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Factors affecting teachers' continuation of technology use in teaching

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Abstract This study was conducted to investigate the continuation of technology use in science and mathematics teaching of the teachers who attended a professional development program between 2010 and 2012. Continuation of technology use was hypothesized to be affected by the professional development program and by personal, institutional, and technological factors. Twelve teachers and three school leaders participated in the study. Data was collected through interviews. Findings showed that the continuation of technology use differed for the teachers involved in the professional development program. While all teachers reported to have gained knowledge and skills through the professional development program and were positive about technology use in education, only some teachers continued the use of technology. The data revealed that despite the challenges that all teachers in the sample encountered when using technology in their teaching (such as large classrooms, problems with electricity supply, lack of time and lack of technology tools), the encouragement of school management was a critical factor in teachers' continuation of technology use. Implications of the findings are discussed.

Keywords Technology use · Enabling and hindering factors · Tanzania · Secondary education · Interview

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1 Background

Like many other developing and developed countries in the world, the government of Tanzania has been striving to introduce Information and Communication Technology (ICT)[1] in education since 1997 when the first official computer studies syllabus was introduced in secondary schools (Hare 2007). In teacher education, technology was introduced through the "ICT for Teacher education program" (ICT-Connect-TED) project in 2002. The program aimed at improving the quality of teachers through the use of ICT (Hare 2007; Tilya 2008). Until 2004, ICT-Connect-TED managed to provide computers and a networking infrastructure to all 34 teacher training colleges in Tanzania. Since 2004, all teacher training colleges, including universities have computers and internet connection which enable the pre-service training teachers to have access to teaching and learning materials through internet. Pre-service teachers are learning on how to download pictures, videos and animations from the internet and use them for teaching purposes. In 2005, ICT was introduced in schools through the e-school forum to design programs supporting the introduction and use of ICT in secondary schools (Hare 2007). The project covered a wide range of activities including ICT infrastructure development in schools, technical resources, student management, content and curriculum development, program co-ordination and funding. Unfortunately, this initiative covered mostly secondary schools. Primary schools were not part of this program, however, efforts are being made to integrate technology in primary schools as well. Already the government of Tanzania has developed the curriculum for integration for ICT in pre-primary and primary education level (Swartz and Wachira 2010). As an effort to ensure effective integration of technology in teaching, ICT for teachers' professional development (ICT-TPD) framework was developed in 2009 to guide teachers' professional development programs aimed at developing technology integration competencies. The framework focused on the development of teachers' technology integration knowledge and skills in science, mathematics and English subjects (United Republic of Tanzania 2009). This was an in-service training program aimed at ensuring that teachers are effectively using the ICT tools that were available in schools. While the government of Tanzania has done most of the effort to ensure that schools with electricity connection have access to computers, there is still a big challenge on the internet accessibility. In most of the schools teachers are still using modems to connect their computers to internet through mobile phone companies such as Vodafone, Airtel and Tanzania Telecommunication Company (TTCL). In schools, internet connection is unreliable and very slow, while at teacher training colleges and universities have reliable internet which is as well supplied by mobile phone companies, but the universities and teacher training colleges are capable of buying bigger bundles, thus, making the internet faster and reliable.

In support of the ICT-TPD policy three small scale intervention studies were conducted in the 2010 to 2012 timeframe, in which a professional development program was designed and evaluated (Kafyulilo 2013; Kafyulilo et al. 2014, 2015). The studies adopted the collaborative design of technology-enhanced science and mathematics lessons in teacher teams, as an approach for teachers' professional

[1] In this study the terms "ICT and technology" were used interchangeably to refer to any digital tool that can support teaching and learning

development. Teams of 3–6 science/mathematics pre-service and in-service teachers collaboratively designed technology-enhanced lessons and taught the designed lessons to peers (microteaching – pre-service teachers) or in the classroom (in-service teachers). The designed and taught lessons were later on reflected upon with peers.

