

The Internet and teacher education: Traversing between the digitized world and schools

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ABSTRACT

In the face of rapid technological and economic developments globally, pre-service teacher education programs in the Asia-Pacific region are challenged to prepare teachers who are open to new ideas, new practices and information and communication technologies (ICT), to learn how to learn, unlearn and relearn, and to understand and accept the need for change. Extending Popper's (1978) framework of the three worlds – the physical world as World 1, the mental world as World 2, and the world of products of human ideas as World 3 – this paper examines how teachers may assume agency to mediate the tensions and opportunities between these worlds in order to chart possible developmental trajectories that may provide future directions for pre-service teacher education. With respect to the use of ICT for teaching and learning, pre-service teacher education programs are then expected to move pre-service teachers away from learning specific ICT application and towards learning how to learn, and more important, moving towards a commitment to constructivist-oriented teaching and learning practices.

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The rapid development of information and communication technologies (ICT), in particular web-based technologies and the Internet, has enabled more and more people to live in an increasingly interconnected world. The connection is more than just social in nature. More importantly, knowledge, ideas, and expertise are now easily linked and spanned to form new ideas and practices. The rate at which new ideas and consequently new products are created is faster than any individuals can handle. This key characteristic of the purported knowledge society inevitably challenges traditional notion of schooling. Many education researchers have argued that the premises of schooling have shifted and schools should be remodeled to fit the knowledge society (Bereiter & Scardamalia, 2006; Greenhow, Robelia, & Hughes, 2009; Jonassen, Howland, Marra, & Crismond, 2008; Sawyer, 2006). While the calls from these researchers have informed policymakers in many countries to equip schools with ICT and to provide teachers and school leaders with professional development, the shift towards constructivist-oriented pedagogies is still not a salient feature in school (Laurillard, 2008; Lim & Chai, 2008; Selwyn, 2008). Many teachers are still using ICT to support traditional teaching or are generally doubtful about the effectiveness of ICT to mediate teaching and learning practices.

Researchers have identified several interacting factors that may explain why ICT has not brought about pedagogical changes as

envisioned by policymakers. They may be categorized into exogenous/contextual or endogenous/personal factors. Assessment system, curricular structure, school policies and resources availability are common contextual factors, and teachers' skills, values, knowledge and beliefs are some personal factors that may encourage or hinder teachers' use of ICT in the classroom (Hew & Brush, 2007). Therefore, more effort has to be made to build the capacity of teachers and to support them to assume the role of change agents in the school context.

Drawing upon Popper's (1978) framework of the three worlds, this paper first identifies and examines the key competencies that beginning teachers need to take up the affordances of ICT to facilitate students' development of 21st century skills. The identification of these key competencies would then generate the implications for the design of pre-service teacher education programs. Popper's idea of the three worlds comprises the physical world as World 1, the mental world as World 2, and the world of products of human ideas as World 3. Analyzing the dilemmas that he faces from the tensions arising between these three evolving worlds, Teo (2009), an experienced teacher from Singapore reflects upon his identity in the demanding tides of reforms in the society vis-à-vis the school. Extending his work and that of Bereiter (1994), this paper examines how teachers may assume agency to mediate the tensions and opportunities among these worlds so as to chart some possible developmental trajectories that may provide future directions for pre-service teacher education. Fig. 1 is a visual representation of the adapted framework that guides the discussion for the rest of this paper.

In the following sections, we first describe World 1 where teachers operate in and World 3 where researchers and other knowledge

