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Re-orientation of Science and Mathematics Teachers' Instructional Strategies for Information Communication Technology Integration

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ABSTRACT

This article reports on a study which explored teachers' re-conceptualization and re-orientation process during their in-service training for ICT-pedagogy integration in teaching and learning. The qualitative research design was used for the study. It was found that there was a limited ICT infrastructure as well as inadequate technological access and reliability, the participating teachers were engaged in authentic "hands-on' learning experience and that the teachers' engagement in the learning activities demonstrated they had not developed expertise in ICT usage for teaching and learning. It was therefore recommended that opportunities to acquire professional ICT integration skills for both teachers and trainers be expanded.

Conference Subtheme: The Role of ICTs in Education

Keywords: Re-conceptualization, Re-orientation, ICT-pedagogy integration

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INTRODUCTION

Background and Context of the Study

The global trend of ICT adoption in education has resulted in the need to change the current teacher-centered methodologies to student-centered learning settings that are technologically enhanced (UNESCO, 2002). A broad range of evidence shows that ICT integration in teaching support student-centered approaches and has potential to improve teacher effectiveness, enhance learning, and improve learner outcome (Wang, 2001). Consequently, equipping serving teachers with basic ICT skills and competencies required to help them to transit to educational uses of technology has become a key component in the educational reform efforts across the world (Internal Society for Technology in Education, 2002). In developed countries ICT is at the centre of educational reforms and it is infused within the teacher training curriculum and classroom pedagogy (UNESCO, 2008), with the result that serving teachers have transited from traditional teaching practices to technologically-enhanced educational delivery methodologies. This has the potential to improve education systems so as to equip students with skills required to effectively function in the current knowledge-based society (The Partnership for 21st Century Skills, 2007). Thus, developed countries provide quality educations to their citizens.

Despite the positive effects of ICT adoption in education in the developed countries, developing countries have not fully embraced these technologies in their educational curricula. For instance, in Sub-Saharan Africa the fact that ICT has a role in transforming teaching and learning has not impacted on the design and delivery of teacher preparation curricula in spite of the formulated ICT in education frameworks and policies (Unwin, 2005) and seems to focus more on the tangible ICT infrastructure and internet connectivity. Consequently, teachers lack the knowledge and skills to effectively integrate ICTs in their teaching (UNESCO, 2005).

In Kenya, the national ICT policy on education puts emphasis on pedagogical approaches that aim at enhancing interactive learning (MOEST, 2006) so as to improve the quality of education. Through this framework, the government has in effect designated the training process. This means that any ICT-pedagogy integration frameworks should be aligned to this approach. Recently, in an attempt to enhance and reform education through the use of ICT, an ICT-pedagogy component was introduced in the Ministry of Education's Strengthening of Mathematics and Science in Secondary education in-service training (MOEs SMASSE INSET) program as one of the government's concerted efforts to provide quality education that will improve performance in the secondary mathematics and science. In this regard, the Center for Mathematics, Science and Technology Education in Africa (CEMASTEA), which is the host institution for the SMASSE INSET program, was mandated to re-orient teachers to technology-enhanced methods of teaching.

Problem Statement

Although the MOE through its policy framework designated the training approach, it did not provide clear guidelines regarding the envisioned process for teacher preparation in ICT-pedagogy integration (CEMASTEA, 2009), neither did it have a proper framework for evaluating and certifying ICT training programs in place (MOEST, 2006). Furthermore, at the time of study, the digitization of secondary school science and mathematics curriculum had yet to be done and what was in use was mainly the text or print-based education technologies. Evidently, this left the design and implementation of the ICT-pedagogy integration curriculum solely at the discretion of the training institutions. Even more critical was the fact that CEMASTEA, was itself at the time 'unprepared' as captured in the institution's situational analysis which revealed the need to develop the internal staff capacity in ICT (CEMASTEA, 2009: p.28). This being the case, it was necessary to explore and document the training practice for ICT-pedagogy integration as carried out at a by CEMASTEA at a SMASSE INSET center.

Purpose of the study

The purpose of the study was to examine the ICT-pedagogy integration training at *Manga* (pseudo name for the study center) district SMASSE INSET centre, document contextually useful lessons to inform future ICT-pedagogy integration curriculum developers and implementers, guide policy regarding context-specific ICT-pedagogy integration activities, as well as provide a basis for further research in respect of ICT-pedagogy integration practices.

Research Questions

Main Question:

How mathematics and science teachers are prepared for ICT-pedagogy integration at the *Manga* district SMASE INSET center?