The professional development program aimed at developing technology integration knowledge and skills for science and mathematics pre-service teachers, who were college students (study 1, Spring 2010) (Kafyulilo et al. 2015) and in-service teachers or practicing teachers, conducted with teachers from a school which is nicknamed as school A (study 2, Spring 2011, Kafyulilo et al. 2014). Study 3 was conducted with practicing teachers from two schools nicknamed as school B and C. (Spring 2012) (Kafyulilo 2013). The professional development aimed at developing teachers' technology integration knowledge and skills. In the professional development program, teachers became acquainted with Technological Pedagogical Content Knowledge (TPACK), which is the framework for describing the knowledge required by teachers to effectively integrate technology in science and mathematics teaching (cf. Koehler and Mishra 2005). In all studies, teachers learning took place through a workshop in which they explored technology applications for their subjects, and collaboratively designed technology-enhanced science and mathematics lessons, which they used in their teaching and reflected upon with their peers. The findings of the three studies conducted showed that the participants in the professional development program developed their technology-integration knowledge and skills as was revealed through self-reported data, lesson plans evaluation, interviews, focus group discussion and observations of the lessons in the classrooms. Studies by Agyei and Voogt (2012), Alayyar et al. (2011) and Jimoyiannis (2010) also show that professional development programs that involve teachers in the collaborative design of technology-enhanced science or mathematics lessons are promising for teachers' development of technology integration knowledge and skills and lead to effects that are sustainable over time (cf. Agyei and Voogt 2014).

The focus of professional development programs is on the development of knowledge and skills to be used after finishing the professional development (Harvey and Hurworth 2006; Zehetmeier 2009). The aim of the current study was to investigate if and why pre-service and in-service teachers continued to use technology (or not) in their science and mathematics teaching after attending the professional development program. This study was conducted in 2013 as a follow up to the three previous studies, hence 6–18 months after pre- and in-service teachers participated in the professional development program. Continuation of technology use in this study is defined as using the knowledge, skills and beliefs about technology-integration (TPACK) as acquired during the professional development program for the preparation and teaching of science and mathematics lessons.

1.1 Theoretical framework

Baldwin and Ford (1988) describe the continuation of practices, knowledge, skills and beliefs in terms of the transfer of training, which is described as the degree to which trainees effectively apply the knowledge, skills and beliefs gained from training to a job. Baldwin and Ford present a training transfer model, which has three parts; the training input factors, the training output, and the transfer conditions. According to Baldwin and Ford (1988) there are three training input factors that determine the

transfer and maintenance of knowledge, skills and beliefs over time. These factors include the training design, trainee characteristics and work environment.

The factors presented by Baldwin and Ford (1988), as determinant of the transfer of the training, are presented in this study as factors determining the continuous use of technology in teaching and are categorized as follows: the training design is presented in this study as *professional development factors* and comprise of the teachers' perceived values of the professional development program, and the opportunity for continuous learning (Pritchard and McDiarmid 2005; Torodova and Osburg 2010). Trainee characteristics are presented as *personal factors* and comprises of teacher belief, knowledge and skills, time and engagement (Buabeng-Andoh 2012). The environment is presented as *institutional factors*, comprising the accessibility to technology, support from the management, and environment (Almekhlafi and Almeqdadi 2010; Eickelmann 2011). Since the focus of the professional development program being evaluated by this study was about technology integration in science and mathematics teaching, *technological factors* (cf. Buabeng-Andoh 2012) were investigated in addition to the three factors presented by Baldwin and Ford (1988).

Professional development factors Baldwin and Ford (1988) describe this as the training design factors which includes the incorporation of the learning principles, the sequence of training materials and the job relevance of the training content. According to Pritchard and McDiarmid (2005), the level of satisfaction with the knowledge, skills and abilities that are developed in the professional development program has a strong influence on the interest of the teachers to implement the new innovation (cf. Torodova and Osburg 2010). Studies by Putnam and Borko (2000), Torodova and Osburg (2010) and Voogt et al. (2011) report that, for a successful professional development program, teachers need to be involved in determining their learning needs and participate in the learning opportunities that are school-based, continuously supported, information rich, and facilitating theoretical understanding and collaborative problem solving.

Personal factors These are all factors related to the individual teacher, such as knowledge and skills, beliefs, time availability and engagement in the use of technology in teaching (cf. Agyei and Voogt 2014; Baldwin and Ford 1988). According to Fullan (2007), "educational change depends on what teachers do and think: it's as simple and as complex as that" (p. 129). Collis and Moonen (2001) argue that, if the teachers' first experience of working with technology fits with their experience and belief about the learning process, they will build up self-confidence towards technology and will engage in the use of technology in teaching. In addition, Guskey (2002) argues that teachers can accept a professional development program if they believe that it will expand their knowledge and skills and contribute to their growth and enhance their effectiveness in teaching.

