Transforming Classroom Practices through Teachers' Learning of TPACK: The Case of In-service Teachers at Kibasila Secondary School in Tanzania

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Abstract

This study investigated the extent to which teachers' learning of Technological Pedagogical Content Knowledge (TPACK) has an impact on their classroom practices. The study involved 12 in-service teachers and 40 students from Kibasila secondary school in Tanzania. During the study, teachers participated in training about TPACK and later on joined in teacher design teams to design and teach technology-enhanced Biology, Chemistry and Physics lessons. Data were collected by using a teacher questionnaire, an observation checklist, a student questionnaire, a students' observation checklist and a teacher interview. Results showed that after learning TPACK, teachers' classroom practices shifted from teacher-centered approach to learner-centered approaches that utilize technology. Students, on the other hand, reported to have more interest on the lessons that integrated technology. In addition, there was an increase in the interaction between students and teachers during the classroom session. Given these findings, we concluded that, teachers' development of TPACK has an impact on the improvement of teaching with technology and increase of students' interests in science subjects.

Introduction

Education reforms all over the world are demanding for the adoption of the learner-centered teaching approaches rather than the traditional teacher-centered approaches. However, our social and institutional contexts have limited opportunities for the use of effective learner-centered approaches which cultivate students' creativity and innovations (Koehler & Mishra, 2009). In most of the schools in Tanzania, there are fixed study schedules, a time bound curriculum, and examination oriented learning (Kafyulilo, Mafumiko & Mkonongwa, Submitted). This causes teachers to worry more about the time to finish the syllabus and the examination, rather than the competencies that students can develop during their learning process. To be able to finish the syllabus on time, teachers opt the use of lecture method which treats students as mere recipients of the knowledge rather than source of knowledge. To develop students' self-learning, the adoption of Information and Communication Technologies (ICT) in education is paramount. According to Keong, Horani & Daniel (2005), the use of ICT in teaching science and mathematics improves learning through increased collaboration among students, allows students to focus on strategies and interpretations of answers rather than spending time on tedious computational calculations and helps students to maintain a high level of communication and sharing of knowledge. In addition, ICT helps students to visualize difficult and/or dangerous concepts and processes that cannot be visualized by eyes (example cell division).

In this paper ICT is referred to any product that will store, retrieve, manipulate, transmit or receive information electronically in a digital form (Luppicini, 2005). In this paper a technology will be used as synonymous to ICT. Although technology refer to analogue and digital, old and new technologies (Koehler & Mishra, 2009), the discussion in this paper has focused on new technologies (digital), particularly a computer. Koehler & Mishra (2009) argue that, "by their nature, newer digital

technologies which are protean, unstable and opaque, present new challenges to teachers who are struggling to use more technology in their teaching" (p.61). To overcome these challenges, Koehler & Mishra (2005) call for an approach that treats teaching as an interaction between what teachers know and how they apply what they know in the unique circumstance or contexts within their classroom. According to Koehler & Mishra (2009) teachers need to realize that, "at the heart of good teaching with technology, there are three knowledge bases: content, pedagogy, and technology, plus the relationship among and between them". These three knowledge bases (content, pedagogy and technology), form the input for Technological Pedagogical Content Knowledge (TPACK) framework. TPACK is the basis of good teaching with technology, requiring an understanding of the representation of concepts with the help of pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones" (Mishra & Koehler, 2006, p.66). The interplay between the various components of TPACK at a given context is what makes good teaching with technology (Kohler & Mishra, 2009).

