Teachers' Professional Development in a Computer-supported Collaborative Learning Environment: A Descriptive and Interpretive Enquiry

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Abstract

The Masterplan II for IT in education launched by Singapore's Ministry of Education demands the adoption of a student-centred and constructivist oriented pedagogy. This study adapted the Knowledge Building Community (KBC) as a professional development model for teachers to develop the necessary competencies and beliefs for the reform. A computer-supported collaborative learning (CSCL) environment supports the adapted Teacher Knowledge Building Community (T-KBC). It is based upon social-cultural views of learning, recent theoretical developments in teacher education and adult learning theories. A qualitative case study approach was adopted to study the teachers' experiences of the T-KBC. Content analysis of the postings indicated that the teachers participated fairly actively in online knowledge building and they formed a socially cohesive community. The moderately sustained online discussion was developed to some depth. The teachers were interviewed for their beliefs about epistemology and pedagogy and these data were analyzed along with their reported experiences of the T-KBC. They reported a range of epistemological beliefs that varied along the relativist continuum. Their reported beliefs and practices of teaching and learning appeared to be related to their epistemological beliefs but they were mediated by their beliefs about the school contexts. The teachers' online participation fits their reported beliefs to some extent. Regardless of their beliefs, the teachers seemed rather satisfied with their learning and teaching experiences in the T-KBC. They reported changes in their views about students as knowledge constructors. However, they perceived that the time constraints caused by the curricula and the examinations would hinder them from implementing the reform. The findings apparently provide supports for emerging theories about learning, teacher professional development and claims about the affordances of CSCL. It seems that the T-KBC is a viable model for preparing practising teachers for the types of classroom learning that the reform is targeting. However, other systemic changes are needed.

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Abbreviations

CMC	Computer-mediated communication
CSCL	Computer-supported collaborative learning
INSET	In-service teacher education and training
ICT/ IT	Information and Communication technology/ Information Technology
KBC	Knowledge Building Community
KF	Knowledge Forum™ (An asynchronous communication platform)
MOE	Ministry of Education
MP 1	Singapore's Masterplan for IT in Education (1997-2002)
MP 2	Singapore's Masterplan II for IT in Education (2003-2008)
PD	Professional development
T-KBC	Teacher Knowledge Building Community
TPD	Teacher professional development

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Chapter 1

Introduction

This study aims to describe and interpret the data obtained from a group of teachers who participated in three professional development modules that were been designed to develop teachers' competencies and dispositions toward facilitating student-centred learning in a computer-supported collaborative learning (CSCL) environment. Research in this area is aligned to the current interest in the use of CSCL for teaching and learning. Through qualitative case study (Merriam, 1998), this study hopes to provide insights into the characteristics of teachers as knowledge builders and their development in a computer-supported knowledge building community. Furthermore, it could contribute to the knowledge of how to facilitate teacher's change processes for educational reform and teaching and learning in a CSCL environment in general.

Background of the study

The emergence of the knowledge-based economy has resulted in educational reform in many developed and developing countries across the world (Day & Sachs, 2004). Underlying this worldwide reform effort in education is the recognition that for any nation to stay ahead and remain competitive in the economic league table, there is a need to cultivate knowledge workers with high standards of academic achievements (Drucker, 2001). However, the meaning of achievements in the knowledge society is no longer confined to scoring good grades in specific subjects such as Mathematics or Science. Nowadays, it necessarily includes critical and creative thinking dispositions and the ability to collaborate productively in team settings to add value to the existing cultural artefacts (Bereiter, 2002a; Johnson, 2002).

Singapore, like many developed countries, has been compelled to explore the difficult terrain of educational reform. Its student population has already attained a high level of academic achievements as measured by several international studies (for example, see MOE,

2004a; Borja, 2004). However, there seems to be also consensus among Singapore educators and policy makers that students are lacking in the critical, creative and the collaborative dimensions of knowing. This recognition is reflected in a series of reform initiatives that the Ministry of Education has implemented since 1997. The overarching goals that guided the initiatives were articulated in the Thinking School, Learning Nation (TSLN) vision (MOE, 1997a). In support of the TSLN, several initiatives have been implemented over the years. These included the first Masterplan for IT (MP1) (Information Technology) in Education (MOE, 1997b); the inclusion of Project Work (MOE, 2001); the subsequent Masterplan for IT in Education (MP2) (MOE, 2002) and more recently, the "Strategies for Active and Independent Learning" (MOE, 2004b) and the Innovation and Enterprise initiative (MOE, 2004c). From the titles of these initiatives alone, it seems plain that the Singapore government is determined to cultivate a generation of knowledge workers who could thrive in the knowledge-based economy. One of its prime means is through the incorporation of information technology in the schools (see also Mahizhnan, 2000; Looi, Hung, Bopry, & Koh, 2004; Luke, Freebody, Lau, & Gopinathan, 2005).

The first Masterplan for IT in education successfully provided an admirable IT infrastructure to all schools in Singapore. Singapore schools have one of the world highest rates to Internet access and lowest computer-student ratio. The 30-50 hours of training in core IT skills had also equipped most teachers with the basic IT competencies such as sending email, surfing the Internet and using word processor and presentation tools (MOE, 2004d). However, it has also been argued that the achievements of the first Masterplan are insufficient for changing schools and teachers' practices (Lim, 2003; Koh, 2004). Such gaps between the policies and the realities of classrooms are commonly reported in literature (for example, see OECD, 2001; Demetriadis et al., 2003; Becta, 2005). The recognition that classroom practices need to be developed further underlies the key foci of the MP2. For

example, MP2 envisions the classroom for tomorrow to be one in which technology is integrated seamlessly into teaching and learning. The teachers of future classrooms are professionals who can make use of a range of IT and non-IT tools meaningfully to facilitate student-centred learning (MOE, 2002; Williams, 2003). The vision of MP2 is encapsulated in the conception of Engaged Learning (Jones, Valdez, Nowakowshi, & Rasmussen, 1995). It aims to develop passionate and intentional learners who can work collaboratively with others. To cultivate learners with the desired dispositions, complex and authentic problems need to be given to the learners to challenge them. This creates a need for the learners to be engaged in working in groups to build knowledge and solve problems collaboratively. In short, it encourages learner-centred and constructivist-oriented learning. The critical role of information technology in realizing its goals includes engaging learners through authentic representation or virtual reality; enabling collaboration through computer-mediated communication; and supporting complex thinking through using computers as mindtools (Jonassen, 2000).

Underpinning the vision of MP2 are emerging theories of learning and teaching that treat knowledge not as transmittable mental entities but as artefacts constructed by individuals or groups of learners within a multi-dimensional context. Adopting the constructivist pedagogy would imply that teachers who are used to the didactic approach need to make some substantial changes in their teaching practices. The learning curve is predictably steep and teachers may resist such change (Selwyn, Dawes, & Mercer, 2001; Galanouli, Murphy, & Gardner, 2004). Furthermore, teachers may not be familiar with such theories and they may not even agree with the epistemological assumptions embedded within the theories. They need to develop an adequate understanding about constructivism and "an epistemology of classroom learning that is congruent with constructivism" (Windschitl, 2002, p.142) to avoid the pitfalls of naïve constructivism (Prawat, 1992) or shallow constructivism

(Scardamalia & Bereiter, 2003). In considerations of the dilemmas that teachers may face, Windschitl (2002) recommends that efforts for promoting constructivist practice should explicitly target at changing teachers' epistemology.

A CSCL environment that emphasizes collaboration among learners for the co-construction of knowledge seems to be one form of technology that supports the reform efforts characterized by the notion of Engaged Learning. This study posits that the Knowledge-building Community (KBC), a pedagogical model that employs a CSCL environment named Knowledge Forum™ (KF), could advance the course of MP2 and other reform initiatives grounded broadly in the social-cultural perspectives of education. However, implementing CSCL, as in implementing other forms of IT, is a complex process (Pelgrum, 2001; Laat & Lally, 2003). It involves addressing teachers' personal theories about teaching and learning; their concerns about their personal well being, task management issues and the potential impacts on students (Hall & Hord, 2001; van den Berg, 2002). This is coupled with the difficulty of fostering collaborative learning in contemporary schools (Stahl, 2002; Arvaja, Hakkinen, Rasku-Puttonen, & Etelapelto, 2002). Hence, the need for continuous efforts to develop professional skills of teachers is obvious for the achievement of the aims set out in MP2.

Statement of the Problem

Generally, reform-oriented pedagogies such as "Engaged Learning" as proposed by MP2, recast the role of teachers to that of facilitators rather than that of transmitters. Taking on this form of student-centred teaching requires the teachers to be "practical intellectuals, curriculum developers, and generators of knowledge in practice." (Feiman-Nemser, 2001, p.1015). It requires the teachers to make substantial, multi-dimension changes. Other than acquiring the technical skills, teachers need to work through the messy process of integrating the technology into classroom teaching and learning (Zhao, Pugh, Sheldon, & Byers, 2002).

This involves substantial sense-making such as designing activities that are important for the subject matter in a computer-based environment as well as organising and managing the students in such an environment. Recently, researchers have also highlighted the need to change teachers' deeply rooted beliefs about teaching and learning (Ertmer, 1999; Albion & Ertmer, 2002) and their related beliefs about technology (Russell, Bebell, O'Dwyer, & O'Connor, 2003). However, facilitating teachers' epistemological development is usually not the focus of teachers' education (Hofer, 2001; Deng, 2004). Traditional teacher development programmes are usually shallow and fragmented. Teachers usually do not report these disconnected one-shot session targeting at skills development in a positive light (Hawley & Valli, 1999). They do not engage teachers in serious and sustained conversation necessary for teachers to change (Feiman-Nemser, 2001). Neither do they provide the necessary supports for teachers to negotiate the complex terrain of reform. They are considered weak interventions that could hardly counter the effect of teachers' own schooling and their on-the-job experience (Ball & Cohen, 1999; Day & Sachs, 2004). As teachers are the key to the success of reform (Sprinthall, Reiman, & Theis-Sprinthall, 1996; Fullan, 2001; Borko, 2004), there is a need for teacher educators and researchers to innovate professional development for teachers.

Purpose of the Study

This study aims to design an appropriate professional development model in a CSCL environment. Subsequently, it will investigate how teachers experience learning and teaching in the CSCL environment and how such experience facilitates teachers' development. It posits that through providing experiential learning (Kolb, 1984) in a CSCL environment structured as a knowledge building community (KBC) (Scardamalia & Bereiter, 1996), practising teachers could develop some competencies and dispositions that help them to become better facilitators for student-centred learning.

The Significance of the Study

This study may contribute to the development of CSCL and the field of teacher professional development in several ways. First, it may contribute by providing detailed description of how collaborative knowledge building leads to new knowledge or understanding among participants (Stahl, 2001). This is a key question that needs to be addressed, given that evidence of CSCL leading to better learning outcomes is still lacking (Lipponen, 2002). Second, as an emerging field of educational technology, studies in a variety of contexts are necessary for the development of CSCL. Teacher training and their adaptation to CSCL classroom implementation is one such context (Van Aalst & Chan, 2001). Third, most studies of teachers' adaptations to CSCL were conducted in the context of western societies and they focused on pre-service teachers (for example, see Lamon, Reeve, & Caswell, 1999; Woodruff & Brett, 1999). There is therefore a need to study how teachers in the Asian context view CSCL. Preliminary study in the local context suggested that there is a need to design and develop a comprehensive PD model to help practising teachers in using CSCL meaningfully (Chai, Tan, & Hung, 2003). The teachers need to develop skills in scaffolding students' inquiries and managing group processes. They also need to re-examine their assumptions about teaching and learning.

This study is also supported by recommendations made by local studies related to teacher development for IT integration. For example, Wettasinghe (2002) studied the types of changes and the causes of change among primary school teachers in Singapore with the implementation of MP1. Her research indicated that Singapore teachers had experienced substantial changes of varying degrees due to the IT-related policies that were initiated top down. She recommended that there is a need "to look deeper into the possibilities of using technology as part of CPD (continuing professional development) for teacher-technology training." (p.68). Other studies in the same areas also pointed out the need for further effort in

teacher development. Cheong's (2001) study indicated that IT integration is a complex process. He recommended collaboration and interaction with colleagues as one main component of the PD structure. Sin's (2002) research suggested the need for teachers to be adept in constructive and collaborative teaching practices besides the necessary technical competencies. She also pointed out that teachers also would need to be active participants in the design and development processes for innovations in teaching to be effective. From the perspective of policy and management, this study could also advance knowledge on change management (Tan, 2002).

Research Questions

The following research questions will guide this study.

1. How do teachers build knowledge collaboratively in a KBC?
2. What are the teachers' reported epistemological beliefs and their reported beliefs about computers in education?
3. How do teachers reportedly perceive teaching and learning in a KBC?

These questions are interrelated. The first question will investigate how the teachers interact to build knowledge. Using Gunawradena, Lowe and Anderson's (1997) model of interaction analysis, this study will examine the meaning negotiation and co-construction of knowledge that occurred online. It also aims to provide some accounts of how knowledge building happens, which is an identified gap in the literature of CSCL (see above). The second question studies the teachers' beliefs about knowledge and knowing; teaching and learning and their beliefs about IT in education, which are important areas of study that need further research (Schraw & Olafson, 2002; Albion & Ertmer, 2002). Together with the first question, the accounts generated will serve to ground the present researcher's understanding of the teachers' perceptions of what teaching and learning in a KBC mean to them, which is the third question. The focus on teachers' experience is because how teachers experience new

forms of teaching and learning is an often neglected but important problem that should be addressed in changing practices (Pring, 1999). Goodson (2003) argued that neglecting teachers' perspectives could undermine new initiatives since they are central in implementing the initiatives. The third question will also find out about the perceived changes as reported by the teachers resulting from the experiences.

Definition of Terms

The focus of this study is on the use of CSCL for teacher professional development. This thesis uses the term CSCL to refer to learning environments supported by computer-mediated communication (CMC) for the purpose of collaborative learning. Typical examples of such CSCL environments include the Knowledge Forum™ (KF), Belvedere, and CoVis (see Lehtinen, Hakkarainen, Lipponen, Rahikainen & Muukkonen, 1999). In the literature, examples of intelligent tutoring systems and software simulations that helped to anchor face-to-face discussion were also included as forms of CSCL environments (see Koschmann, 1996; Koschmann, Hall & Miyake, 2002). These applications may or may not involve the use of CMC. It seems that any computer applications that are structured to support collaborative learning can be classified as a CSCL environment. For this study, as the platform used involves mainly CMC for the support of collaborative learning, the term CSCL is confined to such applications. However, the employment of CMC need not necessarily imply that teaching and learning occur exclusively online. In this study, the KF platform is employed during the face-to-face sessions and beyond them. In other words, the professional development activities are conducted in a blended environment.

Another term that requires some definition is teacher professional development (TPD). Synthesising from Day (1999) and Kelchtermans (2004), TPD refers to the processes that lead to changes in teaching practices and teachers' thinking about the practices. These changes should enable teachers to achieve the goal of teaching in better ways. They are the

results of meaningful interaction between the teachers and their contexts; both the natural contexts as in the school contexts that the teachers happen to be in, and the designed contexts as in professional developments activities organised formally for teachers learning. It is important to note that the designed contexts derive their meanings from the existing natural contexts. TPD can therefore only be understood in relation to the teachers' life and the complex education environments that they are in.

Structure of the Thesis

This thesis consists of six chapters. The first three chapters are the Introduction, the Literature Review and the Methodology. The findings in this thesis are separated into two chapters. Chapter Four reports the findings generated by the content analysis of the online interactions. Chapter Five documents the experience of the participants. Relevant discussion about the findings will be detailed in these respective chapters. The last chapter draws out the conclusions and the implications of this study and future directions for research. Before moving on, the personal background and possible biases of this researcher is made explicit in the next section.

The Researcher

I grew up in a traditional learning environment in which teaching was almost exclusively conducted through the transmission model. This was true even during my undergraduate days, when I studied Chinese Literature in the National University of Taiwan. I did very well in the traditional learning environment that assessed the learners mainly through examinations. This helped me to obtain an undergraduate scholarship offered by the Singapore Ministry of Education. My personal learning history did not help me to raise questions about the transmission mode of instruction. To date, I still hold the view that there are some merits in the traditional approach.

After graduation, I attended postgraduate diploma courses to obtain my teaching qualification. I taught for seven years in a secondary school, first as a subject teacher and later as a Head of Department. It was during the years that I served as head when the first IT masterplan was implemented. I had trouble understanding the initiative and leading the other teachers in the change. We were quite lost and did whatever we could to fulfil the administrative requirements such as spending 10% of curriculum time in the computer laboratories. I saw older teachers suffering or opting for early retirement, partly due to the technological demands. This experience prompted me to take up a Master's Degree specializing in instructional design and technology. I believe my school experience has influenced me to adopt a more sympathetic stance towards schoolteachers struggling with IT in the classroom.

