

The Development of Teacher ICT competence and confidence in using Web 2.0 tools in a STEM professional development initiative in Trinidad

Vimala Judy Kamalodeen, Sandra Figaro-Henry, Nalini Ramsawak-Jodha and Zhanna Dedovets

School of Education, The University of the West Indies, St. Augustine

Technology use for transforming the teaching-learning environment has been well researched and forms a critical component in Science, Technology, Engineering and Mathematics (STEM) education. Schools and teachers therein need to be well positioned to embrace curricula change and employ Information and Communication Technology (ICT) for teaching and learning. However, as in-service teachers may not have been exposed to STEM education in their teacher preparation programmes, continuous professional development (PD) is the avenue through which change can be effected. This paper describes the gains in competence and confidence of teachers in four selected Web 2.0 tools (Skype videoconferencing tool, emails, blogs, and wikis) while participating in a STEM ICT PD initiative. A phased approach to ICT PD was used in which an online phase bridged two face-to-face workshop series. Participants were 86 teachers from 25 purposefully selected early childhood, primary and secondary schools in Trinidad. A mixed methods approach was used to collect data through the Web 2.0 tools, online questionnaires and a paper ICT self-competency checklist. Analyses revealed all teachers achieved gains in competence in using all four Web 2.0 tools, but to different levels. Gains in confidence were evident from teacher self-reports and their posts that explained their stated levels of confidence as none, low or high. Higher levels of competence arose from working in digitally-rich environments at the PD centre rather than in their schools, which were usually less digitally-rich. Support from facilitators also promoted competence and confidence, especially during the face-to-face component of the PD. There are implications for ICT PD that models a phased approach as it relates to improving STEM education and recommendations are made for school leaders to improve the digital environments of their schools.

Key Words: Teacher professional development, ICT competence, ICT confidence, Web 2.0 tools, STEM education, Trinidad, Mixed methods

Background

Education today is impacted by large-scale transformations such as globalization and internationalization. Economic and intellectual development of a country is linked to the ability of the education system to be responsive to the changing needs of a post-industrial society and cater for the delivery of modern quality

education. Science, Technology, Engineering and Mathematics (STEM) education has been placed on a global agenda as one mechanism for promoting 21st-century skills such as communication, collaboration, problem-solving, creative and critical thinking. Even in a small country like Trinidad and Tobago, STEM education has been suggested as a way to develop a highly educated and skilled workforce to drive its oil and gas-based economy successfully. STEM education can facilitate the preparation of students into careers that meet the needs of industry. STEM education enacts a curriculum based on the idea of educating students in the four specific disciplines utilizing an interdisciplinary and applied approach (Hom, 2014). In-service teachers are not always prepared to implement STEM curricula and require ongoing professional development (PD).

According to Bybee (2010), the term STEM education is widely used and is conceptualized as Science and Mathematics education, without a realization of the contribution of Technology and Engineering. In Trinidad and Tobago, curriculum focus has been on Science and Mathematics. For effective STEM education, the Technology component must play a more central role. Teachers need to be able to use technology in a variety of ways for successful STEM teaching and learning. This need provides the foundation for the first STEM professional development initiative in Trinidad for teachers at early childhood, primary and secondary education levels. This PD is designed with a focus on building technology competence and confidence in teachers as a preparation for implementing STEM in the classroom. The UNESCO Teacher ICT Competency Standards (2015) indicate that teachers are required to use ICT for technology literacy, knowledge creation, and for knowledge deepening, which all support STEM classrooms. These standards are designed to move teachers along a continuum of skills and competencies in using existing and emerging technologies. In this paper, ICT is used interchangeably with technology.

While classroom teachers possess discipline-specific knowledge, they may not possess sufficiently, the knowledge and skills needed for technology-rich STEM classrooms. Ertmer and Ottenbreit-Leftwich (2010) cite Mueller et al. (2008) that “even if in-service teachers know how to use technology in their classrooms, they may still lack confidence to actually use it” (p. 273). Thoughtful professional development is therefore necessary for teachers to gain not just competence, but also confidence in using ICT, for successful STEM classrooms. Ertmer and Ottenbreit-Leftwich (2010) advise that careful thought must go into professional development for in-service teachers which take into account the length of time, the duration and how often teachers should meet. As such, new professional development initiatives should be purposefully designed to support teachers in building both competence and confidence in technology use.

Traditional approaches in Trinidad and Tobago to professional development in ICT integration involve one-off workshops (Kamalodeen, 2014). This approach to teacher professional development, which still exists, has been found to be deficient in several ways, in particular, the quality, sustainability, cost, time for teachers to learn, decontextualized learning experiences, lack of mentoring and opportunities to work together and engage in reflection (Dede, Ketelhut, Whitehouse, Breit &

McCloskey, 2009; Lawless & Pellegrino, 2007; Levin & Wadmany, 2008; Ostashevski & Reid, 2010; Kamalodeen, 2014). Building ICT competence through professional development therefore, requires a different approach, which allows for ongoing support while teachers try new technologies in their classrooms after the period of formal PD is over. Teachers at different stages of their careers face several barriers in integrating ICT successfully including a lack of time, difficulties in curriculum adaptation, lack of teacher PD and a lack of administrative support (Kamalodeen, 2014).