Institutional factors The primary institutional factor influencing the continuous use of technology after the professional development program is the value and belief system of the school, driven mainly by the school administration through motivation; rewards, incentives and financial support to teachers (Harvey and Hurworth 2006; Pritchard and McDiarmid 2005). Eickelmann (2011) describes the institutional factors in terms of the support for individuals in schools, support from peers; participation in decision making

and availability of technological tools (cf. Almekhlafi and Almeqdadi 2010). Agyei and Voogt (2014), and Almekhlafi and Almeqdadi (2010), report the limited technological resources in schools as one of the great impediments to the up-take of technology in schools. In addition, Collis and Moonen (2001) describe the environmental factors such as availability of electricity and classroom settings as other factors determining the technology uptake by teachers.

Technological factors Collis and Moonen (2001) mention two technological factors that affect continuous use of technology: Ease of use and Effectiveness. Ease of use refers to the convenience, adequacy, reliability and user friendly of the technology, whereas effectiveness refers to the likelihood of the long tangible benefits for the institution, improved learning and communication.

Table 1 presents a summary of the factors contributing to the continuous use of technology in science and mathematics teaching as represented through the model of training transfer (Baldwin and Ford 1988) and other authors.

1.2 Research questions

This study was conducted to determine the likelihood of the pre-service and in-service teachers' continuation of the use of technology in their science and mathematics teaching after having participated in the professional development program. The main research question addressed in this study was "*What factors affect the continuation of technology use in science and mathematics teaching among pre-service and in-service teachers who attended the professional development program*?" This main research question was further divided into two sub-questions:

1. To what extent are the pre-service and in-service teachers who previously attended the professional development program still using technology in science and mathematics teaching?

Table 1 Factors determining the continuous use of technology by teachers

Factors	Variables	Based on
Professional development	The perceived value of the professional development program Opportunity for continuous learning	Agyei and Voogt (2012), Baldwin and Ford (1988), Eickelmann (2011), and Harvey and Hurworth 2006)
Personal	Knowledge and skill Belief or attitude Time availability Personal Engagement	Almekhlafi and Almeqdadi (2010) Baldwin and Ford (1988), Buabeng-Andoh (2012), Collis and Moonen (2001), Harvey and Hurworth (2006)
Institutional	Access or availability of technology Management support: rewards incentives Environment	Almekhlafi and Almeqdadi (2010), Baldwin and Ford (1988), Buabeng-Andoh (2012), and Eickelmann (2011)
Technological	Effectiveness Ease of use	Collis and Moonen (2001)

2. What are the professional development, personal, institutional, and technological factors that affect continuation of technology use in science and mathematics teaching of pre-service and in-service teachers who attended the professional development program?

1.3 Participants

From each implementation (pre-service teachers (N=13) in Spring 2010, teachers from school A (N=10) in Spring 2011 and teachers from school B (N=10) and C (N=9) in Spring 2012) of the professional development program a biology, physics and chemistry teacher/ math pre-service teacher was selected to participate in this study. All teachers who participated in this study were selected on the basis of their prior participation in the professional development, program. In addition to the teachers, the school management, which was represented by the deputy principals of each school, also participated in the interview. The deputy principals who participated in this study did not participate in the professional development. However, their involvement in this study was considered important in establishing whether or not there was a support from the school to the teachers in the use of technology in teaching. School A and school B are government schools each with one computer lab and approximately 30 computers, of which, only one computer in school A and two in school B were working. School C is a private school with three computer labs and approximately 20 working computers in each lab.

1.4 Instruments

A semi-structured interview guide for the pre- and inservice teachers involved in the study (see Appendices A and B) was developed by the researcher to assess the professional development program, and the institutional, personal and technological factors that were affecting the teachers' continuation of technology use. Pre-service teachers participated in the interview through a phone call; whereas teachers from school A, B and C, participated in a face-to-face interview. Examples of interview questions were "How often do you use technology in your teaching?" and "What are the factors determining technology integration in teaching at your school?".

In addition the deputy principals of the three schools (A, B, and C respectively) participated in an interview (see appendix). The interview guide (see Appendix C) was developed by the researcher to investigate the principals' awareness of the professional development program, their opinion regarding technology integration in teaching and factors that influence teachers' use of technology in teaching in their school. Example questions were "How often do you use technology in your teaching", "What is your opinion about the use of technology in teaching", and "To what extent does your school management support you in using technology in your teaching?"