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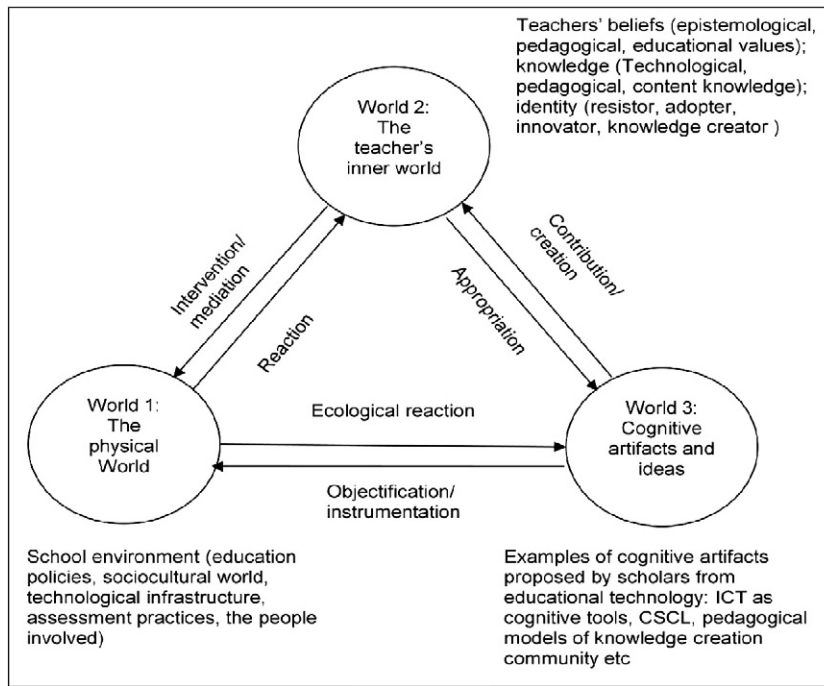


Fig. 1. The three interacting worlds of teachers.

creators generate ideas to change the “reality”. This is followed by the conceptualization of teachers' World 2 and our conjecture of how teachers may foster generative relations between these worlds. We then review current practices of pre-service teacher education for ICT use in the classroom and propose key principles of preparing pre-service teachers for the life-long process of professional development for ICT in education.

1. World 1: the physical world out there

The physical world in which the teachers work in is a multidimensional one. It includes people (for example, students, colleagues, school leaders, and parents), the sociocultural environment (education policies and assessment practices), and the rapid changing ICT environment; the latter has become the most salient feature of World 1 for today teachers. Most children and young people in Asia-Pacific countries, especially in the major cities, live, work, play, learn and communicate over the Internet. The speed and the ease of computation with spreadsheet applications such as Excel have made the manipulation of data accessible to school students. Digital recording media such as video camera, sound recorder and data loggers have made data collection easier and more reliable. Privileged information that was once hard to access is now becoming easily available over the Internet. Abstract concepts and phenomenon are made more accessible to children through visualization and animation. Young children may even be taught to create interactive models of natural/social phenomenon. These and many other affordances of ICT may be employed to support independent, flexible, collaborative, iterative and meaningful learning (Jonassen et al., 2008). These changes have also prompted many educators to reconsider key epistemological and pedagogical questions such as what knowledge is, what it means to know, how knowing may be measured/captured and how it should be nurtured. These questions have serious implications for the types of key competencies that teachers need and hence, on teacher education (Kirschner & Selinger, 2003; Lock, 2007).

Among the technological advancement, the Internet has been regarded as one of the most influential and transformative technology for teaching and learning (Leu, O'Byrne, Zawilinski, McVerry, & Everett-Cacopardo, 2009; Lee & Tsai, 2010). The continuous evolution

of Internet-based technology and its accompanying effects on all aspects of modern life has changed what students should learn, how learning should happen, where and when learning can happen. For example, the emergence of Web 2.0 technology has altered the notion of authorship and the relations between readers and writers in a fundamental way. Literacy has to be redefined to accommodate digital literacies (Leu et al., 2009; Mills, 2008; Myers, 2006). Authoring for the purpose of connecting with people, shaping and maintaining online identities, and sharing knowledge are becoming part of a learner's holistic development (Greenhow, Robelia, & Hughes). Enabled by online forum or conferencing applications, students may interact with experts who are working at the cutting edge of specific discipline who may be miles away from the students. Discussions may extend beyond classroom walls and curriculum time with possibilities of many-to-many communication mode. This challenges the traditional discourse structure of one teacher to many students, typically in the form of teacher initiates, students respond, and teacher evaluates (Chai & Tan, 2010). Pedagogically, ICT has made the construction of “knowledge” a viable approach of developing the creative ability of students. As existing knowledge is constantly challenged and recreated, ICT has made revisions of digitize cognitive artifacts a less tedious process, encouraging users to examine and explore ideas and create as many versions and variation as they choose to.