Ertmer and Ottenbreit-Leftwich (2010) propose that, “similar to affecting knowledge change, a change in teacher confidence can take an extended amount of time (Brinkerho, 2006) and is best implemented in small steps (Kanaya et al., 2005), and suggest using familiar tools to build confidence in teachers” (p. 274). This new approach should assist teachers in becoming active rather than passive receivers with respect to professional development in ICT (Warren, 2009). This provides a pathway to allow for access to information and assistance that differs from a one-shot application of ICT teacher professional development (Donuk, 2013). Educational reform that includes modernized curricula requires teachers at all levels to be competent and confident in using ICT. This influences teacher professional development programmes to now have a focus on building teacher ICT competence. Web-based communicative and collaborative tools coupled with the power of Internet connectivity can allow for the design of cost-effective, compelling, engaging and interactive ways of developing skills and competencies in teachers.

Aspects of ICT competency that are needed by teachers include the ability to work strategically with colleagues and to empower students with skills needed to master STEM. Communicative and collaborative tools such as Skype, emails, wikis and blogs have increased in popularity. They are open access and freely available to teachers and students (Dabbs, 2012). Studies have shown that the use of these tools has been successful in teacher professional development. For in-service teachers, PD models that blend offline and online modalities hold promise to maximize the potential for success in developing key 21st-century ICT competencies (Hodges, Grant, & Polly, 2013).

Purpose of the Study

To determine whether Trinidad teachers experienced gains in competence and confidence in using selected Web 2.0 tools namely Skype, emails, blogs and, wikis in a STEM ICT professional development initiative.

Research Questions

1. What are the gains in teachers’ competence using selected Web 2.0 tools in a STEM ICT professional development initiative?
2. What are the gains in teachers’ confidence using selected Web 2.0 tools in a STEM ICT professional development initiative?

Literature Review

ICT Competence and Confidence

The UNESCO ICT Competency Framework for Teachers (2015) provides a much-needed guide for developing and developed nations, more than twenty years after computers have been in the classroom. The framework suggests that teachers use ICT in three ascending levels of competence: for technology literacy, knowledge creation, and for knowledge deepening, which all support STEM classroom transformation. The lowest level of the framework for teachers is related to the technology literacy approach, which includes basic digital literacy skills and digital citizenship. Higher levels of competencies allow for the teacher to select and use appropriate off-the-shelf educational tutorials, games, drill-and-practice software, and web content in computer laboratories or with limited classroom facilities to complement standard curriculum objectives, assessment approaches, unit plans, and didactic teaching methods. At the highest level of the UNESCO ICT Competency Framework, teachers and students create artifacts of learning using selected technologies, act as coaches in the classroom, and teachers act as model learners to both students and colleagues. For teachers to progress from one level of competence to another, teachers require effective ICT professional development.

There have been some frameworks to measure ICT standards for teachers, but the one adopted by Trinidad and Tobago is the UNESCO framework. Some terms associated with ICT have been used interchangeably including Information Technology (IT), Technology and Digital. Further ICT skills and competencies have often been used interchangeably. However, in this study ICT competence is used as it refers to the functional use of digital knowledge, skills, and attitudes and presents a more comprehensive view of the use of technology (Tondeur, Van Braak, Ertmer, & Ottenbreit-Leftwich, 2016).

Even today, there is a lament that teachers often possess little ICT competence and thus a concomitant lack of confidence in using ICTs in teaching (Lang, Craig and Casey, 2016). Ertmer and Ottenbreit-Leftwich (2010) point out that teachers need PD to increase their competence through knowledge of technology, technology tools and how to integrate technology into the teaching/learning experience. Feelings of confidence need to accompany the knowledge of ICT. Feelings of confidence can be facilitated by having teachers use technology, thus building their personal experiences (Ertmer & Ottenbreit-Leftwich, 2010). But not all teachers believe that technology is necessary for learning and Tondeur, et. al, (2016) indicate that teachers' ICT use varies with their pedagogical beliefs. Even teachers with traditional teacher-centered pedagogical beliefs can benefit from technology if its use aligns to teachers' classroom practices. Therefore, regardless of teachers' pedagogical methods, technology should be introduced in ways "that align with teachers' current approaches, thus appealing to their values and increasing the likelihood that teachers will integrate and use technology" (Tondeur, et. al., 2016, p. 15). An increase in teachers' ability to create and implement technology-assisted

lessons has been found by Glazer, Hannafin, Polly and Rich (2009) when they are engaged collaboratively with ICT. This assists with building ICT competence and confidence.

Web 2.0 Tools in Education

Web 2.0 is a collective term for “a series of Web-based technologies that include blogging and microblogging platforms, wikis, media-sharing sites, podcasting, content aggregators, social networks, social bookmarking sites, and other emerging forms of participatory and social media (Jimoyiannis, Tsiotakis, Roussinos & Siorenta, 2013, p. 248). Web 2.0 tools enable interactions that are otherwise not possible outside of a classroom setting. Dabbs (2012) suggests that Web 2.0 provides the opportunity to revolutionize ICT use in the classroom if teachers are willing and able to do so. Web 2.0 technologies provide a myriad of opportunities and advantages for teachers. The proliferous and ubiquitous nature of these tools enables quick, widespread and easy access for educators to communicate and collaborate. Researchers have lauded the potential of Web 2.0 tools for collaboration and communication (Dabbs, 2012) and since 2004, Williams and Jacobs documented the transformative potential of tools such as blogs for teaching and learning.