Sub-questions:

1. What ICTs are used at the INSET center?
2. What essential activities related to ICT integration are the mathematics and science teachers exposed to during the INSET?
3. How are the teachers engaged in the activities?
4. Why are the teachers engaged in the particular activities?
5. What challenges do the teachers experience as they engage in the activities?

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Rationale and significance of the study

This study intended to bridge the gap in literature concerning the re-conceptualization and re-orientation of mathematics and science teachers at the INSET center. The findings could be used to inform policy makers, curriculum developers and teacher educators on how to design and deliver ICT-pedagogy integration curricular that are contextually relevant.

Conceptual Framework

The fundamental components of Mishra and Koehler's (2006) theoretical framework for ICT-pedagogy integration include content (what to deliver), pedagogy (how to deliver), social interaction (how to interact with others in the learning environment), and technology (how to support learning through ICT).
In ICT-enhanced learning settings, content is mainly presented in digital form, which means that teachers' ability to create multimedia could be a necessary pre-requisite condition if the teacher is to appropriately fit technology into the curriculum (Earle, 2002). It follows therefore that focus needs to be on teachers' knowledge of the appropriate ICT tools, and how to use them to create and manage the technological teaching resources. This suggests that the pedagogical goal for the INSET curriculum should be situated learning, and this has the potential to afford the teachers an opportunity to learn about teaching with technology while connecting it to their practice Jung (2003). This, in my view, would increase the likelihood that they will use ICT in their own classrooms to enhance learning and consequently improve the quality of education.

Further, the social interaction component is crucial in learning to integrate ICT into teaching because in real-life, people usually turn to others for help when they encounter problems in their work and life (Wilson & Lowry, 2000). Therefore, adoption of cooperative learning (Vygotsky's, 1978; Kagan, 1994) at INSETs could take care of teachers' varying technological proficiency, and in turn, help them develop skills required to facilitate social interactions in their own classes.

Finally, access to, and availability of appropriate digital technology resources and the lack of understanding of their use to achieve specific learning can limit their use in classrooms (Beetham & Sharpe, 2007). Therefore, teachers require skills and knowledge of setting up and use of the standard sets of operating and application software systems, tools and educational software (Mishra & Koehler, 2006). And since digital technologies rapidly change, teachers must be helped to develop the ability to continually learn and adapt to new technologies (Wang, 2008) and repurpose them appropriately for teaching and learning.
The phenomenon of teachers integrating technology into their pedagogy is founded on the premise of technological pedagogical content knowledge (TPCK) proposed by Mishra and Koehler (2006) which proposes that for teachers to effectively integrate ICT-pedagogy into the curriculum, they require a strong technological, pedagogical and content-based knowledge. But since gaining expertise in both a subject's content and its pedagogy occurs over time and with practice, it implies that the framework is applicable to INSETs because the teachers are all practicing and expectedly have gained meaningful teaching skills. Thus, the TPCK framework can be translated into a successful training approach for ICT integration curriculum in INSET programs.

The success of ICT integration into the teaching process depends not only on the availability of technology, but more on the pedagogical design (Earle, 2002; Mandell, Sorge & Russell, 2002; Wang & Woo, 2007). Hence, the process of integrating ICT in teaching and learning has to be done at both pedagogical and technological levels with much emphasis put on pedagogy, so that teachers can understand the appropriate pedagogies and technologies to use in representing specific concepts in consideration of learners' prior knowledge.
Additionally, teachers need to demonstrate a set of competency-related ICT skills besides pedagogical knowledge (Garcia & Tejedor, 2006). In this respect, UNESCO has proposed ICT competency standards for teachers (ICT-CST) outlined in three ICT integration approaches namely, technology literacy, knowledge deepening and knowledge creation (UNESCO, 2008). This makes the UNESCO ICT-CST framework a valuable reference for guidelines on formulation INSET's ICT integration competency standards for the teachers and trainers.

Teacher preparation for ICT integration should hinge on activities that develop effective teaching skills (Shazia, 2000). According to Boud and Prosser (2002) the activities should be highly engaging and build on teachers' prior knowledge. This means effective ICT integration curriculum is one in which the learning activities can be contextualized and be completed using supports and learning resources available in the learning setting. In this regard, the learning tasks would best be carried out in the teachers' own context of practice, and be designed to meet their professional needs. This would most likely compel the teachers to make context-specific decisions on ICT usage and thereby address their own needs and that of their learners.
Research indicates that the use of ICT can support student-centered learning approaches and make the hard-to-implement instructional methods such as simulation or cooperative learning, more feasible (Roblyer, Edwards & Havriluk, 2004). Thus educational software has the ability to expose all types of learners to authentic tasks that can promote development of problem-solving skills in real life.

