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DOES TEACHERS' COMPETENCIES IN ICT INFLUENCE THEIR USE OF ICT IN TEACHING MATHEMATICS: WHAT WORKS AND WHAT DOESN'T

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ABSTRACT

This study sought to determine the kind of training teachers needed for effective use of ICT in teaching mathematics. An exploratory sequential mixed methods research design was employed to conduct the study. The study targeted all teachers teaching in public and private lower primary schools in Mombasa County, Kenya. A sample size of 40 lower primary schools were purposively selected based on the availability of ICT tools for instructional purposes in their schools. Three teachers teaching in the lower grades were selected using simple random sampling technique particularly in cases where more than three teachers existed. Teacher Questionnaire, Teacher Interview Protocol and Observation Protocol were used to collect data for this study. Data was analyzed qualitatively using descriptive phenomenological analysis in which data transcriptions were categorized into themes and sub-themes. The findings indicated that teachers' training on basic ICT skills did not significantly influence their use of ICT in teaching mathematics. However, technological pedagogical and content knowledge (TPACK) was found to significantly influence their use of ICT in teaching of mathematics. It was recommended that pedagogical use of ICT in teaching mathematics should be incorporated in all teacher-training curricular in order to equip teachers with TPACK.

Keywords: Teaching of Mathematics, ICT, Teacher Competencies

1. INTRODUCTION

Puckett, and Cabuk (2004) argued that teachers' acquaintance, confidence, and competency in using ICT in teaching was largely dependent on their training. Mingaine (2013) maintains that teacher professional development is key to successful implementation of ICT in the teaching – learning process. Furthermore, Arntzen and Krug (2010) argued that the pedagogical challenge of using ICT in teaching does not only call for acquisition of basic ICT skills but also most importantly the methods of teaching using ICT to enhance learning. This study sought to investigate the kind of ICT knowledge and skills required for effective integration of ICT into the teaching of mathematics.

i. Teacher Professional Development in ICT use

Puckett, and Cabuk (2004) noted that teachers' acquaintance, confidence, and competency in selecting appropriate learning software and eventually using ICT in the classroom instruction largely depend on their training. Owing to the fact that the use ICT in classroom instruction is relatively new, many teachers are yet to receive adequate training on ICT integration in their pedagogical practices. Mingaine (2013) argues that professional development of teachers is key to successful implementation of technology integration in the educational program. Cubukcuoglu (2013) investigated factors enabling use of ICT in Northern Cyprus secondary schools. The target population included seven volunteer teachers in one of the public secondary school. Data was collected through teacher interviews. The participating teachers indicated that there was lack of adequate training among teachers in their pedagogical use of ICT in the classroom. The teachers interviewed reported that adequate training of teachers was an important determinant in the use of ICT in teaching. The teachers reported that sufficient training was a prerequisite to effective use ICT in teaching. The teachers interviewed suggested that the training of teachers should not just involve impartation of basic ICT skills but should also provide adequate opportunities for teachers to learn pedagogical ways of integrating ICT in their teaching.

Rastogi and Malhotra (2013) in their study in India examined teachers' level of competence in ICT skills; their experiences with ICT; and how best they could apply ICT in their pedagogical practices. Purposive sampling technique was employed to select 20 schools with ICT. In each of the schools, 5 teachers teaching 9th grade were sampled. Questionnaire, interview and observation techniques were employed to collect both qualitative and quantitative data on teachers' attitudes, competencies in ICT and pedagogical practices. The study found that successful integration of ICT in classroom practice depended largely on teachers' level of competence in ICT

knowledge and skills. It also found a strong positive relationship between possession of ICT knowledge and skills and teachers' actual integration of ICT in the classroom instruction. Sadik (2008) argues that the use of technology for learning purposes could only bear fruit if teachers possessed the requisite competencies necessary to enable them use technology appropriately in the classroom.

Inan and Lowther (2010) in their study in USA examined the effects of teachers' characteristics and factors that influence their use of ICT in the classroom instruction. The study found that teachers' computer proficiency had a significant influence on their beliefs about use of ICT in classroom practice. It further found that teachers' beliefs had a strong influence on integration of ICT in their pedagogical practices. One possible limitation of this study was, although it included computer proficiency within the explanatory variables of teachers' use of ICT in classroom practice, it did not consider ICT integration skills as a variable in its definition ICT proficiency. The current study not only considered teachers' basic ICT skills but also looked into teachers' pedagogical integration of ICT into teaching of mathematics.

