THE RELEVANCE OF AUTHENTIC LEARNING ACTIVITIES IN DEVELOPING COMPETENCY AND CONFIDENCE OF INTEGRATING TECHNOLOGY IN TEACHING AMONG PRE-SERVICE TEACHERS IN TANZANIA

Ayoub C Kafyulilo
Dar es salaam University

Abstract

This study explored the ways pre-service teachers from Dar es salaam University College of Education (DUCE) in Tanzania, can develop Technological Pedagogical Content Knowledge (TPACK). 42 pre-service science and mathematics teachers and 4 instructors participated in the study. Findings revealed a limited TPACK among pre-service teachers at DUCE. Participation in authentic learning activities such as training, microteaching, collaborative lesson design and peer reflections, were found to be effective in developing TPACK. Results showed that these activities were relevant to the learning needs of the pre-service teachers and effective in developing knowledge, skills, competencies and confidence of integrating technology in teaching.

Introduction

The idea of integrated knowledge of teachers is not new in teacher education. Discussions about the interplay of different components of knowledge to enhance teaching competencies started as far back as 1980s. One of the pioneers of the integrated knowledge for teachers was Shulman (1986) who focused on the importance of treating pedagogical knowledge and content knowledge as basic requirements for teacher training. Since the presentation of the idea of integrating pedagogical knowledge and content knowledge to make pedagogical content knowledge (PCK) as a basis for teachers to deliver the required learning outcomes, there existed a silence until the early 1990s when computers started to be introduced in schools. Some of the early writers in educational technology such as Marcinkiewicz (1993) and Voogt (1993), described how easily or difficult could a computer technology be integrated in teaching. Marcinkiewicz focused his discussion on how the attitude of teachers towards computer use in teaching is important in having technology integrated in education.

In 2005 two publications were made on the integration of pedagogy, content and technology. Niess (2005) tried to make a link between PCK based on Shulman (1986)'s idea, and TK, and described how the three components can interact to form TPCK. Mishra & Koehler (2005) also came up with the idea of TPCK as a core of good teaching with technology being as well built on the idea of Shulman. Both Mishra & Koehler (2005) and Niess (2005) had a common idea of developing teachers' integrated knowledge of technology, pedagogy and content as important attributes for effective teaching. It was Mishra and Koehler (2009) who extended TPCK to TPACK and added the context as one of the important components in the thinking of the integration between technology, pedagogy and content (Koehler & Mishra, 2009). According to Mishra & Koehler (2009), the context refers to grade level of the students, schools or a class in which technology is used. Teachers are required to know what and how they apply technology in the unique contexts within their classrooms. A teacher is also supposed to develop an ability to flexibly navigate the spaces defined by the three elements; content, pedagogy, and technology and the complex interactions among these elements in specific contexts (Koehler & Mishra, 2009).

Technology integration programs need to focus on the development of teachers' Technological Knowledge (TK), Pedagogical Knowledge (PK) and Content Knowledge (CK). In addition, teachers need to know the interplay between Technology and Pedagogy - TPK, Technology and Content - TCK and Pedagogy and Content - PCK to form TPACK.

Developing TPACK among Pre-service Teachers

Different training activities can be adopted to cultivate pre-service teachers' knowledge in subject matter (science and mathematics), pedagogy and technology (UNESCO, 2008b). According to Jimoyiannis (2010), if pre-service teachers are willing to learn and develop new skills related to their instruction, it is reasonable to engage them in solving meaningful instruction problems through authentic ICT-based learning activities with a sound pedagogical background. Similar studies by Harris & Hofer (2009), Kilic (2010) and Peker (2009) have reported that, when teachers engage in authentic activities such as lesson design, microteaching and reflections, they get an opportunity to develop skills in drawing learners' attention, asking questions, using and managing time effectively and bringing the lesson to a conclusion. Also by engaging in authentic activities, pre-service teachers acquire the skills to choose appropriate technologies to support certain learning activities and overcome difficulties encountered during the teaching process. Kilic (2010) put forth that, teacher candidates can also improve their skills in giving feedback and measurement and evaluation when they engage in a field related activities.

