational ecosystem. The study recommends the following:

First and foremost is infrastructure development. Addressing the digital divide requires a concerted effort to enhance technological infrastructure in less developed regions. This can be achieved through collaborations among local governments, educational institutions, and private enterprises. By working in tandem, these stakeholders can accelerate the provision of reliable internet services, bridging the gap between urban and remote educational settings.

Furthermore, as technology permeates classrooms, the inevitability of technical glitches arises. To mitigate disruptions and ensure smooth lesson delivery, institutions should prioritise establishing dedicated technical support. Whether this entails creating specialised teams or training existing staff members, the goal is to empower educators to concentrate on their core teaching responsibilities, confident in the knowledge that any ICT-related hiccups can be swiftly addressed.

In parallel, the maintenance of the technology tools in play is paramount. Ensuring

that essential mathematical software on school computers undergoes regular checks and updates can guarantee that the academic community has access to relevant, functioning tools. In this realm, strategic collaborations or partnerships with software vendors can be explored. Such alliances might offer educational institutions discounted or even complimentary access to pivotal educational software packages.

In addition to the technological considerations, the educational content—the curriculum—must not be static. Periodic reviews and updates by educational authorities will ascertain that the content remains in step with technological progress. Such proactive measures would grant teachers the latitude to seamlessly weave beneficial ICT tools into their lessons, free from undue time constraints.

Lastly, the role of educators in this digital evolution cannot be underestimated. To optimise the benefits of ICT, teachers must be adept at leveraging these tools. This necessitates continuous training and professional development tailored to the nuances of ICT in mathematics instruction. By consistently enhancing educators' proficiency in this domain and revisiting the curriculum to articulate ICT-centric modules, we can set the stage for a structured, clear, and enriched learning journey for students.

Conclusion and Recommendations

Conclusions

The integration of ICTs in mathematics instruction within Tanzania's secondary schools stands as a testament to the evolving landscape of modern education. This study underscored the vibrant potential of ICT tools in enriching the teaching and learning experience, especially in making mathematical concepts more relatable and applicable to real-world scenarios. However, alongside the promise lies a range of challenges, from infrastructural limitations to discrepancies in teaching methodologies rooted in experience. The TAM aptly frames these findings, suggesting that perceptions of usefulness and ease of use are pivotal in determining ICT adoption. The disparity in tool utilisation among educators, based on tenure, underscores the pressing need for a unified approach to professional development and resource allocation. Moreover, the challenges spotlighted, notably the lack of consistent internet connectivity, absence of vital mathematical software, and curriculum rigidity, necessitate immediate and concerted efforts from educational stakeholders. Collaborative endeavours that bridge the gaps between policymakers, educators, and technical experts could usher in a new era of ICT-integrated mathematics instruction in Tanzania. As we forge ahead into an increasingly digital future, ensuring that our educators are well-equipped and our curriculum is adaptive remains paramount. Only then can we truly harness the transformative power of ICT for the benefit of our students and the broader educational ecosystem.

Recommendation for actions

Based on the findings concerning teachers' perceptions of the ability to use ICT tools in teaching mathematical concepts, the following recommendations are proposed:

i. It is evident that teachers see the value of using ICTs for real-world applications of mathematics but are less confident in their abilities to leverage these tools for foundational topics. Consequently, targeted training sessions should be initiated, focusing on integrating ICT tools into teaching computational techniques, broad mathematical concepts, and problem-solving skills. These sessions can incorporate hands-on workshops, where teachers can actively engage with the tools, facilitating a smoother transition to the digital teaching of these foundational concepts. Intermediate teachers, showing a diverse toolkit, should lead workshops to bridge the learning gap between novices and experts. A unified digital platform integrating popular tools can streamline adoption, while pilot programs can ensure effective tool integration. Establishing feedback mechanisms allows for real-time insights into tool efficacy. Emphasizing real-world applications can enhance tool adoption by underscoring their tangible benefits in mathematics education**.**
ii. Schools should collaborate with ICT experts to develop resources tailored to mathematics topics, ensuring the tools align with pedagogical best practices. Furthermore, continuous feedback loops should be established, allowing teachers to share their experiences, challenges, and success stories with their peers, fostering a collaborative environment that encourages more widespread adoption of ICT tools.
iii. In conclusion, from a TAM perspective, while the "Perceived Usefulness" of ICT tools is recognised across various mathematical topics, there's a discernible gap in the "Perceived Ease of Use," especially for foundational mathematical concepts. Bridging this gap would be essential for a more widespread and effective adoption of ICT tools in mathematics education.
iv. Investment in ICT infrastructure is crucial to ensure that teachers have access to the necessary resources to integrate ICT seamlessly into their teaching methodologies.

Author Contributions

All authors have contributed subsequently towards the design and writing of the manuscript. Furaha Chuma carried out the Introduction part, Literature review, and analysis and edited the manuscript. Christina Raphael worked out on the introduction and literature review and reviewed the manuscript. All authors approved the final manuscript.

Declarations

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