Kagocha (2013) conducted a study in Nyeri County, Kenya focusing on teachers' ICT competencies, access to ICTs and their actual use in their teaching. The findings of this study revealed that most teachers only possessed basic computer literacy skills mainly acquired through personal initiatives. Majority of the teachers did not possess knowledge and skills required to effectively integrate ICT in their pedagogical practices. Pelgrum (2001) argues that the success of any educational program depends largely on knowledge and skills that the teachers who are program implementers possess. The study also found that despite availability and access of desktop computers and internet, teachers didn't adequately use them in their teaching. The study attributed this state of affairs to lack of requisite ICT knowledge and skills amongst the teachers and also lack of technical support in the use of ICT. Furthermore, the study found strong correlation between teachers' ICT competencies and their actual use of ICTs in the classroom.

Tondeur, Krug, Bill, Smulders and Zhu (2015) in their study in Kenyan secondary schools to explore integration of ICT in teaching and learning found that ICT was poorly used by the pupils. It also found that none of the teachers was able to use ICT for pedagogy before the start of a teacher Professional Development (PD) programme. A teacher Professional Development was embedded in the study. Study findings by Tondeur et al, (2015) indicated that the teachers only started using ICT in their pedagogical classroom practices at the end of a two-year teacher PD programme. The field notes and results from the focus group discussions indicated that the use of ICT in teaching and learning steadily increased after the Professional Development programme. The findings however indicated that the increased use of ICT devices was only limited to the preparation of lesson plans. The findings further indicated that teachers' lack of expertise in ICT was a major challenge in the effective use of ICT in classroom instruction. In the light of the study findings, Tondeur and his colleagues suggested that there was need to develop a robust teacher professional development programmes that supports teachers' learning of appropriate use of ICT in their teaching. Moreover, the researchers suggested that teachers should be given opportunities to share their successes and failures, face challenges and make new discoveries (Tondeur et al, 2015). This study only focused on the training needs of secondary school teachers. Training needs of teachers teaching in the lower primary schools were not given much attention. The current study therefore gave more attention training needs of teachers in the use of ICT in teaching mathematics in lower primary schools.

ii. Theoretical Underpinnings of the Study

This study was anchored on the Technological, Pedagogical and Content Knowledge (TPACK) Theory by Koehler and Mishra. Koehler and Mishra (2005) TPACK is a special knowledge comprising connections and interactions among content knowledge (mathematics concepts), pedagogical knowledge (how to teach mathematics), and technological knowledge (how to use ICT to teach mathematics). This theory was developed in order to provide a framework for a body of knowledge required by teachers for effective use ICT in classroom instruction. In this theory, it is argued that teachers need to be equipped with a special kind of knowledge referred to as TPACK rather than just simply imparting them with basic computer literacy skills (Mishra & Koehler, 2006). Mishra and Koehler (2006) argue that equipping teachers with TPACK is the basis of successful and effective use of ICT in teaching. This is because good quality teaching of mathematics relies on thorough understanding of concepts and they can be represented using ICT tools. It also calls for good knowledge of pedagogical techniques that utilize ICT tools in constructive ways during teaching – learning process. This theoretical framework proposes that teachers require TPACK in order to effectively use ICT in teaching mathematics. According to this theory, merely adding ICT skills to traditional teaching techniques and approaches is inadequate.

2. METHODOLOGY

Mixed methods research design involving a combination of quantitative and qualitative data collection and analysis techniques was adopted for this study. Both quantitative and qualitative data collection methods were incorporated in the study. First, the researcher used the questionnaire technique (structured survey) to gather quantitative data and then employed the use of semi-structured interview and observation techniques to gather

qualitative data on teachers' use of ICT in teaching mathematics. The study targeted teachers from all the public and private lower primary schools in Mombasa County. Seventeen (17) public and twenty-three (23) private primary schools in Mombasa County with ICT facilities were purposively sampled for the study. Then 120 teachers teaching in lower primary were randomly selected from the 40 schools sampled.