1.5 Data analysis

The qualitative data from the interviews were transcribed and coded by using the codes that were generated from the study's theoretical framework (deductive coding) (Miles

and Huberman 1994). A random sample of 4 interviews was coded by a second person. The inter-coder reliability was 0.84 Cohen's Kappa which according to Viera and Garrett (2005) indicates almost perfect agreement. The codes and examples of quotations are summarized in Table 2. Qualitative data analysis software, Atlas-ti, version 6.2, was used to code interviews.

2 Results

Findings in this study are presented in four sections: the first section presents the continuation of technology use in teaching, the second section presents the factors affecting the continuation of use of technology in teaching among science and mathematics teachers who participated in the study and the third section presents the school management view on the impact of the professional development program and the institutional challenges on using technology in teaching. Finally the enabling and hindering factors affecting the continuation of technology are summarized.

2.1 Continuation of technology use in teaching

Findings from the interviews showed that teachers from school B and the pre-service teachers continued to use technology in their teaching after the end of the professional development while teachers from school A and C were not using technology. Teachers from school A and school C reported to have not used technology for teaching since the end of the professional development program. However, pre-service teachers and those from school B reported to have frequently used technology in teaching. When technology was used the internet in combination with PCs or laptops were mentioned most often. Those teachers, who applied technology in their teaching, used it for a variety of purposes. The responses are summarized in Table 3.

As reported in Table 3 teachers from school A and C used technology the least in science and mathematics teaching of all the groups. Only one teacher physics teacher from school A reported to have "*used a computer to prepare a database keep students records*" and one teacher from school C said to have "*used internet to search biology teaching materials and for test preparation*". However, at school B and among pre-service teachers, technology use was relatively high. One of the pre-service teachers said to use technology for teaching, because "*some science concepts are difficult to describe without technology, so I prefer the use of animations to demonstrate them.*

2.2 Factors determining the continuation of technology use according to teachers

2.2.1 Professional development program

Almost all participants indicated a high level of satisfaction with the content, sequence and relevance of the professional development program they attended. Only a few teachers reported that the duration of the professional development program was too short. However, the majority of the teachers reported that they developed an understanding of what TPACK is, and the way technology can enhance teaching and learning of difficult science concepts through the collaborative design of technology-enhanced science lessons

Table 2 Deductive codes and their quotations

Code	Sub- code	Code description	Sample quotation
Continuation of technology use	Frequency of use	The frequency of technology use	I always use technology in my teaching…
	Type of technology use	The type of technology use	I used internet to search biology teaching materials and for test preparation
	Purpose of technology use	The purpose of technology use	Some science concepts are difficult to describe without technology, so I prefer the use of animations to demonstrate them
Professional development program (PDP)	The perceived value of the PDP	Teachers' satisfaction with the PDP they attended	The PDP enabled us to know how to use technology to improve science teaching
	Opportunity for learning	Opportunity for a workshop or training on technology integration	Never had the opportunity to participate in any learning program
	Knowledge and skills	Knowledge and skills of using technology	I have the basic knowledge; I can use MS word, internet, and PowerPoint
Personal factor	Beliefs	Teachers' perceptions towards the use of technology	Technology arouses the students' interests in science subjects
	Time	Time available for preparation of technology-enhanced lessons	If we make a good planning, there can be enough time
	Engagement	Teachers motivation to use technology	We want to use technology but we are challenged by the lack of technological tools
	Accessibility	Presence of technological tools at the school	The school has computers but they are not for teaching
Institutional factor	Support	Rewards or incentives from the school administration	No any kind of rewards or incentive… nobody cares whether you use technology or not.
	Environment	Whether or not the classrooms support technology use	Classrooms are overcrowded with up to 80 students.
Technological factor	Effectiveness	The impact of the technology on students learning	It improves students learning in science
	Ease of use	How easy it is to use technology	It depends on the choice of the technology

Table 3 Teachers' responses regarding technology use in teaching (N=12)