Use of ICT in the classroom also has a critical impact on teachers and the strategies they employ to facilitate an interactive learning environment (Jagdish, 2006). Technology can help a teacher explain abstract concepts (Zhao, 2003), thereby improving their teaching efficiency. As such, preparation for ICT-pedagogy integration would benefit the teachers if the learning outcome is ability to deliver content using ICT. It is thus critical that teachers develop the capacity to prepare and use multimedia resources.

The problems and barriers with respect to ICT integration by teachers stem from inadequate training, absence of technical support and institutions that do not embrace ICT usage (Cuban, 2001; Dede, 1998). Ottevanger and World Bank, (2007)

point out that in developing countries poor quality of teaching and teachers is one of the principal causes for poor achievement in using ICT to teach mathematics and science subjects. This suggests that inefficient teacher education programs for ICT-pedagogy integration is the major reason for limited use of ICTs in the classrooms. In addition, the use of ICTs largely depends upon the availability and accessibility of ICT resources. This means that if the teacher cannot access technology as is the case in many educational settings in Sub-Saharan Africa, then it will not be used (Hennessy, Harrison and Wamakote, 2010).

METHODOLOGY

Research Approach and Design

This study, being an empirical inquiry into the ICT-pedagogy training practices, required that the researcher verify the accuracy of the various accounts provided by the respondents regarding the training practices (Robson, 2002) at the designated training center. As such, the study lent itself to a qualitative research design (Denzin and Lincoln, 1994). Further, to obtain a detailed perspective of the empirical inquiry, the researcher explored the "contemporary phenomenon within its real-life context" (Yin, 2003: p.13). Thus, a case study research strategy was most appropriate because it facilitated the collection of data through direct inquiries and observations.

At the time of the study, there were one hundred and eight (108) designated SMASSE district INSET centers, and each was unique in terms of the participants, technical and technological infrastructure, trainers' expertise, and the time scheduling for the ICT integration curriculum. The selection of *Manga* district INSET center as the study site was purposive because this district center was at the time introducing the ICT-pedagogy integration to serving teachers, which happened to be the focus of the study.

Study Population

Eight teachers, two for each of the four subjects (mathematics, biology, chemistry and physics), and four trainers were interviewed. The choice of two teachers per subject was appropriate for the study because while one per subject would not have given varied views, more than two would have been too many for the one week duration of the INSET. However, observation focused on all the participants in a learning session.

Data collection strategies

The duration for the INSET was limited to a week and therefore to obtain a rich amount of information about the training activities and resources used, and to increase the trustworthiness of the study, data was gathered from many sources using observation, studying the training documents and interviews.

Observations

An observation schedule and an observation protocol were used, and focus was on types and numbers of technical and technological resources, location in relation to the designated training rooms, the nature of the learning tasks, the teaching strategies, and the challenges encountered. The observed interactions within the learning context enabled the researcher to examine the social component of the learning design with a focus on the nature of support and help provided to teachers as they learn to change their practice. These instruments thus ensured a systematic approach to verifiable and quantifiable data collection, and one that eliminated selective bias and misinterpretation of observed items. This is in line with Denscomb (2003) that observation draws on visual evidence of events rather than relying on what people say about their experiences or thoughts.

Document analysis

This method was used because data from documents is readily available and less tedious to organize compared to primary data (Howard and Sharp, 1983:141). The documents analyzed were the MOE strategic plan for the period 2006 – 2011, the National INSET district trainers' manual, the subject syllabus, the INSETs daily activity program and artifacts. The instrument comprised a list of items of information to be obtained from the documents, and focus was on the documents' purpose, the content in terms of specific statements about activities, intended objectives, and the technical and technological resources, all related to ICT-pedagogy integration. The most recurrent themes of information relevant to the study were recorded.

Interviews

In line with Cohen & Manion, (2000) advice, a purposive multiple sampling of respondents was adopted to obtain rich in-depth information about their knowledge and engagement in the training practice at the center. The trainers were selected because their role was to implement the ICT-pedagogy integration curriculum, while the teachers were selected because they were the targeted beneficiaries. The interview guide aimed to gather data about the views, knowledge and experiences of the respondents regarding the training practice and securing comparable data from different interviewees. As such the interview was a face-to-face interaction that required semi-structured questions that served as a prompter to provide opportunity for respondents to clarify and elaborate on issues deemed critical to the research questions. The data was captured on a digital voice recorder.