My first encounter with the ideas of constructivism and social constructivism was in 1999 when I started my Master's courses. I was doubtful about this approach. Lacking experience of learning in the constructivist/ social constructivist paradigm, it was difficult for me to comprehend the subtleties involved initially. However, as I progressed through my Master's courses, I was more convinced of its potential usefulness in education, in particular, adult education. This view is strengthened by my experiences in teaching adult learners after I resigned as schoolteacher. From 2001 onwards, I began to teach several in-service courses and I applied some of the constructivist ideas such as engaging the teachers as collaborators in defining the problems they faced in integrating IT into the classrooms and struggled together with them to explicate the issues and formulate the solutions. My personal transition from didactic teaching to facilitating learning was by no means comfortable. There were times when I had to consciously make an effort not to teach. Didactic teaching appeared more direct and easier to handle. Fortunately, the external evaluation of the courses helped to strengthen my belief in the merits of the collaborative inquiry approach and the usefulness of

asynchronous communication in supporting PD for teachers. I began to formulate this study in the context described above.

Chapter Two

Literature Review

In chapter one, the researcher discussed the global and local evolving educational phenomena that had necessitated teacher professional development. This chapter reviews the relevant theories and empirical studies on teachers' learning and development in the area of IT integration. As CSCL is an emerging IT tool that is relatively new and has not been widely implemented in classrooms (Van Aalst & Chan, 2001), it is therefore necessary to draw from the general studies on classroom implementation of IT. The review provides support for the design of the Teacher Knowledge Building Community (T-KBC) and the foci of this study. The literature review also sensitizes the researcher to the significance of events that occurred in the T-KBC and the teachers' accounts of their experience. It helps the researcher to link the findings of this study to the broader literature.

The review is made up of five main sections. Factors or conditions that facilitate or hinder IT integration and the conceptual frameworks that organize the interacting factors form the first part of the review. This is followed by an outline of constructivist teaching in IT-enriched environment. Together, these two sections map out the complex terrains that teachers need to negotiate when implementing IT in classrooms. Studies on epistemological beliefs in general and teachers' epistemological beliefs in particular are then reviewed in the third section to provide directions for this study. The gaps between the reform visions and classroom realities are purportedly resolved through professional development activities. Promising approaches in bridging the gaps are therefore reviewed in the fourth section. In the last section, CSCL research, with specific focus on the KBC model and its underlying theoretical foundations, are synthesized with relevant learning theories to demonstrate how it could serve as a workable form of TPD.

Challenges of Integrating IT into Teaching and Learning

Integrating IT into classroom teaching and learning has been viewed by many educators as a means to changing the traditional didactic approach that prevails in classrooms. These educators believe that the affordances of computers free the learners from performing mundane tasks such as tedious and mechanical calculation, revising documents and keeping records to focus on tasks such as generating hypotheses and testing them (see Koschmann, 1996; Lajoie, 2000; Jonassen, 2000). Many countries are investing huge sums of money to build the necessary infrastructure and raise their teachers' level of IT competencies (OECD, 2000; Hung, 2003; Ofsted, 2004). The fiscal provisions and training seem to have produced positive impacts on the technological infrastructure of schools and teachers' competence and confidence in using computers (Wettasinghe, 2002; Ofsted, 2004; MOE, 2004c). There are also some claims that IT is influencing students' learning outcomes positively (Roschelle, Pea, Hoadley, Gordin, & Means, 2000; Becta, 2005; MOE, 2004c). Despite these positive indications that IT in education is making a slow but steady progress, integrating IT into classroom is still largely recognized by many researchers and teachers as a complex and problematic process (Roschelle et al., 2000; Zhao et al., 2002; Hung, 2003; Hennessy, Ruthven, & Brindley, 2005). Factors influencing teachers' effort in integrating IT can be broadly classified as contextual conditions and personal conditions. In the following paragraphs, these facilitating or constraining conditions are elaborated.

Contextual factors that facilitate or constraint IT integration

A number of contextual conditions arising from teacher's work context are influential in determining the level of IT integration within a school context. These include time, access, resources and support (Leggett & Persichitte, 1998; Galanouli et al., 2004; Fox & Henri, 2005). Among these factors, time seems to be the most commonly reported factor that hinders effective integration (ibid; OECD, 2001). The teaching profession has been

characterized as one of the most time consuming and labour-intensive jobs (Roblyer, 2003). Demand on teachers' time is already great in their routine teaching. Integrating IT requires teachers to learn to function in a new and ever changing technical environment. This is usually coupled with the constructivist way of teaching which is likely to be another unfamiliar territory. To prepare an effectively IT integrated lesson, teachers have to source for information, plan orienting activities, rules and procedures, preview materials and test the equipment. These are time-consuming activities that intensify teachers' perception of time constraint (Goodison, 2003; Lim & Chai, 2004). It is therefore not surprising to hear teachers expressing their dissatisfaction in this aspect (Earle, 2002; Galanouli et al., 2004). An alternative interpretation of this perceived time constraint could be that the teachers themselves lack motivation or interest in learning the new skills. In other words, time constraint maybe an excuse at least for some teachers who are not technically inclined. This perception could also be a syndrome of deeper problems such as low teacher to students ratio or teachers' scepticism towards use of IT.

Access and resources available are also issues that could facilitate or hinder teachers' development for IT integration. Recent studies have reported that schools in the United Kingdom, North America and Singapore are now better equipped in terms of computers to pupil ratio and the instructional software that schools have (MOE, 2004c, Bushweller, 2004; Ofsted, 2004). However, many teachers still face the problem of gaining easy access to the facilities. One emerging problem is the decision with regards to where the computer should be placed (Tiene, 2002). Centralizing the computers in designated laboratories usually requires teachers to book the laboratory. This means that access is not guaranteed. When such arrangement is coupled with designated periods for teacher to bring the class for work on the computer, it may result in inappropriate use. Putting the computers in the classrooms provides easy access but it would require teachers to adopt a station-based learning strategy

since the limited classroom space can only accommodate a few computers (Roblyer, 2003). As resources are limited, it seems that whichever approach being adopted, there are always others who are denied the access. Another emerging dimension of the problem with access is that of digital divide (OECD, 2001; Bitter & Pierson, 2002). Student's access to computers and the Internet at home is becoming a concern to teachers who want to assign students to research or discuss issues online as homework. When some students, even if it is just a few, do not have access to computer and network at home, the assignment inevitably leads to inequality.

Support is an important facilitating condition that can enhance teacher's willingness to use and experiment with technology. School leaders who are able to provide vision, reward innovation and model the use of technology can greatly support and encourage the teachers (Baylor & Ritchie, 2002). It is also necessary for school leaders to align and realign policies so as to address teachers and students' evolving needs. Peer support in terms of sharing of ideas, collaborative problem solving and peer coaching has also been found to help teachers in moving forward (Sandholtz, Ringstaff, & Dwyer, 1997; Bitter & Pierson, 2002; Galanouli et al., 2004). Technical support in terms of having a computer technician to help teachers in solving hardware and software problems could help teachers to focus on teaching rather than solving students' technical problems (Sandholtz, 2001; Lim et al., 2003).

The review above has identified four broad contextual factors that could hinder IT integration into classroom teaching and learning. Each factor, taken alone, constitutes significant challenge to the teachers. In the school context, these factors usually interact dynamically, complicating matters for the teachers. When the factors that are directly related to the teachers are considered, the challenges pose by reforming schools as envisioned by MP2 become more complex. The teacher related factors are reviewed in the next section.

Teacher attributes that facilitate or constraint IT integration

Teacher attributes that affect IT integration can be loosely classified into two broad categories. They are the skills and knowledge category and the attitude and beliefs category. These categories also interact dynamically. The relevant literature in these areas is discussed in the following paragraphs.

In an international survey, Pelgrum (2001) identified teacher's lack of knowledge and skills about IT as a major obstacle to the integration of IT into classroom. To reform teaching practice with IT necessarily means that teachers have to learn how to operate the computer and some of its peripherals. This in itself is not easily achievable and requires constant updating as new operating systems and programmes emerge. This fast-changing characteristic of IT makes skills acquired quickly obsolete, thereby intensifying the learning needs for teachers. Incidentally, in Pelgrum's study, Singapore teachers were the best trained. However, that does not mean that the gaps in understanding and skills have been filled. Acquisition of technical skills is a necessary but insufficient condition for meaningful use of technology in the classroom (Lim & Tay, 2003, Goodison, 2003).

For effective integration to happen, teachers need to have adequate understanding about the affordances and limitations of the IT equipment (Vrasidas & McIsaac, 2001). IT tools can serve different roles depending on the learning problems that students encounter (Chen & Hung, 2003). It could function as an informative tool such as the use of electronic encyclopaedias and the Internet when information is needed. It could also function as a constructive tool or social constructive tool. An example for the former would be students constructing websites that help them to connect their knowledge about certain subject matter. CSCL applications would be a good example for the latter. Matching students' learning problems with appropriate IT affordances, thereby enhancing students' learning constitutes the pedagogical dimension of IT integration that teachers need to know. Without adequate

understanding of this dimension, teachers cannot reap the full potential that technology has to offer (OECD, 2001). Instead, teachers may assimilate IT into their existing practice and treat integration as the bolting-on of IT to routine activities (Lim & Hung, 2003). Haynes et al. (2004) reported a similar tendency among academic staff in higher education to employ IT in support of their existing practice. This implies that for teachers to exploit the affordances of IT effectively, they need to reconceptualize themselves as instructional designers who are capable of diagnosing students' learning problems and matching them with the appropriate affordances offered by a range of IT tools (Hoogveld, Paas, & Jochems, 2003).

Other areas of pedagogical skills that teachers need to cultivate in an IT enriched environment include that of classroom management and facilitation skills (Wong & Wettasinghe, 2003; Hogan & Pressley, 1997). This is especially true when the lesson is carried out in the computer laboratory which usually adopts a student-centred approach. Given the conditions of many expensive and potentially distracting computers around and that students can be over excited about IT-based lesson, teachers need to think about the additional provisions required in terms of disciplinary measures (Lim, Pek, & Chai, accepted). They also have to carefully design orienting activities such as providing worksheets to focus students' attention and facilitate students in understanding the subject matter (Lim & Chai, 2004).

Another category of teachers' attributes that could contribute to successful IT integration pertains to that of attitudes and beliefs. As the beliefs portion is more complex and requires a separate section to deal with, the following paragraph will report only on teachers' general attitudes towards IT in education.

In the past, teachers have been characterized by educational technologists as obstinately resistant to change (Sandholtz et al., 1997; Selwyn et al., 2001). Recent studies however indicate that teachers generally are beginning to recognize the educational value of

incorporating IT into classroom learning (Demetriadis et al. 2003; Hennessy et al., 2005). However, they also adopt a cautious and critical attitude toward IT integration. It seems that most teachers welcome IT and they understand very well that IT skills are core skills for students' benefits in a world where technology is pervasive. Despite that recognition, they are unwilling to adopt IT into teaching and learning just for the sake of using it (Galanouli et al., 2004; Hennessey et al., 2005). Although teachers' openness to change is positively related to teachers' IT competency and its integration in classroom teaching (Baylor & Ritchie, 2002), it seems that to view teachers' resistance simply as a barrier is over simplistic. Silin and Schwartz (2003) proposed that an alternative perspective is to see teachers' resistance as an indication of the salient dilemma that needs to be studied.

In summary, teachers need to be knowledgeable and skilful both in terms of the technical and the pedagogical dimensions. Teachers' openness toward change and positive attitudes toward technology also seem to be positively related with the level of IT integration in their classrooms. In the next section, several conceptual frameworks that help researchers to make sense of how the contextual and subjective factors interact dynamically in the cultural processes of technology infusion into schools (Demetriadis et al., 2003) will be discussed.

Conceptual Frameworks for the Study of IT Integration

The conceptual frameworks that have been used for the study of technology infusion processes in schools and those that were generated based on grounded theory seem to cover more or less the two broad categories mentioned in the previous section. The differences lie in the focus of the study. It can either describe and analyze the IT infusion process using the teachers as the focus or adopt a broader unit of analysis where the teachers become part of an interactive and dynamic system. In the following paragraphs, relevant conceptual frameworks will be reviewed.

Based on the research of Apple Classroom of Tomorrow (ACOT) project (Sandholtz et al., 1997), Sandholtz and Reilly (2004) delineated the five stages of IT integration into classroom. Table 1 provides the descriptions of each stage with some details. These stages were derived from the grounded theory perspective. They described what the teachers' concerns were and how teachers characterized their relationship with technology.

Table 1

Stages of Instructional Evolution in Technology-Rich Classrooms

Stages	Descriptions
Entry	Learning the basics of using technology; technical and classroom management issues dominate
Adoption	Move beyond struggling with technology to successfully using technology on a basic level in ways consistent with existing teaching and learning practices; teaching students to use computers
Adaptation	Move from basic use to using technology for increased productivity. More frequent and purposeful use of technology, but little change in the didactic approach of lecture, recitation and seatwork practices; more computer-assisted instructional package and open tools like databases are being used
Appropriation	Change in attitude towards computer; Can't live and work without computers; Use technology "effortlessly" as a tool to accomplish instructional and management goals
Invention	Use technology as a flexible tool in the classroom. Learning is more collaborative, interactive and customized; new teaching and learning practices emerge; Teachers pleasantly surprised by students' learning with computers

(Adapted from Sandholtz & Reilly, 2004, p.491)

Although Sandholtz's delineation seems helpful for understanding IT integration, it was derived from grounded theory perspectives in a context where the teachers were volunteers in a well-supported environment. Another similar and well known framework for the study of changes or innovation in education in general is the concern-based adoption model (CBAM). Conceptualizing the emotions and the thinking of teachers going through

such changes as concerns, Hall and Hord (2001) postulated seven stages that teachers would move through. The concerns progress from learning and considering personal implications to managing the tasks to considering the impact on clients and organisation. Sandholtz's stages seem to be parallel to that of Hall and Hord in its direction of development.

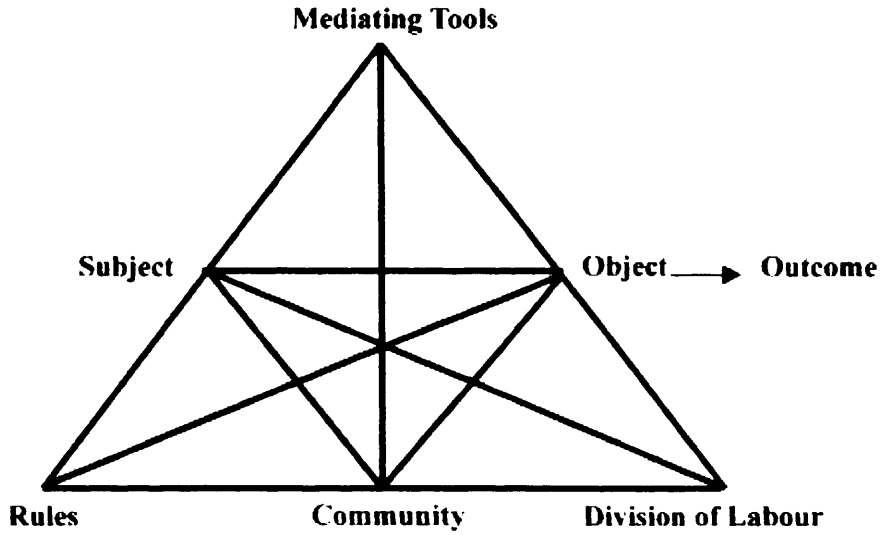
Using the CBAM, Tsu (2000) surveyed teachers from four Singapore schools and reported that most of the teachers surveyed were non-adopters. They were also generally sceptical about the impact of IT integration. However, it seemed that teachers with higher level of computer literacy were more likely to adopt IT. The alternative explanation could be that the more willing teachers were the ones who spend more time in acquiring IT skills. Tsu's findings were less positive than recent studies done by Wettasinghe (2002) and Sin (2002). His study reported teachers' concern at the early stage of MP1. As he suggested that literacy level is positively related to adoption (see also Becta, 2005), and given that technical skills training has been widely provided (Pelgrum, 2001), the trend seems to be that teachers are moving into the adopter stage.