		Pre-service			Sch. A			Sch. B			Sch. C		
		Math	Physics	Biology	Physics	Chemistry	Biology	Physics	Chemistry	Biology	Physics	Chemistry	Biology
Frequency of use	Frequently	x	x	x					x	x			
	Sometimes				x			x					x
	Not at al					x	x				x	x	
Technology used	Computers/laptops	x	x	x	x			x	x	x			x
	TV set/ video									x			
	Internet	x	x	x				x	x	x			x
	Digital camera		x										
Purpose of use	Lesson preparation	x	x	x				x	x	x			
	Personal uses (e.g., email, Facebook)	x	x	x				x	x				
	Teaching		x	x				x	x	x			
	For students' records	x			x			x	x	x			
	Test preparation	x	x	x				x	x	x			x
	Surfing materials		x	x				x	x	x			x

in teams. "*I developed an understanding of how TPACK can be applied in the design and teaching of a technology-enhanced lesson*" said one of the pre-service teachers. A teacher from School C said if it was not the professional development he attended, he would not know how to use technology in teaching. "*Through the collaborative design in teams*, *I learned how different technologies can support students learning*," he said.

The pre-service teachers had the opportunity to further develop learning about technology integration in teaching after the professional development program had finished. They were invited to exert their TPACK knowledge in workshops organized by the Ministry of Education and Vocational Training in the frame of the national ICT development project for science mathematics and English subjects. However, for the in-service teachers hardly any opportunity occurred to continue their learning about technology integration after the professional development. As a teacher of school A said: "*There are no school based staff development programs… sometimes there are ICT training opportunities for science teachers*, *but the principal appoints a person from other subjects*".

2.2.2 Personal factors

Findings on teachers' knowledge and skills revealed that the pre-service teachers, and in-service teachers from school B were confident about their knowledge and skills. Pre-service teachers reported that the technology knowledge and skills gained at the professional development program had helped them to get appointed as facilitator in the national ICT development project for science mathematics and English subjects. Teachers from school A and school C, however, reported the need for additional practice to update their knowledge and skills before they engage in the design of technology-enhanced lessons. "*I can't say that I know very well how to use technology in teaching*, *but I think I need to practice it*, *because I haven't used it for a long time*", said a teacher from school A. In contrast, one of the pre-service teachers said: "*I can use a variety of technologies such as computers*, *camera*, *mobile phones* etc. *to facilitate teaching and learning*, *without any problem*".

Teachers were positive about technology; arguing that technology can transform the learning process from teacher-centered to learner-centered and enhances students' understanding of science concepts. For instance one of the pre-service teachers said "*some science concepts are difficult to describe without technology*, *so I prefer the use of animations to demonstrate them*".

Time was listed as the biggest setback to their use of technology in teaching. "*The main challenge is the timetable …this is the most serious problem we encounter in our plan to use technology*", said a teacher from school B. Despite the challenges emerging from the timetable, teachers from school B and pre-service teachers engaged in the use of technology in teaching. When asked for the reasons for not using technology in teaching, one of the teachers from school A was quoted saying "*We want to use technology but we are challenged by the lack of technological tools*".

2.2.3 Institutional factors

Lack of technological tools in schools was reported by almost all participants, except for the pre-service teachers who were employed in teacher training colleges. "*The*

college has almost all technological tools: *there are computers with internet*, *TV set*, *data projector and overhead projector*…" said one of the pre-service teachers. In contrast, teachers from school A and school B, reported the absence of technology in their schools (available computers were broken), while those in school C mentioned the availability of 'inaccessible technology' at their school, as reported by one of the teachers "*The school has computers but they are not for teaching*" from this school. The available computers in school C were only for teaching computer literacy. Teachers from school B were able to secure their own laptops, while teachers from school A did not have laptops. Although teachers were ready to use their personal laptops for teaching, it was difficult to secure a data projector. "*The problem of facilities is very crucial in this school*, *if you want to get a data projector for teaching*, *you have to write a letter*, *which can sometimes be declined*", said a teacher from school C.

Teachers also indicated a lack of support from the school management in the form of incentives or rewards. For example, a teacher from school A was quoted saying: "…*there is no any support from the management*…*no appreciation*, *no material support*, *no rewards or incentives for whatever we do to improve our teaching*". However, teachers from school B and the pre-service teachers, reported encouragement and recognition of their practices from the school management. "*The management insists for teachers to use technology in teaching*, *and asks other teachers to learn from us*" said a teacher from school B. Similar experience was shared by the pre-service teachers.

Regarding the school environment, only the pre-service teachers were comfortable with the classroom settings, electricity cables and the number of students in the classroom. For the teachers from school A, B, and C, the school environment was a challenge. One of the teachers from school A said, "*My classroom has 157 students*… *the classroom is too crowded*, *there is even no space for a teacher*… *where can I put a screen and the laptop*?"

