Teachers' Beliefs and Their Effects on the Use of ICT in Teaching Science and Mathematics in Tanzania

Catherine Rimba[1] & Albert Tarmo[2]*
[1]Agency for the Development of Education Management (ADEM)
[2]Department of Educational Psychology and Curriculum Studies, University of Dar es Salaam
*Corresponding author[2]: paulo.albert@yahoo.com
Email[1]: catherinerimba@gmail.com

Abstract

This study investigated secondary school teachers' beliefs about ICT use and their espoused use of ICT in teaching science and mathematics. Specifically, the study examined the relationship between teachers' beliefs about ICT use and their espoused use of ICT in teaching science and mathematics. It further assessed the effect of teachers' beliefs about ICT use in teaching science and mathematics. The study employed a cross-sectional survey design, involving 172 randomly selected science and mathematics teachers from Kibaha District in Pwani Region, Tanzania. The findings revealed that teachers held predominantly negative beliefs about ICT use, which corresponds with their limited adoption of ICT in teaching. Furthermore, a strong relationship was observed between teachers' beliefs about ICT use and their espoused ICT adoption in science and mathematics teaching. The study concludes that teachers' beliefs about ICT use significantly influence their espoused adoption of ICT in science and mathematics teaching. It is recommended that initiatives to enhance ICT adoption should focus not only on training and resource provision but also on transforming teachers' beliefs about ICT use, which appear to limit their likelihood of integrating ICT into science and mathematics instruction.

Keywords: *teachers' beliefs, educational technology, science education, mathematics education*

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Introduction

Globally, education systems are under pressure to produce innovative, creative, and competitive workforces to meet the demands of the twenty-first-century market economy. Among the approaches to improving learning outcomes and workforce

performance is the incorporation of Information and Communication Technology (ICT) in teaching and learning (MoEST, 2023). ICT refers to a broad range of technological tools and resources used to create, communicate, disseminate, store, and manage information (UNESCO Institute for Statistics, 2009). ICT enhances the international dimension of educational services and eliminates geographical barriers to teaching and learning (UNESCO, 2002). This is because it allows teachers and students to access resources and communicate in real-time without geographical barriers. It minimises time and distance barriers because teachers and students can network and share resources, knowledge, and experiences through ICT devices (Cholin, 2005). This resonates with the recently revised Tanzania Education and Training Policy, which advocates ICT as an approach that enables teachers to "reach multiple groups of students simultaneously" even in remote schools where resources needed to deliver quality science and mathematics education are in short supply (MoEST, 2023, p. 45). Therefore, ICT is a useful tool for overcoming a lack of teaching and learning resources and improving teaching and learning quality.

The integration of ICT transforms teaching and learning processes by using student-centred methods that allow teachers to organize lessons and learners to actively participate in and control their learning based on their learning needs and interests (Byukusenge, Nsanganwimana, & Tarmo, 2024). This is consistent with Mayer's (2009) argument that ICT supports teachers in planning classroom activities, assigning diverse tasks to students, and monitoring their learning behaviours. More importantly, ICT functions as an invaluable administrative tool, streamlining the management of classroom and school logistics. For instance, it is employed to manage teacher-related data, including attendance, annual leave, job performance, and remuneration. Additionally, ICT plays a crucial role in collecting, storing, and retrieving information about students' academic progress and school fee payments (Hadjilhoma-Garstka, 2011).

Although the role of ICT in improving instructional quality is widely acknowledged, ICT integration in teaching and learning processes has been slow in Tanzania (Kafyulilo et al., 2015; Mtebe & Gallagher, 2022; MoEST, 2023). This is partly because the integration of ICT in teaching and learning processes requires a departure from traditional pedagogies (Byukusenge et al., 2024). Researchers attribute the lack of sustained adoption of ICT to structural barriers such as access to ICT facilities and equipment, low levels of knowledge and skills and a lack of institutional support (Kafyulilo et al., 2015; Njiku et al., 2022). In addition, recent studies have focused on the affective aspects of technology adoption including teachers' attitudes and beliefs (Njiku et al., 2020).

Historically, the Government of Tanzania banned the use of computers and television

for teaching and learning in 1974. Instead, the schools were provided with radios to enable students to listen to the lessons prepared by the then Ministry of Education and broadcasted by Radio Tanzania, the state radio station (Hare, 2007). The restriction was lifted in 1984, and since then, Tanzania has been catching up with the adoption of digital technologies, particularly in science education. Notably, the government is cognisant of the value and efficacy of the effective use of ICT for national development. This is well reflected in its aspiration for Tanzania to become a middle-income country by 2025, as articulated in the Tanzania Development Vision 2025: "*These technologies [ICT] are a major driving force for the realization of the vision. They should be harnessed persistently in all sectors of the economy*" (URT, 2000).

