

ICT Integration in Science and Mathematics Lessons: Teachers Experiences about Professional Development Programme

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Abstract: *The study reported in this paper used Guskey's model (Guskey, 2000) to systematically investigate teachers' experiences about the professional development programme on ICT integration in teaching and learning of Science and Mathematics in secondary schools. The study employed survey research design and an Open-ended Questionnaire was used to gather qualitative data from 63 secondary school teachers in four regional centres (i.e. Dar es Salaam, 13, Mwanza, 16, Singida, 19 and Shinyanga, 15), drawn using purposive sampling technique. Analysis of the data using Data Reduction Technique revealed that 95.2% of the participants had positive experience with the professional development programme. They reported that, the professional development programme made them acquire technological and technological-pedagogical knowledge. However, there was no evidence that teachers learned subject matter content from the programme. Furthermore, teachers appreciated the different kinds of support that they received during / the programme and were optimistic that they will use ICT to improve their teaching and learning of Science and Mathematics in secondary schools. Relevant recommendations for action and further research are suggested based on the findings of the study.*

Keywords: *ICT in Education, ICT Integration, Science, Mathematics and Professional Development Programme.*

INTRODUCTION

Efforts towards exploitation of ICT in teaching and learning in secondary schools in the developed world and in some parts of the developing worlds is increasing dramatically (see for example Voogt, 2010; Collis & Moonen, 2001; De-Boer, 2004; Nihuka, 2008; Kafyulilo, 2013; Alayyar, Fisser & Voogt, 2012; Agyei & Voogt, 2012). Specifically speaking, ICT is extensively exploited in education in most of the developed world for various specific reasons including enhancement of access to learning resources, improvement of classroom interactions, for language and cognitive development etc (Voogt, 2010; Collis & Moonen, 2001). In the context of the developing world and in most sub-Saharan African countries in particular, studies on exploiting ICTs in the teaching and learning in secondary schools are emerging very fast (Kigobe, 2013; Senzige & Serukesi, 2003).

Conclusions from most of such studies reveal that secondary school teachers and students from the developing worlds are quite positive about using ICT in the teaching and learning in schools (Kigobe, 2013; Tagoe, 2012; Mutalubukwa, on-track) and perceive ICT as useful and that they are easy to use in enhancing teaching and learning (Agyei, 2013; Carrier, Finhott-Daniel & Gregory, 2012; Kafyulilo, 2013; Mbwambo, on-track). Also, more students than their teachers are ICT literate because they are able to use most of the microsoft office applications such as word, excel and power point presentation.

The critical importance of ICT in improving education is widely reflected in the literature (see for example Kafyulilo, et al (2012); Swarts & Wachira, 2010). The Government of the United Republic of Tanzania through the Ministry of Education and Vocational Training (MoEVT) had recognized this critical importance of ICT in education since 2007 by formulating the ICT Policy for Basic Education (URT, 2007). Amongst other objectives, the ICT Policy for Basic Education aims to facilitate integration of ICT in education as a pedagogical tool for teaching and learning, equitable access to ICT resources by students and teachers in all types of educational institutions and facilitate the use of ICT resources in schools (UTR, 2007, p. 4).

To realize that ICT is integrated in teaching and learning in schools, the MoEVT endorsed that ICT should not only be taught as a subject but also as a pedagogical tool for teaching and learning in schools (URT, 2007) and subsequently, different initiatives have been in place focusing on promoting teachers skills on ICT integration (see for example Hare, 2007; Tilya, 2008). Although there is evidence that colleges and universities prepare teachers to use ICT in their teaching, studies reveal that teachers are not using ICT in their teaching (Augusti, et al, 2013; Nihuka, 2012; Vesisenaho, 2007). Furthermore, evidence indicates that most teachers use ICT for non-pedagogical uses only which include typing of examinations, writing of letters, processing and storage of students records, marks and grades (Augusti, et al, 2013; Hennessy, et al, 2010).

The issue of offering professional development programme to teachers then becomes critical. To contribute in redressing the situation, OUT presented the teacher education and professional development programme project proposal to the African Virtual University (AVU) in Kenya so as to provide ICT Professional development programme to teachers in Tanzania which was formally signed by the two parties in August, 2010 and the first phase of the professional development programme was implemented in 2011 (OUT & AVU Report, 2011). Among other things, the teacher education and professional development programme aims to increase the capacity of teachers in the use of ICT as a tool for teaching and learning of Science and Mathematics.