2.2.4 Technological factors

Teachers were positive about the effectiveness of technology in teaching. They reported the effectiveness of technology on students' learning, and on simplifying their teaching process. Most of the teachers reported to be comfortable and satisfied with the outcomes of the technology-integrated lessons, they had developed and taught during the professional development program. One of the teachers from school A said, "*When you use technology*, *students can observe scientific processes. This reduces the burden of explaining everything*." The other teacher from school B said, "*With technology it becomes easy to implement approaches which are learner-centered*".

Moreover, the pre-service teachers reported that technology was easy to use, Teachers from school B said that some technologies were difficult to use, while others were easy. "*Sometimes we find a lot of good materials online*, *but we are not able to use theim in our teaching*" said a teacher from school B. Teachers from school A and school C, said the use of technology was difficult during lessons they had designed as part of the professional development program. They added that, the design of animations using PowerPoint and linking of online materials with the PowerPoint was challenging. "*In the lesson preparation can be difficult but teaching is easy*" said a teacher from school A.

2.3 Views of the school management

The different experiences by teachers from schools A and C compared to school B in the support they received from the school management was confirmed by the responses from the school management as summarized in Table 4. In all three schools the limited technological infrastructure hampers the uptake of technology in the schools. While the school management in school A and B is positive about teachers' participation in the professional development program, this seems not the case in school C, where the school management is quite negative about teachers' initiative and motivation to use technology. The school management of school A and school B on the other hand are positive about teachers' participation in the professional development program. In particular they mentioned an improvement of students' performance in science as a result of the professional development program. Although teachers' use of technology hardly continued after the professional development program in school A, the school management appreciated the improved pedagogical practice and the collaboration of the science teachers. In addition, the school management of school B facilitated teachers who participated in the program to support their peers in the use of technology.

2.4 Enabling and hindering factors

Based on the findings a summary of enabling and hindering factors affecting the continuation of technology use for the pre-service teachers and the three schools is presented in Table 5.

3 Discussion and conclusion

This study investigated the pre-service and in-service teachers' continuous use of technology in science and mathematics teaching after the end of a professional development program. The study also investigated the factors determining teachers' continuous use of technology in teaching after the professional development program had ended.

The findings from this study show that, the continuation of the use of technology in teaching and learning was not the result of a single factor, but the combination of all factors presented by Baldwin and Ford (1988). For example the findings of this study showed that in schools where there were technological tools, but where teachers were not motivated and lacked support from the school management, teachers did not use technology in teaching. In addition a professional development program that can enable teachers to develop knowledge and skills of integrating technology in teaching without access to technological tools obviously did not lead to the integration of technology in teaching.

Earlier findings by Hare (2007), and Swartz and Wachira (2010) reported the incidences of Tanzanian teachers' using technology for administration rather than instructional purposes. This was also found in this study where teachers particularly from school A were only using technology for test preparation and for keeping the students' records. However, the findings from pre-service teachers and in-service teachers in school B are in-line with those of Agyei and Voogt (2014) who reported

Table 4 Schools' deputy principals' responses regarding technology use in their schools

Topic	School A	School B	School C
Awareness about the professional development program	Well informed about the project and fully permitted the teachers to participate in the project	Well informed about the project and partly participated in the workshop	Well informed about the project and permitted teachers to participate in the project and use the computer labs
Current use of technology use at school	There is no technology use at all	Teachers use their personal laptop for teaching.	No use of technology for teaching but used for keeping students' records
Teachers performance after the project	Technology was never integrated in teaching, but the pedagogy was highly improved: there was increase in students' performance in biology subject, also the school did well in the national science subjects competition	Highly improved: immediately after the project teachers started using technology. Good students' performance Good evaluations from students on teachers performance	Nothing changed, since the end of the project; everything remained as it was. Teachers are not creative and don't want to learn new things Teachers have low self-confidence on technology use
Opportunity for future use of technology	There is a very good collaboration among science teachers, especially the physics and biology teachers	Teachers are highly motivated to use technology Good collaboration among science teachers	The management is ready to do anything that teachers would like to get done for them to use technology in teaching
Challenges for integrating technology in teaching	No efforts were made by the management to support teachers No technological tools The money sent by the government for running the school is too little Teachers are not motivated Teachers are computer illiterate	No technological tools: teachers are using their own laptops Teachers' illiteracy; there are some teachers who are unable to use technology despite their participation in the professional development program	The computers are for computer literacy not for teaching other subjects Teachers are not motivated (they want to be pushed) No request was received from teachers for implementing any innovation There are too many students to be taught in computer labs
Future plans	If the school receives sufficient money from the government there is a plan to buy new computers for the school	The few teachers who attended in the project will be facilitated to teach other teachers on the use of technology in teaching.	There is a plan to lend laptops to all teachers who are interested There is a plan to adopt the idea of teacher design teams