As a result, the government through the then Ministry of Education and Vocational Training (MoEVT) formulated the ICT Policy for Basic Education, covering "Pre-primary, Primary, Secondary and Teacher Education, as well as non-formal and adult education" (MoEVT, 2007 p. i). The overarching objective of this policy was to integrate ICT in education to enhance the accessibility, equity, quality, and relevance of basic education. To this end, ICT was introduced at the classroom level to enhance the acquisition of knowledge and skills through improved teaching, learning, and assessment. For example, in teacher education, ICT integration commenced with the installation of basic ICT facilities in the government teacher training colleges. This was a joint project between the Government of Tanzania and the Swedish Government through the Swedish International Development Cooperation Agency (SIDA) (Hare, 2007; Mwalongo, 2011). The introduction of ICT curricula and courses aimed at training principals, tutors, and both in-service and pre-service teachers in ICT skills and pedagogies followed (Hare, 2007; Tilya, 2008). The impact of initiatives to train pre-service teachers was expected to spread to schools once these pre-service teachers began teaching (Kafyulilo et al., 2016).

There were efforts to train in-service teachers to use ICT for teaching through continuous professional development. A notable training of science and mathematics teachers for example was organised by the MoEVT in collaboration with the Japan International Cooperation Agency. The training aimed to equip science and mathematics teachers with ICT literacy and build their capacity to integrate ICT into classroom teaching. More than 2000 teachers from 858 schools were trained under the programme, which improved the academic performance of students in science and mathematics (Mtebe, Mbwilo, & Kissaka, 2016). Another notable initiative was the collaboration between the Government of Tanzania and the Global e-School and Communities Initiative (GESCI) through the African Digital Schools Initiative (ADSI). This project provided technical and strategic support for secondary schools in Tanzania's Pwani Region to integrate ICT (Kafyulilo et al., 2016).

Similarly, the Government of Tanzania in collaboration with the SIDA and International Institute for Communication and Development introduced training on the use of ICT for teaching secondary school science and mathematics using the Technological Pedagogical Content Knowledge (TPACK) framework (MoEVT, 2009; Swarts & Wachira, 2010). Teachers were expected to acquire content and pedagogic knowledge about the use and integration of ICT in teaching processes. In this project, universities and colleges were supported in offering ICT courses to instructors, and pre-service and in-service teachers. The aim was to equip teachers with the TPACK needed to use ICT in teaching science and mathematics. For example, Dar es Salaam University College of Education (DUCE) offered an ICT course to science and mathematics teachers which aimed to equip teachers with ICT skills and pedagogies for teaching science and mathematics at secondary schools (Swarts & Wachira, 2010).

Lastly, there have been efforts to deliver science and mathematics subject content for Ordinary level secondary education through the Internet. One of the notable initiatives was the establishment of an e-School forum aimed at supporting the introduction and use of ICT in secondary education in Tanzania (Hare, 2007). For example, the MoEVT in collaboration with Halotel Tanzania developed 70 topics and 147 sub-topics with different multimedia elements in science and mathematics (Mtebe et al., 2016). The multimedia content was made available online for teachers and students to access. The MoEVT also established TV and radio broadcasting programs such as Star TV broadcast programs on different subjects for secondary schools to integrate ICT in schools.

However, careful analysis of the initiatives to support the integration of ICT in Tanzania would reveal that the efforts were largely concerted at structural barriers to and enablers of ICT integration such as the establishment of ICT infrastructure, the provision of knowledge and skills through teacher training, and design and delivery of web-based resources, among others. The focus on structural barriers is further reflected in the most recent Education and Training Policy of 2014, the revised edition of 2023 which stipulates that "*the Government ... will establish conducive environments for the delivery of education and training using ICT at all levels*" (MoEST, 2023 p. 46). Structural barriers are often described as first-order factors that determine the adoption of ICT in teaching and learning (Abedi et al., 2023). There were no initiatives to transform teachers' strongly held beliefs about ICT use and its effect on teaching and learning processes. Teachers' beliefs about ICT are described as second-order factors that strongly influence the adoption of ICT (Abedi et al., 2023). Consequently, the integration of ICT in teaching and learning is occurring at a relatively slower pace than expected.

Problem and its context

The Government of Tanzania, in collaboration with development partners, has invested adequate resources to support the integration of ICT in science and mathematics education as a strategic intervention and part of its national development vision to improve workforce training (MoEVT, 2007). Teachers at different levels have been trained to integrate ICT into their teaching, curricula have been revised to accommodate ICT as a subject, and ICT devices and systems have been installed in different education educational institutions from primary schools to universities, to improve the quality of teaching and learning processes (Hare, 2007; Swarts & Wachira, 2010). Yet, evidence indicates that teachers rarely use ICT as a pedagogical tool for teaching and learning (Kazola & William, 2016; Msele, 2012; Mwalongo, 2011; Ndibalema, 2014). As indicated in the Education and Training Policy (MoEST, 2023), "Tanzania still faces challenges in the use of ICT in teaching and learning" (p. 45). While much research has examined the role of external barriers to ICT integration in teaching (Kazoka, 2016; Mtebe et al., 2016; Tanzania TELECOMS, 2016), less research has examined how factors intrinsic to teachers, such as teachers' beliefs and attitudes, constrain teachers from fully integrating ICT in teaching and learning. This study, therefore, examined teachers' beliefs about ICT use and their espoused use of ICT in teaching science and mathematics in secondary schools. Specifically, the study intended to:

i. Explore teachers' beliefs about the use of ICT in teaching science and mathematics;

ii. Examine teachers' espoused use of ICT in teaching science and mathematics;

iii. Establish the relationship between teachers' beliefs about the use of ICT and their espoused use of ICT in teaching science and mathematics;

iv. Assess the effect of teachers' beliefs about ICT use in teaching science and mathematics.