3. RESULTS AND DISCUSSION

To gather information on the kind of ICT training the teachers had undergone, the following questions were asked to the participants: Have you undergone any form of ICT training before? If yes, where did you get trained? Table 1 presents the findings of the study on teachers ICT training.

Table 1: Descriptive Statistics on Teachers' ICT Training

Category	Frequency	Percentage
Trained	100	91.7%
Not trained	9	8.3%
Total	109	100%

The findings of the study as shown on table 1 indicated that nearly all the teachers had undergone some form of ICT training. Approximately 92% of the teachers indicated that they had been trained on the use of ICT. An insignificant number of the teachers indicated that they never received any formal training on ICT skills. The researcher further sought to establish institutions where the teachers had received their training on ICT skills. Table 2 shows the study findings on places where the teachers had received their training on ICT skills.

Table 2: Descriptive Statistics on Places Teachers Received ICT Training

Category	Frequency	Percentage
Seminar/workshops	42	38.5%
Commercial college	28	25.7%
TTC/University	15	13.8%
TTC/Seminar/Commercial	15	13.8%
None	9	8.3%
Total	109	100%

The findings on table 2 indicated that majority of the teachers had received their training through seminars and workshops. Almost half of the teachers who had trained on ICT indicated that they had received their training from a workshop or seminar. Post-questionnaire teacher interviews revealed that the ICT workshops and seminars in the county had been organized by mainly the Government of Kenya and a local NGO. This trend of increasing teacher-training on ICT skills through workshops and seminars could be attributed to the fact that the Kenyan Government was rigorously training teachers in its quest to successfully implement the Digital Literacy Program in public primary school across the country. One of the teachers who was interviewed reported that the Government of Kenya had embarked on training two teachers from every public primary school. Here is an excerpt of the teacher said:

> *"I got trained in seminar at Sparki Primary School that was organized by the government. We were trained on how to use a computer to teach mathematics, sciuence and English. We were also trained on basic computer basics skills as well proper use and maintenance. This training targeted two teachers teaching in lower primary from every public school in the area."* [teacher in 1st interview]

The findings of the study as shown on table 2 indicate that a quarter of the teacher had received their ICT training from commercial computer colleges. Most of the teachers who had received their training from commercial computer colleges mainly hailed from private primary school. A teacher from one of the private primary schools reported that she had received her training on ICT skills from a commercial computer college in a nearby urban centre. Here is what the teacher had to say:

> *"I received my training from a commercial computer college in Kisauni. The training covered computer packages such MS Word, Excel, Access, Powerpoint, Publisher and graphics. I enrolled in this college through self initiative to gain computer skills for my personal use."* [teacher in 2nd interview].

The study also found that about a quarter of the teachers who participated in the study received training on ICT skills from either a teacher training college or university. Some teachers indicated that they had at least undergone ICT training in all the institutions mentioned above. This implies that they had first enrolled in a teacher training college for a certificate or diploma course then proceeded to the University for a Degree. Later on they attended seminars and workshops on ICT training on-going in schools and finally enrolled in a commercial computer college for further

training on ICT skills. This finding implies that some teacher training colleges and universities were already modifying their curriculum to include ICT training. The study findings indicate that a paltry 8% of the teachers who participated in the study had no formal training on ICT skills. This finding is consistent with Mogire (2013) who found that majority of secondary school teachers in Kisii had trained in basic computer literacy skills. The study found that 91% of the teachers had computer literacy skills. The study however found that although most teachers were trained on ICT skills, they lacked the necessary skills useful in the integration of ICT in teaching. According to Hermans et al (2008) teachers need support to gain deeper knowledge in their use of ICT to enhance learning. Krug and Arntzen (2010) argue that effective use of ICT in teaching does not just include adding ICT skills into existing pedagogical classroom practice but requires sustained and progressive professional development of teachers. Therefore, teachers do not only need to be imparted with basic ICT skills but need to be supported in attaining technological, pedagogical and content competence in order to effectively integrate ICT in their teaching of mathematics.

i. Technological, Pedagogical and Content Knowledge

The study also sought to establish whether the teachers possessed Technological, Pedagogical and Content Knowledge (TPACK) that was deemed necessary for effective and successful integration of ICT for teaching and learning purposes. Literature reviewed revealed that mere possession of basic ICT skills was not enough for effective use of ICT in teaching mathematics. To collect data on TPACK knowledge, the respondents were asked to select an option that best described their knowledge. They responded to nine items measuring TPACK knowledge on a five-point likert scale ranging from no competence, little competence, not sure, more competence and much competence. The scoring of this scale was as follows: No competence=1, Little competence=2, Not sure=3, More competence=4, and Much competence=5. Table 3 shows the results of the study.