Zhao and Cziko (2001) studied teachers' adoption of ICT from the perspective of Perceptual Control Theory. Viewing teachers as goal-directed agents, they proposed that teachers would adopt technology if they perceive it as beneficial in terms of helping them to be more effective in what they were doing. However, using technology should not hinder teachers from achieving other equally or more important goals of teaching. Teachers also need to believe that they are capable of handling technology and they have easy access to the resources. Applying this framework, Demetriadis et al. (2003) discovered that one goal that motivated their participants was to attain a better professional image. Although IT enriched the learning experiences, the teachers were concerned because learning with computers was sometimes perceived as hindering students' ability to score in examinations since learning with computers focused more on group process which was not examinable. Helping students

to pass examinations in this case became the competing goals that could stop teachers from using IT. Demetriadis's report is worth noting in that it reflects the more current emphasis of integrating IT to facilitate constructive and collaborative learning among students. Computers could be programmed to foster individualised learning platforms that provide self-paced learning (Chen & Hung, 2003). Many off-the-shelf tutorial programmes are built for such purposes and they seem to be an easy solution to resolve the goals conflict. However, this solution contradicts the higher goal of fostering knowledge co-constructor. In short, the perceptual control theory can only provide the researcher with a limited understanding of the complex issues.

Moving to a sociocultural perspective of studying IT infusion, the activity theory framework (Cole & Engeström, 1993) has been suggested by a number of researchers as a potential generative and more encompassing framework (Jonassen, 2002; Lim & Hung, 2003; Yamagata-Lynch, 2003a).

Figure 1. The structure of an activity system



Adapted from Cole and Engeström, 1993, p.8

The activity theory proposed that a goal directed event (i.e. the activity) is best understood from a holistic perspective. Translating the framework to an IT integration

process, the subject could be a teacher attempting to use some forms of technology as mediating tools to enhance students' higher order thinking skills (object). The teacher inevitably works in a school (community) that is governed by a set of rules with different people taking charge of different roles (division of labour). The various components within the activity system could form complimentary or contradictory relationships, thereby determining the outcomes of the activity. For example, the school management team may decide to centralize all computers in a few laboratories and to schedule teachers for lab sessions, i.e. a rule is being formulated for access. This could contradict a teacher's wish of implementing the KBC approach, which requires the computers to be available in the classroom for students to record ideas and questions generated as part of the classroom activities. An activity system in the classroom could also be contradicting a larger activity system such as that of a parent association (Lim & Hung, 2003). Connecting back to Demetriadis's report discussed earlier, a school may be pressurized to produce good results by perhaps the parents. This resulted in the teachers' emphasis on examination. However, the policy makers are addressing national competitiveness issues and they thus formulated policy that demands school to foster collaborative knowledge co-constructor. This is an illustration of multiple contradictions between activity systems.

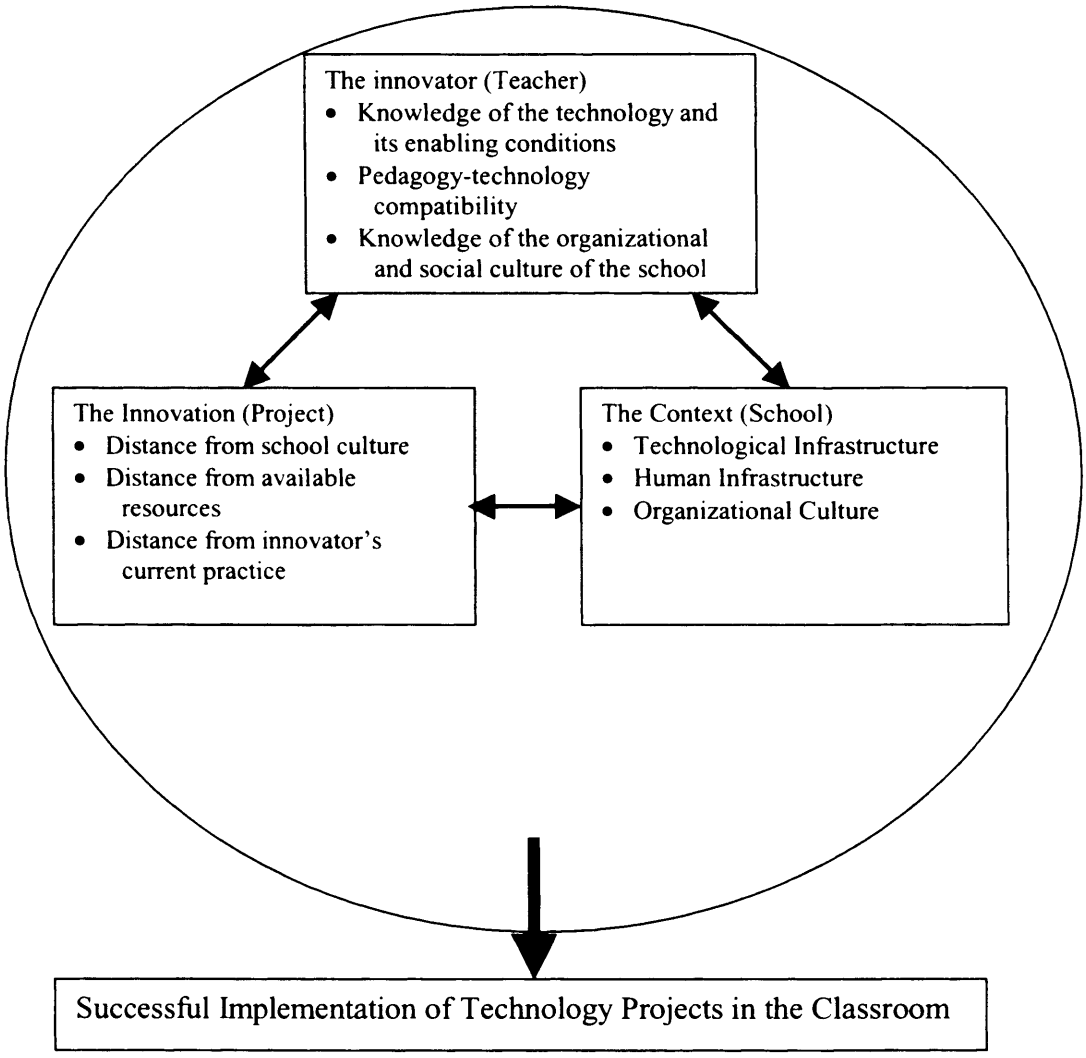
Employing the activity system as a unit of analysis, Lim has published a number of cases as mentioned in the previous section. One important conceptual barrier he identified that prevents effective student-centred IT integration is the mindset of teaching for tests. He demonstrated through a case study done in the United Kingdom how the teachers with different goal orientations differed in their applications of a programme designed for economics courses (Lim, 2001).

The mindset of teaching for tests seems to be a widespread phenomenon that hinders IT integration. Cases reviewed so far include the United Kingdom (ibid), Greece

(Demetriadis et al., 2003), Hong Kong (Fox & Henri, 2005) and Singapore (Lim & Hung, 2003). Tests and examinations carry a lot of weight in determining a student's future placement in the education. Teachers are politically and ethically charged with the responsibilities of maximizing students' development. Their concern is therefore legitimate and a good indication of professionalism. Further developments are needed in the field of educational technology in providing convincing models and examples of IT integrated programmes which can concurrently enhance test scores and foster higher order thinking. The studies done so far are not yet conclusive (see Roschelle et al, 2000; Roblyer, 2003).

As detailed accounts of the complexities involved in integration of ICT by classroom teachers are lacking, Zhao et al. (2002) undertook a project that built a grounded model to illustrate dynamic relationships between technology innovation, the teachers and the context. Figure 2 below shows the tripartite model. To put it simply, whether or not a technological innovation can be integrated depends on the interrelationships between the context, the innovator and the innovation. For example, when a highly innovative technology is implemented in an unsupportive school context by a teacher who is not very apt in negotiating with people, the likely outcome is failure. However, a more capable innovator with a less innovative idea might reap success.

Figure 2. Conditions for classroom technology innovations.



(Zhao et al., 2002, p. 490)

The conceptual frameworks reviewed above provide some possible forms of organisation for the myriad of variables that influence IT integration into classroom. To some extent, the review has demonstrated the multidimensional complexities involved in attempts to change. These frameworks are useful in that they sensitize the researchers to the different levels and dimensions of interactions and enrich their understanding from a holistic perspective. They also highlight the importance of the teachers as change agents and point to the need for teacher educators to address the attitude and the pedagogic beliefs of the teachers, especially when student-centred constructivist learning is advocated (Zhao & Cziko, 2001;

Lim & Hung, 2003, Demetriadis et al., 2003). It seems reasonable to infer that without a change in mindset, i.e. a revisit to what teaching and learning mean in this fast changing society, the teaching and learning opportunities afforded by IT will not be actualized (Deng, 2004). In the next section, what it means to teach constructively is briefly reviewed.

Constructivist Teaching in an IT-enriched Environment

While the term constructivism might mean different things for different users, the common emphasis of constructivism is that knowledge is constructed by the individual based on his/her experiences (Fox, 2001). Knowledge is not transmittable and it does not correspond to some objective reality out there (von Glaserfeld, 1995). The teacher's role in the practice of teaching is to encourage active construction of ideas by the learners and to guide learners' constructive processes such that a better understanding can be achieved. The general procedure is to encourage articulation of prior conceptions about some phenomenon by the learners. These prior conceptions may be derived from daily experiences or constructed through previous learning in school. Based on the articulated conceptions, teachers can then design activities which challenge those conceptions, thereby advancing students' understanding (Desforges, 2000; Brooks, 2002). Drawing on Vygotsky's sociocultural theory of learning, constructivism also emphasizes the importance of improving understanding in socially rich environments where multiple perspectives can be brought to bear (Fox, 2001; Dalgarno, 2001).

It has been argued that for teachers to shift from traditional didactic pedagogy or directed model of instruction to constructivist practice would require a radical change in the focal points of teaching (Prawat, 1992; Windschitl, 2002). This is because the two models were based on two different metaphors of learning founded by fundamentally different epistemological assumptions (Sfard, 1998). The traditional didactic pedagogy treats knowledge as given truth to be acquired by learners and it therefore focuses on strategies that

enhance content delivery and retention. The constructivist teaching practice treats knowledge as human construction produced largely through joint activity. The focus of teaching thus turns towards facilitating learners in actively making sense of world, which is believed to be best initiated and resolved through solving authentic real life problems in a collaborative environment (Fox, 2001; Jonassen, 2000). Table 2 contrasts the directed model and the constructivist model of teaching to illustrate the multidimensional differences in terms of teaching practice between the two models.

Table 2

Differences between Directed and Constructivist Models

Dimensions of comparison	Directed Model	Constructivist Model
Teacher's roles	Expert, transmitter of knowledge, director of structured experiences	Co-constructor, facilitator, guide, coach, designer of authentic experiences
Teaching Style	Didactic dissemination of required information	Interactive/Dialogic pursuit of questions valued by students
Student's roles	Passive recipient of knowledge, learn the given and reproduce appropriate performances	Active and collaborative constructor of knowledge construction, develop competence
Curriculum characteristics	Hierarchical, sequential, static and non-responsive	Based on projects/ problems that drive learning of relevant skills and information, responsive and dynamic
Learning Goals	Stated in terms of mastery of knowledge and facts and demonstration of behavioural competence	Stated in terms of growth or ability of learners to construct or co-construct knowledge
Types of activities	Lecture, recitation, seatwork, test and examination	Group project, hands-on experimentation, search and synthesize information, presentation
Assessment Strategies	Written test and end products, summative in nature	Performance tests and portfolios, formative in nature
Roles of computer	Instructive tools such as tutorial software, drill-and-practice	Informative, constructive, communicative

(Synthesized from Brooks, 2002, p.17; Roblyer, 2003, p. 54 and Chen & Hung, 2003, p. 86)

As revealed in the table, these two models of teaching have very different assumptions about what knowledge is and thus very different views of what teaching and learning should be. This has impacted on their conceptualization of the roles of computers in

teaching and learning. While the directed model views computer as substitute teachers, the constructivist model envisions computers as support for students' collaborative knowledge construction. This is elaborated in the following paragraph.

Educational technologists have argued that computers offer a number of affordances that support features of constructivist teaching (Salomon & Almog, 1998; Roschelle et al., 2000). The computer may be employed to record and present the problem in multimedia format, which should provide rich contexts for learners to explore. It could be programmed to simulate environments and microworlds that are beyond the learners' reach. It could serve as informative tool as the learners seek information through Internet and provide constructive tools for learners to create representations of their understanding. Collaboration is facilitated through networked environments that help to coordinate effort, share information and detect dissonance. Given that computers can process tedious mathematical problems speedily, it frees the learners to focus on meaning making. The computer can also save multiple drafts, keep record of activities which could serve as reference for reflection (Jonassen, 2000; Dalgarno, 2001).

Although it seems that the advancements of IT have made active, constructive, collaborative learning in an authentic environment possible, and many examples that exploit the affordances of computer are now available (see for example, Koschmann, 1996; Lajoie, 2000; Koschmann, Hall & Miyake, 2002), constructivist learning with computers is still not a widespread phenomenon (Mandinach & Cline, 2000; Becker, 2000). Windschilt (2002) classified the dilemmas that teachers have to resolve when they adopt a constructivist approach into four categories. The teachers have to first deal with the conceptual dilemma which includes reconciling the epistemological differences between the didactic and the constructivist pedagogy. Whether or not teachers hold largely constructivist epistemological

stances and more importantly if the epistemological stance is translated to practice or not are questions to be answered (see later section).

Pedagogical dilemmas such as how much time should be given for students to construct their ideas before teachers step in and how to scaffold students' knowledge construction need to be resolved. Creating educational experiences is a difficult task, much more difficult than following a curriculum framework, stated lesson objectives, textbook and prepared materials and teaching for examination. The teacher needs to "have sympathetic understanding of individuals as individuals which gives him an idea of what is actually going on in the minds of those who are learning" (Dewey, 1938, p. 39). With standardized assessment waiting at the end of the semester, teachers have to make correct assessments about his/ her means and ends to protect themselves from being accused of producing poor test scores. Culturally, the students may have been enculturated into teacher-centered approach and resist making sense on their own. Politically, teachers have to be sure that the principal and parents will not cause trouble for them. These are just some examples of the difficult decisions that Singapore teachers have to make (Tan, 2005).

Based on the above delineation, to embrace the constructivist teaching practice is to embrace uncertainties and risks and to increase the teachers' vulnerability (Cohen, 1988). As mentioned earlier, teachers have a moral obligation to fulfill and part of it, if not a large part as conceived by the general public, is to help students perform well in examinations. If the teacher does not have time to design educational experiences; or is unsure about how to design one; and has experienced success in using the straight forward didactic approach; according to the perceptual control theory (Zhao & Cziko, 2001), they will not take the risk. As such, without strong understanding, conviction and commitment to the constructivist thinking, teachers are unlikely to change their practice (Prawat, 1992). The issues pertaining to teachers' epistemological beliefs have been identified as an area in IT integration that

deserves attention (Albion & Ertmer, 2002; Looi et al., 2004). In the next section, studies on epistemological beliefs in general and teachers' epistemological beliefs in particular are therefore reviewed.

Epistemological Beliefs and its Relationship with Teaching and Learning

As a construct, "beliefs are thought of as psychologically held understandings, premises, or propositions about the world that are felt to be true" (Richardson, 1996, p.103). Many teacher educators and researchers consider teachers' beliefs as one important area that needs to be addressed both in teacher preparation and in-service learning (see Tatto & Coupland, 2003). This emphasis on teachers' beliefs generally follows from the findings that beliefs are largely congruent with teachers' classroom practices and act as filters that bias teachers' practice and their own learning (Kagan, 1992; Pajares, 1992; Richardson, 1996). They seem to be relatively stable and resistant to change. They are tacitly and perhaps unconsciously held by teachers and are difficult to articulate (ibid). Richardson (2003a) proposed that teachers' beliefs about classroom teaching and learning were derived mainly from "personal experience; experience with schooling and instruction; and experience with formal knowledge" (p.5) (see also Van den Berg, 2002). Among these three sources, experience with schooling and instruction seems most influential for pre-service teachers.

Given the importance of teachers' beliefs, many studies have been conducted in this area. However, this field of research is at times rather confusing because of the ambiguous terminology and the divergent foci of the studies. Studies about teachers' beliefs can come under a number of different titles such as teachers' perceptions, attitudes, cognition, practical knowledge, personal epistemologies etc (Hofer, 2001; Kane, Sandretto, & Heath, 2002). Since beliefs are accepted truth, while knowledge is generally recognized as "justified true belief" (Audi, 1995, p. 234), it is not difficult to see how these terms are sometimes used interchangeably among researchers in this field of study. The exact dimension of beliefs

studied can also range from general constructs such as beliefs about teaching to a specific focus such as beliefs about technology (Tatto & Coupland, 2003).