Theoretical Framework

The technology acceptance model (TAM), which addresses the role of users' beliefs in influencing their use of technology (Davis, 2003), guided the study. The model is based on the theory of reasoned action (TRA) which proposes that individuals' beliefs influence their intentions and ultimately determine their behaviours (Ajzen & Fishbien, 2005). It was based on this assumption that we considered the TAM useful for examining teachers' beliefs about ICT use and their espoused use of ICT in teaching science and mathematics in secondary schools.

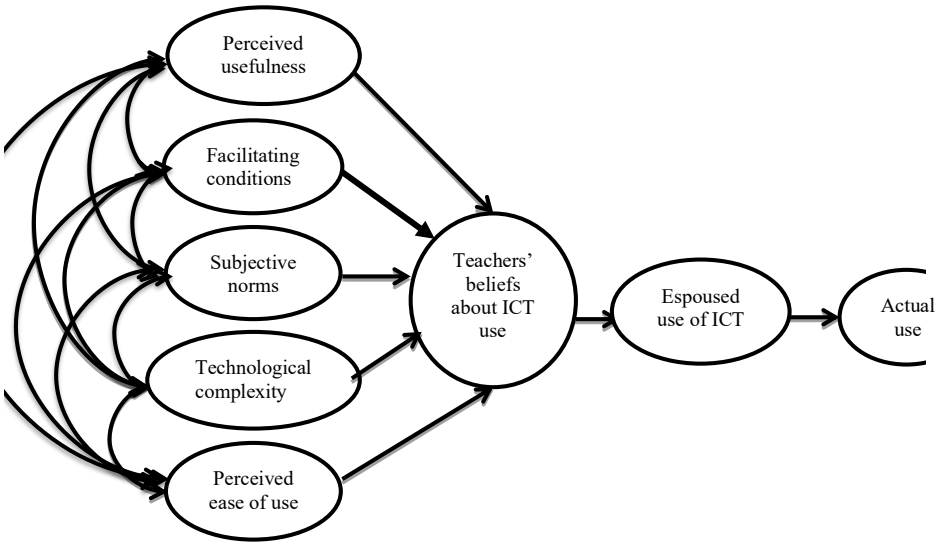

Figure 1: *Technology acceptance mode*

Teachers' beliefs about ICT use were theorised to have a direct effect on their espoused use of ICT in teaching science and mathematics (Liu, Koehler & Wang, 2018). TAM proposed that, when users interact with new technology, many variables influence their initial acceptance but perceived usefulness (PU) and perceived ease of use (PEU) are core variables that play a significant role in their continued acceptance and adoption (Davis, 2003). Further, Venkatesh et al. (2003) proposed that additional variables could be added as factors that influence users to accept and use technologies in TAM to the perceived usefulness and perceived ease of use. This study extends the TAM by adding variables such as facilitating conditions, subjective norms and technological complexity. These variables directly influence beliefs on ICT use to enhance the espoused use of ICT in teaching and learning science and mathematics that leads to actual usage.

The variables, subjective norms, facilitating conditions, technological complexity, perceived usefulness, and perceived ease of use, were used to build the study model. These variables provided the bridge between teachers' beliefs about ICT use and their espoused use of ICT in teaching science and mathematics. Espoused use of ICT was used as the main variable that determined the actual usage of ICT among teachers. Teachers' beliefs about ICT use acted as the independent variable. Espoused use of ICT acted as the dependent variable and was measured through teachers' beliefs about ICT use by using subjective norms, facilitating conditions, technological complexity, perceived usefulness, and perceived ease of use. Subjective norms can be determined by considering the perceived expectations of other individuals and their motivation to achieve.

Successful integration of ICT in teaching and learning depends largely on the teacher's support to use ICT. Facilitating conditions are factors that exist in the environment which influence a person's desire to use a certain technology (Teo & van Schaik, 2009; Venkatesh et al., 2003). For example, technical support is an important driver for teachers to use ICT for their instructional purposes. Technological complexity has a direct influence on beliefs about ICT uses. Hare (2007) observed that inadequate training towards ICT use in education hinders the integration of technology in teaching and learning. ICT use is perceived to be relatively easy to use when individuals are likely to develop positive beliefs towards its use and predict their espoused use of ICT in teaching and learning. Teo et al. (2009) found that perceived ease of use determines beliefs and intention to use technology. Perceived usefulness has an influence on beliefs towards ICT use and espoused use of ICT in teaching. For example, studies by Teo (2009) suggested that teachers use technology when they believe that it enhances performance in the teaching and learning process. Moreover, teachers' beliefs about ICT use were measured using subjective norms, facilitating conditions, technological complexity, perceived usefulness, and perceived ease of use.