Reliability of the Instruments

This was determined by an education specialist who reviewed and judged them as appropriate. The instruments were then piloted on four M.Ed students who were secondary school science and mathematics teachers, and who had undertaken the course of ICT in education. This helped the researcher to identify problems that the subjects were likely to encounter when responding to items, and accordingly improved the effectiveness of the instruments in collecting relevant data.

Rigour

Data obtained from document study and the ICT facilities analysis protocol was analyzed and then used to corroborate that from session observation and interviews to improve the believability of the data, and consequently, the trustworthiness of the study findings (Robson, 2002). Multiple forms of data in form of descriptive statements were obtained and also compared for purposes of triangulation in order to further increase the trustworthiness of the study (Lodico, Spaulding, & Voegtle, 2010) and hence rigor in the research. This helped to counter threats to validity (Robson, 2002).

Data analysis

Data analysis was directed at identifying and describing significant patterns in the data obtained in order to construct a theory of the ICT-pedagogy integration process at the INSET center. First, in line with Best and Kahn (2005), data from various methods was organized by grouping the interview responses, observation occurrences and document findings according to the research questions.

This was then followed by interpreting the raw data obtained to transform it into a coherent depiction of the study (Sally 2000). In this regard, descriptive codes were used to sort the data into purposeful categories based on the research sub-questions. The recurring coded ideas were then combined and paraphrased into themes that described and gave insight into the perspectives of the respondents' views, document analysis and the researchers' observations in light of literature reviewed. Specifically, one piece of data from an interview statement or theme was compared with others in observation and document analysis of the same category that were either similar or different in order to conceptualize the possible relations between the various pieces of data. Based on the themes a theory about how mathematics and science teachers are helped to re-conceptualize the teaching and learning process and re-oriented to the newer technology-enhanced teaching approaches at the INSET center was developed (Lodico et al. 2010).

SUMMARY OF FINDINGS

The research sub-questions served as a starting point for understanding the training process. However, more enlightening were the themes that emerged as interviews were carried out, observation of the sessions done, and training documents gleaned. Below are the findings.

Inaccessibility and inadequacy of the ICT facilities

Data showed that although the ICT-pedagogy curriculum aimed at exposing teachers to ICT facilities for them to experience the ICTs potential benefits in teaching, there was a limited technical infrastructure as well as inadequate technological access and reliability. This limited the teachers' interaction with ICTs and consequently, acquisition of technical competence. This resonates with Unwin's (2005) remark that most teachers in the sub-Saharan region are victims of inadequate exposure to appropriate ICT-pedagogy integration. A remark that seems to shatter Shazia's (2000) observation that teachers engaged in ICT integration need adequate access to technology to successfully explore and apply appropriate technologies in their classrooms

Re-orientation of teaching skills

It was also noted that despite the ICT infrastructure constraint referred to above, the participating teachers were engaged in authentic "hands-on' learning experiences in which they created or used already prepared technology-enhanced teaching materials to support their current classroom practice. These activities were thus experiential based on real-life practice of the teachers and aimed to help them to acquire skills to repurpose technologies to suit educational requirements and therefore enhance student learning.

The ICT-Pedagogy Curricular Instructional Processes

Data showed that the ICT-pedagogy integration curriculum was centered on an approach that espouses learner-focused learning settings. As such, the pedagogical approach used to deliver the ICT-pedagogy content was by engaging teachers in experiential learning that required them to complete technology-enhanced subject-oriented tasks facilitated by subject-focused discourse. This learning set-up provided peer support that comprised the peer coaching observed during the acquisition of ICT literacy skills, as well as modeling and scaffolding during the ICT-pedagogy integration activities. In this way, the ICT-pedagogy integration curriculum approach exposed teachers to collaborative activities. Thus the instructional strategies used at the INSET center established the theory of cooperative learning as the pedagogical approach used to deliver the ICT integration curriculum at the INSET. Further, data showed that the trainers were not experts in ICT integration and could not demonstrate effectively the delivery of the content using collaborative strategies. It is thus likely the teachers experienced limited 'best practice' to develop effective collaboration skills which happen to be enabling factors in interactive ICT-enhanced learning environments.

UNESCO (2005), advises that collaboration strategies for supporting learning should be facilitated by ICT-pedagogy integration experts who can articulate the why of an action, or intervene at critical points of learning by providing hints and prompts, or even adjust the learning task to match the learners level of performance. Advocates of educational reforms through use of ICTs argue that learning takes place when a learner completes tasks with the support of the more knowledgeable others or technology (Newhouse, Trinidad & Clarkson, 2002).