In short, the networked environment changes the teacher's World 1 significantly. Teachers in schools are charged with the professional responsibilities of facilitating the development of students so that the latter may be prepared to live and work in the fast changing society. As such, teachers cannot ignore these drastic and fundamental changes in World 1. Instead, they have to formulate responses that are congruent with their professional obligation. In the next section, we trace the rapid changes currently occurring to their roots.

2. World 3: the ideological world up somewhere

World 3, as conceptualized by Popper (1978), consists of the products of human minds. Popper includes airplane and the American Constitution as examples of World 3 objects. We have delimited World 3 object to cognitive artifacts and intangible ideas (Bereiter,

1994), which is a subset of Popper original's conception. When the ideas produced by man are concretized/objectified to become physical objects, we relegate them as part of the physical world; they become physical objects that teachers and students may interact with. In addition, when ideas are converted into physical objects, the objects are more or less cast in its form but the ideas behind the objects remain as improvable ideas for further refinement. World 3 in this paper refers to the improvable ideas that are essential for the continuous growth of the knowledge society (Bereiter, 2002). All things that are part of culture, in contrast to nature, originate from World 3. Prior to the digital age, the main tools for working on World 3 objects for its own involvement are what Vygotsky (1978) refers to as psychological tools such as language and symbols. The invention of the computers has now greatly enhanced human's work in World 3 due to the various affordances of computers that are designed to support and enhance human cognition. As World 3 objects are being physically objectified, they enter World 1 and interact with existing World 1 objects. As a result, there are ecological reactions that may provide important information for the improvement of World 3 ideas. The Internet has provided a public residence that may allow World 3 objects to be more available for teachers and students to participate in the process of improving them.

Other than ideas that have the potential to be converted into technological objects that change teachers' World 1, many ideas about how ICT may be employed to change classroom teaching and learning practices have also been created. These ideas include Dodge (1995) proposal of engaging students in web-based inquiry-oriented activities, Scardamalia and Bereiter (2006) proposal of engaging students in knowledge building community, and Jonassen et al. (2008) proposal of using ICT as cognitive tools to support meaningful learning. Jonassen (2000) explains how students may form intellectual partnership with ICT tools. Low level mechanistic cognitive tasks such as memorization, tedious computation, and record keeping may be dedicated to computers. Students then engage in higher order thinking activities such as theorizing, hypothesizing, and predicting. Jonassen et al. (2008) have documented myriad examples and studies of how different ICT applications may be employed as cognitive tools to support students' active and collaborative knowledge construction.

Scardamalia and Bereiter (2006), on the other hand, have provided many case studies on how students may engage in collaborative knowledge building in classroom communities. Students' efforts in dealing with authentic problems within the knowledge building community are supported by asynchronous multimedia databases named Knowledge Forum. Scardamalia and Bereiter's research indicate the possibilities of empowering young students to carry out creative knowledge work mediated by ICT. These pedagogical models are generally based on sociocultural theories of learning that perceive learning as an intra-mental and interpersonal process of interacting with the environment (Vygotsky, 1978). Many recent ideas such as distributed expertise, community of practice, activity theory and situated learning have provided the theoretical framework for ICT and web-based pedagogical models.

While education researchers continuously invent and refine pedagogical ideas that may bring forth more fruitful way of using ICT in classrooms, schools are generally lagging behind in adopting and implementing these ideas. Due to teachers' relationships with World 3 objects and their roles in mediating between World 1 and World 3, many educators recognize the importance of teachers' participation in the process of creating pedagogical ideas and models. The quality of such mediation by teachers pivots upon their World 2.

3. World 2: the inner world of the teachers

The inner/mental world of teachers is the phenomenological world that they experience the exogenous World 1 and World 3. This is an infinitely complex world that educational psychologists and learning

scientists are attempting to make sense of. We propose that the teachers' phenomenological world may be organized into two interacting dimensions of beliefs and knowledge. The beliefs and knowledge are sensitive to the sociocultural and political contexts (Chai, Teo, & Lee, 2009; Hammer & Elby, 2003), and teachers' decisions in terms of how they relate to World 1 and World 3 are determined partially by the existing meaning structure (which is a combination of their beliefs and knowledge) within them, and the moment-to-moment discursive decisions that the teachers make by exerting their epistemic agency.