Methodology

Research approach

The study employed a quantitative research approach because the research questions required the use of standard instruments to collect quantitative data, which was then subjected to rigorous statistical analysis. The study adopted a cross-sectional survey design.

Sampling and data collection

Structured questionnaires were administered to 172 out of the 181 science teachers employed to teach Physics, Chemistry, Biology, and Mathematics in the 15 secondary schools dispersed across Kibaha District in Tanzania's Pwani Region. The district has a well-established ICT in-service training centre, which trains science and mathematics teachers to integrate ICT into teaching and learning. Schools were clustered into private and public. Afterwards, stratified random sampling was used to select teachers considering gender and teaching subjects. Questionnaire items were adapted from those developed by Teo and Zhou (2014) and Teo (2012). The questionnaire comprised items measuring the seven constructs presented in the research model (see Figure 2). The constructs, with the respective number of items for each in brackets, were as follows: teachers' beliefs about ICT use (4 items), espoused use of ICT (3 items), perceived usefulness (4 items), perceived

ease of use (4 items), subjective norms (3 items), facilitating conditions (4 items), and technological complexity (4 items). The questionnaires were administered to teachers, who responded to each item by selecting one of the five points along the Likert scale.

Data analysis

Data were analysed using Statistical Product and Service Solutions (SPSS) version 21 together with Analysis of Moments Structures (AMOS) 25.0. SPSS was used to run descriptive statistics while AMOS was used to build variable models. Structural equation modelling (SEM) was employed as the main technique for multivariate analysis in this study. SEM consists of two parts: the measurement model and the structural model. The measurement model was tested by using pooled confirmatory factor analysis, which combines all variables involved in the study, as shown in Figure 2.

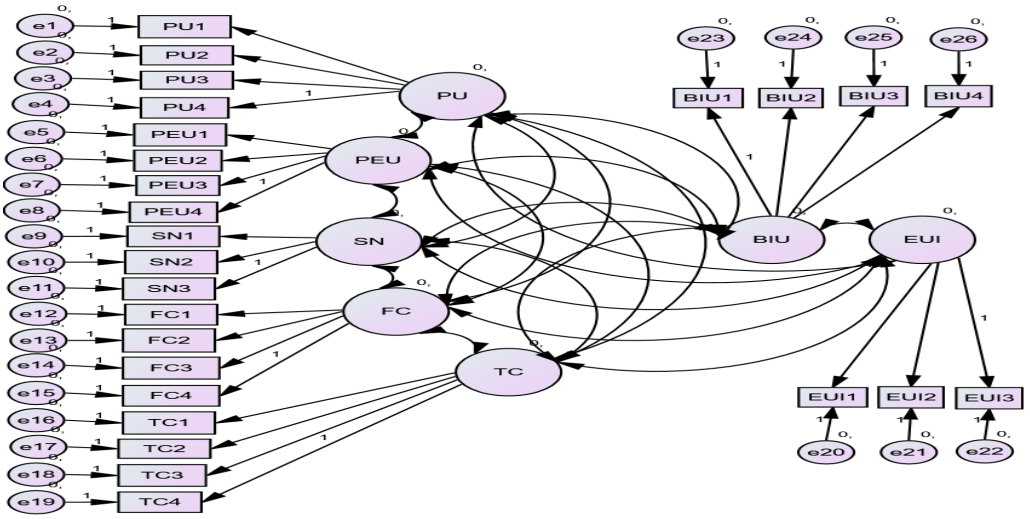

Figure 2: *Modelling the Measurement Model for Pooled Variables*

The model was assessed by using pooled confirmatory factor analysis (pooled CFA). Hair et al. (2010) suggest that any item having a factor loading less than 0.50 and squared multiple correlations less than 0.3 should be deleted from the measurement model. After executing pooled CFA, Figure 2 shows items FC2, FC3 and FC4 from the facilitating conditions (FC) variable and item TC4 from the technological complexity (TC) variable have low factor loading (below 0.5). These items caused the model to have poor fit hence deleted and run again the model.

Table 1

Pooled-CFA Reports for Every Variable in the Measurement Model

Construct	Code	Item	FL	t value	AVE	CR
PU	PUI	Using ICT will improve my teaching of science and mathematics.	.668		0.59	0.81
	PU3	Using ICT will increase my productivity.	.840	9.257		
	PU4	I find ICT a useful tool in my teaching of science and mathematics.	.782	8.779		
PEU	PEU1	I find it easy to get ICT to do what I want it to do.	.793		0.62	0.83
	PEU2	Interacting with ICT does not require a lot of mental effort.	.786	11.051		
	PEU4	Learning how to use ICT in teaching and learning is easy for me.	.780	10.956		
SN	SN1	People whose opinions I value will encourage me to use ICT in teaching.	.662		0.73	0.91
	SN2	People who are important to me will support me in using ICT in teaching science and mathematics.	.966	14.447		
	SN3	People who influence my behaviour will encourage me to use ICT in teaching science and mathematics.	.982	14.656		
	FC1	I have the necessary resources, such as a PC and internet access, for using ICT in teaching science and mathematics.	.613			
TC	TC1	Learning to use ICT in teaching takes up too much of my time.	.807		0.62	0.84
	TC2	Using ICT in teaching science and mathematics is so complicated that it is difficult to know what is going on.	.932	9.536		
	TC3	Using ICT in teaching science and mathematics requires too much time.	.578	7.681		
EUI	EUI1	I will always try to use ICT in my day-to-day teaching of science and mathematics.	.575		0.64	0.84
	EUI2	I plan to continue to use ICT when teaching science and mathematics.	.918	8.113		
	EUI3	I will use ICT frequently when teaching science and mathematics in the future.	.861	7.970		