In particular, blogs are considered as tools for reflection (Hicks, Young, Kajder & Hunt, 2012) and wikis for collaboration across space (Siemens, 2005). Comparisons have been made between free or low-cost web-based video conferencing tools such as Skype with its more expensive counterparts to enable synchronous teaching and learning by providing for more interactive and collaborative environments. These comparisons have yielded similarities in their usefulness for these types of interactions (Karabulut & Correia, 2008). While emails are established tools of asynchronous communication, and are sometimes conceived as ‘old technology’, Weir (2012) suggests that it is still one of the most popular tools used in schools for administrative purposes. Web 2.0 facilitates, encourages and supports digital two-way communications and collaborations, which ultimately permits a shift from individualized to social learning. This shift facilitates communicative, motivational and participatory benefits (Jimoyiannis, Tsiotakis, Roussinos & Siorenta, 2013).

Web 2.0 Tools in STEM PD Initiatives

Open source software and free Web 2.0 tools can positively impact the teaching and enriching of STEM courses, literacies and competencies for this century and beyond (Asunda, 2011). Costa, DeCastro-Ambrosetti, Shand, Tran and Cho (2011) describe the Fullerton Math/Science Digital Credential Program Pathway that demonstrates a model for the transformation of STEM teacher preparation programs through development of STEM teacher educator technology skills and the creation of digital-rich learning environments for pre-service STEM teachers. The model was a hybrid online model that included a mentoring component. They focused on building skills in communication and collaboration, presentation, organization and critical

thinking. Their focus is on pre-service teacher preparation by enhancing the skills of the teacher educators themselves through active participation. The literature suggests that teachers can be prepared for STEM education through pre-service programmes. However, there is a need for in-service teachers to access professional development to create STEM classrooms (Wilson, 2011).

Teacher PD in Web 2.0 tools

Authentic technology-mediated online learning experiences are proposed to develop teacher technology competence based on research in teacher PD in the USA and Europe (Forkosh-Baruch & Hershkovitz, 2012; Reid & Ostashewski, 2010). Researchers can avoid the pitfalls of traditional approaches to PD using one-off workshops by designing PD that meets the needs of teachers as they work (Ter & Herrington, 2014). Activities engaging technology that are authentic to STEM and are sustained over time can allow for greater technology competence and confidence.

Method

This study used a mixed methods approach (Johnson, Onwuegbuzie & Turner, 2007) to measuring and analyzing gains in teacher competence and confidence using selected Web 2.0 tools in a STEM ICT PD initiative in the Republic of Trinidad and Tobago. Mixed methods are currently being debated and researched for their value in combining qualitative and quantitative techniques in various studies. It was felt that the combination of qualitative and quantitative approaches allows for more robust explanations of the processes being investigated and, ultimately, the development of a more holistic picture of teacher behavior (Morse, 2003).

The study focused on Web 2.0 tools facilitated and activated through the Internet and this itself allowed for a bricolage of methods (Denzin & Lincoln, 2005). Qualitative and quantitative approaches complemented each other (Tashakkori & Teddlie, 2008) to answer the two research questions concurrently as these involved the use of online data from the Web 2.0 tools simultaneously (Onwuegbuzie and Collins, 2007). While there is much support for its use (Sandelowski, Voils & Knafl, 2009), a judicious approach to complementarity needs to be adopted (Mayoh, Bond & Todres, 2011) as there can be conflict between qualitative and quantitative paradigms. Data were collected through Web 2.0 tools, online questionnaires, and a paper ICT self-competency checklist. According to Johnson & Onwuegbuzie (2004), “mixed methods research frequently results in superior research because of the approach’s key defining feature –methodological pluralism” (p. 247).

Participants

Participants in this study were in-service teachers from 25 purposefully selected schools at all three education levels in Trinidad. These levels were Early Childhood Care and Education (ECCE), primary and secondary. The schools were selected based upon ease of access, range of performance on the basis of school ratings from

the Ministry of Education of Trinidad and Tobago, and a mix between government and government-assisted schools. There were 10 teachers from five ECCE schools, 34 teachers from 10 primary schools and 42 teachers from 10 secondary schools. Initially 100 teachers were invited to participate from the 25 schools, but 86 attended the PD. Urban and rural schools were selected. Teachers from these schools were recommended for participation in the STEM PD by the principal and thereafter voluntarily participated. There was a higher number of female than male participants and teachers varied significantly in their teaching experience and initial ICT preparation. The latter was not a factor in being recommended for the STEM PD initiative. All 86 participants constituted the sample for the study.