One interesting result that has emerged from the myriad studies on pre-service and beginning teachers' beliefs was that they commonly perceived teaching as a simple act of transmitting knowledge (Wideen, Mayer-Smith, & Moon, 1998; Richardson, 2003a). This implies that the calls for TPDs that nurture a more comprehensive outlook of what knowledge, teaching and learning mean are warranted. It also helps to explain why changing didactic teaching practice to constructivist teaching practices is difficult. However, Richardson (2003a) also noted that there seemed to be more beginning teachers who held constructivist beliefs dogmatically in recent years. If the beginning teachers are holding constructivist beliefs but are not translating them into practice, one possible explanation could be that the school contexts are inhibitive. Another could be that the teachers hold two sets of independent beliefs, one for epistemology and the other for schooling. The third possibility is that they may feel more comfortable and able to manage teaching in a didactic way since the constructivist approach requires them to relinquish their authority, and respond and build-on to the students' ideas, which is not easy for inexperienced teachers. Lastly, the constructivist view reported by them is what they have been receiving in teacher education. These possibilities could also be interrelated.

An important limitation of the studies of teachers' beliefs is that the subjects were pre-service teachers rather than practitioners. Studies that investigated the links between teachers' reported epistemology and their reported beliefs about teaching and learning in general were also uncommon (Schraw & Olafson, 2002; Chan & Elliot, 2004). In the next few paragraphs, studies that focused on epistemological beliefs are reviewed.

Researchers generally recognised 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 construct of core epistemological theories or beliefs can be composed of four dimensions about knowledge. They are "certainty of knowledge, simplicity of knowledge, source of knowledge, and justification of knowledge" (ibid, p.133). They relegated beliefs about learning and teaching as peripheral beliefs related to the core epistemological beliefs. The relegation of core or peripheral seems arbitrary and the implied connection may not be what the relationships actually are. Regardless of the dimensions of the beliefs to be studied under the general heading of epistemology, researchers generally agree that the beliefs about knowledge and education processes exert powerful, subtle and unconscious influence on teaching; learning and their outcomes (for example, see Pajares, 1992; Fang, 1996; Gess-Newsome, Southerland, Johnston, & Woodbury, 2003; Schommer-Aikins, 2004). The following sections briefly highlight and discuss some results of empirical studies to date.

Development of Epistemological Beliefs

Perry (1970) started empirical studies of the development of college students' epistemological beliefs in the late 60s. He mapped predominantly male Harvard undergraduates' epistemological beliefs into nine stages of development. Inspired by Perry's works, Belenky, Clinchy, Goldberger, and Tarule (1986) studied women's ways of knowing and Baxtor Magolda (1992) investigated gender-related implications of epistemological development. King and Kitchener (1994), on the other hand, elicited participants' reflective thinking through ill-structured problems posed to the participants. These studies generated more or less comparable development stages that revealed some general patterns. Individuals seemed to go through at least four main stages of development labelled as dualism, multiplicity, relativism and commitment within relativism (Hofer & Pintrich, 1997; see also Brownlee, 2004). Table 3 shows the comparable stages of the different models. It is important to note that all researchers have delimited that these stages are general patterns that

they have generated inductively. The researchers are aware of the limitations of stage theories and they do not claim that the stages of epistemological development are linear (e.g. King & Kitchener, 2004).

Table 3

Models of Epistemological Development

Intellectual and ethical development (Perry)	Woman's ways of knowing (Belenky et al.)	Epistemological reflection (Baxtor Magolda)	Reflective Judgement (King & Kitchener)
Dualism	Silenced, received knowledge	Absolute knowing	Pre-reflective thinking
Multiplicity	Subjective knowledge	Transitional knowing	Quasi-reflective thinking
Relativism	Procedural knowledge:	Independent knowing	
Commitment within relativism	Constructed knowledge	Contextual knowing	Reflective thinking

(Adapted from Hofer & Pintrich, 1997, p. 92)

In the first stage, individuals hold dualist or absolutist epistemological beliefs. Knowledge is treated as simple and certain. External authorities such as experts or books are the sources of knowledge. Individuals acquire knowledge through receiving it from the authorities.

In the second stage, multiplicity, individuals encounter diversity in ideas and begin to recognize the uncertainty of knowledge. Authorities are not all knowing. Individuals' subjective views are treated as valid as those of the authorities are. Knowing in this stage requires more than receiving and the knower has to think and judge subjectively. However, absolute truth still exists.

In the third stage, contextual relativism takes hold as a predominant view. Absolute truth does not exist. Knowledge is recognized not only as uncertain and but also contextual. Knowing requires the knower to judge the claims of knowledge by examining the evidences generated within the context. Perry (1970) argued that this development amounts to a paradigm shift. In the second stage, dualistic right-or-wrong thinking is still the dominant view and relativist knowing is treated as special circumstances where authorities do not have an answer or they want people to think about the subject matter. In the third stage, dualistic thought becomes a special case and relativist epistemology underlies all judgments.

The last stage of development is committed relativism. It is a stage where individuals are committed to certain beliefs, accepting it as absolute truth with the awareness that they do not have absolute proof with regards to certain assertion. As shown in Table 3, it seems that one can be fairly confident in accepting a general assertion that the development of individual's epistemological beliefs is one which knowledge becomes less certain and more complex whereas the self as knower becomes more prominent.

Other than the similarity between the stages of epistemological development, two other common patterns emerged from the above studies. First, the stage of development is closely related to one's education level. Second, only a small portion of people reached the advance stage of epistemological development (Hofer & Pintrich, 1997; White, 2000). For example, only 14% of the Baxter Magolda's (1992) subjects achieved contextual relativism after four years of liberal education.

Comparing the developmental stages of epistemological beliefs to Sandholtz's (1997) stages of IT integration and the stages of CBAM (Hall & Hord, 2001), there seems to be an interesting (hidden) parallel. It seems that the stages of development from all three depictions are closely linked to one's position as a knower in relation to the knowledge to be learned or constructed. When we do not know much about a particular field, we tend to receive

knowledge. In the context of innovating teaching practices that may not be perceived as needed, we may even ignore or reject information that suggests possible alternative perspectives. As we progress, the self as knower and a knowledge constructor becomes important because the certainty of knowledge diminishes as we know and reflect more about something. This path of development is reflected through Sandholtz's and the CBAM model as a teacher progresses from non-adopter to adopter and finally innovator. The implication seems to be that if one does not have sufficient "intellectual capital", one will not reach the fully developed stage. The current calls for TPD invite teachers to be co-constructors of knowledge through collaborative inquiry (see later section). The current reform, on the other hand, calls for students to be knowledge constructors (for example, see Bereiter, 2002a). Both calls require teachers to assume a higher epistemological stance. If the teachers do not have sufficient exposure to knowledge construction, they would not know how to facilitate students' knowledge construction process (see Windschitl, 2003). Teachers may also need to be conscious about their changing roles. TPD could facilitate the developments needed if they are conceptualized along this perspective of engaging teachers as knowledge producers rather than as a means for skills upgrading.

Effects of Epistemological Beliefs

Research that studied how epistemological beliefs influenced individual cognitive and metacognitive processes begun in mid 80s. Early studies included Ryan's investigation on how dualistic or relativistic epistemological beliefs would affect learners' evaluation of their learning and Dweck's work on how belief about innate ability would influence students' learning strategies and persistence towards learning (in Schommer-Aikins, 2004). Schommer (1990) furthered this area of study by moving beyond the one-dimensional conception of epistemological beliefs. She proposed a model of five more or less independent dimensions of epistemological beliefs. They are "the structure, certainty, and source of knowledge, and

the control and speed of knowledge acquisition" (Schommer, 1990, p. 498). Although the inclusion of the dimensions related to learning was disputable, perhaps because the later dimensions seemed to be associated with beliefs derived from schooling rather than reflection on knowledge, she argued that these dimensions were connected to learning outcomes and were therefore important to know. Schommer further contributed to this field by devising the Epistemological Beliefs Questionnaire. It facilitates quick measurement of individuals' epistemological beliefs that could be linked to learning outcomes such as scores of mastery test. Using the questionnaire and the results of assessments on reading comprehension activities, she studied how beliefs about learning affected reading comprehension among students. Her research suggested that students who believed in quick learning tended to oversimplify complex information, be overconfident in their test performance but did badly in mastery tests. Students who believed in certainty of knowledge were more likely to adopt an absolutist mindset when they were given inferential task (Schommer, 1990). Schommer (1993; see also Schommer-Aikins, Mau, Brookhart, & Hutter, 2000) also reported that secondary students who were less inclined to believe in quick learning were performing better in schools.

Qian and Alvermann (1995) studied the relationship between students' epistemological beliefs and conceptual change learning using Schommer's Epistemological Beliefs Questionnaire. They reported that "students' immature beliefs about Simple-Certain Knowledge and Quick Learning predict their poor performance in conceptual change learning" (p.290). A recent study by Mason and Boscolo (2004) employing epistemological understanding as an independent variable and students' performance on controversial issues as the dependent variable (genetically modified food) seemed to further verify the general influences of epistemology on learning outcomes.

The results of the above studies generally confirmed that advanced epistemological outlooks are correlated to students' engagement in learning and it is related to a number of learning outcomes (see also Schraw & Sinatra, 2004). This implies that there is a need for teachers to design learning activities that foster epistemological developments. Teachers also need to address students' epistemological perceptions regularly to nurture mature epistemological beliefs (Qian & Alvermann, 2000). These suggestions presume that teachers hold appropriate epistemological beliefs. Studies on teachers' epistemological beliefs are therefore reviewed next.

Pre-service Teachers' Epistemological Beliefs

The thrust towards constructivist teaching has naturally created the need to investigate teachers' epistemological beliefs. Undoubtedly, the constructivist approaches to teaching and learning would demand that teachers recognize the relativistic nature of all knowledge claims, which implies teachers need to be at the advanced stage of epistemological development. However, empirical studies in this area are not as abundant as studies on students' epistemological beliefs. The following paragraphs review some of the relevant studies engaging pre-service teachers as participants.

Adapting the ill-structured problems of the reflective judgement interview (King & Kitchener, 1994) to problematic classroom situations, White (2000) elicited 20 American student teachers' epistemological beliefs. She categorised their responses into five categories. The distributions of student teachers' epistemological beliefs were Departing Absolutist (2); Intuitive Relative (3); Selective Relative (10); Informed Relative (2), Reflective Relative (3) respectively. The teachers were mainly second and third year students. The results showed that they held a range of epistemological beliefs distributed across the categories. The uncertain nature of some knowledge prompted the student teachers to re-examine their epistemological beliefs that led to development. White discussed the concern about student

teachers not moving beyond the beginning stages of relativistic thinking. Student teachers may think that since all knowledge is relative, the knowledge base of education is a matter of opinion. They may fail to develop the ability in "judging betterness" (p.302). This concern is echoed by Holt-Reynolds (2000) who discovered that student teachers might equate active engagement in activities as learning if they were not properly guided to discern the importance of instilling disciplined ways of establishing knowledge claims among students. This effect of relativistic epistemological belief seems undesirable and potentially dangerous when this belief is passed on to schoolchildren at a young age.

Brownlee (2001) studied 29 Australian student teachers' core epistemological beliefs about knowing and their peripheral belief about learning. The findings also indicated that student teachers hold a range of epistemological beliefs. For her samples, 18 (62%) students held the belief that personal truths are constructed individually based on evidence. 10 student teachers held beliefs that accept knowledge as both constructed and received. Only one student teacher reported that he/she believed in received knowledge. Fourteen out of 18 "constructivists" also held the belief that "learning is a process of active, personal construction of meaning" (Brownlee, 2001, p.146). Her findings imply that epistemological view is closely related to belief about learning. Brownlee (2003) interviewed 11 out of the 29 teachers in their third years of teaching. Two teachers reported that they were less constructive while the rest of the teachers were either becoming more constructivist or remained the same. Anecdotal evidence seemed to suggest to her that as teachers grew professionally, they gained a stronger sense of being an expert and constructor of knowledge.

Compared to Hofer and Pintrich's review, Brownlee's studies had a higher percentage of participants who held advanced views of knowledge and learning while White's subjects were more distributed across her categories. This is probably because the first two groups of participants were graduates while White's subjects were undergraduates. Sutton, Cafarelli,

Lund, Schurdell, and Bichsel (1996) reported the epistemological development of 32 student teachers near the end of their teacher education. More than half of them were assessed to be at the higher end of Belenky et al.'s (1986) categories. The implication seems to be that as student teachers progress toward graduation, they become more relativistic and hold more complex epistemological views. Taken as such however, the results seem to contradict Wideen et al.'s (1998) review that reported beginning teachers' concept of teaching was commonly a simple act of transmitting knowledge. The connections between epistemological development and view of teaching and learning seem to be indirect.

The above studies were carried out in the western context involving a small number of participants. Whether or not pre-service and practising teachers who were brought up in the context of Asian culture hold similar epistemological outlooks is a question to be answered. The Asian culture seems to be more inclined toward collectivism and respect for authority, thereby fostering the view that knowledge is certain and it is passed down by authority (Lau, 1996; Youn, 2000). Recently, two studies have shed some light on the epistemological outlook of Asian pre-service teachers. Chan and Elliot (2004) surveyed 385 Hong Kong pre-service teachers using the Epistemological Beliefs Questionnaire and the Teaching and Learning Conception Questionnaire. The results indicated that the teachers were not inclined to view knowledge as certain. They seemed to believe that knowledge is acquired through effortful learning process. Also, they believed in neither the transmission nor the constructive view of teaching and learning exclusively.

One preliminary study conducted in Singapore classified student teachers' epistemological beliefs as transmission, cognitive, and constructivist (Tan, Hung, Looi & Chai, 2004). A pre-treatment, open-ended survey showed that the distribution of belief as seven, six and five students respectively. The treatment involved engaging these student teachers in a KBC within a module entitled "Creating Constructivist Activities with ICT". A

post-treatment survey indicated a shift of distribution to three, two and thirteen students in the respective categories. This study, though preliminary in nature, indicated that there might be a greater need to shift local teachers' epistemological beliefs and employing the KBC model could be a viable approach.

Practising Teacher's Epistemological Beliefs and its Effects

Investigations that explored the relationships between teachers' epistemological beliefs and teaching practice were rare (Hashweh, 1996; Schraw & Olafson, 2002; Chan & Elliot, 2004; Schraw & Sinatra, 2004). Hashweh seemed to be the first researcher to provide empirical data about teachers' epistemological beliefs and their teaching practice. He surveyed 35 Palestinian science teachers about their epistemological beliefs through questionnaire constructed around critical incidents about students' misconception and elicited teachers' view and responses to the situations. He classified the teachers as knowledge constructivists, learning constructivists, knowledge empiricists and learning empiricists. The knowledge constructivist sees science as a process of constructing explanations and theories and the learning constructivist sees science learning as a process for children to construct better understanding toward science. The empiricists, on the other hand, represent traditional teaching approach of passing on objective knowledge that corresponds to the external world. His study indicated that constructivist teachers were more aware of students' misconceptions. They were also more likely to draw on their rich repertoire of teaching strategies to facilitate conceptual change among the students.

Using the data gathered through the Epistemic Belief Inventory and interviews, Schraw and Olafson assessed the epistemological worldviews of a group of 24 in-service teachers. They categorised the teachers' worldviews as realist, contextualist or the relativist. They hypothesized that each worldview corresponded to a teaching approach. The realists would teach through knowledge transmission; the contextualists would teach through group-

based collaboration; and the relativist would facilitate individual student's construction. They reported that no teacher was inclined toward an exclusively realist worldview and 21 teachers indicated preference over contextualist or contextualist and relativist positions. However, the teaching practices of these teachers did not appear to be congruent with their expressed beliefs. The teachers cited contextual reasons such as time constraints, unsupportive administration and lack of professional development to explain the inconsistencies.

Kang and Wallace (2005) studied three science teachers' epistemological beliefs in the context of conducting laboratory activities. The cases revealed that when the teacher viewed science as a concrete body of facts, he/she was likely to transmit knowledge. However, advanced epistemological beliefs did not translate directly into more ambitious form of teaching. One intervening factor could be their assessment of students' readiness of doing science like a scientist. Science could be separated from students. Teachers could also separate real science from school science, thereby treating the teaching and learning of science as essentially different from doing science. Fang (1996) reviewed studies of teachers' beliefs and practices in the field of reading and she also reported the conflicting results about the problem of consistency/ inconsistency between teachers' beliefs and practices. These cases provide support for Prawat's (1992) postulation that for teachers to teach using the constructivist approach, they need to view both the content knowledge and the students as connected and evolving entities.