BIU	BIU1	Using ICT in teaching science and mathematics makes work more interesting.	.669		0.54	0.82
	BIU2	Working with ICT in teaching science and mathematics is fun.	.693	7.787		
	BIU3	I like using ICT in teaching and learning.	.802	8.718		
	BIU4	I look forward to those aspects of my job that require me to use ICT in teaching.	.758	8.364		

Key: PU = Perceived usefulness, PEU = Perceived ease of use, SN = Subjective norms, FC = Facilitating conditions, TC = Technological complexity, EUI = Espoused use of ICT, BIU = Teachers' beliefs about ICT use.

Table 1 indicates that after removing the low-factor items and executing pooled CFA, results show certain fit indexes have not achieved the required level. The researchers have been required to modify a measurement model due to redundant items to achieve the required fit. After pooled confirmatory analysis, variables (PU, PEU, SN, TC, BIU and EUI) have achieved the acceptable composite reliability (CR) exceeding 0.60 and average variance extracted (AVE) exceeding 0.50. These results have a high level of validity and reliability in measuring a model. The estimated parameters were statistically significant at the $p < 0.05$ level, meaning that the value exceeded 1.96 for regression weights as indicated by the t-value. All variables have achieved the required level of estimation of greater than 0.5 for AVE. Further, the region of each estimated parameter to its standard error is statistically significant at a probability level less than 0.01 or 0.05 as indicated by the t-value. The path diagram in Figure 3 shows relationships between reflective variables in a model and the results that have been presented in Table 2.

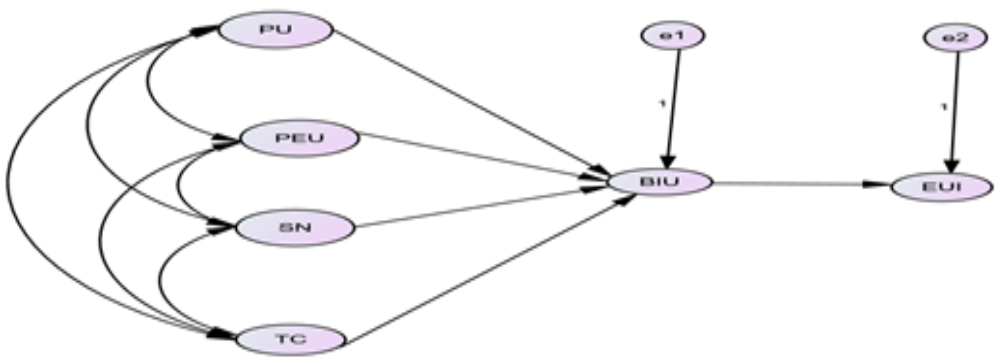

Figure 3: *Structural model*

Table 2

Discriminant Validity Assessment for Reflective Variables in the Model

Construct	PU	PEU	SN	TC	EUI	BIU
PU	**0.768**					
PEU	.208	**0.787**				
SN	.126	.196	**0.854**			
TC	-.038	-.085	-.009	**0.787**		
EUI	.036	.079	.037	-.061	**0.800**	
BIU	-.478	.853	-.041	-.024	.788	**0.735**

The findings in Table 2 indicate that the reflective variables (PU, PEU, SN, TC, EUI, and BIU) were strongly correlated with their indicators compared to the other variables in the model. The correlated variables with their indicators were shown as the square roots of AVE (in bold form). The square roots of AVE for the given reflective variables were greater than other variables, which indicated that the model was free from redundancy, so the model was deemed acceptable for further analysis. The results of the structural model indicate that there was a strong relationship among the variables influencing teachers' beliefs about ICT use and their espoused use of ICT in teaching science and mathematics in secondary schools. Teachers' beliefs about ICT use were explained by perceived usefulness, perceived ease of use, subjective norms, and technological complexity, which accounted for 17.8% of the variance found in teachers' beliefs about ICT use. Among the four variables measuring teachers' beliefs about ICT use in teaching science and mathematics, only perceived ease of use had a strong effect on teachers' beliefs about ICT use, while perceived usefulness, subjective norms, and technological complexity had only a weak effect. The strong effect may have been caused by the significant influence of perceived ease of use in teaching science and mathematics. The strong effect indicated a strong correlation between perceived ease of use and teachers' beliefs about ICT use in teaching science and mathematics. The weak effects may have been caused by the insignificant influence of perceived usefulness, subjective norms, and technological complexity. It indicates weak correlations between perceived usefulness, subjective norms and technological complexity and teachers' beliefs about ICT use in teaching science and mathematics.