Table 5 Implementation level, enabling and hindering factors for technology integration

Study Group	Implementation level	Enabling factors	Hindering factors
Pre-service teachers	Well implemented	Availability of technological tools particularly in teacher training colleges Presence of incentives for good practices (e.g., opportunity to attend some paid workshops or seminars)	Lack of technological tools particularly in secondary schools Lack of incentives for those who were not part of the national ICT development project
School A	Not implemented	Good teachers' collaboration particularly the biology team	No technological tools No electricity in classroom Overcrowded classes with up to 90 students Lack of support or appreciation for good practices from school management Busy time table for science teachers No incentives for extra work
School B	Well implemented	Teachers' used their own laptops Students demanded to be taught by using technology, The management encouraged teachers' to use technology, The management supports teachers' new ideas	No school computers Classes are overcrowded with up to 80 students Unreliable electricity supply Too busy school time table
School C	Not implemented	Availability of technology tools (e.g., 3 computer labs with over 20 computers each; data projector)	Majority of teachers have double employments Low motivation, because of low job security No support and appreciation for good practices from school management

a successful transfer of learning to the job, after a similar approach of professional development program. The findings from school B and also from pre-service teachers entails that the professional development program that was introduced in schools and teachers training college, was effective. Poor transfer of training to the job, as observed in school A and C, were most likely to have been influenced by personal, technological and institutional factors.

In schools A and C, the institutional factors were found to have a strong impact on the transfer of the training to the job. Many of the teachers who did not continue to use technology in teaching, reported the lack of motivation and support from the school management and also the lack of electricity in classrooms. Eickelmann (2011) report the support for individuals in schools, support from peers, participation in decision making and accessibility to technology (cf. Almekhlafi and Almeqdadi 2010) as important factors contributing to teachers' continuation of the use of technology. Evidence from school B shows that, although there were only two computers at the school and there was no internet connection, teachers used their laptops, and modems to download teaching materials and use them for teaching. However, school C, which had three computer labs full of computers and internet connection, did not use technology at all. This means that, the presence of technology alone, and the training of the teachers are not sufficient to make teachers use technology in teaching. The interplay between different factors is the most important in ensuring a continuation of the professional development program.

A new finding from this study, which could also be of interest for future professional development plan is the influence of the students. Teachers from school B, reported the influence of the students who were taught by using technology during the professional development program, to have influenced them to use technology. Students were asking teachers to teach them by using technology as they were taught with technology during the professional development program. It was reported that, the students did not only ask the teachers, but also asked the school management for the use of technology in science learning. This made, both the school management and the subject teachers to reorganize themselves for the use of technology in teaching. This also shows the relevance of a professional development program in which teachers practice the integration of technology in actual teaching.

Based on the findings of this study, we argue that, the professional development program was an important determinant of the teachers' continuous use of technology in teaching after the professional development ended. The professional development program they attended the collaborative design of technology-enhanced science lessons in teams, implementation of the designed lessons and reflection with peers. These components of the professional development program were reported to be important for the teachers' understanding of various technological tools that can support learning, and how they can improve teaching of difficult science topics (cf. Jimoyiannis 2010).

Although the findings of this study agree with those of Eickelmann (2011) and Torodova and Osburg (2010) who report knowledge and skills as important determinant of technology integration, they differ from Agyei and Voogt (2014), who reported that perceptions (belief) is a significant predictor of the continuous use of technology in teaching. However, the findings in this study showed that majority of teachers had a positive belief about technology and yet their use was low. This entails that, factors other than their belief had influenced their continuation of the use technology in science and mathematics teaching. Taking the example of schools that positively integrated

technology in their teaching, we can argue that, the combination of technological, professional development, institutional and personal factors had influence on the continuous use of technology in teaching.