Data Collection and Analysis

Data in this study were mainly quantitative but includes qualitative data for expansion. Quantitative data from checklists and questionnaires were used to measure self-reported teacher competence and confidence. An ICT Competence Self-Assessment Checklist was used at the end of the first face-to-face phase to gauge teachers' reported competence in different tools. An online questionnaire using Google Forms was used at the end of the entire PD to assess participants' confidence in the use of the tools. To verify the reliability and validity of the checklist and questionnaire, the participants were asked to rate the perceived difficulty of each of the criterion. General information on the participants was also collected for cross-tab analysis. Qualitative data from the online tools such as blog posts and wiki edits were obtained from the relative websites and provided evidence of competence and confidence to answer the research questions. Confidence was measured by ratings on a questionnaire and through observation of collaboration and communication over time on the Web 2.0 tools. Data were captured automatically from blogs and wikis, through and from the Internet. Participant data therefore consisted of dates, participant names, email addresses, number of blog posts, number of wiki edits and responses to open and closed questions and actual blog posts. These data were combined for analysis.

Data from the main wiki, the collaborative digital environment, were *quantitized* (Sandelowski et al., 2009), for reporting on gains in teacher competence. While there is still much debate on ways to use Internet data, analysis of website data is still a "new field that is very much in flux" (Bryman, 2008, p. 629) so the use of screenshots of the wiki and surveys in the section below aims to help to validate the data used. Analysis of participant data involved simple counts of opinions, tallies of checklist data and selected data from various tools.

Data Trustworthiness

The study was guided by Lincoln & Guba's (1985) four criteria of credibility, dependability, confirmability, and transferability, to ensure trustworthiness of the data. Confidence in the truth of the data and credibility of findings were established and maintained by using direct quotes of teacher comments on the blogs and wikis.

These ubiquitous fluid spaces, favored prolonged peer communications, persistent observation, inherent member checking and debriefing, which are sound techniques for establishing credibility. Shared digital spaces, used to capture data, left innate transparent audit trails and satisfied the data confirmability criteria (Lincoln & Guba, 1985). However, transferability of the findings was not a focus of this study.

Procedures

A three-phased ICT PD program took place over four months, which combined face-to-face workshops with Internet-based interactions during the PD period. This design was to facilitate a protracted period to support teachers' PD. The PD was scheduled to minimize school disruption and maximize flexibility of time and location for the participants, who were supported in the use of Web 2.0 tools in all three phases. The PD facilitators comprised lecturers in Science, Technology and Mathematics education as well as lecturers in ECCE and Educational Technology. Four Web 2.0 tools were selected, which were Skype, emails, blogs and wikis, to facilitate communication and collaboration among participants. These tools were selected based on availability, cost, ease of use and low technological entry barriers. The main digital space was a wiki developed using *Wikispaces.com*. Other tools were online chat via Skype, blogs via Weebly.com and emails using Gmail.com. A team member was dedicated to managing the site and its contents. This site facilitated multiple user access and two-way communications. The three phases are presented in Figure 1, illustrating the nature of modalities used.

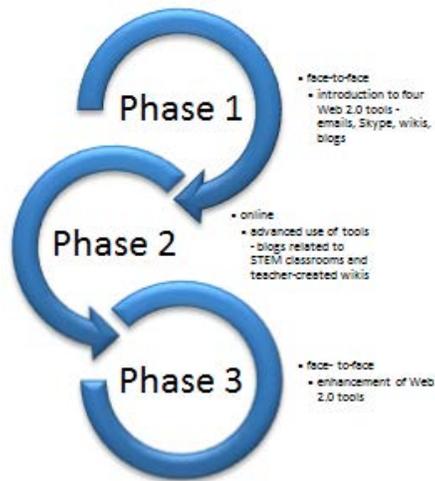


Figure 1. Diagram showing ICT PD phases

Phase 1 consisted of a four-day immersive, face-to-face workshop. There were four sessions, each dedicated to learning one Web 2.0 tool at the

University's PD centre. The PD centre was a digitally-rich environment with a fully equipped computer laboratory with high-speed Internet access and one to one computing facilities. Gmail addresses were created for participants who did not have one. Skype names were created to facilitate Skype meetings held with each participant. Participants were introduced to the main wiki and asked to join it. They also made at least one blog post during this phase. The competencies addressed in Phase 1 are detailed in Table 1.

Table 1: Competencies taught during Phase 1

ICT SKILL	COMPETENCY
EMAIL	Created an email account Logged In and Out of Email Account Composed and Sent Email to a colleague Opened and Replied to Email sent from a colleague
WIKI	Join a wiki Sign into wiki Access different wiki pages
BLOGS	Create a New Post in a Blog Reply to a Post in a blog
SKYPE	Downloaded & Installed Skype on PC/Laptop Created a Skype account Accept a Skype request Add people to my Skype account Take part in a group audio call

Phase 2 was conducted online. Participants used personal and school Internet resources. Participants were expected to use the tools learned during Phase 1. During this phase, facilitators set up regular Skype meetings, used emails for general and private communication, engaged participants in discussions on the wikis, encouraged personal reflections and created interactive activities on the blogs. Table 2 outlines the online sessions during Phase 2.