Among the myriad beliefs that may influence teachers' use of ICT, we consider teachers' epistemological and pedagogical beliefs as core beliefs that warrant further attention. Education researchers recognize that epistemology is an important field of philosophy that examines critically the theories about the nature and justification of knowledge. Hofer and Pintrich (1997) proposed that the core construct of epistemic belief to be composed of "certainty of knowledge, simplicity of knowledge, source of knowledge, and justification of knowledge" (ibid, p.133). Individual epistemic beliefs are related to many constructs that are related to learning. These constructs include deep or surface approaches to learning, students' performance on controversial issues, self-regulated learning, Internet-based learning and etc (Braten, 2008; Brownlee, 2001; Mason & Boscolo, 2004). Given that the Internet is used widely by all who have access to it to search for information for a variety of purposes, Tsai (2008) points out the importance of employing the Internet not only as a cognitive and metacognitive tool but also as an epistemological tool. He emphasizes the importance of enhancing students' epistemological development by engaging them in questioning the epistemic value of the information found on the Internet. Chai (2006) study on teachers' epistemological beliefs suggests that teachers' epistemological beliefs are related to the depth of their discussion in Knowledge Forum. It is therefore important to enrich teachers' epistemological beliefs to use the Internet effectively for their own learning and teaching practices.

Studies have shown that epistemological beliefs are significantly related to teachers' pedagogical beliefs and their practices in the classroom (Chai & Khine, 2008; Ertmer, 2005; Hashweh, 1996; Samuelowicz & Bain, 2001; Wong, Chan, & Lai, 2009). These studies categorize beliefs along the continuum of traditional/transmissive approach and the progressive/constructivist approach. While teachers' epistemological beliefs are related to teachers' pedagogical beliefs, the latter is related to teachers' beliefs about the traditional or constructivist use of ICT in the classroom (Teo, Chai, Hung, & Lee, 2008). Sang, Valcke, van Braak, and Tondeur (2010) have also reported that teachers' constructivist beliefs and teachers' computer self-efficacy are predictors of teachers' willingness to use ICT. That is, teachers with constructivist-oriented pedagogical beliefs are more motivated to use ICT. The relationship between teachers' beliefs and how they use ICT in the classroom may or may not be a direct one. Lim and Chai (2008) report in their study that teachers' espoused beliefs may be different from their practice due to various reasons; one possible one may be teachers' knowledge.

Building on the notion of pedagogical content knowledge, education researchers have argued that integrating ICT into teaching and learning practices requires more than technological, pedagogical and content knowledge; these three forms of knowledge have to be integrated as Technological Pedagogical Content Knowledge (TPCK) (Angeli & Valanides, 2005; Mishra & Koehler, 2006). For example, a Mathematics teacher needs to understand the key concepts of statistic (content knowledge), operate Excel software (technological knowledge) and craft an authentic problem for a particular group of students (pedagogical knowledge) in order for him/her to engage students in ICT-enhanced problem-based learning. This form of knowledge is highly contextualized since the key concepts that the teacher should target, the type of ICT tool he/she should employ and the scenario or problems that the teacher should design to ensure authenticity are dependent on the teacher's understanding of World 1

that he/she works in. While Mishra and Koehler (2006) and Angeli and Valanides (2005) have advocated that engaging teachers in designing learning with ICT may build teachers' TPCK, So and Kim (2009) research indicates that it is not easy for pre-service teachers to design authentic and engaging problems. Constructivist-oriented teaching is less structured than traditional teaching and usually demands a higher degree of knowledge and skills for teachers to negotiate the challenges it poses (Windschitl, 2002).

While teachers' beliefs and teachers' knowledge may be separated conceptually, teachers operate as a person with general educational goals and specific objectives in real life. As such, we may subsume teachers' beliefs and knowledge, and other of their attributes, under the more encompassing construct of teachers' identity. In relation to the use of ICT, teachers can and do assume different identities. In the past, teachers have been characterized by educational technologists as obstinate resistor to change (Selwyn, Dawes, & Mercer, 2001). Recent studies however indicate that teachers generally are beginning to recognize the educational value of incorporating ICT into classroom teaching and learning practices (Hennessy et al., 2005). However, teachers are cautious and critical toward ICT in education; while they recognize that ICT skills are core skills for students' benefits in a world where technology is pervasive, they are reluctant to adopt ICT just for the sake of it (ibid).