The findings in this study can have implications for future professional development programs that aim to develop technology integration knowledge and skills. First, the professional development factor was important for the teachers' continuous use of technology in teaching, because it initiated the development of technology integration knowledge and skills. Second, conditions for a long term impact of the professional development program depends on the teachers' technology integration knowledge and skills, accessibility to technology and the ease of use of the available technology. Third, support form school management is essential for teachers' continuous use of technology in teaching.

Appendices

A In-service Teachers' interview

1. What are the activities do you do in the design team?
2. Which new design teams have been formed in your department or other departments?
3. What are the motivating or conducive factors for your continuous collaboration in design teams?
4. What are the hindering factors for your continuous collaboration in design teams?
5. What design team activities have so far taken place in your design team meetings?
    a. Do you have any written meeting agendas for the design team meetings you have held so far?
    b. Do you have any written meeting report from the meetings you have held so far?
6. What challenges do you encounter in design teams and how are they being solved?
7. How can design teams be motivated in your school?
8. What measures have you taken so far to maintain design teams in your school?
9. How is your school/management supporting the teachers' collaboration in teacher design teams?
10. What technology is available at your school for use in science/mathematics teaching?
11. How often do you use technology in your teaching?
    a. What technology do you use more often?
    b. In which lesson do you normally use technology?
12. What are the added values of technology on your classroom instruction and students learning?

13. What do you perceive to be useful and ease of the use of technology in teaching?
14. What do you think are some of the negatives of using technology in teaching?
15. What improvements have you made so far in your instructional practices with technology?
16. What are the challenges you encounter in your endeavors to integrate technology in teaching?
17. What factors hinder or stimulate the use of technology in your teaching?
18. How have the following supported or hindered your use of technology in teaching at your school?

    a. Your belief about teaching science/mathematics using technology
    b. Your knowledge and skills of teaching science/mathematics by using technology
    c. Availability of technological facilities at your school
    d. Availability of time for implementing technological instructional methods
    e. Rewards/incentives provided by your school for implementing technological innovations
    f. School culture (time table, supervision, training)
19. What are your suggestions for successful integration of technology in your school?

B Pre-service teachers' interview

1. What importance do you give to the professional development program to develop TPACK, which you attended at DUCE in 2010?
2. To what extent have you implemented the knowledge and skills of technology integration (TPACK) that you gained from the professional development program you attended at DUCE?
3. What technology is available at your school for use in science/mathematics teaching?
4. How often do you use technology in your teaching?

    a. What technology do you use more often?
    b. In which lesson do you normally use technology?
5. What are the added values of technology on your classroom instruction and students learning?
6. What do you perceive to be useful and ease of the use of technology in teaching?
7. What do you think are some of the negatives of using technology in teaching?
8. What improvements have you made so far in your instructional practices with technology?
9. In what ways do you think teacher design team is important in developing your technology integration knowledge and skills?
10. What are the challenges you encounter in your endeavors to integrate technology in teaching?
11. What factors hinder or stimulate the use of technology in your teaching?

12. How have the following supported or hindered your use of technology in teaching at your school where you got employed after the teacher education?

    a. Your belief about teaching science/mathematics using technology
    b. Your knowledge and skills of teaching science/mathematics by using technology
    c. Availability of technological facilities at your school
    d. Availability of time in implementing technological instructional methods
    e. Rewards/incentives in implementing technological innovations
    f. School culture (time table, supervision, training)
13. What are your suggestions for successful integration of technology in your school?
14. What are your plans or expectation do you have on the use of technology in the future classroom teaching?

C Focus group discussion for in-service teachers

1. What value do you give to the professional development program you attended one year/seven months ago?
2. What are your opinions regarding the use of technology in science teaching?
3. What are you opinions regarding the collaboration in teacher design team to design technology integrated science lessons?
4. To what extent do you think collaboration in design team has helped you to understand technology integration in science teaching?
5. In what ways do you think collaboration in design teams helps you to develop knowledge and skills of integrating technology in science teaching?
6. To what extent is your school management supporting the idea of collaboration in design team?
7. To what extent is your school management supporting the idea of integrating technology in science teaching?
8. What do you consider as factors (personal, school or professional development) affecting your effective collaboration in design teams?
9. What do you consider as factors (personal, school, professional development, technological) affecting your effective integration of technology in the subjects you teach?
10. What should be done, to have teacher design teams well implemented in your school?
11. What should be done to have technology well integrated in your teaching?
12. What else and how do you think can be done to make the ideas from the professional development program well implemented in your school?

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