Re-conceptualization of the teaching practice

According to Mishra & Koehler (2006) TPCK is the basis of good teaching that teachers need in order to demonstrate effective use of ICT to facilitate conceptual change and deep understanding of concepts. Data obtained from the training Centre showed the teachers were well grounded in PCK, and re-orienting their teaching skills to ICT usage required them to transit from PCK to TPCK. To achieve the transition, the teachers were engaged in computer literacy and its professional application in teaching so as to enhance their understanding of the representation of concepts using technologies. However, it was candidly clear that the teachers' engagement in the learning activities showed that despite the initial exposure to ICTs and opportunity to try them out, they had not developed expertise in ICT usage for teaching and learning. This implied that they still required expert demonstrations and more opportunities for practice in order for their pedagogical practices to develop beyond their current teaching skills. Thus ICT-pedagogy integration training and support need be a continuing process beyond the INSET for ICT usage to become part of teaching skills so that teachers integrate ICT in their practice.

Challenges

With any change come challenges. Accordingly, data showed that due to time, technical and technological resource-constraints individual teacher problems could not be adequately addressed, and this formed a barrier to teachers' development of technical competence which is a significant factor in their preparation for ICT integration into teaching.

Data also showed that although teachers were engaged in experiential learning, they encountered limited technological and professional support. This may have resulted in the lack of confidence and probably the resistance to ICT usage that was witnessed in one group. Thus limited technical and professional support for the teachers is likely to have posed a barrier to the teachers' development of TPCK and subsequent integration of ICT in their teaching.

These findings implied that shortage of time and enormity of learning tasks coupled with limited technological and professional support can be a barrier to teachers learning to integrate ICT into their teaching. The findings then reveal that lack of adequate opportunity required to experience and try out use of technology in teaching are tremendous odds that teacher education programs must overcome in order to integrate ICT into their curricula and adopt it in teaching. Thus though ICT facilities are not the primary factors in ICT integration in learning environments, they are an enabling factor. This, for the INSET centre means there is urgent need formulate policy guidelines that aim to promote access to and provide more technical and professional support in order to increase opportunities for teacher engagement with ICTs. This is likely to increase the likelihood that ICTs will be adopted in teaching.

RECCOMMENDATIONS

The study revealed issues whose implications could impede ICT adoption in education and the envisaged improvement in the quality of education. As an intervention strategy, recommendations aimed at expanding the opportunities of both teachers and trainers to develop the capacity to integrate ICT in their teaching.

To CEMASTEA

- Consider to disseminate a comprehensive but flexible national ICT integration framework for the SMASSE INSET program so that district center organizers can develop and implement contextualized action plans.
- Consider using the ICT-CTS proposed by UNESCO as a reference framework to formulate a set of ICT competency standards to describe the trainers and teachers expertise. This could easily be adopted and adapted to suit the varied INSET centers because for each approach selected, there are expected appropriate curricular goals and teacher skills.
- To sustain the trainers' and teachers' learning, extend the INSET duration beyond a week and negotiate with the MOE to give the teachers an incentive for committing their time to improve their classroom skills.

To INSET Centre Organizers

- Develop and implement a detailed ICT integration action plan that is aligned to the national ICT integration framework, detailing out essential learning activities and the professional and technical resources.
- Propose for the acquisition of a generator to supplement hydro-electric power and additional ICT facilities, and then formulate a policy for access to the facilities.

To Teachers Trainers

- Take the initiative to acquire a personal laptop and modem and purpose to improve on ICT integration skills, by taking advantage of the many training opportunities for ICT-pedagogy integration in science and mathematics that are freely accessible online.

Area for Further Research

This study does not warrant generalization of the findings to the other 107 SMASE INSET centers or other ICT-pedagogy integration programs. As such there is need to carry out a similar study to conclusively establish the practice of preparing the teachers for ICT-pedagogy integration in teaching subjects.

IN CONCLUSION

It is commendable that the MOE in Kenya has its focus on provision of quality education through helping serving teachers to adopt ICT into their teaching. The data revealed that despite ICT resource and professional constraints, the re-conceptualization and re-orientation process helped the teachers acknowledge that educational technology is a catalyst for shifting teaching skills from teacher-centered to learner centered approaches. This makes ICT an integral component of the broader national education reforms that is geared towards provision of quality education. However, limited technical, technological and professional support can hinder teachers from thriving in their transition to the technology-enhanced methods of teaching as envisioned. But based on the findings it is evident that technology together with an update of the pedagogy has the potential to positively impact on the teachers' classroom skills and consequently, the quality of education offered in secondary school mathematics and science subjects.

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