A study by Özgün-Koca, Meagher & Edwards (2010) show that, technologies; including graphing and some computer-based mathematics learning programs can enhance young students' conceptual and procedural knowledge of mathematics. Studies (Keong et al., 2005; Niess et al., 2009; Voogt, 2009; Voogt, Tilya, & van den Akker, 2009) also acknowledge the importance of technology integration in enhancing learning in science and mathematics subjects. According to Keong et al (2005), constructivist pedagogical approaches are easily supported by the use of technology where students use technology to explore and reach an understanding of mathematical concepts by concentrating on problems solving process rather than on calculations related to problems. Students' engagement in constructivists learning activities increases their classroom interaction, activeness and learning outcomes. Although several studies report the importance of technology in enhancing teaching and learning, the majority of teachers in Tanzania are not embracing the use of technology in their classrooms (Hare, 2007; Sugiyama, 2005). There are several factors that are thought to contribute to the low level of technology uptake in teaching: lack of technological tools, limited supply of electricity in most schools, limited teachers technological knowledge, limited teachers' technology integration competencies, etc. Hare (2007), Kafyulilo (2010), Sugiyama (2005) and Tilya (2003) report that, among other factors, the low level of technology integration competency among teachers is the most important factor contributing to low uptake of technology by teachers in schools in Tanzania. According to Kafyulilo (2010), most of the teachers in Tanzania have basic knowledge of ICT but they don't know how ICT can support learning.

In understanding that TPACK is an important framework for technology integration in teaching and learning, a professional development arrangement was made for teachers to develop TPACK. Science teachers participated in a training to conceptualize them with the idea of TPACK and the manner in which each component interact with one another in the process of teaching and learning. After the training, science teachers collaborated in design teams to design science lessons (physics, chemistry and biology) that integrate technology, pedagogy and content. These lessons were prepared for a period of four weeks and taught in the classroom. Our interests in these lessons was to find out *how classroom practices are transformed through teachers' learning of TPACK, and the way students perceived the integration of technology in their science learning process*. In assessing these components, two research questions were addressed:

1. What is the effect of teachers' development of TPACK on their classroom practices with technology?
2. How do students experience the integration of technology in their science lessons?

Methodology

A case study research design was adopted in this study where Kibasila secondary school was taken as a case; science teachers and students were the unit of analysis. Teachers' technological competencies prior to intervention and after intervention were assessed by using an observation checklist and a teacher questionnaire. On the other hand, students' experience of learning science subjects with technology was assessed also by using an observation checklist and a student questionnaire. During the study, learning needs were identified by teachers, and a professional development program was organized involving training and lesson design in teacher design teams. Physics, Chemistry and biology lessons were designed and taught in the classroom.

Participants

The study was carried out at Kibasila secondary school in Dar es Salaam, Tanzania. There were 12 teachers who participated in the study: four teachers in each of the subjects: physics, chemistry and biology. In addition, the study involved form two students from the science stream (students who study physics, biology, chemistry and mathematics). A total of 40 students participated in a technology-integrated lessons that were designed by their teachers.

The Professional Development Program

A professional development program to develop teachers' knowledge of integrating technology in science teaching was carried out through a workshop/training which was followed by teachers' collaboration in teacher design teams. The workshop intended to introduce the concept of technology integration in education by using the TPACK framework developed by Mishra and Koehler (2006). In design teams, teachers designed lessons that integrate TPACK and used these lessons to teach students in a classroom. The topics for the lessons were chosen on the basis of the teachers' scheme of work, but a discussion in design teams, focused on the understanding of the learning difficulties that students experience in each of the topics that were chosen and the way technology could redress these difficulties. In the process, teachers also considered the pedagogical approach that uses technology in a constructivist ways; example, task based learning, inquiry learning and problem based learning were among the pedagogical approaches used during the lesson design process.

The lessons were organized as follows: the biology team made a video to demonstrate the first aid provision procedures and used it to teach in the classroom, where students watched the video and engaged into a classroom discussion to identify and write down all the first aid procedures that were showed in the video. The physics team made a PowerPoint animation of Hooke's Law of Elasticity. In this animation, students were to observe the change in the extension of the spring with the change in weight and carry out a similar experiment by using the actual laboratory equipment. The chemistry team also used a PowerPoint to animate the movement of ions in an electrolytic solution as a result of electric current moving within a copper II sulfate solution. Students were to carry out a similar experiment and describe the results they observed from the experiments in relation to the observation made on the animations.