These limited studies that have investigated practising teachers' epistemological beliefs seem to highlight the possibility of teachers' epistemological beliefs not being enacted in practice. This disconnection is consistent with some parts of the earlier review (Fang, 1996; Schraw & Olafson, 2002). However, it contradicts other studies that claim that beliefs are generally consistent with behaviours (Kagan, 1992; Pajares, 1992; Richardson, 1996). Teachers usually cite contextual factors as hindering them in enacting their beliefs when they

are confronted about the inconsistencies. While this could mean that they perceive themselves as rather powerless, it could also be an act to shift the blame elsewhere. It seems rare to hear teachers' "public confession" about not having the necessary skills or knowledge. However, such self-attribution is important since it shifts the locus of control to the self. The differences between espoused beliefs and actual practice could also mean that the beliefs about teaching and epistemological beliefs are activated by two different contexts and are not connected, at least not strongly connected. These three possible interpretations taken together imply that researchers need to be careful when interpreting data collected for the study between the links of beliefs and practice.

Studies that investigated how teachers' use of technology is related to the epistemological beliefs, in particular constructivist orientation, indicated that teachers who frequently tasked students to use computers and the Internet were more oriented to the constructivist approach (Becker & Ravitz, 1999; Becker 2000). However, Dexter, Anderson and Becker's (1999) investigation indicated that although computers helped teachers in moving towards constructivist teaching, the keys to change are reflection upon experience, formal learning and school context. They suggested that providing opportunities for teachers to construct appropriate pedagogical knowledge in a supportive environment helps to facilitate teachers' change process. Based on these studies, it seems reasonable to say teachers' beliefs and practices are mediated by the complex contextual factors in the sociocultural environments of schools.

From the above review, it seems that both practising and pre-service teachers report a range of epistemological beliefs. Within that range, it is also likely that most teachers are more relativistic in their thinking. However, they would need more than just relativistic belief about knowledge to be constructivist in practice. It seems that they need to examine the inconsistencies of their beliefs and practices and integrate several different but related

dimensions of beliefs. One important aspect is their view of the child as knowledge constructor. They would also need to be supported by school leaders in removing some barriers.

The review so far has generally shown that nothing short of a transformation is needed for a teacher to engage students in IT enriched constructivist teaching and learning. The obvious solution to address this need is continual professional development. However, how effective the professional development activities are depends on the form and the content, and how these are incorporated into the teachers' work life. The next section reviews innovative approaches that could facilitate the teachers in transforming their practices.

Teachers' Professional Development

Teachers' professional development in the context of implementing innovative teaching practices can be conceptualized as transformational learning (King, 2002) from the adult learning perspective. It had also been characterised as conceptual change (Hashweh, 2003; Gill, Ashton, & Algina, 2004) process from the science learning perspective. Regardless of the perspective one adopts, both perspectives draw their explanatory framework from Piaget's concept of accommodation. They postulate the change process as one in which prior beliefs or frames of reference have to be first articulated and then confronted or challenged by some forms of anomalies. This process produces cognitive conflicts that require the teachers to accommodate the anomalies either by reorganizing the original conceptual framework or limiting its explanatory power. However, teachers are reluctant to explicate their beliefs, let alone question or change them (Wilson & Berne, 1999; Hashweh, 2003). Articulating one's beliefs is a laborious and thus unappealing task. Challenging and changing one's rooted beliefs is even more painstaking. Unless there is a strong reason for doing so, it seems to be a better strategy for especially experienced teachers to just keep to the practice that one is comfortable with.

Viewing TPD as belief/ conceptual change, which is equivalent to transformation, it is understandable why many teacher educators are deeply dissatisfied with the usual form of in-service education and training (INSET) (Wilson & Berne, 1999; Ball & Cohen, 1999; Barab, Makinster, Moore, & Cunningham, 2001; Grossman, Wineburg & Woolworth, 2001; Kelchtermans, 2004). Traditional TPD have been widely criticized for being decontextualized and fragmented one-off events. They are aimed at updating teachers on recent changes such as introducing new assessment schemes or textbook series rather than developing teachers' intellectual capacities (Grossman et al., 2001; Kelchtermans, 2004). The teaching method employed in INSET is usually an expert presentation of the content with some hands-on practice (Wilson & Berne, 1999; Barab et al., 2001). INSET workshops are widespread and firmly in place as policy makers usually assume teachers' lack of knowledge and skills could be addressed through direct instruction (Day & Sachs, 2004). Providing INSET to enable teachers for constructivist teaching seems like a bizarre disconnection between form and intent since INSET practices are the direct opposite of constructivist teaching. Despite the criticisms, the traditional form of TPD seems to be effective in meeting certain training needs such as equipping teachers with basic computer literacy (for example, see Pelgrum, 2001; Wettasinghe, 2002). However, judging from the review in previous sections that illustrate the complexities involved in implementing innovative practices, it should be clear that traditional TPD is insufficient in transforming teachers' practices toward ambitious teaching.

To achieve the vision set out by constructivist teaching, teacher educators and researchers have articulated a list of essential features for TPD activities. These features include what teachers should do, where they should do it and when. First, teachers should be provided with ample opportunities to a) collaborate and discuss critical issues with peers and researchers; b) experiment with the innovation that could involve technology; c) observe

exemplary models; d) reflect on pedagogical beliefs and teaching practices (Sandholtz et al., 1997; Darling-Hammond & Sykes, 1999; NRC, 2000; Earle, 2002; Zhao et al., 2002; Ertmer, 2003; Richardson, 2003b). Second, TPD is believed to be best situated in the site of practice, i.e. the school, and in a community setting (Ball & Cohen, 1999; Cochran-Smith & Lytle, 1999; Barab et al., 2001; Grossman et al., 2001). Third, it is essential that adequate time is allocated for TPD for in-depth reflection and understanding to occur (Wilson & Berne, 1999; Cochran-Smith & Lytle, 1999). Wideen et al.'s (1998) review showed that prolonged engagement of a year or more resulted in positive change in pre-service teachers' perspective whereas a single course rarely produced changes. The content of TPD would then be teachers' critique and co-construction of innovative ideas; implementation, observation and perhaps documentation of the problems and the effects on students' learning; reflection and reconstruction of what it means to teach and learn (for example, see Kwakman, 2003; Butler, Lauscher, Jarvis-Selinger, & Beckingham, 2004). Explicating and maximizing the connections between teaching and learning within this context is the focus of the activities (Sykes, 1999).

Collaborative Inquiry as a form of teacher professional development

Innovative PD that incorporates the above mentioned features has begun to emerge recently. It is usually referred to as collaborative inquiry (Darling-Hammond, 1996) or collaborative innovation (Randi & Corno, 1997). The essence of collaborative inquiry is that the collaborators (regardless of whether they are researchers, experienced teachers, pre-service teachers or parents) adopt inquiry as their stance (Cochran-Smith & Lytle, 1999) 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 field experiences. This form of TPD is obviously more congruent with constructivist teaching. It recognizes the 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).

Collaborative inquiry has been found to promote a number of changes among participating teachers and sometimes their teaching practices. (Randi & Corno, 1997; Kraft, 2002; Burns, Menchaca, & Dimock, 2002). Randi and Corno's review of studies on teachers implementing innovative practices indicates that when teachers are engaged in collaborative innovations, they are more willing and able to produce meaningful adaptations. However, when they are not invited to contribute, research-based ideas could be subverted in implementation. Kraft's study suggests that collaborative inquiry among teachers helps to transform teachers' meaning perspective by enabling them to query their assumptions. Employing data generated by TIMMS as a catalyst, Huffman and Kalnin's (2003) research indicates that collaborative inquiry promotes ownership among teachers concerning school reform. It also places the teachers in a continuous improvement trajectory. Van Zee, Lay and Roberts's (2003) effort in designing collaborative inquiries between pre-service teachers and teacher researchers was also fruitful in the sense that it promoted the pre-service teachers' sense of efficacy. A recent study by Butler et al. (2004) in the context of supporting teachers' effort in promoting self-regulated learning among students has documented sustained changes in teaching practices. The main activities of the collaborative research (as they call it) were introductory workshops, co-planning, co-teaching and debriefing.

Studies on engaging teachers in collaborative innovations for integrating instructional technology into classrooms also indicated positive results. For example, Sandholtz (2001) compared two PD programmes that were evaluated as successful by teachers. They have the common features of allowing the teachers to work with peers or researchers, experiment with

the use of computers in classroom, observing expert teachers or other teachers and group reflections. Yamagata-Lynch (2003b) reported the results from a TPD programme that incorporated design, implementation and evaluation activities among teachers. Online and face-to-face discussion among teachers and university staff supported the activities. The programme helped teachers to gain new skills and confidence. It also raised the teachers' status as competent computer users for classroom teaching. In short, empirical studies that support collaborative inquiry for TPD are growing in number.

Despite the rosy picture, collaborative inquiry and other similar forms of TPD are not without problems. Collaboration implies coordination between different parties that could be a logistic nightmare (van Zee et al., 2003). Time constraint is another common problem (Huffman & Kalnin, 2003). It also seems to be a labour intensive endeavour where sustained commitment and ongoing support are essential (Butler et al., 2004). In the Singapore context, the Teacher's Network provides a platform for collaborative inquiry. Tripp's (2004) study indicated that the facilitators were facing complex challenges in establishing critical and constructive discourse among the participants. The comments and challenges between teachers were more confined to the friendly practical solutions rather than critical questions about the others' underlying assumptions or beliefs. Grossman et al. (2001) also reported the difficulties involved in sustaining a productive community that was created within a school.

Collaborative inquiry focuses on building the teacher's capacities in becoming a reflective practitioner. This inevitably involves hard work since teachers are adult learners who have acquired dispositions and have multiple roles to fulfil. It is questionable how far policy makers and teachers would support this form of TPD as it is potentially very expensive. Would teachers and perhaps teacher educators be committed to it? Especially for the teachers, what would motivate or stop them from undertaking collaborative inquiry? There is therefore

a need for more studies to be conducted. In the next few paragraphs, further considerations for collaborative inquiry are drawn from the adult learning perspective.

Teachers as adult learners

One of salient characteristics of teachers as learners is that they are adult learners. Developing adult learners is different from teaching schoolchildren to some extent. Adult learners have unique learning characteristics that should not be ignored if one hopes to be successful in teaching them (Huang, 2002). Knowles (1990) listed six guiding principles for educating adults based on adult learner characteristics. They are as follows:

A) Adults need to know why something is worth learning before they will undertake the learning tasks.

B) Adults have strong need for self-direction.

C) Adults have vast and heterogeneous experiences that can serve as rich resources for learning. The experiences constitute the self-identity of adult learners that when ignored or devalued, may be perceived as rejecting the person involved. Adult learners may also possess mental habits and biases that could impede learning.

D) Adults are ready to learn things that help them to cope with their life situation.

E) Adults' orientation to learning is problem-centred.

F) Adults are usually motivated by internal pressures such as self-esteem and job satisfaction.

These principles could also hold true for most learning situations. It is not difficult to imagine young children or teenagers being more motivated when they are given a choice to learn things that could solve real life problems that they are confronted with. The major differences seem to be the greater experiences and self-awareness of goals that adults have. Based on these principles, Knowles argued that "the emphasis in adult education is on the experiential techniques—techniques that tap into the experience of the learners, such as group

discussion, simulated exercises, problem-solving activities, case method, and laboratory methods instead of transmittal techniques. Also, greater emphasis is placed on peer-helping activities" (Knowles, 1990, p.66). Based on Knowles's recommendations, the design of TPD should recognize teachers' personal experience as a legitimate source of knowledge, their need for self-direction and their general orientation toward solving real life problems. Pre-authentication, i.e. instructor deciding what constitutes an authentic problem without negotiating with the learners, is to be avoided (Huang, 2002). Knowles' recommendations seem to fit well and provide further support for the collaborative inquiry model. They are also congruent with Wells's (1999) notion of dialogic inquiry. Wells (1999) proposed the setting up of communities of inquiry among teachers and researchers where classroom experiences and external sources of information (such as from research literature) are used as resources for knowledge building. Through co-construction and negotiation of the meanings of classroom activities, both parties could collaboratively build knowledge that leads to improved practice.

The foregoing sections have delineated teachers' learning needs, the complexities involved in TPD and potential form of TPD that fosters teachers' development. In the next section, the affordances of CSCL in general and the KBC model in particular are reviewed and elaborated.

CSCL and the Knowledge Building Community

Typically, a CSCL environment is deployed to connect learners located at different places to solve a common problem. The learning and/or problem solving process are usually enhanced by specific software design (van Bruggen, Kirschner, Jochems, 2002). Building on CMC affordances, CSCL creates ample learning opportunities for learners to interact actively (Harasim, 2000; Lipponen, Rahikainen, Lallimo, & Hakkarainen, 2003). It removes the time and space constraints such that learners enjoy greater flexibility and opportunities to process

information pertaining to the discussed issues/problems (Hara, Bonk, & Angeli, 2000). This is an important affordance since research has shown that in traditional classrooms, the average teacher wait-time is about one second. By lengthening teachers' wait-time to 3-5 seconds, the length and qualities of students' responses can be significantly improved (Rowe, 1974). The text-based interaction also promotes reflection and provides records for extending the discussion and examining the learning process (Li, 2004). In sum, these affordances are intended to facilitate distributed learning, situated cognition, in-depth inquiry, co-construction and co-reflection (Putnam & Borko, 2000; Hung & Chen, 2003). CSCL therefore seems to be a promising medium in supporting TPD. This is further supported by Wallace (2003) who had reported that generally, students in higher education valued the opportunities to interact with their peers and their instructors online on topics that were considered important by them. Online interaction contributes to students' satisfaction and perceived learning.

However, technology affordances do not translate directly into better learning or teaching (Zhao, 1998; Wallace, 2003). Common problems faced by educators employing CSCL include low participation rate among learners; insufficient depth concerning the issues discussed; shallow interactions and diverse themes (Lipponen et al., 2003; Wallace, 2003; Hudson & Bruckman, 2004). Zhao and Rop's (2001) review of studies that employed networked technologies for in-service teacher development revealed that although the technological affordances helped teachers to connect to each other anytime anywhere, studies in this area did not document substantial evidences on CMC promoting in-depth reflective discourse. There is therefore a need to design and evaluate CSCL that can move beyond opinion or experience-based discussion to achieve in-depth theory-based discussion (Järvelä & Häkkinen, 2002). For this purpose, the KBC model seems to be an appropriate model with ample theoretical supports.

The Knowledge-building Community

A KBC is formed when a group of committed individuals jointly identify authentic problems and assume the responsibilities to advance each other's understanding with regards to the problems (Hewitt, 2001; Scardamalia, 2002). The primary task of KBC is to produce knowledge. Examples of such communities include all forms of research and development teams from universities and private organisations (Scardamalia & Bereiter, 1999). Scardamalia and Bereiter (2003) argued that the emergence of the knowledge society requires schools to reconceptualize themselves as agencies that enculturate knowledge workers/producers whose key task is to add value to knowledge. They postulated that by immersing students in an environment that is anchored on knowledge production, students would naturally employ a range of cognitive, metacognitive and interpersonal skills to adapt to the environment. They also argued that by restructuring school as KBCs, other important goals such as foundational learning, creative and critical thinking are not forgone but subsumed and achieved under the knowledge building goal. In the next few paragraphs, a brief description of a KBC classroom is synthesized based on several cases reported (see Caswell & Lamon, 1998; Lamon, Reeve, & Scardamalia, 2001; Messina, 2001)

In the classroom, a KBC is usually initiated by the social negotiation of a broad theme of inquiry relevant to a discipline. Ideas and questions that the members have about the theme are then articulated and posted in the forum as notes. The forum then operates as a joint database where the ideas take root and grow. This initial stage encourages ownership and responsibility among community members and enhances the authenticity of the theme of inquiry (Scardamalia, Bereiter, Mclean, Swallow & Woodruff, 1989).

Subsequently, the notes are treated as improvable ideas. As the participants engage themselves in the various means of advancing understanding (for example read, conduct empirical research, reflect, discuss, invent etc), they challenge each other's ideas through

face-to-face interactions and building new notes or revising existing notes. This phase is essentially a social process mediated by knowledge-building discourse that focuses on sharing new knowledge, synthesizing new knowledge with prior knowledge, detecting gaps in understanding, co-construction of theory and so on. It leads naturally to the growth of the database which reflects the progress of the community as a whole (Scardamalia & Bereiter, 1994). As initial questions are being answered, participants are encouraged to ask further and deeper questions thereby creating an ever deepening pursuit. They are also encouraged to take up the responsibility to organize and re-organize the databases through design features such as creating new views. The closure of a KBC is usually artificially decided by school terms since true knowledge building is never ending.