Table 3: Descriptive statistics on teachers' TPACK knowledge

	Statement:	**Level of Competence**				
	I can use ICT facilities to:	**None**	**Little**	**Not Sure**	**More**	**Much**
1	Upgrade instructional materials	63.3%	17.4%	0%	14.7%	4.6%
2	Determine math needs of learners	73.4%	12.8%	0.9%	10.1%	2.8%
3	Develop appropriate math activities	68.8%	15.6%	0%	12.8%	2.8%
4	Implement effective class management	67.9%	14.7%	0.9%	14.7%	1.8%
5	Engage effective pedagogical practice	62.4%	19.3%	0%	15.6%	2.8%
6	Develop effective math assessment	67.9%	23.9%	0%	6.4%	1.8%
7	Update mathematics knowledge	50.5%	13.8%	0.9%	28.4%	6.4%
8	Update ICT knowledge and skills	61.5%	15.6%	0.9%	16.5%	5.5%
9	Engage social media such as facebook, whatsapp to enhance math learning	71.6%	18.3%	0.9%	3.7%	5.5%
10	Prepare suitable lesson plan	53.2%	11.0%	0%	27.5%	8.3%
	Mean Score	64.05	16.24	0.9	13.76	4.23

Majority of teachers (64%) indicated that they were unable to integrate ICT in their teaching of mathematics despite most of them having been trained on ICT skills. The study findings as shown on table 3 indicate that nearly three quarters of the teachers did not possess Technological, Pedagogical and Content knowledge. The findings indicate that nearly 60% of the teachers had no competence at all on all the ten items of TPACK. The study results further indicate that more than two thirds of the teachers indicated that they had no knowledge of using available ICTs to update their mathematics instructional materials. Only a third of the teachers had the necessary competence to use ICTs to update their mathematics instructional materials.

According to the study findings, more than two thirds of the teachers sampled had no competence at all in the use of ICT tools in developing appropriate mathematics learning activities. Only approximately a third of the teachers indicated that they were competent enough to use ICT in developing mathematics learning activities. However, quite a number of teachers indicated that they were competent enough to update their mathematics knowledge as well as develop lesson plans using ICT tools. According to the study findings, nearly half of the teachers indicated that they were competent in using ICT resources in updating their mathematics knowledge. Likewise, approximately a half of the teachers who participated in the study indicated that they were competent in using ICT to develop mathematics lesson plans. This assertion could be attributed to the fact that updating mathematics knowledge and developing lesson plans using ICT did not require specialized ICT skills. Basic skills in ICT use could have been sufficient for a teacher surf the internet and download teaching materials. Similarly, development of a lesson plan using ICT tools might have just required basic understanding of Word or Power-point program on a computer.

Generally, the study found that the teachers were low on the Technological Pedagogical and Content Knowledge (TPACK). Literature shows that TPACK is a pre-requisite for effective use of ICT for teaching-learning purposes. The study findings as shown on table 4.20 indicated that more than two thirds of the teachers (64%) had no competence in all the items of TPACK knowledge. Only about a third (34%) indicated they were at least competent on TPACK knowledge items. A half of these teachers had little competence, while another half was much more competent. One teacher was not sure of his/her level of confidence on TPACK knowledge. Table 4 shows the computed mean scores for the TPACK knowledge items of the Teacher Questionnaire.