The second phase of the professional development programme was conducted between 17th ó 22nd February, 2014 in four regions of Tanzania which included Dar es Salaam, Singida, Shinyanga and Mwanza. In all regions, the professional development programme sessions were conducted in the ICT laboratory of the Open University of Tanzania. The study reported in this paper investigated teachersø

experiences about the second phase of the professional development programme on ICT integration in the teaching and learning of Science and Mathematics in secondary schools.

FOCUS OF THE STUDY

As pointed out earlier, this study investigated teachers' experiences about the second phase of the professional development programme on ICT integration in the teaching and learning of Science and Mathematics in secondary schools. Specifically, the study addressed the following specific objectives:

- To reveal participants' reactions about the professional development programme on ICT integration in the teaching of Mathematics and Science,
- To identify lessons to participants from the professional development programme,
- To identify the support received by participants during the professional development programme, and
- To find out if Participants use the new knowledge acquired from the professional development programme.

In order to address the identified specific objectives, the following research questions were formulated:

1. What are the participants' reactions about the professional development programme on ICT integration in the teaching of Mathematics and Science in schools?
2. What specific topics did the participants find interesting and they actually had learned from the professional development programme?
3. What kinds of support did the participants receive during the professional development programme? To what extent did the participants find the support useful?
4. Are the participants going to use the new knowledge acquired from the professional development programme? Why / why not?

THEORETICAL UNDERPININGS

Literature Review

Evidence reveals a growing literature on teachers' experiences about professional development programmes that focus on promoting ICT integration in teaching and learning in secondary schools (see for example Alayyar et al, 2012; Agyei & Voogt, 2012; Kafyulilo, 2013; Nihuka, 2011). Most of these studies report teachers' experiences about professional development programmes in terms of their reactions to the programme, what they actually learn from such programmes, the kinds and their perceived usefulness of support offered during professional development programme, applications or use of the new knowledge acquired from professional development programme and in terms of the impact of the programme on student learning.

In terms of teachers' reaction to professional development programmes, literature indicates that teachers are quite positive about professional development programmes on ICT integration in teaching and learning (Agyei & Voogt, 2012; Alayyar, et al, 2011; Kafyulilo, 2013). Teachers provide several reasons to explain

why they are positive about professional development programmes, which include the fact that professional development programmes contribute to improved teaching practices of teachers and enhancement of student learning (Kafyulilo, 2013; Nihuka, 2011).

Teachers learn several things when participating in a professional development programme in relation to ICT integration in teaching and learning in secondary schools. According to Alayyar, et al, (2012), as a result of participating in professional development programme, teachers learn several things which make them competent and confident in using ICT in teaching and learning. Specifically, teachers learn different kinds of ICT tools (i.e they acquire technological knowledge), how to use specific technology to improve teaching and learning practice in schools (i.e. they acquire technological-pedagogical knowledge) and how to support students learning in the new learning environment (i.e. they acquire knowledge on how to support students). Related findings are also reported by several other studies (see for example Kafyulilo, 2013; Agyei & Voogt, 2012). Furthermore, professional development programmes contribute to teachers' preparedness in designing ICT-based lessons and in teaching lessons using ICT thereby improving their teaching practice and enhancing student learning (Nihuka, 2011).

Providing support to teachers during professional development is critical for successful teacher learning (Kafyulilo, 2013; Nihuka, 2011). Therefore, an effective professional development programme will always consider offering relevant and useful support to teachers during and (where necessary) after the programme in terms of helping them how to design ICT-based lessons, how to manage classroom and student learning and how and when to use ICT in teaching and learning (Nihuka, 2011; Kafyulilo, 2013).

As regards the support, literature indicates that teachers participating in professional development programmes are quite satisfied and find the support they receive as useful and relevant for their professional growth (Alayyar, et al, 2012; Kafyulilo, 2013).

In terms of teachers' use of the new knowledge acquired from professional development programmes, studies indicate that when systematically conducted, professional development programmes make teachers integrate ICT in teaching and learning (Alayyar, et al, 2012). Nihuka (2011) provides three major reasons that make teachers actually use ICT in their teaching, which include: the potential of ICT in addressing challenges of traditional teaching, practicality of ICT and the continued provision of support to teachers.

Lastly, an effective professional development programme should ultimately have positive impact on student learning and academic outcome (Guskey, 2000; Joyce & Showers, 1995). However, studies provide mixed evidence to support this claim. For example, whereas Bates (2000) and Tsang and Senta (2001) report significant improvement in student learning and academic outcomes, on the other hand another studies by Waigandt & Whittaker (2005) report no significant improvement on

student learning and academic outcomes as a result of professional development programme.