Wells (1999) characterized the above processes of building better understanding as the "spiral of knowing" (p. 85). Individuals achieve advancements in knowing by first making meaning through personal experiences. They then move to enhance their understandings by a process of knowledge negotiation that is mainly constituted in comparing and refining one's ideas with others' ideas obtained from literature, empirical works and peers. The refined understanding then becomes the new interpretive framework for further understandings and actions.

As a pedagogical model, the KBC exploits both the social and the technological affordances of the communal database. Students are empowered to identify area of interest to build expertise. They gain status and respect among their peers as they contribute to the database. As research teams are formed according to interest, the less knowledgeable members from other teams or weaker students within the teams contribute by asking questions about explanations or ideas that are not clear to them. They also benefit from participating in the KBC since the asynchronous platform prevents anyone for dominating the conversation. Diversity allows ideas to be challenged and improved. Also, ideas are accepted

or rejected, not because the teacher says so but because the community has detected flaws in them. In short, it creates a more democratized classroom. On the technological dimension, an asynchronous discussion platform allows many-to-many concurrent communication. Teachers cannot and need not dominate classroom talk anymore. Notes stored can be retrieved and revised. Searching for similar ideas or information can also be done efficiently. The knowledge building processes are also scaffolded through customisable metacognitive prompts (see Scardamalia, 2000, 2002). The generic prompts that are embedded in the system include "My Theory", "I need to understand", "A better theory" etc. They are designed to gear students towards theory building. Although these affordances can be abused, it is not difficult to imagine the community formulating suitable rules to stop undesirable behaviours.

In the field of CSCL, the KBC seems to be one with longest and most successful history (Miyake & Koschmann, 2001). Research studies indicate that KBC promotes in-depth learning, problem solving, inquiry, reflection and epistemological growth among students. In terms of traditional assessment such as standardized reading and vocabulary tests, KBC students scored significantly higher than other students (Scardamalia et al., 1992; Lamon et al. 1994; Scardamalia, Bereiter & Lamon, 1996).

Based on the description above, it should be obvious that the KBC is very different from what one sees in the usual classroom. Successfully implemented, the classroom will be filled with young and serious researchers pursuing in-depth understanding through a myriad of activities at the same time. Students may also go beyond the teacher's level of knowledge at times (for example, see Caswell and Lamon, 1998). This implies that teachers need very different dispositions in facilitating and managing the students. They need to value students' naïve ideas, let go of control and facilitate different strands of inquiry concurrently. The mode of teaching is student-centred and responsive rather than prescriptive. How teachers

experience this alternative form of teaching is an interesting question that needs more studies especially in the Asian context.

Theoretical Foundations of KBC

From the description above, the KBC model is clearly oriented toward the constructivist and social-constructivist view of learning. As constructivism has been reviewed earlier, the following paragraphs focus more on the sociocultural theory of learning and its recent derivations.

Vygotsky's (1978) sociocultural theory stressed the importance of social interaction for the development of cognitive ability. Interacting with more capable peers or experts creates for the learners a Zone of Proximal Development (ZPD). The ZPD is defined by Vygotsky as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers." (p.86) Interactions in ZPD give the learners opportunities to appropriate "ways of seeing" and problem solving (Hung, 1999) that are mediated through language. As such, the development of higher cognitive ability would be greatly hampered if social interactions were limited. Social interaction is therefore an important means for one to learn.

Lave and Wenger's (1999) notion of community of practice (CoP) also supports the importance of social interaction in learning and helps to clarify its role further. In the social setting of apprenticeship, apprentices are afforded opportunities to participate in the various activities that constitute the practice. Through such participation, the apprentice learns to be a practitioner. Lave and Wenger characterized the learning journey as one that moves from legitimate peripheral participation to full participation of the practice. Within this journey, an important aspect of participation is that of learning to talk professionally. Lave and Wenger distinguished the forms of talk that occur in an authentic CoP and that of school-based CoP.

The former is talking within the practice, situated or contextualised by the practice. The latter is talking about the practice in a circumscribed environment, which may not help newcomers in appropriating the actual use of language and therefore the problem solving dispositions within the practice. Brown and Duguid (2000) presented similar arguments that emphasized the importance of situating learning in practice. This emphasis of situating talk within the context of a practice is incorporated in a KBC by emphasizing the primary importance of initiating an inquiry with authentic problems within a discipline (Hewitt, 2001).

Solving authentic problems presents cognitively demanding tasks for an individual learner. Forming a KBC in a classroom facilitates the processes involved by creating a context where the distributed nature of intelligence and its potential will be fully exploited in a collaborative situation (Pea, 1993; Roth, 1999). In a KBC, learners can distribute the responsibilities of the difficult and complex learning tasks. This avoids cognitive overloading of individual members and allows members to develop differential expertise (Roth, 1999). At the same time, learners with different backgrounds and abilities enter the learning environment with different ideas and perspectives. The diversity in ideas, abilities and perspectives forms the collective resources of the KBC that members can draw on. It creates multiple ZPDs where all members can support each other mutually towards the achievement of learning goals (Oshima, 1998). It also creates a natural social environment for the members to articulate and explain their ideas, which requires the members to be precise and concrete. In sum, it enriches learning by creating opportunities for members to understand from others' points of view and expose them to diverse ways of conceptualising and investigating a given phenomenon (Kolodner & Guzdial, 1996). At this point, it is important to note that generally, the sociocultural theories of learning as reviewed above are the same set of theories that were employed by researchers calling for collaborative inquiry (see Barab et al., 2001; Grossman et al., 2001; Yamagata-Lynch,2003b; Butler et al., 2004).

Although the KBC model draws on constructivist-oriented theories, it is important to differentiate the notion of KBC and the social-cultural frameworks. Scardamalia, Bereiter, and Lamon (1994) have criticized the current Vygotskian view as narrowly focused on the internal cognitive structures of the learners at the price of neglecting the social structures that facilitate knowledge advancement. Bereiter (1997) has also criticized the situated perspective of learning for not addressing the problem of transfer adequately. The distinguishing feature of the KBC is its emphasis on critical and creative work on ideas. This emphasis shifts attention away from the internalization and appropriation of existing practices and knowledge to the co-construction of new knowledge. Learning about the practice and knowledge becomes a by-product of being a knowledge worker.

The focus of the KBC on the co-construction of new knowledge is of course an idealistic one. In practice, an ideal KBC is difficult to achieve. The members of the community need to be strong linguistically to articulate their thoughts in a text-based learning environment and they also need to be willing to adopt an active stance towards learning. Although multiple perspectives could enhance the quality of solutions for complex problems, CSCL researchers have noted that successful outcomes are not guaranteed. The community has to negotiate for a common framework for the understanding of the problems, which could be a problem in itself (Beers, Kirschner, Boshuizen, & Gijselaers, 2005). They also need to deal with the jointly constructed problem representations and solutions at an epistemological level (Tsai, 2001), i.e. they need to assess the warrants for the claims made. This could pose challenges even for experts at times. The epistemological beliefs embedded in the notion of KBC will be delineated next.

The epistemological belief underlying the KBC model is Popper's (1965) construct of World 3. Other than World 1 (the physical world) and World 2 (the subjective world inside the mind), Popper postulates a World 3 that is constituted of cognitive artefacts. The theories

created by scientists are among the cognitive artefacts. These theories, once created, are largely autonomous and can generate a range of possibilities as others interact with it. They are treated as tentative theory that should be subjected to error elimination under Popper's schema for the search of truth. In other words, all knowledge created is open to further inquiry and improvement. This epistemological stance is translated directly into the practice of treating all knowledge as ideas and as improvable in a KBC (Scardamalia, 2002). Bereiter (1994) argues that school has focused on changing students' minds (i.e. World 2) and neglected the enculturation of students into World 3. In a KBC, students are empowered to produce cognitive artefacts such as explanations of phenomena they have encountered. These cognitive artefacts (or knowledge object as Bereiter likes to call them) are then subjected to the community scrutiny for improvement. Bereiter (1997) argues that this process is similar to scientists' intellectual work. Engaging students in the improvement of knowledge object will inevitably lead students to the examination of existing theories (i.e. the theories produced by established scientists). Bereiter (2002a) posits that by engaging learners in a KBC, we are empowering learners to work constructively and creatively with ideas, i.e. to treat learners as knowledge producers.

Given the theoretical supports and empirical studies, the adoption of KBCs is not widespread. One possible explanation is that it is a radical innovation as Scardamalia (2000) has admitted. Culturally and historically, schooling is about learning and receiving knowledge. Except for higher education, schooling is not about producing knowledge. Teachers who have not experienced producing knowledge throughout their education experience may not understand what it means (see Windschilt, 2003). So far, it seems that KBC is consistently practised only in the Institute of Child Study (ICS), an experimental school affiliated to the University of Toronto where KBC originated, and a couple of other public schools in Canada. Bereiter (2002a) had also commented when schoolchildren

enculturated in KBC showcased their products and interacted with outsiders, their work was usually treasured more by the professionals working in industries that create new and advanced products based on knowledge advancements than the educators. Although the evidence is anecdotal, it is indicative of the scale of change needed.

TPD for fostering KBC

Hewitt (2001) reported one teacher's effort in developing the instructional strategies for fostering KBC. This teacher has a doctoral degree and is well grounded in constructivist perspectives. It took him two years to develop the necessary classroom skills. Can the fragmented nature of teacher college curriculum and TPD (Wideen et al., 1998) support less qualified teachers to develop the necessary dispositions for fostering KBC? Are there ways of enculturating teachers for KBC? Scardamalia and Bereiter have been organising summer institutes. However, it seems that the KBC is more likely to spread via the postgraduates, especially the PhD graduates like Jun Oshima in Japan and Carol Chan in Hong Kong. They have ample exposures under close supervision of the masters. Since graduation, they have conducted a number of isolated studies in their respective countries. As argued, for innovations to reach the classrooms, teachers need to buy in and be equipped with the necessary competencies. As such, it seems reasonable to design alternatives TPD activities for the purpose of fostering KBC.

Resta, Christal, Ferending, and Puthoff (1999) reported a project that helped practising teachers in Texas to implement KBC in the classroom. The teachers reported changes in their view on curriculum, their perceived roles and their views of students. Teachers in the ICS implementing the KBC had published some of the struggles they encountered when they implemented KBC (Caswell & Bielazyc, 2001; Moreau, 2001). Caswell shifted from activity-centred pedagogy and teacher-designed experiments toward a students directed inquiry where student designed the experiment. Moreau reported that she

developed sensitivity in when and when not to intervene with students' inquiry. Both teachers worked within a fully supported environment where teachers have the right to decide on time-tabling. In Hong Kong, Yuen (2003) observed that some teachers gained a sense of shifting toward the facilitator role when they attempted to implement KBC. Yuen proposes that further research and TPD are needed to facilitate teachers' transformation (see also Resta et al., 1999; van Aalst & Chan, 2001). It is important to note that in Yuen's study, some students reported that they disliked the approach and would rather prefer that the teachers teach them. This may be interpreted as resistance from the students due to their education. It also raises questions as to whether or not a teacher has the right to implement innovative pedagogical approaches that maybe perceived by students as not helping them to learn.

To date, Singapore schools can be characterized as adopting teacher-centered pedagogy predominantly. Teachers are highly focused on delivering and covering the curriculum and they seldom criticize knowledge or connect knowledge to the real world in their classrooms (Liu, Kotov, Rahim, & Goh, 2004; Deng, 2005). This portrait is congruent to Lau's (1996) characterization of Asian culture. The question of how would teachers perceive teaching and learning in a KBC then becomes important if one is to foster KBCs in Singapore school.

Woodruff and Brett (1999) tasked a group of pre-service teachers to discuss issues and relate them back to theories in a KBC. The pre-service teachers were unable to define clear issues to pursue. The pressures from demands in other courses prevented the group from pursuing in-depth understanding. The content generated was largely about practicum experiences and references to theory and reading were rare. This raises the question of how will teachers employ the KF platform, especially when they become practitioners. Studies on how in-service teachers interact online for the co-construction of knowledge seem rare. The need to investigate this question is also coupled with a general lack of empirical evidence that

shows how knowledge building discourse happens (Stahl, 2004). This need leads the present review into the next section on the ways of analyzing and characterizing online interactions for learning or knowledge building.

Analysis models of CSCL

Online interaction, as a form of discourse, is a complex and discursive phenomenon that is different from face-to-face communication in that it lacks nonverbal cues (Garrison et al., 2001). As cues that aid interpretation are confined to text, interlocutors are inclined to be clear and more organized in sending the messages. Captured in the servers, these records provide valuable data for research. However, not many studies have been conducted employing the readily available transcripts (Hendriks & Moar, 2004; Marra, Moore, & Klimczak, 2004). More studies are needed to help educators in understanding and therefore enhancing learning in online environments.

Researchers in this field generally agree that mixed method multidimensional analysis is necessary to provide in-depth understanding (for example, Wegerif & Mercer, 1997; Hmelo-Silver, 2003). To date, several researchers had attempted to develop coding schemes to account for the different aspects of online interactions. One pioneer in formulating content analysis model for online interactions is France Henri (1992). She proposed a model that includes five dimensions. The dimensions are participation, social, interactivity, cognitive skills, and metacognitive skills respectively. Henri believed that her model would help educators to understand the learning processes that occurred online comprehensively. Although the model is lacking in clear criteria and detailed descriptions (Howell-Richardson & Mellar, 1996), it is a useful tool for laying the groundwork.

Hara et al. (2000) adapted the model for a study of 20 students' online discussions in the area of cognitive psychology at graduate level. The results indicated that although students' participation was limited to one posting per week, the postings were cognitively

deep. For the dimension on interactivity, they devised message maps that depicted students' interaction clearly. The study also revealed the difficulty in achieving high inter-rater reliability for the metacognitive dimension.

While Henri's model has provided some indicators of learning for Hara et al.'s study, it remains silent about collaborative knowledge building. Hewitt (1996) proposed that the measure of the connectivity of the online forum could provide indications of the extent of collaborative knowledge building. The connectivity of a forum is reflected mainly through the mean size of the note clusters and the mean depth of the note clusters. In other words, researchers could gain some indications of collaborative knowledge building by looking at the number of cluster of notes and isolated notes in the forum, the number of notes per cluster, and the level of depth achieved. Another less rigorous but more common ways of assessing collaboration is to compute the average length of the threads (Guzdial & Turns, 2000; Lipponen et al., 2003). The average thread length is equivalent to Hewitt's mean size of notes cluster. Although the computation of average length of threads is insufficient for full understanding of online interactions, it provides an indicator on how sustained the interactions were. Methodologically, it is also important to note that unbiased ways of assessing connectivity need to be established. One possible way would be to view connectivity from the participants' perspectives, i.e. to restrict connectivity to only explicit links created by the participants.

Noticing the gaps in Henri's model, Gunawradena et al. (1997) developed an interaction analysis model (IAM) to examine meaning negotiation and co-construction of knowledge. The model describes co-construction of knowledge as five progressive phases. Table 4 provides a brief summary of the phases and sub codes.

Table 4

The Five Phases of Interaction Analysis Model (IAM)

Phase 1: Sharing/Comparing of Information
Phase 2: Discovering dissonance, gaps in understanding or areas for improvements among ideas or concepts
Phase 3: Negotiation of meaning/ co-construction of knowledge
Phase 4: Testing and modification of proposed synthesis or co-construction
Phase 5: Agreement statements/ application of newly-constructed knowledge

Each phase consists of other sub-phases such as asking questions and proposing solution for problems. As the IAM was developed in the context of an online debate using grounded theory approach, how useful is the model in explicating the knowledge building processes that are not in the format of debate needs further research. For example, it is not difficult to imagine a facilitator of an online discussion starting a knowledge building discourse by identifying an area of dissonance or gaps in understanding (Phase 2) or even with a negotiation of the meanings of terms (Phase 3). In a KBC, participants are usually encouraged to identify gaps in understanding early. In such cases, the participants may move back to phase 1 or proceed to the later phases.

Garrison et al. (2001) also created a model for analysing online interactions based on their conceptualization of online learning as practical inquiry for higher education. The model has four progressive phases, starting from a triggering event where the problems are presented. The learners then move through the exploration, integration and the resolution phases. They claimed that their model was not inconsistent with that of IAM. Although the general progressions of knowledge construction for both models were parallel, there were some differences in terms of the sub-phases. As the model was only tested on three sets of online messages which amounted to only 95 messages, it was less descriptive than the IAM.