Table 2.: Phase 2 PD with online sessions

Weeks	Activities
Week 1.	Blog 1. Let's talk STEM- ECCE, primary, secondary
Week 2.	Blog 2. My attempts to improve my thinking
Week 3.	Blog 3. Suggestions for transforming my classroom
Week 4.	Wiki. Introduction to STEM education
Week 5.	Wiki. ICT for project-based learning
Week 6.	Wiki. ICT for project-based learning
Week 7.	Wiki. Creating and sharing presentations using ICT
Week 8.	Wiki. Create your own wiki

Phase 3 took the form of a face-to-face closing meeting where teachers presented the Web 2.0 learning activities they designed, discussed and exchanged ideas on pedagogical and instructional issues, teachers completed an online questionnaire on ICT confidence, and made plans for implementing STEM projects in their classrooms.

Limitations of the Study

This paper reports on the gains in ICT competence and confidence, which is only one aspect of the whole STEM PD initiative. As such, findings are reported specifically with respect to the ICT PD. Additionally, attrition took place over the PD period, impacting participation and resulting analysis, so findings were based on actual participant data on the main wiki space. Further, since entry-level ICT skills were not required to gain entry to the STEM initiative, participants ranged from novice to expert in ICT. Finally, purposive sampling does not yield the same levels of validity as randomised samples. This was not an experimental study.

Results and Discussion

The findings are presented to demonstrate gains in competence and confidence in four online Web 2.0 tools. Data from participation in the wiki plus self-reported checklists indicate that teachers achieved competence in using emails, making blog posts, participating in Skype chats and editing and adding content to a wiki. Several differences in competency levels were revealed among teachers. Overall, participants rated their confidence in using these online communicative and collaborative tools as high.

Teachers' ICT Competence in Selected Web 2.0 Tools

Teachers self-reported that they achieved competence in all four Web 2.0 tools used in the ICT training (see Figure 2). Based on tasks associated with the online collaborative and communicative tools, 100% were able to create and use emails successfully, 88% were able to make at least one post to a blog. 72% were able to create their own wiki and 57% took part in a Skype meeting. It is noted that participation in the Skype meetings was significantly lower than that of Emails, blogs and wikis. The latter are asynchronous tools while Skype meetings were synchronous and required peer group members to be online with their mentor at the same time.

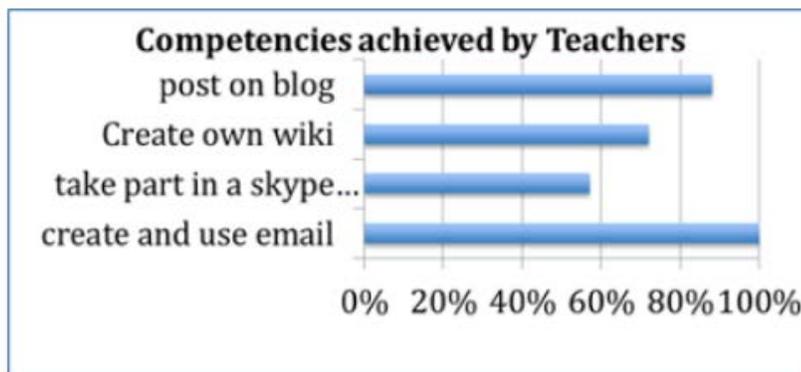


Figure 2. Teachers' gains in ICT competence in four Web 2.0 tools

In addition to teachers' self-reported competencies, analysis of teacher participation on each of four Web 2.0 tools is now presented to complement findings of their competencies.

All teachers gained competence in creating email addresses using Gmail. While only 27 teachers reported that emails were new, as most teachers had an email address prior to the training, they could not recall it correctly or recall the password for that address. They claimed that a relative or colleague or friend did it for them. Of those with email addresses, several were not Gmail addresses or were not thought professionally suitable. Gmail was chosen by the facilitators as it could be used for future Google applications such as Google Drive and Docs. As such all 86 teachers who attended the training were able to create a Gmail address that they used during the training and thereafter. Samples of these Gmail addresses are not shown here due to confidentiality of participant data. Emails were successful for all teacher participants and its continued popularity over other Web 2.0 tools was due to its familiarity and ease of use (Wainer, Dabbish & Kraut, 2011) which strengthens its position as a tool of choice.

With regard to Skype, 57 % of teachers gained competence in taking part in a Skype video meeting. They were able to create Skype addresses to communicate with each other, which were stored on the contacts page on the wiki. The reported

gain in competence for Skype is the lowest of all four Web 2.0 tools. This activity was conducted during evening sessions of the PD workshop and teachers were required to use their own Internet access and devices. The synchronous nature of this activity plus the deficiency in resources contributed to the significant number of teachers (43%) who were unable to acquire this competence.

Fifty-one (51) teachers reported a gain in competence in using a wiki. They were able to log onto the wiki and make edits. They did not use a wiki before and were now able to read and write content on the wiki. Analysis of the wiki reveals that all teachers registered as members with editing rights. On the wiki page shown in Figure 3, several teachers (names blocked) discuss their students' creative writing skills. This conversation indicates a degree of ease of use of the wiki as well as the versatility of the wiki itself to accommodate discussions such as these. This sample of post and reply allows the reader to see the thoughts of the participants who post, and to also read the replies of two other participants. These posts are an indicator that teachers seemed to find the wiki easy to use and to add content as they wished. Additionally, 72% of teachers reported that, by the end of the PD, they were able to create their own wiki-page (Figure 3). Teachers at all three levels - ECCE, primary and secondary achieved this competence.