Based on the research of the Apple Classroom of Tomorrow (ACOT) project, Sandholtz and Reilly (2004) delineate the five stages of ICT integration into the classroom. Table 1 provides the description of each stage of ICT integration. These stages were derived from the grounded theory perspective. They described what the teachers' concerns were and how teachers characterized their relationship with technology. Building on their work, we include a column on teacher's identity evolution to serve as a description of an ideal teacher development trajectory.

Constructivist-oriented teaching practices require teachers to be "practical intellectuals, curriculum developers, and generators of knowledge in practice" (Feiman-Nemser, 2001, p.1015). Engaging teachers in serious and sustained conversation in a learning community is necessary for such change to take place (ibid). The fulfillment of the trajectory described should be the joint venture of teacher educators and the teachers.

With this comprehensive understanding of teachers' activities with respect to these three worlds, implications may be generated to inform the design of pre-service teachers' ICT in education curriculum.

4. Considerations for ICT in education in pre-service teacher education

Based on the above review, it is clear that educating teachers to integrate ICT in their classrooms is a complex and messy task. Teachers are required to a) use ICT competently and manage the complexities of the ICT-enhanced classrooms (World 1), b) possess appropriate beliefs, TPCK and a sense of one's developing identity (World 2); c) appropriate pedagogical ideas and contribute to their

refinement (World 3). To develop this set of competencies, more than one course/unit is required in the pre-service teacher education program. Many pre-service teacher education courses on ICT are more inclined to focus explicitly on the first two worlds, with World 3 being neglected or implicitly addressed. In this section, we first summarize the key findings of a recent review of ICT courses for pre-service teachers and analyze the reviews based on our three world framework. The discussion will inform our proposed design for an ICT in education curriculum for pre-service teachers.

4.1. Review of existing ICT in education courses

The importance of ICT has prompted most teacher education institutes (TEIs) to conduct at least one introductory course on educational technology for pre-service teachers. Such course typically introduces constructivist-oriented teaching approaches supported by a range of ICT tools. Course delivery strategies include lectures, demonstration, hands-on, individual assignments, group work, and online communication (Kay, 2006). Constructivist-oriented approaches, such as problem-based, project-based and inquiry-based learning, are commonly advocated to foster pre-service teachers' understanding of the affordances of ICT for teaching and learning (see for example, Lee, Chai, Teo, & Chen, 2008; ; Lisowski, Lisowski, & Nicolai, 2006; Lock, 2007). To develop ICT in education competencies, reported activities include workshops, self-learning with TEI support, and peer coaching. As for the forms of learning, Haydn and Barton (2007) study indicates that pre-service teachers' "accounts of significant moments in their progress in using ICT related to seeing things modeled, face-to-face encounters, and working collaboratively with others, learning from each other." (p. 1030). Instructors/mentors' modeling and collaborative learning strategies are therefore important for building the capacity of pre-service teachers to use ICT in the classroom. As for assessing pre-service teachers' learning outcomes, two broad areas are reported. The first area pertains to the teachers' ICT competencies and their use of ICT in classrooms (World 1). The second area measures teachers' attitude and beliefs towards use of ICT and their pedagogical reasoning (World 2). Artifacts analysis, surveys, short argumentative or reflective papers and classroom observations have all been employed to assess teachers' learning. Generally, the evaluation of such courses reported in literature suggests that they enhance pre-service teachers' self-efficacy in using ICT for teaching and learning (see Kay, 2006; Lim, Chai, & Churchill, 2010). Analyses of pre-service teachers' performances show that they are capable of generating potentially fruitful ideas that may enhance students' learning (Dexter, Doering, & Riedel, 2006); implying that pre-service teachers have the potential to enrich World 3 ideas.

4.2. Design implications for pre-service teacher education program

The foregoing discussion highlighted two key challenges that teacher educators faced: (1) moving from learning specific ICT applications to learning how to learn, and (2) fostering deep commitment towards constructivist-oriented teaching practices. In the design of pre-

Table 1
Stages of instructional and identity evolution in ICT-enhanced classrooms.
Adapted from Sandholtz and Reilly (2004), p.491.