The study reported in this paper used Guskey's model (Guskey, 2000) to systematically investigate teachers' experiences about the professional development programme on ICT integration in the teaching and learning of Science and Mathematics in secondary schools based on 4 aspects of the model, namely: teachers' reactions, teachers' learning, support and use of new knowledge. The 5th aspect of the model was not considered in the reported study because of the fact that teachers were yet to practice what they have acquired from the programme in their classrooms.

Professional Development Evaluation

Thomas Guskey suggests five critical stages or levels to consider when evaluating a professional development programme (Guskey, 2000). The five stages are collectively referred to as Guskey's model of evaluating professional development programme. The five stages are hierarchically arranged from simple to more complex. The stages include: participants' reaction, participants' learning, support, participants' use of the new knowledge and skills and students' learning outcomes (see figure 1).

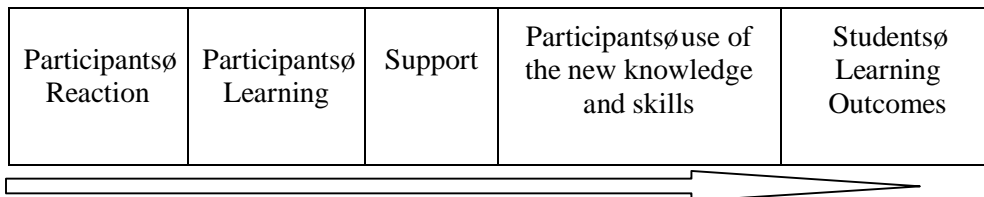


Figure 1: Guskey's Model of Evaluating Professional Development Programme (Guskey, 2000)

The Guskey's model is adapted for this study because of its power in addressing a broad range of 'what' and 'why' questions more adequately than most other models (including that by Kirckpatrick, 1959). However, for purposes of the study reported in this paper, the fifth stage (i.e. students' learning outcomes) was not explored because of time constraint.

METHODOLOGY

Design of the Study

The study employed *survey research design* because of its potential to provide straightforward approach to the study of perceptions (Robinson, 2011) which was the nature of the study reported in this paper. The design allowed gathering of generalizable data from the secondary school teachers who participated in the ICT Integration in Science and Mathematics Professional development programme.

Sample and Sampling Technique

A total of 63 secondary school teachers, drawn from four regional centres were invited to participate in the study. Out of the 63 participants, 13 were from Dar es Salaam, 16 were from Mwanza, 19 were from Singida and 15 were from Shinyanga. The sample used purposive sampling techniques which enabled inclusion of all secondary school teachers who participated in the professional development programme.

Instrument for Data Collection

The study used *Questionnaires* to collect qualitative data for the study. The questionnaire comprised of open-ended questions to which, the respondents were requested to express their perceptions in relation to four different aspects of the professional development programme as guided by Guskey's model of evaluating professional development programme as a framework of the study (Guskey, 2000). Based on the model, the open-ended questions were categorized into four questions that were geared to measure participants' reaction, participants learning from the professional development programme, support and participants use of the new knowledge. The fifth aspect of the model (i.e. student learning outcome) was irrelevant in this respect and thus was not measured during this research.

All qualitative data were analysed using *Data Reduction Technique* (Miles & Huberman, 1994) where categories were identified, frequencies established and percentages computed. Where necessary, the frequencies and percentages are presented in Tables supported by relevant utterances.

FINDINGS

Participants Reactions about the Professional development programme

The first research question investigated participants' reactions about the professional development programme on which they were participating. Analysis of the responses from open-ended questionnaire indicated that 95.2% of the participants found the professional development programme comprehensive, well conducted and to their expectations. Most of the responses were of the nature similar to the following utterances:

"I liked the professional development programme on ICT integration in the teaching of Science and Mathematics subjects because it was comprehensive". Another one added that *"instructors seemed qualified because they conducted the professional development programme very well and to my expectations"*.

In terms of the extent to which ICT can be integrated in Science and Mathematics subjects, the participants perceived that:

"to some extent the objectives of the professional development programme had been met since the facilitators organized their presentations in such a way that they used demonstrations to demonstrate clearly how a specific topic of a chosen subject can be taught using power point presentation and we were given opportunity to practice the same during the professional development programme, although for a short time".