Research Instruments

Five data collection instruments were used in this study: a teacher questionnaire, teacher interview, student questionnaire, teacher observation checklist and student observation checklist. The teacher questionnaire was adopted and modified from Schmidt et al (2009) and Graham et al (2009) respectively. A student questionnaire was adopted from Tilya (2003) to test the students' experience of learning with technology. The questionnaire inquired students' self-evaluation of the learning achieved during a technology integrated lesson in comparison to a non-technology integrated lesson. The teacher interview was adopted from Handelzalts (2009) and Tilya (2003) and administered at the end of the project to assess teachers' experience and opinions on learning TPACK and students' learning outcomes as a result of the TPACK development. A Teacher's observation checklist was modified from Graham et al, (2009), Harris et al (2010), Schmidt et al (2009), and Tilya (2003). This was used in the pre-intervention phase to test the science teachers' technology integration

competencies, also during the post-intervention phase to assess the change in the technology integration competencies as a result of the professional development program. There was also a students' observation checklist which was developed to assess students experience in learning with technology.

Findings

To answer the first research question a Wilcoxon signed ranks test for two related samples was used to analyze the level of significance in the difference between pre and post intervention results. In addition effect sizes were calculated to determine the magnitude of the change between pre and post intervention results. Findings revealed a significant difference between pre and post intervention teachers' technology use and classroom practices as shown in Table 1.

Table 1: Pre and Post Intervention Results for Teachers' Perceived Ability to Use Technology in their Teaching (N=12)

	No of items	Pre Intervention M (SD)	Post Intervention M(SD)	*P*	Effect size
Use of technology improves teaching productivity (enhance students' interactions, assessment and classroom managment)	5	2.85 (0.73)	4.23 (0.67)	0.002	1.97
Use of technology supports learning activities that facilitate students' higher order thinking	4	3.48 (0.73)	4.21 (0.52)	0.012	1.15

Scale: 1 = Strongly disagree, 2 = Disagree, 3 = Undecided, 4 = Agree, 5 = Strongly agree

Results in Table 1 indicate that, teachers' perceived ability of using technology in teaching, was improved as a result of the intervention. The difference between pre and post intervention results indicate the magnitude of change to be large (effect size higher than 0.8) in both use of technology to improve teaching productivity and supporting different students' learning activities. Since the intervention was intended to develop TPACK, these results make us to believe that, the change in the teachers' belief about technology was a result of TPACK development among teachers.

Classroom obervation confirmed teachers' perceived impact of technology in their teaching as a result of TPACK development (Table 1). Through observation checklist, a lot of changes in teachers' classroom practices after participating in the professional development that intended to develop TPACK, were noticed. There was a remarkable difference between the teaching conducted prior to the teachers' participation in the professional development program and that conducted after. For example the observation of students learning activities revealed that when learning with technology, students participation and interactivity with a teacher was enhanced compared to the pre-intervention observation in which teachers did not use technology in their teaching. However, students' level of technology use could not be exhibited due to the limited number of computer tools for learning that were available at Kibasila secondary school.

Although students were not directly using technology (computer) for their learning process, they collaborated and discussed concepts related to what they were able to observe when a technology application was used. A teacher could sometimes appoint a student to go in front of the class to demonstrate a concept to the class (this was particularly observed in the physics and chemistry classes). For example in a physics lesson, in which teachers prepared an animation of the Hooke's law of elasticity by using PowerPoint, students were asked to go in front of the class to read the scale change as a result of an added weight on a spring. A student was as well appointed to lead a discussion on what could happen if the weight exceeds the elasticity limit of the spring. Similarly the chemistry lesson was made in PowerPoint animating the movement of ions in an electrolyte solution. Students were appointed to go in-front to connect the electricity current by making a click on the

animated electrolysis. Other students were observing the resulting ion movement for each click on the designed electrolysis. However, the biology team adopted a different approach in which students watched the video about first aid provision, and had to recall all procedures in their discussion groups. In regards to the kind of learning activities that were observed in the pre-intervention and those observed in the post- intervention, we can postulated that classroom practices were enhanced as a result of technology integration in teaching. Instead of using the lecture method, the teachers were able to involve students in the learning process through discussions based on what students observed from the demonstrtions through technology.