Table 4: Descriptive Statistics on Means for TPACK Knowledge

	Statement on TPACK Knowledge	Mean	Standard Deviation
1	Upgrade instructional materials	1.80	1.27
2	Determine math needs of learners	1.56	1.10
3	Develop appropriate math activities	1.65	1.16
4	Implement effective class management	1.68	1.16
5	Engage effective pedagogical practice	1.77	1.21
6	Develop effective math assessment	1.50	0.93
7	Update mathematics knowledge	2.27	1.48
8	Update ICT knowledge and skills	1.89	1.34
9	Engage social media e.g. facebook	1.53	1.08
10	Prepare suitable lesson plan	2.18	1.50

The results as shown on table 4 revealed that the teachers scored lowly on a scale of TPACK knowledge. Most of the teachers scored nearly 2.0 on all ten items measuring TPACK knowledge. On average, the teachers scored 1.78 on all ten items of the TPACK knowledge which was rounded off to a score of 2.0 out of 5.0. This implies that the teachers generally had little competence on the measure of Technological, Pedagogical and Content Knowledge. This finding is in agreement with findings by AL Herbi (2014) who found that there was low level TPACK knowledge among Saudi High School teachers which resulted in low level ICT use in teaching mathematics. AL Herbi (2014) found that TPACK knowledge among the teachers was the main predictor variable for effective use of ICT in the classroom instruction.

ii. Relationship between ICT Training and its Use in Teaching Mathematics

To explore whether there was a relationship between ICT knowledge and skills and teachers' use of ICT tools in teaching mathematics, the researcher tested the following hypothesis using Pearson Moment Correlation Coefficient Technique.

H_20: There is no significant relation between teachers training on ICT skills and their use of ICT devices in teaching mathematics.

To explore this relationship, the researcher tested hypothesis H_20 using Pearson Moment Correlation Coefficient technique. First, the researcher correlated scores on teachers' basic ICT skills against their use of ICT tools in the teaching of mathematics. Second, the researcher correlated scores on teachers TPACK knowledge against their use of ICT devices in teaching mathematics.

iii. Relationship between Teachers' basic ICT skills and Use of ICT Teaching Mathematics

To explore this relationship, data on teachers' training on ICT and use of ICT devices was gathered through a self administered Teacher Questionnaire. On teachers' basic ICT skills, the respondents were asked to indicate whether they had any training ICT skills. They responded by selecting either Yes or No. To collect data on use of ICT devices to teach mathematics, the teachers were asked to respond to the following statement in the Teacher Questionnaire: I use ICT (computers, laptops, projectors, tablets) during teaching and learning of mathematics. They responded to this statement by ticking one of the following alternatives: Never, once per term, once per month, once per week and daily. The item was scored as follows: Never=1, Once per term=2, Once per month=3, Once per week=4, A few times per week=5, and Daily=6. Table 5 shows the results of Pearson Moment Correlation Coefficient test on relationship between teachers ICT training and their use of ICT in teaching mathematics.

Table 5: Pearson Correlations between ICT Training and Use in teaching Mathematics			
		ICT Training	ICT used to teach mathematics
ICT Training	Pearson Correlation	1	-.220
	Sig. (2-tailed)		.121
	N	109	109
ICT used to teach mathematics	Pearson Correlation	-.220	1
	Sig. (2-tailed)	.121	
	N	109	109

**. Correlation is significant at the 0.05 level (2-tailed).

The relationship between teachers' training on basic ICT skills (as measured by a score on basic ICT skills on the TQ) and the use of ICT in teaching mathematics (measured by a score on teachers' use of ICT tools in teaching mathematics on the TQ) was investigated using Pearson Moment Correlation Coefficient technique. Preliminary analysis was performed to ensure that no violation of the assumptions of normality, linearity and homoscedasticity was done. The results of the study as shown on table 5 indicated that the correlation between teachers' ICT training and their use of ICT devices in teaching mathematics was not significant where r = -0.220 and p = 0.121 > 0.05. The p value 0.121 was found to be more than the critical value of 0.05. The null hypothesis was therefore accepted on the basis of this result. The study therefore found no significant correlation between teachers' training on basic ICT skills and their use of ICT tools in teaching mathematics. This finding suggested that there was no strong relationship between teachers training on basic ICT skills and their use of ICT tools in teaching mathematics. This finding corresponds with earlier finding in the present study which revealed that despite majority of the teachers (93%) having been trained on basic ICT skills, most of them (83%) did not use ICT devices in their teaching of mathematics. It was found that only about a fifth of the teachers (17%) actually used ICT tools in their teaching of mathematics. This finding is consistent with Kagocha (2013) who found that most teachers in Nyeri County only possessed basic computer literacy skills acquired through personal initiatives. Consequently, majority of them did not use ICT in their classroom instruction because they did not possess relevant knowledge and skills required to effectively integrate ICT in their pedagogical practices. Therefore, Pelgrum (2001) argues that the success of any educational program depends largely on specialized knowledge and skills that the teachers possess. Mishra and Koehler (2006) described TPACK as the emergent and expertise knowledge that was necessary for teachers to acquire in order to effectively integrate ICT into their classroom practice.