Recent studies of online interactions roughly fall within the dimensions described above with adaptations to the specific contexts and purposes of the study. The common dimensions employed are participation, cognitive processing and social interactions (see Wallace, 2003). For example, Guzdial and Turns (2000) assessed over 1000 undergraduates' use of online forums mainly from the participation dimension. Average number of postings, average length of threads, proportion of participants/ non-participants and on/off task notes were the indicators they employed to assess learning. Lipponen et al. (2003) categorised the students' postings of as on/off task, and further classified the functions of the postings as providing information, asking research/ clarification questions, and something else. They also measured the mean size of notes and the depth of notes and mapped out the social relations through case-by-case matrix. In the participation dimension, other than notes creation and responses/comments, they also made use of log files to study who-read-whose notes. Schellens and Valcke's (2005) also employed similar dimensions. For the cognitive dimension, their scheme of classification is geared towards knowledge building rather than learning. They claimed that the scheme is parallel to Gunawardena et al.'s scheme. They have also differentiated between the use of theoretical and experiential information in the online messages for knowledge building. Analysis in this aspect is important, as one concern in CSCL is superficial exchange. The most recent application of IAM was conducted by Marra et al. (2004). They analyzed a small sample of 47 notes using IAM and Newman, Webb and Cochrane's (1996, in Marra et al.) model. They found that the IAM produced better descriptive data and inter-rater's agreement was more easily reached since the IAM was better defined.

In summary, content analysis models developed to date have tried to understand the rich data captured in online forum from different aspects. Across the studies reviewed, low participation with insufficient depth seems to be a perpetual problem (Garrison et al., 2001;

Hudson & Bruckman, 2004; Marra et al., 2004). This casts doubt on claims about the opportunities offer by CSCL or CMC in general. This study attempts to contribute to CSCL study by documenting how in-service teachers co-construct knowledge online.

This review has analyzed the complex contextual and personal problems that practising teachers face when they are expected to promote student-centred constructivist learning supported by IT as delineated in the vision of MP2. Drawing on recent studies of TPD in the form of collaborative inquiry and the KBC, which are both founded on the recent development of sociocultural theories of learning, it argued that a possible solution is to allow the teachers to experience teaching and learning in a KBC. Implementing the KBC in classroom is a way to achieve the MP2 initiative. Engaging teachers in KBC also seems to be congruent with the notion of collaborative inquiry and the recommendations offered by adult learning theories. A double-loop learning system (Salomon & Perkins, 1998) is formed through the T-KBC and it could offer an enriched environment to facilitate teachers' development. Chapter 3 will provide more information with regards to the design of T-KBC.

Chapter 3

Method

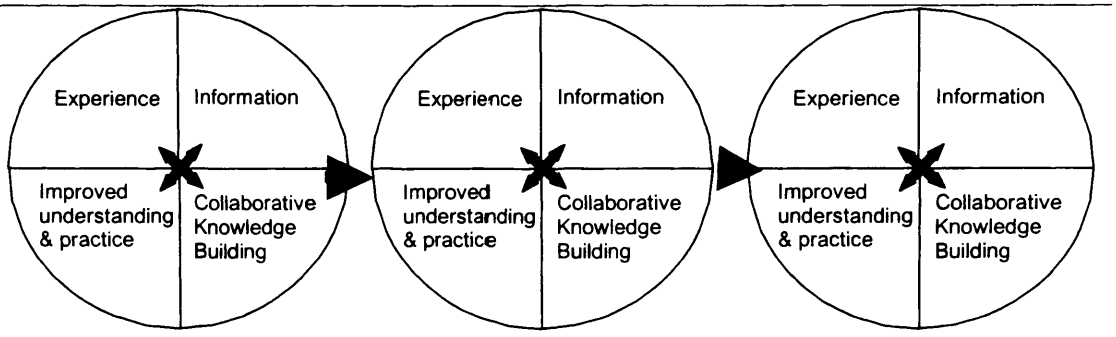
The following sections outline how this study attempts to answer the research questions selected and how are the methodological issues addressed. Before going into the methodology, the intervention design is delineated and the research questions are reiterated and expanded. This will provide adequate background information for the reader to assess the adequacy of the methodology.

The Teacher Knowledge Building Community

Synthesizing from the literature review, this study engaged in-service teachers as adult learners in a KBC for collaborative inquiry. Figure 3 below depicts the intervention graphically.

Figure 3. The teacher knowledge building community (T-KBC)

Stages and Activities	Stage 1: Experiencing KBC (9 weeks)	Stage 2: Designing students' KBC (5 weeks)	Stage 3: Implementing/ Facilitating Students' Collaborative Knowledge Building (10 weeks)
Dates	9th Jan 04→ 5th Mar 04	20th May 04→ 24th Jun 04	1st Jul 04→ 4th Sep
Module Title	Integrating IT into curriculum	Visualizing students' thinking with IT tools	Facilitating Students Hypermedia Creation



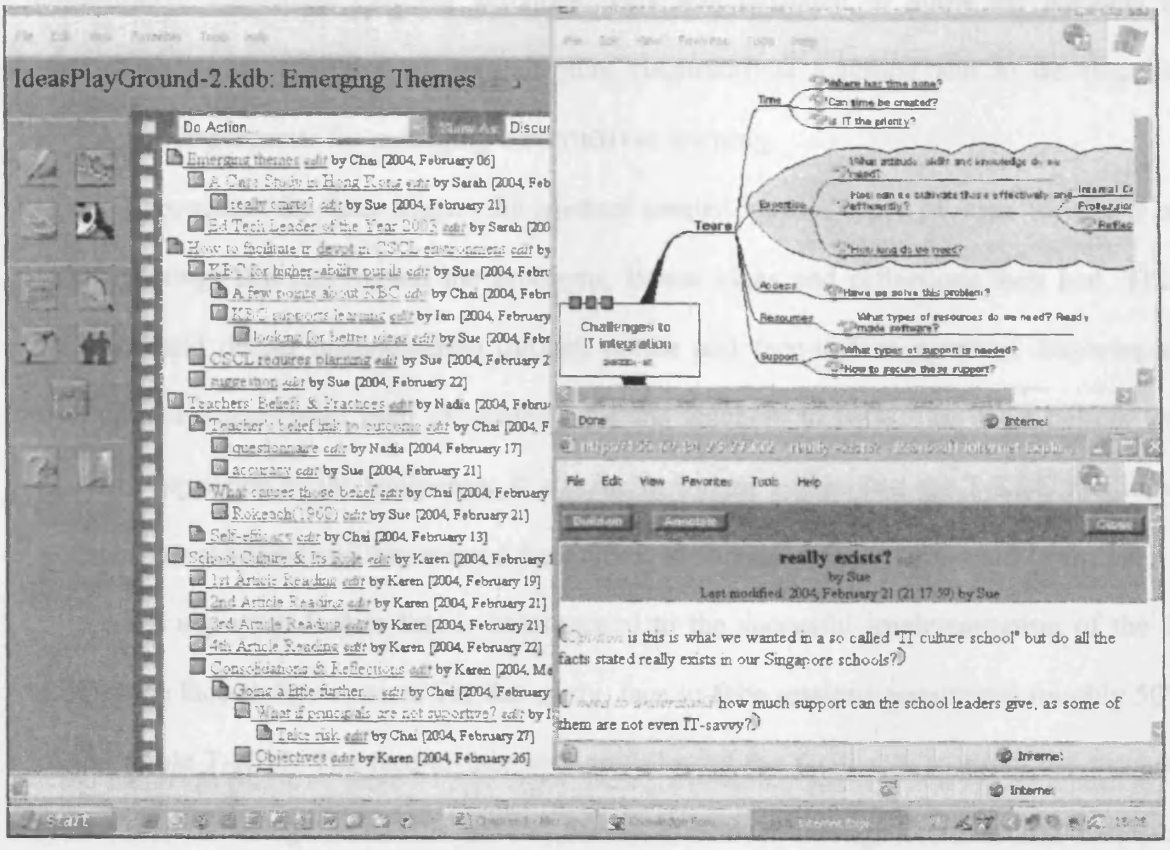
(Ongoing Knowledge building discourse throughout the intervention)

(Adapted from Wells, 1999, p. 85)

For simplicity, this adaptation is referred to as teacher knowledge-building community (T- KBC). The T-KBC was divided into three stages. Stage 1 engaged teachers in

identifying authentic problems that they faced when they were integrating IT into their teaching practice. This was done in accordance with adult learning principles and the KBC recommended practice (Knowles, 1990; Scardamalia, 2002). The facilitator initiated the problem identification process by crafting a broad theme such as what are the problems with students' thinking. The teachers then drew from their personal experience and wrote about the problems they encountered and their initial understanding of them. This activity constituted the first session of postings. They also substantiated the top left quadrant of a cycle of dialogic inquiry (Wells, 1999). The problems and initial problem representations, once articulated, served as information (the top right quadrant) for other members. New information was also brought in through the teachers' personal research and the readings provided by the facilitator. The progression of the dialogic inquiry is generally in the clock-wise direction as depicted by the diagramme but it could start from the information quadrant and move backward to the experience quadrant. In other words, the process is not necessarily linear. Through collaborative inquiry (the bottom right quadrant), the teachers were expected to build knowledge as a community about the identified issues based on their rich experience, experimentation, and related readings. They were also tasked to plan IT integrated lessons, share their plans, make improvements based on peer inputs, implement and reflect upon it. By moving through the "spiral of knowing" (Wells, 1999, p. 85), it is hoped that the teachers would produce better understanding and practice. The cycle was planned to allow the teachers to gain first hand experience on co-construction of knowledge. Figure 4 below shows a screen capture of the KF interface that depicts the online activities.

Figure 4. A screen capture of Knowledge Forum interface



Stage 1 was followed by a 10-week course break because the participants were involved in other professional development activities and they were busy preparing the children for examination. The examination period was in mid May. The first interview was conducted during this 10-week break.

After experiencing the KBC, the teachers were tasked to design a suitable KBC with appropriate themes of inquiry for classroom implementation in the second stage. The teachers planned their students' KBC based on the existing curriculum and they were free to choose whichever grade level and class they deemed fit so as to enhance the authenticity of the projects. These project ideas were again subjected to peer and facilitator's critique for improvement and refinement. This happened during the mid-year school vacation to allow the teachers to have ample time in planning the necessary materials and activities.

The third stage was the actual implementation where the teachers facilitated students' collaborative knowledge building activities. This was designed to allow the teachers to understand the complexities of implementing constructivist teaching and to develop the necessary competencies for managing constructivist learning.

Throughout the three stages, the teachers created various types of notes (a note is an online posting) that represented the problems, lesson ideas and reflections they had. They were to build deeper understanding through online and face-to-face sessions. Experiences from all the stages were used as contexts for the teachers to reflect on their beliefs and practices supported by the facilitators. It was the facilitator's hope that the T-KBC facilitated teachers' development and thus moved them closer to the realization of Engaged Learning.

An important feature that is instrumental to the succesful implementation of the T-KBC is the face-to-face session. For this study, face-to-face sessions constituted roughly 50% of the whole T-KBC. The face-to-face sessions allowed the facilitator to equip the teachers with basic knowledge and skills needed for each module through lectures and hands-on learning. It also allowed the facilitator to consolidate understanding that emerged through the online discussion. Further questions that could lead to deeper inquiry were also highligthed during these face-to-face sessions. Beside these, the face-to-face sessions fostered the social relationship among the teachers by allowing the teachers to clarify unclear messages and share their experiences. As such, the face-to-face element has contributed to the participants' experience of the T-KBC. In other words, the results reported in this study were obtained from a blended environment rather than an exclusively online environment.

Research Questions

The following research questions were the foci of this study.

1. How do teachers build knowledge collaboratively in a KBC?
    a. How actively do the teachers participate and interact socially in a KBC?

b. What are the patterns of interaction among the teachers for the purpose of knowledge construction as reflected through the IAM?

2. What are the teachers' reported epistemological beliefs and their reported beliefs about computers in education?
    a. What are the teachers' reported prior beliefs about knowledge and knowing?
    b. What are the teachers' beliefs about learning, teaching and technology?
3. How do teachers reportedly perceive teaching and learning in a KBC?
    a. How do the teachers reportedly perceive learning in a KBC?
    b. How do the teachers reportedly perceive teaching in a KBC?
    c. What are the perceived changes that teachers reportedly experienced as a result of teaching and learning in a KBC?

Research Paradigm and Approach

The research paradigm for this study was that of constructivist-interpretivist paradigm. The adoption of the interpretive paradigm was consistent with the theoretical foundations of the T-KBC, especially that of situating learning in a community of practice through dialogic inquiry (Wells, 1999; see also Martínez, Dimitriadis, Rubia, Gómez, Fuente, 2003). In other words, the intervention design and the research paradigm are in agreement. This means that the researcher did not view the participants (i.e., the in-service teachers) in this research as passive recipients of external stimuli who respond mechanistically to the stimuli. On the contrary, the participants were regarded as individuals who actively interpret and construct the meanings of their experiences (Cohen, Manion, & Morrison, 2000). Drawing on the constructivist-interpretivist paradigm, this study attempted to understand the meanings of the experiences from the participants' perspective. It is also important to note that within this paradigm, interpretation is not viewed as an independent act. Interpretation or meaning construction happens in an evolving context and it is the outcome of complex interactions

between the individual and the context (Bogdan & Biklen, 1998). In other words, the findings of this research are co-constructed by the researcher and the participants within the context of the T-KBC. Informed by Mead's work on symbolic interaction, this study adopted the stand that the important thing to understand about interpretation is what has been considered when the interpreters interpret (ibid).

The constructivist-interpretivist paradigm was selected based on the researcher's interest; personal belief and numerous studies in teacher education (for example, see Cole & Knowles, 2000). The researcher argues that as professionals and adult learners, teachers consciously or unconsciously interpret the environmental inputs. How teachers understand the initiatives passed down from higher authorities and perceive the various aspects of the school context, and interpret newly introduced pedagogies, play a pivotal role in influencing the teachers' subsequent decisions.

The researcher taught in a secondary school for seven years. Due to the launch of MP1, he went through numerous professional development workshops. A majority of the workshops made little sense because the instructors did not pay adequate attention to the reality school was facing or the difficulties involved in integrating IT. What IT meant for the policy makers was different from what it meant for the practising teachers. The policy makers could see IT as a means toward student-centred learning while teachers might perceive it as a cumbersome and intimidating add-on that required too much time and effort to be used meaningfully in classrooms (see Earle, 2002; Demetriadis et al., 2003). These experiences informed the researcher about the importance of understanding the participants' perspectives for it is through such understanding that concerns and issues can be adequately addressed and opportunities for the construction of new and meaningful structures can be created. Although the choice of paradigm is to a large extent determined by a researcher's experience and personal belief (Guba & Lincoln, 1989), the researcher was also informed by the work of

other teacher education researchers who are interested in teachers' learning and change. The qualitative paradigm has facilitated many researchers to provide "thick descriptions" that illuminate teachers' learning and development over time (Lee & Yarger, 1996).

In terms of research approach, this study adopted a mixture of design research (Bereiter, 2002b) or design experiment (Collins, 1999; Reeves, 1999) and qualitative case study (Merriam, 1998) to answer the research questions. Lipponen, Hakkarainen and Paavola (2004) argued that CSCL study founded on the notion of knowledge building should adopt the design experiment approach. The design experiment approach is an emerging research approach in the field of the learning sciences. Its main goal is to "carry experimentation into real-life settings in order to find out what works in practice" (Collins, 1999, p.290). It differs from the experimental design in that it does not attempt to control the variables within the context. Rather, the researchers attempt to explicate the complex interactions of variables in the natural environment of the classroom. The value of this approach lies in bridging the gap between theory and practice (Collins, Joseph, & Bielaczyz, 2004). This is because design research is usually conducted in close collaboration between the researchers and the practitioners for the purpose of creating and sustaining innovative practices in a real life context (Lipponen et al., 2004). In a sense, design research and collaborative inquiry (see chapter two) are two different ways of talking about the same activities, depending on whether one is taking the perspective of a practitioner or researcher.

Brown (1992) carried out the seminal work in this orientation in her study of communities of learners. In her studies (for example, Brown, 1992; Brown & Campione, 1994), she mixed and matched qualitative and quantitative methods to suit her purpose. She made use of pre-and-post test to measure students' achievements and compare the results between experimental and control groups. She also supplemented the reports with case studies to explicate the microgenetic process of learning. Researchers in the context of KBC

have also employed this approach for their studies (for example, see Scardamalia et al., 1992; Scardamalia et al., 1994). These efforts have helped practitioners to better understand the notion of community of learners and KBC, which are both gaining wider acceptance in schools. As this study involved the design and implementation of the T-KBC in the real world context of developing teachers, the design experiment is a suitable approach.