WIKI ADDRESS	LEVEL
spaces.net	Secondary
wikispaces.net	Primary
.wikispaces.net	primary
http://ww2m.wikispaces.net	Primary
http://www.ispaces.net	Primary
htti.is.net	Primary
.wikispaces.net	Primay
.wikispaces.net	Primary
.net	Secondary
http://www.smas.wikispaces.net/	Std 1
http://.wikispaces.net/	STD 2
ispaces.net	Primary-Std. 3
htti.utante.wikispaces.net/	STD1
http://re.wikispaces.net/projectplanning	ECCE
http://-et/	ECCE 4+
ikispaces.net	ECCE
	primary

Figure 3. Screenshot of some teacher-created wikis in ECCE, primary and secondary levels (with anonymity enhanced through blocking certain wiki addresses)

With regard to blog use, 88% of teachers indicated (Figure 2) that they gained competence in making blogposts and in posting a reply. Teachers were able to blog and made 119 blogposts during the PD period. Five (5) blogs were created: Let's Talk Secondary STEM, Let's talk Primary STEM, Let's Talk Early Childhood

STEM, My Attempts to Improve My Thinking and Suggestions for Transforming my Classroom. The greatest number of blogposts were by secondary teachers (55 comments), followed by primary (46 comments), and least of all by ECCE teachers (16 comments).

The bulk of the blogposts took place during the face to face PD and decreased to 57 during the online component when teachers were in school (Figure 4). The reliance on teacher personal and school resources during this period negatively affected teacher participation with teachers indicating difficulties with Internet access.

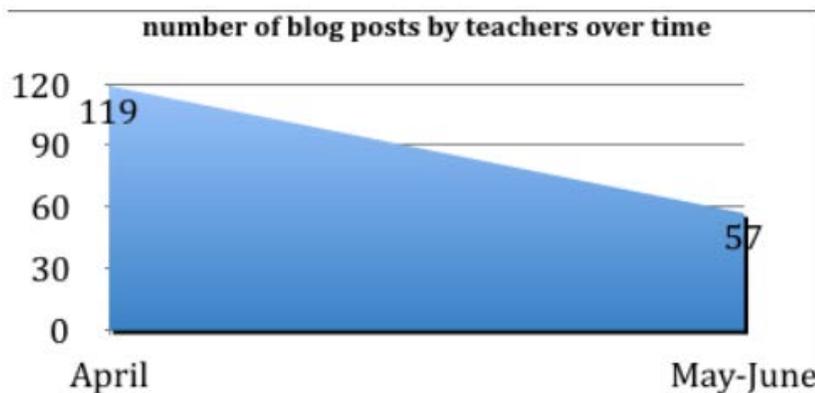


Figure 4. Illustration of decrease in participation over the PD period from Phase 1 to Phase 2

The main wikispace allowed ECCE, primary and secondary teachers to share opinions and perspectives on the PD. The space allowed participants to express how they felt about changes in competence in the Web 2.0 tools. Generally, teachers claimed that they found the SKYPE tool to be the most challenging, yet the most exciting. Among the three school levels, early childhood teachers were the most expressive of their gains in competence.

An early childhood teacher indicated that she was “*thinking about technology*” and wondered “*what’s next?*”. Another early childhood teacher never turned on a computer before the ICT in STEM PD, yet used the class blog to communicate with facilitators and students, and requested help: “*I will like to learn more about ict skills development [i] had no knowledge of computer before so I’m asking for help can you please help me*”.

Another early childhood participant described her PD experience with the Web 2.0 tools:

“we were all given opportunities to make mistakes and correct them without feeling intimidated. however, my greatest challenge were with the ICT sessions although i knew how to type and print documents. i was limited to internet procedures...”

Primary teachers expressed delight at learning new tools. Some samples of their competence are shared here:

“This has been a learning experience for me. The ICT sessions were especially interesting as I was able to use the technology to do more than just research.[it] allowed me personal growth.”

“ ... In the ICT class I learnt to create an email address, to send emails and to blog...”

“I learnt new stuff [Eg.] How to setup a gmail account, how to Skype, used WIKI...”

“I was able to develop skills and knowledge that were all new to me and will definitely enhance my development as a professional. The skills acquired at the ICT were, the creation of a gmail account, Skype account, using the wiki space and creating blogs as i engage in currently.”

Secondary teachers were generally more familiar with Web 2.0 tools than primary and early childhood. There were few comments about their competence and their gains were fairly low as they were mostly familiar with the four Web 2.0 tools.

Teachers' ICT confidence in selected Web 2.0 tools

Overall teachers rated their confidence as high in all of the tools with emails gaining the highest levels of confidence (93%). Out of the three other tools, teachers reported a 70% level of confidence in blogs compared to 68% in wikis and 62% in Skype (Figures 5, 6, 7, 8). These levels seem to be aligned to their self-reported gains in competence in the same tools, as reported earlier. Overall though, confidence scores are lower than that of competence scores yet matched to relative competency levels seen earlier. Complementary qualitative data for posts on wikis and blogs are included later in this section to expand on teachers' self-reported levels.