Stages	Teacher's Identity	Descriptions
Entry	Novice	Learning the fundamentals of using ICT; technical and pedagogical issues dominate
Adoption	Adopter	Successfully using ICT on a basic level in ways consistent with traditional teaching practices; teaching students to use computers
Adaptation	Routine user	Use ICT to increase productivity. More frequent and purposeful use, but little change in the didactic approach; more instructional software and open tools are being used
Appropriation	Integrated user	Can't live and work without computers; Use ICT "effortlessly" as a tool to achieve multiple job goals
Invention	Emerging innovator	Use ICT as a flexible tool in the classroom. Learning is more collaborative, interactive and customized; new teaching and learning practices emerge

service teacher education program, teacher educators have to address these challenges.

4.2.1. From learning ICT applications to learning how to learn

The first challenge is mainly due to rapid changes in World 1, Markauskaite (2007) and Lee et al. (2008) surveys reveal that while pre-service teachers generally possess basic ICT competencies such as working with word processor, presentation and e-mailing applications, they lack advanced ICT competencies such as those pertaining to producing multimedia and web-based resources. In addition, pre-service teachers generally perceive a strong need for the development of ICT competencies (Evans & Gunter, 2004; Lee et al., 2008). To thrive in World 1, pre-service teachers need ICT competencies to operate the technology. However, the fast changing technological world threaten the value of training pre-service teachers to use specific ICT applications. Also, there are simply too many applications in the market. It is thus important for teacher educators to identify applications that are likely to take root in the classroom and have good transfer value in terms of how the generic structure of the ICT application is being designed. We propose that essential types of software may include open tools (e.g. spreadsheet), learning management systems, and knowledge construction tools (e.g. concept mapping tools, wikis). The choice of tools may be grounded on the content to be taught. Assuming that the pre-service teachers have moderate ICT skills, further development of ICT skills would be exploratory in nature rather than following prescribed steps; that is, pre-service teachers are encouraged to explore various features of the software and create potential useful teaching and learning resources. This fosters pre-service teachers' capacity for learning how to learn. Instructor's intervention is opportunistic and just-in-time as it caters better to the diverse range of ICT competencies among pre-service teachers. Employing this approach, Lee et al. (2008) have reported significant gains in pre-service teachers' perceived general ICT skills.

4.2.2. Deep commitment towards constructivist-oriented teaching practices

The second challenge of educating pre-service teachers lies in changing teachers' beliefs and knowledge. Teacher educators generally realize that a single course focusing on ICT competencies and knowledge is unlikely to adequately prepare pre-service teachers for the use of ICT in classroom (Angeli & Valanides, 2005; Steketee, 2005). Markauskaite (2007), and Lee et al.'s (2008) study reveals that pre-service teachers are not as confident in their pedagogical competencies when planning and using ICT for teaching and learning. Therefore, the key challenge for teacher educators is how to accommodate the need for the development of ICT in education competencies and foster deep commitment towards constructivist-oriented teaching practices. Beliefs about teaching has been characterized as episodic, acquire through experience, deep rooted and difficult to change (Ertmer, 2005). Feiman-Nemser (2001) postulates a minimum of six months time for change in beliefs to occur.

Despite these challenges, many educators advocate the necessity of belief change for constructivist-oriented teaching to emerge (ibid, Darling-Hammond, 2006; Ertmer, 2005). Many teacher educators attempt to change teachers' beliefs by engaging pre-service teachers in constructivist-oriented learning (Dexter et al., 2006; Lim & Chan, 2007; Lock, 2007). While experience may help to build images of alternative learning approach, Dawson (2006) highlights that it is not the experience but reflections on those experiences that stimulate teachers' shift in beliefs. Research studies have also indicated that beginning teachers may revert to traditional teaching methods when supporting conditions are lacking (Cady, Meier, & Lubinski, 2006; Chai et al., 2009). To foster deep changes, we propose that pre-service teachers be given the opportunities to articulate their beliefs within a community (see also Darling-Hammond, 2006), which forms the starting point of the iterative processes of beliefs change.