The argument by Kilic (2010) proposes an approach in which pre-service teachers design an authentic teaching activity and teach the lesson to peers in a way similar to real classroom teaching. The challenges that a pre-service teacher may get from peers during microteaching can help him to reflect the challenges he may experience in a real teaching (Peker, 2009). According to Peker (2009), pre-service teachers should engage in the designing of a technology rich lesson, carry out a Microteaching, engage into a reflection with the peers and redesign the lesson incorporating the ideas raised by peers during the reflection session and conducting another microteaching to the same group (peer group) for further critiques. The process is cyclic as shown in Figure 1.

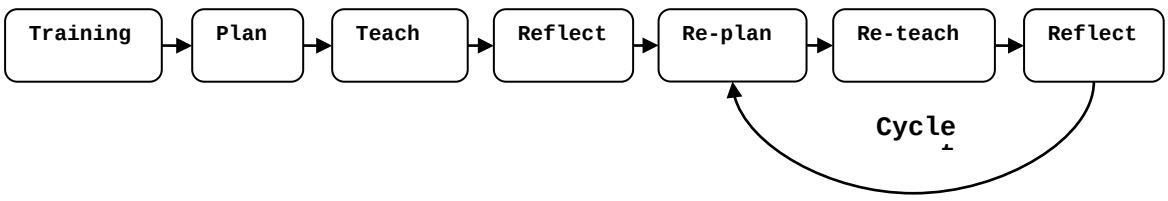

Figure 1: TPACK Training Cycles Adopted at DUCE (adapted from Peker, 2009)

According to Peker (2009) the cycles in Figure 1 can be repeated as many times as possible depending on the ability of pre-service teachers to demonstrate the required competencies.

Studies report that, the extent to which teachers will integrate technology in teaching depends significantly on the way they learned with technology (Doering, Hughes & Hoffman, 2003; LeBaron, McDonough & Robinson, 2008). Thus, this study is trying to propose the best learning strategy for pre-service teachers that can lead to effective integration of technology in their teaching. Authentic learning activities were adopted in this study as methods for pre-service teachers' learning of TPACK. Participation in these activities was considered important in establishing the relationship between what teachers can

learn from the college and the knowledge requirement for integrating technology in science and mathematics teaching. Thus the study answered the following research questions:

1. *What intervention program is effective for developing technology integration competencies among pre-service teachers at DUCE?*
2. To what extent is the intervention relevant to the learning need of the pre-service teachers?
3. How do the intervention program contribute to the development of competency and confidence of integrating technology in teaching?

Methodology

An action research design was adopted in this study, where planned intervention in the day-to-day learning practices was adopted to develop pre-service teachers' competency in integrating technology pedagogy and content at DUCE (cf. Mertler, 2006). Adopting the approach used by Lundeberg, Bergland, Klyczek & Hoffman (2003), pre-service teachers participated in a survey and microteaching to identify their present competencies in technology integration in teaching.

Participants

Four instructors from the department of curriculum and teaching at the Dar es salaam University College of Education in Tanzania and 29 pre-service science and mathematics teachers participated in the study. College instructors were involved in the study to provide an overview of the pre-service teachers' preparation processes. Their information was useful in understanding the level of competency of the pre-service teachers in TPACK. The large part of the study involved the pre-service teachers in the Bachelor of Education in Science {B.Ed (science)}. Participants were taken as "a case" for the study because by the time of the study, they were in the last month of their bachelors' program. Thus, were expected to demonstrate an exemplary technology integration competencies acquired by pre-service teachers at DUCE.