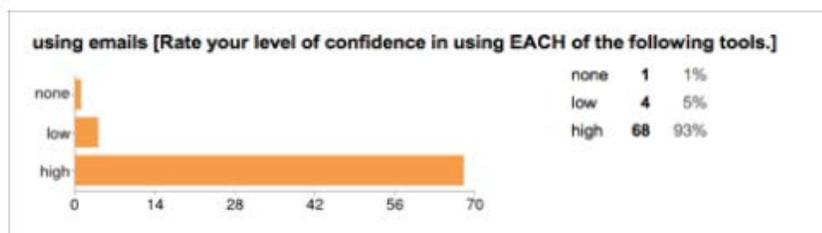


Figure 5. Teachers reported confidence in using emails

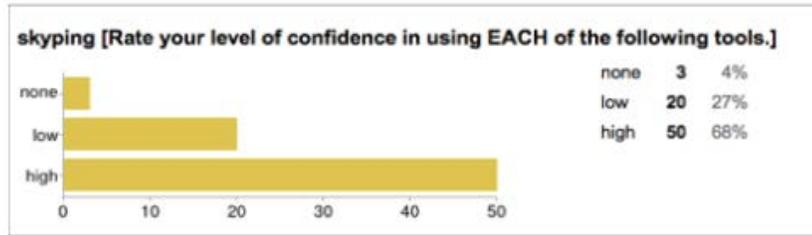


Figure 6. Teachers reported confidence in using Skype



Figure 7. Teachers reported confidence in using wikis

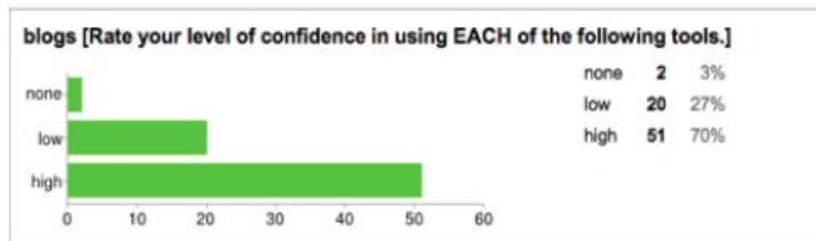


Figure 8. Teachers reported confidence in using blogs

Participants reported gains in confidence in all four Web 2.0 tools. These were across all education levels. Expressions of confidence are categorised thematically in four categories: excitement over what was learnt, comfort with the tools in the future, perceived benefits and applicability to the classroom. Blogs were used to facilitate teacher reflections and teachers reported a high level of confidence in using this tool. Of all tools, the lowest levels of confidence was seen in using Skype. Participants indicated some challenges in using it, in spite of being excited by its synchronous nature. Other teachers indicated that they felt “energized” and “enjoyed all the activities.” Secondary teachers also expressed that they experienced benefits in using the Web 2.0 tools, even though they predicted challenges in using the tools in the classroom. Some of these benefits were perceived support from STEM facilitators, application of knowledge to the classroom and exposure to new ideas and strategies. Table 3 provides some sample posts that illustrated confidence.

Table 3: Samples of posts showing teacher confidence in Web 2.0 tools

Expressions of Confidence	Participant post
Enthusiasm /excitement	<p>Early Childhood 1: I am so excited to actually implement some of these strategies and ideas with my group...</p> <p>Primary1: I am anxious to use Skype to collaborate with my peers.</p> <p>Primary 2: I am energised to go back to school and implement all the different skills of creative and critical thinking which would facilitate students to engage in good problem-solving activities.</p> <p>Secondary1: enthused enough to work on overcoming the challenges with the aid of my STEM mentors.</p>
Benefits	<p>Secondary 1: The STEM programme has been a beneficial, informative and interesting training workshop</p> <p>Secondary 2: My expectation of this workshop was to help me, as a secondary school teacher, to become more innovative in the classroom. ...I in fact gained much more.</p>
Applicability of tools to the classroom	<p>Early Childhood1: I can now go into the [ECCE] Centre and work along with the students and teachers</p> <p>Primary1: ... In the ICT class I learnt to create an email address, to send emails and to blog.... I can now think creatively, critically and solve problems. I am now prepared to share this information with my students.</p> <p>Secondary1: This workshop had taught many essentials that could be taught in the classroom and be applied to everyday life.</p> <p>Secondary 2: Also, the aspects of using WIKI tools can also be used in classrooms and communicating with my peers in the programme.”</p> <p>Secondary 3: The workshop has, in fact, introduced ideas and strategies that would take the teacher on the road to being innovative as well as equip students with the tools to be better problem solvers and innovators.”</p>
Comfort with tools	<p>Early Childhood1: It actually brought me into a comfort mode because of the different modes of interactions and teaching styles...I say this because I am a kinesthetic learner and many times in the classroom I am face[ed] with the challenge of me being expected to complete abstract tasks and to make no contextual linkages, which hinders my learning capacities.</p> <p>Primary1: I learnt new stuff Eg. How to setup a gmail account, how to Skype, used WIKI and HOORAY I AM BLOGGING!</p>

While the majority of teacher participants rated their confidence levels as high, a number of them also rated their levels as low or even none. According to one ECCE teacher “*my greatest challenge were with the ICT sessions [sic] although i know how to type and print documents, i [sic] was limited to internet procedures [sic]*”. A primary teacher indicated that the ICT itself was challenging when she said “*What was very challenging for me was the ICT. I am not a computer person, so some of the terms and ‘things’ done on the computer were very confusing and frustrating for me*”. A secondary teacher indicated that “*time*” was a challenge for her during the PD and anticipated the same for implementation in the classroom, especially due to intensive Science curriculum.