The espoused use of ICT was determined by beliefs about ICT use, which explained 62.1% of the variance in the espoused use of ICT. The result shows a strong correlation between teachers' beliefs about ICT use and their espoused use of ICT in teaching science and mathematics. The results of the research model indicate that the majority of teachers had negative beliefs about ICT use in teaching science and mathematics. These negative beliefs might have been due to the weak correlations

between perceived usefulness, subjective norms and technological complexity and teachers' beliefs about ICT use in teaching science and mathematics. Few teachers had positive beliefs about ICT use in teaching science and mathematics, and this might be due to the strong correlation between perceived ease of use and teachers' beliefs about ICT use in teaching science and mathematics. Teachers' espoused use of ICT was determined by their beliefs about ICT use through subjective norms, perceived usefulness, perceived ease of use, and technological complexity in teaching science and mathematics. Hence, teachers' espoused use of ICT influences actual use. Also, the region of each estimated parameter to its standard error was statistically significant at the probability level of less than 0.05; which means the values exceed 1.96 for regression weight as indicated by the t-value of the research model in terms of coefficient correlation and statistical significance.

Table 3

Results of the Research Model

Variable	Coefficients correlation	t-value	Result
BIU <--- PU	-.478	-.747	Not supported
BIU <--- PEU	.853	1.229	Supported
BIU <--- SN	-.041	.027	Not supported
BIU <--- TC	-.024	-.093	Not supported
EUI <--- BIU	.788	5.604	Supported
EUI <--- PU	-.377	-1.043	Not supported
EUI <--- PEU	.672	1.202	Supported
EUI <--- SN	-.032	-1.199	Not supported
EUI <--- TC	-.019	-.764	Not supported

The findings in Table 3 show that a probability level of less than 0.05 supports the results while a probability level of greater than 0.05 does not support the results as indicated by the t-value. Further, a strong correlation was indicated by the correlation coefficients of greater than 0.5 values, which support the results while the correlation coefficients of less than 0.5 values indicate low correlation, which does not support the results.

Results and Discussion

The results of this study are presented and discussed for each objective considering the analysis procedures described in Figure 2 and Figure 3 and Table 1, Table 2, and Table 3.

Teachers' beliefs about ICT use in teaching science and mathematics

Most of the science and mathematics teachers held negative beliefs about the use of ICT in teaching processes. Teachers' beliefs about ICT use depended on PU, PEU, SN, and TC. This means that teachers' beliefs about ICT use depended on teachers' support for using ICT, teachers' feelings about the benefits of using ICT as a pedagogical tool, and teachers' feelings on the usefulness and relative ease of use of ICT.

The path coefficient correlation from PEU to BIU was .853, PU had a coefficient correlation of – .478, TC had a coefficient correlation of – .024, and SN had a coefficient correlation of – .041 (see Table 3). BIU was significantly determined by PU, PEU, SN, and TC for 17.8% of the variance in BIU. The findings are supported by the path coefficient correlations between the variables. The results of the analysis show that among the four variables (PU, PEU, SN, and TC) that measured teachers' beliefs about ICT use in teaching science and mathematics, only perceived ease of use showed a strong effect of greater than 0.5 value on teachers' beliefs about ICT use. The strong effect of perceived ease of use on teachers' beliefs about ICT use reflects a strong correlation between perceived ease of use and teachers' beliefs about ICT use. The strong correlation between perceived ease of use and teachers' beliefs about ICT use indicates positive beliefs about ICT use in teaching science and mathematics. This means that teachers' perceived ICT as relatively easy to use strongly influenced their beliefs about ICT use in teaching science and mathematics. Teachers who had positive beliefs about ICT use were more likely to use ICT in their teaching processes compared to those with negative beliefs about ICT use.

Subjective norms (SN), perceived usefulness (PU), and technological complexity (TC) had a weak effect of less than 0.1 in measuring teachers' beliefs about ICT use in teaching science and mathematics. The weak effect of less than 0.1 indicates a low correlation between perceived usefulness, subjective norms, technological complexity, and teachers' beliefs about ICT use hence reflecting negative beliefs about ICT use in teaching science and mathematics. If teachers lack technical support, perceive ICT to be useless, and receive no encouragement to use ICT in their teaching, their beliefs about ICT use in teaching science and mathematics will be more negative.

BIU explained less than half (17.8%) of the variance in teachers' beliefs about ICT use among secondary school teachers. Only perceived ease of use influenced teachers' beliefs about ICT use in teaching science and mathematics. The influence of perceived ease of use on teachers' beliefs about ICT use indicates a strong correlation between perceived ease of use and teachers' beliefs about ICT use, thus indicating positive beliefs about ICT use among teachers. PU, SN, and TC

did not influence teachers' beliefs about ICT use due to low correlation thus, reflecting negative beliefs about ICT use among teachers. This is despite the fact that teachers were trained through in-service training programs on how to integrate ICT into teaching. These findings are consistent with previous studies which have established that PEU is a core variable for determining teachers' beliefs about ICT use and their espoused use of ICT in teaching science and mathematics (Davis, 2003). Similarly, Compeau and Higgins (1995) found that teachers with positive beliefs about ICT use were able to use ICT more effectively and more often than those with negative beliefs. This is because they tend to hesitate to use ICT when they encounter obstacles.