Instrument

Data were collected by using students' questionnaire. This questionnaire was used for pre and post-intervention assessment of pre-service teachers' competency in technology integration. In addition, there was a reflection questionnaire, which was administered at the end of the program. The student questionnaire was adopted from Schmidt et al. (2009), and had five points Likert scale where 1 = strongly disagree, 2 = disagree, 3 = not sure, 4 = agree and 5 = strongly agree. However items measuring the confidence level had four points Likert scale, where 1 = not confident, 2 = somewhat confident, 3 = confident and 4 = very confident. This questionnaire had a reliability of 0.84 Cronbach' alpha, which was considered sufficient for drawing conclusions out of it.

Interventions

Four intervention activities were planned for the project. First, in a group of seven, pre-service teachers prepared a short lesson and presented to peers (microteaching). Each microteaching session was videotaped to ease peer reflection. During microteaching, student teachers were found to have limited TPACK, thus, a training was conducted to introduce the

concept of TPACK to pre-service teachers before they engaged in the peer reflection. After the training, pre-service teachers engaged in an analysis of the video of the microteaching they conducted to identify some weaknesses in their technology integration in teaching. To address these weaknesses, a redesign of the lessons was proposed. Groups similar to those which participated in the microteaching re-designed lessons (Table 1).

Table 1: *Groups Participated in the Design of the Lesson*

Group	Subject	Learning activity
Group No. 1	Physics	Simulations of simple pendulum. Determining the relationship between angle of release, length, time and number of oscillations
Group No. 2	Mathematics	Calculation of radius and diameter: Using different mathematics symbols available in the computer to draw and calculate radius and diameter given that π is constant.
Group No. 3	Mathematics	Using charts to presents statistical data: using tabular data to create a chart or graph by using excel.
Group No. 4	Biology	Simulations DNA coding: observing the interaction between ribosome RNA, transfer RNA and messenger RNA.

In reference to Table 1, each group designed a lesson according to their subject specialization: Mathematics, Physics, Chemistry and Biology. However, there was only one pre-service teacher studying chemistry; thus, was advised to join in the physics group. Since more than half of the student teachers under the study were doing mathematics, two mathematics groups were made. Throughout the lesson design process, the researcher was playing the role of an observer, facilitator and a guider.

Instruments' Validity

All instruments were evaluated by three experts: one from the University of Twente, doing research on TPACK and teaching courses related to education technology and two from the University of Dar es salaam who are also teaching ICT Courses. Through this evaluation, questions about technological tools that are used in the pre-service teachers' learning at the college, were modified to exclude all tools that were not available at the college such as interactive whiteboard.

Results

By the end of the intervention, pre-service teachers were given an opportunity to express their experience on each of the intervention activity they engage-in. A questionnaire comprising of both open and close ended questions was administered to pre-service teachers to assess the relevance of the training, microteaching, collaborative lesson design and peer appraisal on the teachers' learning needs. The reflection questionnaire also assessed the extent to which teachers were developing knowledge, skills and competencies by engaging in those learning activities. In additional, teachers insights and confidence on technology integration was assessed.

Relevance

It was revealed from the study that all intervention activities were relevant to the pre-service teachers' teaching and learning needs (professional development).

Table 2: Relevance of the Intervention Activities to the Pre-service Teachers Professional Development

Intervention	*X*	*M*	*SD*
Microteaching was relevant to my study programme	29	4.50	0.51
The training was relevant to my study programme	29	4.46	0.51
A collaborative lesson design was relevant to my study programme	29	4.38	0.57
Reflections with peers was relevant to my study programme	29	4.42	0.58

As shown in Table 2, pre-service teachers indicated that microteaching, training, collaborative lesson design and reflection were relevant to their study programs. These intervention activity deemed relevant to the learning needs of the pre-service teachers because they were aiding to the pre-service teachers' knowledge, skills, confidence and competency of using ICT in teaching. Majority of pre-service teachers agree that microteaching, training, collaborative lesson design and peer reflections were aiding to the development of their knowledge about TPACK, ICT integration skills and insights. As a results of these activities they became confident and competent to use technology in teaching.