Participant Learning from the Professional development programme

The second research question was set to find out specific topics that the participants found to be interesting during the professional development programme and what they had actually learned as a result of participating in the professional development programme. Findings on identified interesting topics and what participants had learned are presented in Tables 1 and 2 respectively.

Table 1. Topics that Participants found to be Interesting

Interesting Topics	Frequency	Percentage (%)
Multimedia	52	82.5%
Desktop publishing	10	15.9%
PowerPoint presentation	51	81%
Spreadsheet / Excel	52	82.5%
Internet	58	92.1%
Database management	12	19.0%
Microsoft Word	10	15.9%
Animation	05	7.9%
Computer handling	06	9.5%
Computer networking	04	6.3%
Computer hardware	02	3.2%

Findings in Table 1 indicate that majority of the participants (frequency and percentages provided in brackets) found the following topics interesting: multimedia (52, 82.5%), power point presentation (51, 81%), spreadsheet / excel (52, 82.5) and internet (58, 92.1%).

Table 2 presents findings in relation to the specific contents that the participants had actually learned as a result of participating in the professional development programme.

Table 2. Contents that the Participants had Learned from the Professional development programme

Topics that Participants Learned the Most	Frequency	Percentage (%)
Internet	54	85.7%
Multimedia	10	15.9%
Spreadsheet / excel	45	71.4%
How to design a website	10	15.9%
Power point presentation	61	96.8%
How to search and retrieve open educational resources	60	95.2%
How to integrate multimedia in teaching	54	85.7%
How to prepare and use power point presentation in classroom	56	88.9%
How to use spreadsheet / excel to manage students marks	62	98.4%
Maintenance of computer	22	34.9%

Desktop publishing	11	17.5%
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It is to be noted in Table 2 that, as a result of participating in the professional development programme, majority of the participants learned how to search and retrieve open educational resources (60, 95.2%) and how to integrate multimedia in the teaching of Science and Mathematics (54, 85.7%). Furthermore, the participants learned how to prepare and use power point presentation in the teaching of specific topics in Science and Mathematics (56, 88.9%) and how to use spreadsheet / excel to manage students marks (62, 98.4%).

However, a large proportion of the participants were of the opinion that the professional development programme should have been delivered for at least 3 -4 weeks to allow more time for practice of participants for much more impact of their learning.

Support Received by Participants

The third research question of the study investigated the kinds of support that the participants received during the professional development programme and the extent of usefulness. As presented in Table 3, participants received four major kinds of support, namely: well facilitated sessions (60, 95.2%), readily availability of learning resources (56, 88.9%), technical support (54, 85.9%) and institutional / financial support (52, 82.5%).

Table 3. Support Received by the Participants

Kinds of Support	Frequency	Percentage
Readily availability of learning resources	56	88.9%
Institutional / financial	52	82.5%
Technical	54	85.9%
Well facilitated sessions	60	95.2%

Findings in Table 3 indicate that majority of the participants (95.2%) indicated that the sessions were well facilitated by facilitators whom they regarded to be well qualified. According to the participants, the facilitators used participatory approaches which provided the opportunity for the participants to practice what they learn, as evidenced in the following utterance:

“the sessions were well presented; I liked the sessions because all facilitators seemed knowledgeable and qualified in their teaching profession. The participation in the practices helped me understand better how to use ICT in the teaching of Science and Mathematics”.

Furthermore, a large proportion of the participants (88.9%) indicated that the learning resources such as power point presentations and the lesson notes were readily available during the professional development programme. According to the participants,

“the availability of learning resources helped us to follow the presentations properly and acquired skills on how to integrate ICT in teaching of Science and Mathematics”.

Regarding institutional / financial support, findings in Table 3 indicate that 52 respondents (82.5%) appreciated the support provided by the District Offices in terms of granting the permission to participate in the professional development programme. Additionally, the participants indicated that:

“the financial support from the Districts in terms of per-diems were quite useful for us because it helped us participate in the professional development programme much more comfortably”.

Furthermore, majority of the participants acknowledged and appreciated the financial support from the African Virtual University (AVU) in terms of tuition fees and the associated logistics which made it possible for them to participate in the professional development programme. However, the participants were of the opinion that at least one laptop should be provided to each participant at the end of the professional development programme so that they can use such laptops to improve the teaching of Science and Mathematics in schools.

On the issue of technical support, findings in Table 3 indicate that 54 respondents (85.9%) appreciated the readily availability of technical support during the professional development programme. Particularly, the participants identified support in terms of fixing computers which had stopped working during the professional development programme and helping the participants to troubleshoot computers which had technical problems was very useful for them. Overall, 95.2% of the participants ranked the support received as relevant and useful to a greater extent.