Students' Opinions about Learning with Technology

To answer the second research question students at Kibasila secondary school were given the opportunity to share their experiences with the technology-enhanced lessons through a questionnaire after having attended the six lessons (2 for biology, 2 for physics and 2 for chemistry). The results are presented in Table 2. Analysis of students' perceived learning experience with technology showed to be very positive. Where almost all responses ranged between agree and strongly agree in a five point scale.

Table 2: Students' Experience with the Use of Technology in Science Learning (N = 40)

	No of items	Mean	Std. Deviation
Student's knowledge of computer (have seen it before, used it)	4	3.59	1,04
Students' attitude towards learning science with technology	11	4.45	0.52
Use of technology enhances learning of difficult concepts	5	4.24	0.64
Technology helps students to be more involved in the learning process than the traditional classes	6	4.35	0.57

Scale: 1 = strongly disagree, 2 = disagree, 3 = undecided, 4 = agree, 5 = strongly agree

As reported in Table 2, the majority of students were positive towards learning with technology. Students perceive computer as interesting and useful in the learning of difficult science concepts. They also reported that through the use of technology, they were more involved in the learning process than when they learned without the use of technology. However, although majority of students agree that the use of technology particularly computer was effective for their learning, only few of the students had prior knowledge about computers. Some of the students reported to have seen the computer for the first time the day when the teacher used it for learning in this experiment. As it can be seen from the results, computer knowledge of the students has a high standard deviation and a low mean compared to the other constructs. These results show that the students varied a lot in their technology knowledge and skills.

When responding to a question about students' engagement in the learning process, during technology enhanced lessons, teachers had the opinion that, through the use of technology students' attention and activeness in the learning process was enhanced. They also reported that as a result of using technology students' did well in the assignments they were given (Table 3).

Table 3: Teachers' Opinions Regarding Students' Engagement in the Learning in a Technology Integrated Class

Question	Responses (number of respondents in brackets)
To what extent do you think students' learning in science improved through	Students attention to the lesson was increased (4) Students were very active: were asking questions which are relevant to the lesson (4) They did well in the assignment they were given (5)

the integration of technology in teaching?	They told us that they enjoyed and understood the lesson (3) Students became more creative and innovative during the session (1) There was an increased appreciation to a teacher after the lesson (1) Students interaction in the classroom was enhanced (1) Students asked for other lesson that use technology (3) They were able to observe process which are difficult to observe in the regular classes (1) Students were excited by our lesson; they told us (3)

Some of the statements made by teachers about the benefits that students got from using technology were the shift in the learning approach from teacher-centered to a learner-centered approach which allowed for students' collaboration. As a result of these changes, students' attention to the lesson increased, students' interest in the lesson was also enhanced and teaching became easy. Students were used to learn about mitosis, electrolysis, static electricity and others, only by imagination. The use of animations that demonstrate how actually the mitosis process takes place in the cell, enabled students to draw a closer understanding of the concepts they were learning. This was stated by a chemistry teacher who said that, *"...students were able to observe things that could not be seen in a normal situation. Through animation, students were able to see the movement of ions during electrolysis; this gave them an idea of what takes place during electrolysis"*. In addition, some teachers argued that through the learner-centered approach, students learned how to collaborate to solve some questions that they were assigned by their teachers. For example a physics teacher stated that, "... *the teaching approach which involved students participation in the learning process, required them to collaborate to answer some questions while learning. Thus, students learned how to collaborate in solving problems...*" Another teacher from biology subject acknowledged that the new teaching approach enhanced students' interactions in the classroom and their learning outcomes as could be seen in the assignments. "*...we all noticed that students were asking very good questions related to the lessons they were taught, also in the assignment all students did better than they normally do in the normal lesson...*" From these arguments that are made by teachers, it appears that the lesson that integrates technology had an impact on the students learning and learning practices.