Knowledge

As it is for relevance, pre-service teachers agreed that the intervention activities (microteaching, training, collaborative lesson design and peer reflections) were aiding to their understanding about TPACK.

Table 3: *The Impact of the Intervention on the Pre-service Teachers' Knowledge of TPACK*

Intervention	*X*	*M*	*SD*
The Microteaching helped me to attain sufficient knowledge about TPACK	29	4.42	0.50
The training helped me to attain sufficient knowledge about TPACK	29	4.46	0.71
Peers' appraisal helped me to attain sufficient knowledge about TPACK	29	4.38	0.64
The collaborative lesson design helped me to attain sufficient knowledge about TPACK	29	4.27	0.60

In regard to the Findings in Table 3, training, microteaching and peer appraisal, seem to have equal impact on the development of pre-service teachers' knowledge of TPACK. However, the differences between interventions does not justify superiority of any of the intervention in the development of an understanding of TPACK among pre-services teachers.

Skills

Pre-service teachers agreed that all intervention activities were effective in helping them to attain sufficient skills of integrating technology with pedagogy and content.

Table 4: *Technology Integration Skills Development in each Intervention Activity*

Intervention	***X***	***M***	***SD***
I attained sufficient technology integration skills during microteaching	29	4.23	0.59
I attained sufficient technology integration skills during training session	29	4.42	0.58
I attained sufficient technology integration skills during Lesson Design	29	4.47	0.60
I attained sufficient technology integration skills during peer appraisal/reflection	29	4.50	0.51

As reported in Table 4, pre-service teachers found the interventions activities effective for the development of their technology integration skills. Comparatively, the difference between one intervention and the other is negligible, leading to the assumptions that all intervention activities were equally contributing towards the development of technology integration skills.

Insights

As it was for relevance, skills and knowledge, pre-service teachers agreed that all intervention activities had an impact to their insights over TPACK (Table 5).

Table 5: *Intervention Activity that Enhanced Pre-service Teachers' Insights*

Intervention	***X***	***M***	***SD***
I attained sufficient insights on TPACK during microteaching	29	4.31	0.74
I attained sufficient insight on TPACK during training session	29	4.35	0.56
I attained sufficient insight on TPACK during Lesson Design	29	4.27	0.45
I attained sufficient insight on TPACK during discussion with Peers	29	4.46	0.51

Although all intervention activities had high contribution towards pre-service teachers' insight over TPACK (Table 1), peer appraisal seem to have slightly higher impact compared to other activities. During the discussion with peers' pre-service teachers had an opportunity to challenge each others' outcome of the design and presentation with TPACK. Thus many were excited to learn or do more than what they just presented.

The Impact of the Intervention on TPACK Competency and confidence

Post intervention survey results showed that after the training, pre-service teachers were able to integrate technology, pedagogy and content in their teaching (Table 6). Different technology integration competencies were tested in the post intervention phase, where results showed that majority of teachers agreed to have acquired the required competencies for integrating technology with pedagogy and content.

Table 6: *Pre-service teachers' Competency in Specific TPACK Areas*

Competencies	***X***	***M***	***SD***
I can teach a lesson that appropriately combine science/math, technology and teaching approaches	29	4.18	0.66
I can use strategies that can combine content, technology and teaching approaches that I learned during the interventions	29	4.18	0.66
I can select technology to use in my classroom that enhances what I teach, how I teach, and what students learn	29	4.32	0.57
I can choose technologies that enhance the content for a lesson	29	4.23	0.43
I can provide leadership in helping others to coordinate the use of content, technologies and teaching approaches in my classroom	29	3.95	0.72

Findings (Table 6) have shown that, pre-service teachers' competency in providing leadership on the use of TPACK had the lowest mean and highest standard deviation. This implies that, despite competency in integrating technology, pedagogy and content that pre-service teachers believed to have gained from the interventions, they were still unconfident to use their knowledge to teach others. This was evident from the analysis of pre-service teachers' confident to integrate technology in various learning aspects. Results indicated that pre-service teachers' confidence to use technology in various aspects of teaching, was average in a 4 points scale; where, 1 = not confident, 2 = somewhat confident, 3 = confident and 4 = very confident (Table 7).