Blogs are useful tools for reflection and blogs created in this PD were quite successful. This could be due to the closed nature of the blog to the STEM PD participants and facilitators only hence offering a sense of social security for teachers to express themselves (Wang & Hsua, 2008). The wikispace was versatile and allowed a number of other Web 2.0 tools to be embedded such as discussion forums, that allowed for capturing teachers' expressions of confidence. Teachers were willing to create a new wiki but sustained interest in collaborative writing was not seen. Generally the views and responses took place on the same day of creation but not afterward and Judd, Kennedy and Cropper (2010) suggest that a number of factors can hinder the success of wikis. They analyzed wiki text and timelines and found that users were unable to sustain interest in a topic over time and that there was little evidence of collaboration despite adopting a learning design that was intended to support it. Teachers generally shared opinions but rarely shared best practices or resources.

Conclusion and Recommendations

The combined data from the selected Web 2.0 tools and teacher self-reports provide sufficient evidence that the PD enabled teachers to gain ICT competence and confidence. These competencies included creating and using emails, creating Skype addresses and taking part in online Skype video conferences, collaborating on a wikispace, and communicating their thoughts on blogs. Teacher's ICT entry skills to the PD varied significantly but the PD allowed for all participants to make meaningful gains in competence and confidence. Overall, teachers benefitted from engaging in authentic technology-mediated online learning experiences in digitally rich environments, as argued by Forkosh-Baruch and HersHKovitz (2012) and Reid and Ostashewski (2010) for teachers in USA and Europe.

Importantly, teachers demonstrated the ability to collaborate and communicate with STEM facilitators and other participants and thus gained confidence in using these tools. These collaborations allowed teachers opportunities to engage in and experience the type of learning that their students are or will be experiencing and understand the environment that facilitates this kind of learning, as alluded by Ostashewski and Reid (2010). Teachers were able to develop competence and confidence over time, in both technology-rich PD environments and less technology-rich environments at home, though with varying degrees of success. Conversely, time to engage with the technology was also a constraint and this supports Kamalodeen's (2014) earlier findings among secondary teachers in particular. A continued focus on teacher engagement with technology is needed for teachers to gain greater confidence (Ertmer and Ottenbreit-Leftwich, 2010).

Success in developing ICT competence in teachers at all three education levels rather than separately is laudable and worthy of further investigation. While differentiation of instruction is needed, a whole system approach can enable transfer of knowledge needed to initiate the building of STEM classrooms from early childhood. More in-depth examination of teachers' competence and their

experiences at each level can allow for a more customised and personal approach to take place within a larger initiative.

The face-to-face PD location was a digitally rich environment, which according to Costa et al. (2011) is needed for successful learning. High quality Internet access allowed ease of access to Web 2.0 tools and when participants were in spaces that were less digitally-rich, such as their schools and homes, participation waned. Teachers also felt more supported during the face-to-face phases rather than during the online phase. A decrease in blogs during the online phase was clearly evident. While Lawless and Pellegrino (2007) suggest that technology-PD workshops are deficient in several ways, this study indicates that these constituted the more successful component of the PD model. Aspects of this PD that may have contributed to success include “teachers being well-equipped with ICT, there was a focus on changing the process of learning using ICT which included hands-on support and opportunities to discuss problems with peers and facilitators and explore solutions over time” (Ertmer & Ottenbreit-Leftwich, 2010, p. 12). Digital environments are therefore critical to the success of teacher PD in technology competence and confidence.

These factors all contributed to allow teachers to gain ICT competence and confidence in the timeframe allotted for the PD. While hands-on support was available throughout the PD, it was greater during the face-to-face phase. A greater focus on online support aspect is needed to help to strengthen gains in competence and confidence. More efforts and resources are required for those participants in less digitally-rich schools and homes.

This ICT PD has implications for professional development programmes geared at improving STEM education. If teachers have access to digitally rich environments at their schools and homes, they can continue to gain competence and confidence in ICT and hence make the goal of translation into practice, and ultimately transformative practice, more of reality. More effective STEM education can be facilitated if teachers are technologically competent since ICT tools are an inseparable component of STEM education. Designers of STEM PD that focus on technology should continue to experiment with ways to bring an increased focus on authentic learning activities and ways to improve classroom enactment. We support the recommendation made by Hodges, Grant, and Polly (2013) for school leaders and administrators to support teacher PD and provide more digitally-rich environments in schools for STEM to flourish.

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