Teachers' espoused use of ICT in teaching science and mathematics

The results showed that teachers in Kibaha District espoused limited actual use of ICT in teaching science and mathematics. Among the four variables measuring teachers' espoused use of ICT, only perceived ease of use showed a total effect of greater than 0.5 on the espoused use of ICT in teaching science and mathematics. The total effect of perceived ease of use on espoused use of ICT indicates a strong correlation between perceived ease of use and espoused use of ICT. This strong correlation creates actual use by showing positive beliefs about ICT use in teaching science and mathematics. This implies that when teachers perceive ICT to be relatively easy to use, it might cause them to develop positive beliefs about ICT use and hence could reinforce their espoused use of ICT that influences actual use. Further, SN, PU, and TC showed a total effect of less than 0.1 in measuring teachers' espoused use of ICT in teaching science and mathematics. This small total effect of perceived usefulness, subjective norms, and technological complexity indicates a low correlation between PU, SN, TC, and espoused use of ICT, thus creating limited usage of ICT. A low correlation indicates negative beliefs about ICT use in teaching science and mathematics. Convincing teachers to use ICT, supporting them in learning how to use it, and fostering the perception that ICT is both useful and easy to integrate into their teaching naturally cultivate positive beliefs about its use.

Further, the finding explained the variance greater than half (62.1%) in the espoused use of ICT among teachers teaching science and mathematics in the Kibaha District. Only PEU had a significant influence on teachers' espoused use of ICT in teaching science and mathematics (see Table 4). Thus, indicates a strong correlation between PEU and espoused use of ICT, which reflects positive beliefs about ICT use among teachers. Further, PU, SN, and TC had a non-significant influence on teachers' espoused use of ICT thus, indicating a low correlation between variables hence reflecting negative beliefs about ICT actual use among teachers (see Table

4). These findings concur with previous studies, which suggest that PEU is a significant determinant of intention to use ICT among teachers (Teo et al., 2009).

Table 4

Mediation Analysis

Effect	Path			Indirect effect	Direct effect	Total effect	VAF	Result
Direct without mediator	BIU	<---	PU	Not applicable	-.478	-.478		Not significant
	BIU	<---	PEU	Not applicable	.853	.853		Significant
	BIU	<---	SN	Not applicable	-.041	-.041		Not significant
	BIU	<---	TC	Not applicable	-.024	-.024		Not significant
	EUI	<---	BIU	Not applicable	.788	.788		Significant
Direct without mediator	EUI	<---	PU	Not applicable	-.399	-.776		Not significant
	EUI	<---	PEU	Not applicable	.546	1.218		Significant
	EUI	<---	SN	Not applicable	-.156	-.188		Not significant
	EUI	<---	TC	Not applicable	-.058	-.077		Not significant
Indirect with mediator	EUI	<---	PU	-.377	Not applicable	-.776		Not significant
	EUI	<---	PEU	.672	Not applicable	1.218	55.2%	Significant
	EUI	<---	SN	-.032	Not applicable	-.188		Not significant
	EUI	<---	TC	-.019	Not applicable	-.077		Not significant

These findings indicate that only PEU had a positive and significant influence on the espoused use of ICT through teachers' beliefs about ICT use, while PU, SN, and TC did not significantly influence the espoused use of ICT. This shows that teachers' beliefs about ICT use are representative of the relationship between PEU and EUI in teaching science and mathematics. Teachers' beliefs about ICT use have a variance accounted for (VAF) value of 55.2%.

Relationship between teachers' beliefs about ICT use and their espoused use of ICT

We found a strong relationship between teachers' beliefs about ICT use (BIU) and their espoused use of ICT(EUI) in teaching science and mathematics with a coefficient correlation of .788 which is significant at $p < 0.05$ level. EUI explained by BIU accounted for 62.1% of the variance found in EUI. Thus, findings indicate a strong correlation between BIU and espoused use of ICT by showing a strong effect of greater than 0.5. The results reflect positive beliefs about ICT use and hence reinforce teachers' espoused use of ICT which influences actual use in teaching

science and mathematics. Positive beliefs about ICT use and their espoused use in teaching processes among teachers may be the result of encouraging teachers to use ICT in their teaching subjects, supporting them to use ICT, and teachers perceiving ICT as easy to use.

Furthermore, this finding explained more than half (62.1%) of the variance in the espoused use of ICT among secondary school teachers in the Kibaha District. The influence of teachers' beliefs about ICT (BUI) use predicts and has a significant influence on the espoused use of ICT (EUI) in teaching science and mathematics. Thus, indicates a strong correlation between BUI and EUI hence supporting positive beliefs about ICT's actual use among teachers. This result confirms the relationships between teachers' beliefs about ICT use and their intention to use ICT as explained by the Theory of Reasoned Action (Ajzen & Fishbein, 2005).