iv. Relationship between Teachers' TPACK and use of ICT Teaching Mathematics

To explore this relationship, data on teachers' TPACK knowledge and their use of ICT tools in teaching mathematics was gathered through the self administered Teacher Questionnaire. On teachers' TPACK knowledge, they were asked to select an alternative that best described them on the statements given measuring TPACK scale. The teachers responded by selecting one of the following: No competence=1, Little competence=2, Not sure=3, More competence=4, and Much competence=5. The level of TPACK knowledge was measured on a five-point likert scale as indicated above. SPSS software was used to compute a total score for TPACK knowledge called Total TPACK score. Total TPACK score was correlated with scores from teachers' use of ICT to teach mathematics using Pearson's Moment Correlation Coefficient technique at .05 sig. level. The results of this test are displayed on table 6 below.

Table 6: Pearson Correlations between TPACK and Use in Teaching Mathematics			
		ICT used to teach mathematics	Total TPACK
ICT used to teach mathematics	Pearson Correlation	1	.864**
	Sig. (2-tailed)		.000
	N	109	109
Total TPACK	Pearson Correlation	.864**	1
	Sig. (2-tailed)	.000	
	N	109	109
**. Correlation is significant at the 0.05 level (2-tailed).			

Preliminary analysis was also performed to ensure that there was no violation of the assumptions of normality, linearlity and homoscedasticity. The results of the study as shown on table 6 indicated that the correlation between teachers' TPACK knowledge and their use of ICT in teaching mathematics was significant where r = 0.864 and p = 0.000 < 0.05. The p value 0.00 was found to be less than the critical value of 0.05. The null hypothesis was therefore rejected on the basis of this result. The findings of the study indicated that there was a strong positive correlation between teachers' TPACK knowledge and their use of ICT in teaching mathematics. This finding implies that higher scores on teachers' TPACK knowledge may lead to increased use of ICT in teaching mathematics. The coefficient of determination was computed to determine the size effect of teachers' TPACK knowledge on their use of ICT in teaching mathematics. This was done by squaring the r = 0.864 to get percentage of variance; which was found to be 0.746. This suggests that teachers' TPACK knowledge accounted for up to 75% variance in their use of ICT in teaching mathematics. This finding suggests that the Kenyan Government and school managers could increase teachers' use of ICT in their teaching by up 75% by training them on TPACK knowledge. According to Mishra and Koehler (2006) Technological, pedagogical and content knowledge (TPACK) is an emergent kind of knowledge that forms the basis of good use ICT in classroom instruction. Likewise, Marks (1990) asserts that TPACK is a class of knowledge that is central to the teachers' use of ICT in the classroom.

According Mishra and Koehler (2006) good teaching does not just involve simply summing up ICT skills into traditional teaching techniques and approaches. But rather, it depends upon deep knowledge of how ICT can be used to access and manipulate mathematics concepts. It has been established in research literature that the mere availability of ICT tools in the classroom does not guarantee successful implementation and effective use of ICT in teaching (Koehler & Mishra, 2005; as cited in AL Harbi, 2014). It is essential for teachers therefore to possess relevant knowledge and skills in order to effectively integrate ICT into their classroom practice. TPACK was found to be the kind of knowledge that teachers required in order to effectively adopt and use ICT in their teaching (AL Harbi, 2014). According to AL Harbi (2014) TPACK represents the connection between three domains of knowledge: Knowledge of ICT (technological knowledge), knowledge of subject matter (mathematics concepts) and knowledge of processes and methods of teaching mathematics (pedagogical knowledge). Shin, Koehler, Mishra, Schmidt, Baran and Thompson (2009) as cited in AL Harbi (2014) assert that for teachers to effectively integrate ICT into their mathematics teaching, they must understand how ICT, mathematics pedagogy and content interact with one another to generate effective teaching techniques with ICT tools. Tondeur et al (2015) found that teachers only began to integrate ICT into their classroom practice after undergoing a professional development programme. Before the programme was initiated, there was no meaningful use of ICT in the classroom.

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