Participants Use of New Knowledge

The last research question investigated whether or not the participants are going to use the new knowledge on how to integrate ICT in the teaching of Science and Mathematics. Responses from open-ended questionnaire indicated clearly that majority of the participants in all the four regional centres (i.e 81% Dar es Salaam, 72% Singida, 68% Shinyanga and 67% Mwanza) were optimistic to use ICT in their teaching in schools. Confidently, participants indicated that they will use internet to search and retrieve learning resources so as to enrich their lesson notes (89.2%), use spreadsheet / excel to teach topics such as linear equations in Mathematics and management of students' marks (65.1%) and prepare and use power point presentation to deliver their lessons (92.1%).

According to the participants, ICT will improve students' learning (56%), promote students' interest to learn Science and Mathematics (70%) and improve classroom interactions during lessons (52%).

As a strategy to encourage the integration of ICT in teaching and learning in secondary schools, the participants were of the opinion that:

our employer, the Ministry of Education and Vocational Training should consider improving ICT infrastructure in secondary schools and put in place a clear mechanism to motivate school teachers to use ICT in their teaching by providing incentive”.

CONCLUSIONS AND RECOMMENDATIONS

The study reported in this paper investigated teachers' experiences about professional development programme on ICT integration in the teaching and learning of Science and Mathematics in secondary schools. Findings have indicated that teachers had positive experience with the professional development programme because it was comprehensive, gave them hand-on-task opportunities (although in limited occasions) and that it met the objectives of the programme. These findings collaborate to those reported in previous studies by Alayyar et al, 2012 and Agyei & Voogt, 2012). Furthermore, teachers found the content of the programme as interesting particularly the content on internet, spreadsheet / excel and multimedia amongst others.

As experience by teachers, the professional development programme made them learn several things. Specifically, teachers acquired knowledge about the different kinds of technologies (i.e. technological knowledge) such as internet, spreadsheet / excel and power point presentation amongst others. They also learned how to use specific technology in teaching (i.e. technological-pedagogical knowledge) which included how to use spreadsheet / excel to manage student marks, how to search open educational resources from internet, how to prepare and use power point presentation in teaching and how and when to integrate multimedia in teaching. Unfortunately, there was no evidence from the findings to indicate that teachers learned subject matter content that they could use to teach using specific technology. A holistic knowledge that is referred to as *Technological-Pedagogical and Content Knowledge* (TPCK) is crucial in promoting teachers' competence and confidence to integrate ICT in teaching and learning (Agyei & Voogt, 2012; Kafyulilo, 2013; Nihuka, 2011). The aspect of subject matter content was therefore expected to be reflected in the professional development programme reported in this study so as to make the programme more robust and make teachers benefit fully professionally.

Another experience is that, teachers appreciated the different kinds of support that they received during the professional development programme particularly in terms of technical, institutional / financial and availability of learning resources. Teachers found the support as relevant and useful to a greater extent. Previous studies indicate that where necessary, one-to-one and continuous personal support for teachers who are attempting to use ICT in teaching is crucial to ensure fearless familiarization of the new way of teaching using ICT (Bianco, Collis, Cooke & Margaryan, 2002).

Evidence from the findings indicates that teachers are optimistic to use ICT to improve teaching and learning of Science and Mathematics in secondary schools. According to the teachers, when used effectively, ICT improves student learning,

promotes students interest to learn Science and Mathematics and improves classroom interactions during the lessons.

Despite teachers' positive experience about the professional development programme, two major recommendations are made based on the findings. First, teachers should make deliberate attempts to integrate ICT in the teaching and learning of Science and Mathematics in secondary schools based on the knowledge acquired from the programme. After all, above all barriers of ICT integration in teaching, teachers' interest is central, so once a teacher is determined to use ICT, then s/he will use and will find the best way to redress the barriers. Second, future professional development programmes should be informed by sound evidence from previous studies. For example, evidence from studies by Agyei & Voogt (2012), Agyei (2012) and Kafyulilo (2013) have indicated that professional development that involves *Teachers Collaboration in Design Teams* are quite effective in promoting teachers knowledge and skills of integrating ICT in the teaching and learning of Science and Mathematics. Lastly, a follow up study should be designed to determine the extent to which teachers teaching practice has improved as a result of professional development programme and its impact on student learning of science and mathematics.

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