Table 7: *Pre-service Teachers' Confidence in Technology Integration*

Confidence areas	***X***	***M***	***SD***
I am confident to use technology for communication and networking in my course	29	3.17	1.49
I am confident to use technology for my own development and learning	29	3.55	1.43
I am confident to use technology to facilitate teaching specific concepts	29	2.62	0.98
I am confident to use technology to support various students' learning styles	29	2.97	0.82
I am confident to use technology to facilitate teaching pupils with disabilities	29	3.03	0.78
I am confident to use technology to facilitate activities that support higher order thinking	29	2.90	0.98
I am confident to use technology to support creativity	29	3.00	0.71
I am confident to use technology to foster pupils' ability to use technology in their learning	29	3.17	0.81
I am confident to use technology to access web information sources e.g. Eric, Google etc	29	3.38	0.62

Overall the findings (Table 7), indicate that pre-service teachers report to have confidence in some aspects of technology integration but not in other aspects. Aspects related to students creativity, higher order thinking and learning styles scored slightly lower than those related to teachers' personal development. This has an indication that, pre-service teachers are still not so confidence to bring technology in the classroom for better learning outcomes. This also poses challenges for the next interventions to focus not only on

development of the teachers' competency but also the confidence to use the knowledge in facilitating learning.

Discussion

It was established from the intervention that, the process of planning a lesson, presenting to colleagues, getting critiques from colleagues and re-planning again in a cyclic way was effective in enhancing pre-service teachers' competency in TPACK. The findings of this study agree with those of Somekh, (2008) who found that pre-service teachers' participation in different hands-on activities was effective in enhancing technology use in teaching. Participation in activities that reflect the actual teaching, enables pre-service teachers to learn how to bring together their technological, pedagogical and content knowledge which are learnt as separate disciplines at the college. As reported in Polly, Mims, Shepherd & Inan (2009), teachers' technological skills alone are not resulting in the effective use of technology in teaching in ways that are likely to impact students learning. Effective technology integration occurs when pre-service teachers participate in activities that enable them to experience on the firsthand how technology is integrated in the actual teaching and learning process.

It was revealed from the interventions that microteaching, training (lecture) about TPACK, collaborative lesson design, and peer appraisal were necessary components for developing technology integration competencies. The integration of these activities was found relevant to the pre-service teachers' training program, and were aiding to knowledge, skills and insights over technology integration. In addition, pre-service teachers' competency and confidence of integrating technology in teaching was enhanced as a result of the participation in these activities. Studies by Guzey & Roehrig (2009), Killic (2010) and Niess et al (2009) also acknowledge the importance of hands on activities such as lesson design (what to teach, how to teach and with what technology to teach), in enhancing pre-service teachers' TPACK. The lesson design activity, subjected pre-service teachers in an inquiry thinking process which was guided by questions such as what to design, why to design this, what technology, with what teaching approaches etc. This gave them an opportunity to reflect on the critical relationships between content, technology and pedagogy (cf. Guzey & Roehrig, 2009; Ozgun-Koca et al, 2009). According to Özgün-Koca et al. (2010), as teachers decide whether and how to use technology in their teaching, they need to consider the science or mathematics content that they will teach, the technology that they will use, and the pedagogical methods that they will employ. This was well implicated during the lesson design process.