Explicit approaches to scaffold belief development have been reported as being more effective than implicit approaches (see Lederman, 2007). In addition, it is insufficient for a single course to effect belief change. Darling-Hammond (2006) suggests that it should be a TEI-wide effort supported by a clear vision of what constitute good teaching, coordinated effort in delivering a coherent program, and intensely supervised practicum. Practicum or field experiences are generally viewed as authentic experiences for pre-service teachers to synthesize the theoretical knowledge through implementing the ICT-enhanced lesson they planned. In short, changing beliefs is necessary part of teacher education and it requires extensive effort and long term and skilful intervention from the teacher educators (Chai & Tan, 2009).

As discussed in the previous sections, most ICT in education courses for pre-service teachers do not explicitly address the relationship between pre-service teachers and World 3 (Angeli & Valanides, 2005; Lee et al., 2008; Lim & Chan, 2007). We propose this to be an area for future research and development in teacher education. It is clear that with the rapid advancement of ICT, new affordances of ICT for teaching and learning will emerge on a regular basis. However, affordances have to be perceived and taken up, and they are dependent on the experience and understanding of teachers about ICT, and teaching and learning (Norman, 1999). Teachers' contextual understanding of the sociocultural system of the school they are in; the students they are teaching and the content they are dealing with provide a unique situation for them to contribute to the refinement of ideas created by education researchers and software developers. In essence, teachers are the mediators who can bridge the gap between the World 3 objects and the World 1 reality. Without their inputs, many potential ideas and artifacts may not be adopted to enhance students' learning outcomes.

The form of activity that could help to engage teachers as innovators of practice and contributors to knowledge is generally known as collaborative inquiry (Darling-Hammond, 1996). The fundamental nature of collaborative inquiry is that the collaborators (regardless of whether they are researchers, veteran teachers, or pre-service teachers) adopt inquiry as their stance towards the innovations. For the teachers, adopting inquiry as stance implies that they are engaged in theorizing their teaching practices, analyzing and comparing personal theories with others' theory and research, and generating localized knowledge (ibid). In other words, the teachers are treated as active learners who are tasked to co-construct knowledge in a community based on their experiences. Collaborative inquiry is obviously congruent with constructivist teaching. It recognizes teachers as the key agents for change (Darling-Hammond, 1996) and accepts that they should be the producers of knowledge for the profession (Feiman-Nemser, 2001). It has been reported that collaborative inquiry foster change in beliefs that are conducive for constructivist-oriented teaching (Chai & Merry, 2006). In short, we are proposing that teacher education be conceptualized as a process of enculturating pre-service teachers to be knowledge contributors. That is, pre-service teacher education is more about knowledge production than learning (see Bereiter & Scardamalia, 2006).

5. Conclusion

This paper has started out by highlighting the more demanding role that teachers have to take on in today's schools; teachers are expected to be mediators and knowledge brokers and provide guidance, strategic support, and assistance to help students with diverse needs to assume increasing responsibilities for their own learning. There is indeed an urgent need to prepare teachers to prepare for these challenges in schools. Extending Popper (1978) framework of the three worlds – the physical world as World 1, the mental world as World 2, and the world of products of human ideas as World 3 – this paper has examined how teachers may assume agency to mediate the tensions and opportunities between these worlds. By doing so, this paper has charted possible

developmental trajectories that may provide future directions for pre-service teacher education programs with respect to the use of ICT: (1) moving from learning specific ICT applications to learning how to learn, and (2) fostering deep commitment towards constructivist-oriented teaching practices.

Pre-service teacher education programs then have to provide the opportunities for pre-service teachers to examine and change their underlying beliefs about teaching and learning. However, even if the beliefs of pre-service teachers have been successfully shifted towards a more constructivist one, the question is whether it will necessarily bring about transformation in their classroom practices. When these pre-service teachers enter the real world as classroom teachers, the school culture or/and the pressures of being a practising teacher may nurture or destroy their constructivist pedagogical beliefs. A supportive environment is indeed an important factor in fostering constructivist practices amongst teachers. In such an environment, teachers' beliefs about teaching and learning are likely to be reinforced by the consensus of their professional peers and by the expectations of students in their classrooms. At the same time, the professional learning of teachers is a continuum from pre-service through to induction and in-service. The pre-service teacher education program should not feel pressurised to overload the curriculum in order to prepare graduates who are fully competent when they first walk through the school gate. The program through the university or teacher education institution should instead work closely with schools, and public and private organizations to build the competencies of teachers at each stage of their career.

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