Discussion and Conclusions

It has been revealed in this study that teachers' development of technology integration competencies has some potential of transforming classroom practices and cultivating students' learning. As revealed from the findings, students participation in the learning and interaction in the classroom was enhanced in a technology enhanced classroom as compared to a non-technology enhanced class. Results have shown an increase in the level of interaction amongst students, with teachers and with the subject when a technology (computer) was used in the teaching process. It has further been revealed that, teachers' participation in the professional development program to develop TPACK had an impact on their use of technology and classroom practices. The findings in this study are supported by those of Doering, Hughes & Huffman (2003), who reported that presence of a technology integration model has an impact on the way teachers are thinking about technology. However, the TPACK is not used in this study as a technology integration model, rather a framework for designing a professional development program for teachers to develop technology integration competencies (Koehler & Mishra, 2009). By considering TPACK, Kibasila secondary school teachers were able to focus their lessons design around technology, pedagogy and content in an integrated manner.

Through their understanding of TPACK teachers engaged in the process of designing lessons that take into account the understanding of the representation of concepts with the help of; pedagogical techniques that use technologies in constructive ways to teach content; knowledge of what makes concepts difficult or easy to learn and how technology can help redress some of the problems that students face; knowledge of students' prior knowledge and theories of epistemology; and knowledge of how technologies can be used to build on existing knowledge to develop new epistemologies or strengthen old ones (Koehler & Mishra, 2009). Above all, teachers from Kibasila secondary school were able to use technology to engage students in a participatory learning approach in which students

were taking part in the learning process as opposed to the commonly used teacher-centered method (c.f. Baylor & Ratchie, 2002).

Students were also positive about the use of technology in the lessons. Majority of students (nearly all) reported to enjoy learning with computers, and that they understood the lesson better when a teacher used a computer. The opportunity to see some scientific process through animation, helped students to understand some concepts such as mitosis more easily. Majority of students wanted to see their teachers using technology in the future. Similar to the observation of Ozgun-Koca et al (2009), students from Kibasila secondary school reported to understand difficult concepts when technology was used in teaching. Instead of learning by imagination, they were able to observe the actual process through animations. Teachers were also of the opinion that their students learned better when computer was used in their teaching. Learning became student-centered and interactive. Similar findings are reported in Hayes (2007) who reported an increase in learner-centered teaching approaches when technology is employed for teaching. In addition to learning approaches, Kibasila secondary school teachers argued that, students understood easily some scientific concepts, and developed interests and motivation to the lesson they were learning (cf. Ozgun-Koca et al, 2009). Learning with technology offered an opportunity for students to learn through collaboration to solve a task given by their teachers as opposed to the commonly used approach of question and answer. The collaboration approach had two advantages to students; one was the opportunity to share ideas and concepts, thus, being able to answer the assignments properly; second, was the social gain, where new friendships were established. Hayes (2007) uphold that, use of technology in teaching doesn't only change the way a teacher teaches, but also the way students learn. Given the fact that teachers' use of technology and classroom practices are enhanced when they learn TPACK (Guzey & Roehrig, 2009), it is recommended that more effort should be made to develop TPACK to teachers in Tanzania. This will consequently lead to the development of technology integration competencies that teachers have been missing for quite a long time (Sugiyama, 2005; Tilya, 2003).

In the present study, lessons were prepared in PowerPoint and presented to students in the classroom. Students were mostly observing the teachers presentation, interacting with the teachers about the idea presented through PowerPoint and worked in groups to solve some tasks that they were given by their teachers. For measurement of the effectiveness of technology in students learning, future plan should involve students' use of technology. The few available computers should be divided in such a way that few students attend the lesson at a time. This could be important in assessing students' creativity and innovations as they use computers.

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