The effects of teachers' beliefs about ICT use in teaching science and mathematics

We found that teachers' beliefs about the use of ICT affected their use of ICT in teaching science and mathematics in secondary schools. The total effects of BIU caused by PU, PEU, SN, and TC ranged from – .478 to .853. PEU had a total effect of .853, PU had a total effect of – .776, SN had a total effect of – .188, and TC had a total effect of – .077. These results indicate that subjective norms (SN), perceived usefulness (PU), and technological complexity (TC) had a total effect of less than 0.1 on BIU, reflecting negative beliefs about ICT use in teaching science and mathematics. Only PEU had a total effect of greater than 0.5 on BIU, indicating positive beliefs about ICT use. These results show that when teachers perceive ICT as easy to use, they are more likely to use ICT in teaching science and mathematics. It is possible that the teachers in this study were affected by practical aspects of ICT use and made personal decisions on whether to use ICT as a teaching tool due to their negative beliefs about ICT use in teaching processes. Some studies have revealed that teachers' beliefs differ with their gender, study year, and subject domain (Beck et al., 2000). For example, of the 172 teachers who responded to this study, 102 teachers had received ICT training during pre-service teacher education, 139 teachers had received ICT training through in-service programs, 37 teachers had received both in-service and pre-service ICT training, and 166 teachers owned ICT tools and were aware of the use of ICT as a teaching tool. Further, the literature has shown that teachers use ICT to prepare notes and examinations (Mwalongo, 2011). In addition, 109 of the teachers in this study had been teaching for over 7 years. Richardson (2003) postulated that the number of years teachers have taught affects teachers' beliefs and practices.

Teachers' beliefs about ICT use affect their espoused ICT use in teaching science and mathematics. Among the four variables, measuring teachers' espoused use of ICT in teaching science and mathematics, subjective norms, perceived usefulness, and technological complexity had a total effect of less than 0.1 on the espoused use of ICT through teachers' beliefs about ICT use. This means that encouraging teachers, helping them learn how to use ICT, and supporting them to perceive ICT as useful in teaching and learning science and mathematics will help them to use ICT more effectively in their teaching. Only PEU had a total effect of greater than 0.5 on espoused use of ICT through teachers' beliefs about ICT use in teaching science and mathematics. These results echo those by Mwakapemba et al. (2024) who found that teachers had positive attitudes towards the use of government-supplied tablets for teaching. This implies that teachers perceiving ICT as easy to use enhances their positive beliefs about ICT use, which positively affects their espoused use of ICT in teaching science and mathematics. Teachers use ICT as a tool to enhance, enrich, and deepen the teaching processes. For example, teachers can use ICT to explain difficult concepts in Physics, Chemistry, Biology, and Mathematics that cannot be easily explained using text alone. In addition, teachers can use ICT to design teaching and learning environments to make it easier to access and view information by using multiple information resources. Generally, the results demonstrate the vital role that teachers' beliefs play when deciding to use ICT as a pedagogical tool (Deng et al., 2014).

Conclusions and Recommendations

This study found that most of the science and mathematics teachers hold negative beliefs about the use of ICT in teaching and learning. These beliefs significantly limit their espoused adoption of ICT in instructional practices. Moreover, a strong relationship exists between teachers' beliefs about ICT and their actual use of technology in science and mathematics teaching. Notably, deeply held negative beliefs exert a stronger influence on teachers' use of ICT in science and mathematics teaching than external factors alone. These results suggest that efforts to enhance the sustained adoption of ICT in teaching science and mathematics should extend beyond addressing contextual barriers, such as the supply of ICT equipment, teacher training, internet access, IT personnel, and digital content development. While the Education and Training Policy attributes the limited use of ICT to a "shortage of equipment and human resources in teaching ICT" (MoEST, 2023, p. 45), this study demonstrates that teachers' deeply held beliefs can also act as significant barriers to ICT adoption in teaching and learning. Therefore, policy interventions should focus not only on removing structural barriers but also on transforming teachers' pre-existing dispositions towards ICT integration. We argue that the successful

adoption of ICT in science and mathematics education will be determined by both improved contextual conditions and teachers' positive beliefs about ICT use as a pedagogical tool.

Transforming teachers' beliefs about ICT use in teaching requires continuous professional development that challenges their pre-existing misconceptions while enhancing their confidence and technical skills. It is recommended that the Ministry of Education, Science and Technology, in collaboration with development partners, implement mandatory initial and in-service training to reinforce teachers' positive beliefs about the adoption of technology in science and mathematics teaching. Moreover, mentorship arrangements combined with hands-on training should be established to provide science and mathematics teachers with opportunities to use technology in their own learning with the support of experienced peers, thereby building their confidence and competence. Future researchers are encouraged to explore additional variables beyond PU, PEU, SN, FC and TC, as teachers' beliefs may be influenced by personal characteristics such as gender, years of study, teaching experience, and subject domain (Beck et al., 2000). Likewise, using fewer than five question items per observed variable can lead to identification issues unless a pooled CFA approach is applied. However, these recommendations remain largely theoretical and require further empirical investigation to validate their efficacy in shaping teachers' beliefs about ICT use. This presents a critical gap for future research to address.

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