Teachers' lack of confidence to use technology in teaching was considered to be one of the reasons for low technology uptake in teaching (cf. Cox et al, 1999; Kirschner et al, 2008). However, participation in activities that reflect the real teaching and challenges that can be experienced in the real teaching was found to enhance pre-service teachers' confidence and motivation to use technology. Studies (Cox et al, 1999; Tondeur, Valcke & Braak, 2008; Thomas & Knezek, 2008; Webb, 2008) confirm that, the extent to which technology will be used in teaching depends significantly on the extent to which a teacher is competent and confidence to use technology. However, the findings of this study show that, majority of pre-service teachers were more confident to use technology for their own development than for developing specific competency to students and providing TPACK leadership. This was mainly caused by lack of skills of using different technological tools to enhance students learning. As evidenced in this study, the more pre-service teachers had the

opportunity to use technology the more they learned and developed confidence on ICT integration in teaching. Thus training on specific technological skills and availability of technological tools are other important components for effective development of TAPCK among pre-service teachers.

Conclusion

The findings from this study show that, pre-service teachers can gain the required competencies (knowledge, skills and abilities/attitude) as well as confidence when they engage in authentic learning activities which reflects the real teaching and learning process as it occurs in the classroom settings. Activities such as microteaching, lesson design and reflection with peers reflects the actual activities that are carried out in the teaching and learning process. However, a training was considered an important stepping stone towards an understanding of the concepts related to technology integration and the overall idea of TPACK. This study, therefore, propose the adoption of this approach in a more systematic ways of developing TPACK, where pre-service teachers participate in a training workshop about TPACK, design a lesson (collaboratively), carry out a microteaching and reflect on the whole process from the design of the lesson to teaching. This approach seem appropriate when developing technology integration competencies to novice pre-service teachers particularly in the context of Tanzania and other developing countries. Experienced teachers may have a different route towards a competent technology integrating teacher.

References

Beyerbach, B., Walsh, C., & Vannatta, R. (2001). From teaching technology to using technology to enhance student learning: Preservice teachers' changing perceptions of technology infusion. *Journal of Teaching and Teacher Education, 9* (1), 105-127

Cox, M., Preston, C. & Cox, K. (1999, September). *What motivates teachers to use ICT*? Paper presented at the British Educational Research Association Annual Conference. London, UK.

Doering, A., Hughes, J., & Huffman, D. (2003). Preservice teachers: Are we thinking with Technology? *Journal of Research on Technology in Education, 35*(3), 342-363

Guzey, S. S., & Roehrig, G. H. (2009). Teaching science with technology: Case studies of science teachers' development of technology, pedagogy, and content knowledge. *Contemporary Issues in Technology and Teacher Education, 9*(1), 25-45.

Harris, J., & Hofer, M. (2009). Instructional planning activity types as vehicles for curriculum-based TPACK development. In C. D. Maddux, (Ed.). *Research highlights in technology and teacher education 2009* (pp. 99-108). Chesapeake, VA: Society for Information Technology in Teacher Education (SITE).

Jimoyiannis, A. (2010). Designing and implementing an integrated technological pedagogical science knowledge framework for science teachers' professional development. Computers & Education, xxx, 1–11 doi:10.1016/j.compedu.2010.05.022

Kilic, A. (2010). Learner-centered microteaching in teacher education. *International Journal of Instruction, 3*(1), 77-100

Kirschner, P., Wubbrls, T., & Brekelmans, M. (2008). Benchmarks for teacher education programs in the pedagogical use of ICT. In J. Voogt & G. Knezek. (Eds), *International handbook of information and technology in primary and secondary education.* New York: Springer.

Knezek, G., Christensen, R., & Fluke, R. (2003, April). *Testing a Will, Skill, Tool Model of technology integration.* Paper Presented at the Annual Meeting of the American

Educational Research Association. Chicago, IL.

Koehler, M. J. & Mishra, P. (2005). What happens when teachers design educational technology? The development of Technological Pedagogical Content Knowledge. *Journal of Educational Computing Research.* 32(2), 131-152.

Koehler, M., & Mishra, P. (2009). What is technological pedagogical content knowledge? *Contemporary Issues in Technology and Teacher Education, 9*(1), 60-70

LeBaron, J., McDonough, E., & Robinson, J. M. (2009). Research Report for GeSCI Meta-Review of ICT in Education. Retrieved 13th February, 2010 from http://www.gesci.org/assets/files/Research/meta-research-phase1-F.pdf

Lundeberg, M., Bergland, M., Klyczek, K., & Hoffman, D. (2003). Using action research to develop preservice teachers' confidence, knowledge and beliefs about technology. *The Journal of Interactive Online Learning. 1*(4), 1-16

Marcinkiewicz, H. R. (1993). Computers and teachers: Factors influencing computer use in the classroom. *Journal of Research on Computing in Education, 26* (2), 220-37

Mertler, C.A (2006). *Action research: teachers as researcher in the classroom*. Califonia: Sage Publications Inc

Mishra, P., & Koehler, M. (2006). Technological Pedagogical Content Knowledge: A Framework for Teacher Knowledge. *Teachers College Record, 108*(6), 1017–1054

Niess, M.L. (2005). Preparing teachers to teach science and mathematics with technology: Developing a technology pedagogical content knowledge. *Teaching and Teacher Education, 21*, 509–523

Niess, M. L., Ronau, R. N., Shafer, K. G., Driskell, S. O., Harper S. R., Johnston, C., Browning, C., Özgün-Koca, S. A., & Kersaint, G. (2009). Mathematics teacher TPACK standards and development model. *Contemporary Issues in Technology and Teacher Education, 9*(1), 4-24.

Özgün-Koca, S. A., Meagher, M., & Edwards, M.T. (2010). Preservice Teachers' Emerging TPACK in a Technology-Rich Methods Class. *The Mathematics Educator, 19*(2), 10–20

Peker, M. (2009). The Use of Expanded microteaching for reducing preservice teachers' teaching anxiety about mathematics. *Scientific Research and Essay, 4*(9), 872-880

Polly, D., Mims, C., Shepherd, C.E., & Inan, F. (2009). Evidence of impact: Transforming teacher education with preparing tomorrow's teachers to teach with technology (PT3) grants. *Teaching and Teacher Education, xxx,* 1-8. Doi. 10.1016/j.tate.2009.10.024

Schmidt, D., Baran, E., Thompson, A., Koehler, M.J., Mishra, P., & Shin, T. (2009, March). *Examining preservice teachers' development of technological pedagogical content knowledge in an introductory instructional technology course*. Paper presented at the 2009 International Conference of the Society for the Information and Technology & Teacher Education. Charleston: South Carolina.

Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher, 15*(2), 4-14.

Somekh, B. (2008). Factors affecting teachers' pedagogical adoption of ICT. In J. Voogt, G. Knezek (eds.) *International handbook of information technology in primary and secondary education*, 449–460. New York: Springer

Thomas, L. G., & Knezek, D. G. (2008). Information, communications, and educational technology standards for students, teachers, and school leaders. In J. Voogt, and G. Knezek (eds.) *International handbook of information technology in primary and secondary education.* New York: Springer

Tondeur, J., Valcke, M., & Braak, J. (2008). A multidimensional approach to determinants of computer use in primary education: Teacher and school characteristics. *Journal of Computer Assisted Learning, 24*, 494-506.

UNESCO. (2008a). *ICT competency standards for teachers: Implementation guidelines.* Version 1.0. de Fontenoy: UNESCO.

UNESCO. (2008b). *ICT competency standards for teachers: Competency standard modules.* de Fontenoy: UNESCO.

Voogt, J. (1993). *Courseware for an inquiry-based science curriculum. An implementation perspective*. Enschede: University of Twente.

Webb, M. (2008). Impact of IT on science education. In J. Voogt, G. Knezek (eds.) *International handbook of information technology in primary and secondary education*. New York: Springer.

Author Information

Ayoub C Kafyulilo
Dar es salaam University College of Education
P O Box 2329
Dar es salaam
Tanzania
Email: kafyulilo@duce.ac.tz
Phone: +255784445553