Within the broader framework of design experiments, a case study approach is selected for conducting the research as this study aims to gain in-depth knowledge of teachers' collaborative knowledge building activities and what it means to them (Merriam, 1998). The choice of a case approach is a choice of unit of analysis rather than a choice of method. Case study uses both quantitative and qualitative data to explicate the complex interactions between variables within a bounded system (Stake, 2000). Martínez et al. (2003) postulated that the case study is an appropriate framework for researchers to integrate both quantitative and qualitative data to build deeper understanding about the complex and dynamic phenomenon of online learning. Quantitative data such as those generated by the computer log files can be employed to confirm or disconfirm participants' claims while qualitative data can be used to understand the participants' perspectives. This study was carried out in a similar way. It is hoped that through case study, this research could obtain rich and holistic accounts of the phenomenon that illuminate participants' subjective understandings of their experience in the T-KBC and how that changes them. The participants' accounts could be triangulated by the computer log files and the content of their interactions. Though the particularity of the case study would limit the transferability of the knowledge generated, this study could help educators to participate vicariously in the experience of being a member of KBC and thus build deeper understanding and useful knowledge about teaching and learning in a CSCL environment (Stake, 2000).

Research Participants

The sampling strategy adopted in this study was purposeful sampling (Patton, 1990), i.e., the researcher had set out to select information-rich cases. Based on the research questions, this study recruited teachers who had experienced both teaching and learning in a KBC. They were teachers attending the "Advanced Diploma (Information Technology in Education)" (ADIT) programme conducted by the National Institute of Education, Singapore. Typically, they were teachers who were interested in enhancing their teaching with IT. They usually have 3 years or more of teaching experiences in primary or secondary schools. Based on this sampling strategy, it is more likely that the participants represent only a small proportion of the practising teachers in Singapore who have positive attitude towards IT in education.

To date, 10 teachers who matched the criteria were identified. These teachers were from 2 intakes of the ADIT programme (2003 and 2004). The first intake constituted the pilot study for this research. Three out of 11 teachers who had attended Advanced Diploma were identified. The KBC was initiated in January 2003 and ended on September 2003. The researcher did not interview all the teachers due to time constraints and the fact that the research at that time was a pilot study in nature. The second intake was another group of seven teachers attending the ADIT programme. The course dates and structure were similar to the first course (see Figure 3). All participants from the second intake were interviewed to avoid bias sampling as they constituted the main study. The teachers had completed their courses and they were interviewed after they had obtained their grades for the respective modules. Table 5 below provides the background information of the participants.

Table 5

Background of Research Participants

Participants' Pseudonym	Years of service	Level Taught	Teaching subjects
Ann	3	Primary	Malay language
Clare	15	Primary	English, Mathematics, Science, Social Studies
Grace	4	Primary	English, Mathematics, Science
Ian	7	Primary	Mathematics, Social studies
Karen	5	Primary	English, Mathematics, Science
Sarah	5	Primary	English, Mathematics, Science
Nadia	3	Primary	English, Mathematics, Science
Nora	9	Primary	Malay Language
Zoe	4	Primary	Malay Language
Sue	3	Primary	English, Science

Ann, Clare and Grace were participants of the pilot study. The rest were from the main study. Among the participants, Ian was the only male teacher. All of them were Asian, either Chinese (6) or Malay (4), and all taught in the primary school. Karen and Sarah were in the same school and the rest of them came from different schools spread across Singapore. One other important characteristic about this group of teachers was that half of them were Muslims. Based on the teachers' reports, the Islamic background seemed to have an effect on some of their epistemological beliefs though the effect was not uniform.

Data Collection

To provide rich descriptions for this study, four main sources of data were gathered. They were (a) web server logs; (b) documents generated and captured in KF; (c) interview transcripts; (d) field notes about what happened during face-to-face meetings. The first source of data was the comprehensive web server logs generated by subjecting the online interactions to the Analytic Toolkit® (Burtis, 1998). The logs provided the researcher with information on the actions that the participants performed over time. Actions such as posting of notes, who read whose notes, who built-on whose notes, and growth of database provided valuable descriptive data. For learning and knowledge building to occur in the T-KBC, which is founded on the social constructivist theories of learning, participation and collaboration are important conditions. The web logs allowed the researcher to gain understandings on how active the teachers were in building knowledge and how cohesive the groups were.

The second source of data was the content of the notes posted by the teachers. These notes comprised discussion of various issues, lesson plans, peer critiques and teachers' reflection. The online interactions provided the raw data for building a description of how the participants build knowledge collaboratively. The lesson plans and teachers' reflection about their lesson, together with the daily monitoring of the online interactions of the students' databases helped the researcher to gain a "virtual presence" into the classrooms. This information provided a vital source of data for the researcher to document what transpired during the implementation of KBC in the classrooms. It also helped to contextualise the researcher's understandings about teachers' perspectives and developments.

The third source of data was the interviews. To lessen the cognitive loads that the researcher had to cope during the interviews, semi-structured interviews were adopted. This approach allowed the researcher to seek understanding by exploring and probing participants' viewpoints in an open but structured environment (Drever, 1995). All interviews were

transcribed verbatim. For the purpose of this study, interviews were treated as "complex social and sociolinguistic events" (Block, 2000, p. 761) that required careful planning and skilful implementation. Before the interviews, open-ended and non-threatening questions were drafted for obtaining rich data without imposing the researcher's preconceived ideas (Charmaz, 2003). The interview schedules were subjected to peer examination to ensure that the questions were open-ended (see Addenda 1 & 2). When conducting the interviews, care was taken to ensure that the participants felt secure to express themselves freely (Cohen et al., 2000). This was achieved through having proper introduction and closure. The researcher allowed the participants to choose the venue and the time they were comfortable with. The researcher also adopted careful questioning and active listening, while constantly focusing on the objectives of the research (Kvale, 1996). Important messages, as and when they were detected, were rephrased and sent back to the participants to help the researcher in understanding them correctly and accurately (ibid). The present researcher has prepared himself through conducting a preliminary study (Chai et al., 2003) and a pilot study (Chai, 2004) before he engaged in the main study.

Two interviews were planned for this study. The first interview was conducted after the first stage of the intervention to gather data on teachers' personal theories/ beliefs about knowledge, teaching, and learning. Because it is important to gain trust and establish rapport before the conduct of in-depth interview that probes into matters of personal nature (Fontana & Frey, 2000), the researcher did not choose to conduct the interview before the intervention started. Also, as part of the requirement for the T-KBC, the teachers were to produce a lesson plan and implement it in their classroom in the initial phase of the first module. The lesson plan revealed something about how individual teacher perceives IT as a teaching tool and it was used as a reference to ground the first interview. The purpose of the first interview was for the researcher to gather some baseline data for the purpose of comparison with the second

interview after the completion of the intervention. In the second interview, the teachers were asked to describe their experiences teaching and learning in a KBC, what the experiences meant to them, if and how that helped them to change. As mentioned earlier, the researcher had adequate understanding of what happens in the classroom through virtual presence. This is achieved through daily monitoring of the student databases once the classrooms implementation started. It allowed the researcher to know what the main foci of the discussion were and observe some parts of students' progressive understanding about the subject matter. Although it is obvious that virtual presence could not be as rich and informative as actual presence, it should help the researcher in obtaining authentic accounts from the teachers rather than plausible ones (Cooper & McIntyre, 1996).

Field notes were taken as another source of contextual information that could help to illuminate teachers' actions and their thoughts about them (Bogdan & Biklen, 1998). As far as possible, field notes were recorded within the day of each face-to-face or interview session. The field notes contained information such as teacher's life, teacher's work, school's policy etc gathered during class time or even tea breaks. For this study, they were not analyzed. Instead, they were useful for filling in contextual information when the cases were reported. The researcher had also written some reflective notes after viewing the online interactions. The reflective notes helped the researcher to identify emerging themes as the researcher monitored the online discourse and project implementation.

Data Analysis

Active participation, in-depth processing of discussion topics and social cohesion are important conditions for knowledge building to occur in a CSCL environment (Guzdial & Turns, 2000). The web server logs that were quantitative in nature provided relatively unbiased data for the researcher to describe how actively the teachers had participated in knowledge building, the depth of discussion and the social cohesiveness of the community.

Indicators of active participation included the number of notes contributed by the participants and the average number of words per note. The depth of discussion was assessed through the computation of the average thread length. The thread length is the number of notes in a single connected chain of notes (ibid). As an example, a forum which has two clusters of notes, where one cluster consists of four notes and the other two, would have an average thread length of (2+4)/2, which is 3. The logs were also analysed using social network analysis techniques to provide description about the social cohesiveness of the community (for example, see Lipponen et al., 2003). These three indicators provided the background descriptions for answering the first research question. For example, one cannot infer that a discussion thread leads to in-depth discussion by simply computing the thread length. Content analysis is needed for such inferences.

As mentioned, quantitative data alone are insufficient in providing an in-depth understanding of the computer-mediated learning processes (Henri, 1992). The online messages need to be examined qualitatively to account for how knowledge building occurs. For qualitative analysis of the notes, Gunawardena et al.'s (1997) interaction analysis model (IAM) for examining meaning negotiation and co-construction of knowledge that occur within computer conferencing was employed for this study. The IAM was selected for the purpose of analyzing the notes because it seemed to be the most appropriate and promising model, due to its theoretical foundations and the recommendations of empirical studies to date. It was built on the data generated by an online debate that was based on the social constructivist theories of learning. Marra et al. (2004) considered the IAM as one of the more reliable and user-friendly models among the limited models designed for online interaction analysis. However, the researcher was mindful that the IAM was developed as a grounded model in the context of an online debate. A debate necessarily forces the participants to choose sides and argue for the chosen stance whereas co-construction of knowledge in a KBC

emphasizes on shared responsibility and collective advancement rather than the competition among learners (Bereiter, 2002a). Moreover, interactions are essentially discursive and context specific. Given these recognitions, the researcher was mindful not to force fit the data into the IAM scheme. In other words, the researcher coded the data using the IAM but he remained open to creating new categories and modifying old categories.

The IAM codes were largely applicable to this study although there were times when the researcher had to modify the code descriptions. At the end of the coding, two new codes were created and some of the descriptions of the categories were slightly modified. The first new code was created for the reflective summaries and lesson plans created by the teachers. The teachers shared their lesson plans and invited critiques from their peers. A lesson plan is in a sense a cognitive artefact that is derived and synthesized from the teacher's knowledge, beliefs and experience. It is a proposed synthesis (Phase 4) but it is not a product of co-construction. The teachers constructed their lesson plans individually and these were shared as the first note for the initiation of idea refinement process. The researcher therefore decided that the notes should belong to Phase 1 and created a new code 1f for the lesson plans. The reflective summaries that teachers created in response to the readings given were also of the same nature and therefore included in the same phase code. Following such decision, the code descriptions of Phase 1f were provided. For Phase 2, the phase was extended to include the identification of the gaps in understanding. This should be an appropriate expansion as the original Phase 2 of the IAM was created for the discovery of dissonance that emerges through debate. The KBC regards the act of identifying gaps in understanding as a starting point for the knowledge co-construction processes. As such, it was decided that phase 2 should accommodate the identification of gaps in understanding. Another additional code was created in phase 3, i.e., proposing possible solutions for identified problems. It was placed in phase 3 since Gunawardena et al. (1997) defined this phase as the phase in which idea co-

construction occurred through proposals of ideas. Appendix 1 shows the modified IAM with coded examples. For distinction, additional descriptions created by the researcher were added in parentheses.

The unit of analysis was the note, i.e. the message was taken as a whole. This decision was modelled after Garrison et al.'s (2001) study. Coding at sub-message level introduced unnecessary complication on how the messages should be sub-divided. However, within each note, especially the longer notes, one can actually find two to three phase codes. The researcher identified all the indicators on the hard copies but each note was only given one code, which was the highest phase code within that note.

For the analysis of the interview transcripts, a combination of the constant comparative method (Strauss & Corbin, 1990) and thematic coding (Flick, 2002) seemed to serve the purpose of this study well. Open coding was first performed on the transcript of an individual teacher. As far as possible, this study used the participants' expressions as the labels for the codes. Categories were then formed by grouping the labels during open coding. Thereafter, the relationships between the codes and the categories were explicated through the general scheme of axial coding, i.e. linking the causal conditions, phenomenon, context, intervening conditions, action/ interaction and consequences. Table 6 below shows an example of the open coding with some memos written.

Table 6

An Example of Open Coding

Time	Transcript	Open Coding and Memo
30th	S: Because I actually did a survey with my class, I ask them, 'if I taught you this topic and we just go on and you have learned on your own, which one do you think you have discover more?' They said that they will have discover more from, through posting and going to the Internet. R: That's what the students said? S: Yah, they said that. R: That's interesting. S: Yah. But the posting doesn't seem fine, they are not so active or they feel that they, they think that they would have learn more through the KBC. R: Which is parallel to what you have said because you have to do it yourself, to be able to make the comparison. S: Yah. R: In that sense, if we contrast the two thing you are saying, it's like in school, your teaching will be you organize the information and spoon-feed them S: Yah. Prepare them for end of the year paper. R: The real learning, but the real type of learning will be you ask on your own.	Students' perception of superior ways of learning Teacher's dissatisfaction with students performance (There seems to be a disconnection between real learning and school learning) School teaching as teaching for test

These procedures were employed for the pilot interview and it generated some useful findings (Chai, 2004). However, as the main study involved seven teachers, a means of making the cases more comparable is necessary. Based on Strauss's (Strauss, 1987, in Flick, 2002) work, Flick developed the method of thematic coding for comparative study. The purpose of thematic coding is to investigate "the social distribution of perspectives on a phenomenon or a process" (Flick, 2002, p. 185). Through thematic coding, case profiles that

are comparable in terms of its thematic structure are generated. Each case profile typically contains a key phrase that captures the essence of the case from the transcript; a brief and relevant background description about the participant; and the participants' views on the issues investigated. While writing the case profile, it is essential to preserve "the meaningful relations in the way the respective person deals with the topic" (Flick, 2002, p. 186). The case profiles and the thematic structure are constantly adjusted to accommodate emerging categories. The case profiles can then be arranged in a matrix for cross-checking. One fully developed teacher's account based on their case profiles (Sue, Addenda 3) can be found in the CD-Rom attached.

The researcher followed the procedures as delineated by Flick and developed thematically comparable case profiles to identify patterns of teachers' perceptions on teaching and learning in a KBC. The case profile was created using multiple pieces of index cards. As the researcher read the interview transcripts, conceptual labels generated in the pilot study were applied to the segments of the data. New labels were created as and when needed. The labels and the time where the raw data appeared in the transcripts were recorded in the index cards. Each index card contained the participant's name, which interview it was and the category name at the top left and right corners. Figure 5 below shows an example of the index card. These index cards allowed the researcher to compare different teachers' perspective within the same category easily.

Figure 5. An example of coding done on an index card.

Karen, Interview 2	PLE (Personal Learning Experience)
1. Received knowledge (4')	
2. Textbook as source (3')	
3. Teacher as source (3')	

While coding the data from the interviews and the online postings, the researcher also recorded emerging thoughts and themes in the form of memos (see Strauss & Corbin, 1990). The memos were also written on index cards and coded as RR (Researcher's Reflection). They helped the researcher to record important insights and leads for further investigation.

Issues with Reliability, Internal Validity, External Validity and Objectivity

The notions of reliability, internal validity, external validity and objectivity are widely accepted as criteria for assessing the quality of educational research. However, these criteria have been developed from a realist-positivist paradigm. Guba and Lincoln (1989) argued that these criteria were problematic when applied to research grounded in the constructivist-relativist paradigm. They were derived from the assumptions of the existence of an objective and stable reality. This directly contradicts the constructivist's belief in multiple realities constructed by different individuals with unique value systems. Faced with the conflict in this paradigm, many researchers in the qualitative paradigm have attempted to set up new criteria for assessing qualitative research. Cohen et al. (2000) suggested that researchers should discuss the issues of criteria within their chosen research paradigm.

For the purpose of this study, the researcher adopts the standard of "trustworthiness" as laid down by Guba and Lincoln (1989) to guide this study. Based on the notion of trustworthiness, Guba and Lincoln derived four criteria to assess the quality of a naturalistic study. They are credibility, transferability, dependability and confirmability. They are parallel to the positivist's notions of internal validity, external validity, reliability and objectivity respectively.

Credibility is achieved through a number of techniques. They include prolonged engagement, persistent observation, peer debriefing, negative case analysis, progressive subjectivity and member checks. Through such techniques, the researchers immerse themselves in contexts and are enabled to understand and discover the complex issues that

bear on the phenomenon. They repeatedly test their emerging understanding with their personal biases, negative evidences, disinterested peers and the participants. Another technique that enhances credibility is by triangulating different sources of data collected (Lincoln & Guba, 1985). Eisner (1998) characterised triangulation as a process of achieving structural corroboration. Through the process of pitching multiple sources of data against each other, emerging assertions are subjected to careful scrutiny. These techniques, taken together, allow the researchers to match their "constructed realities" to those of the participants as closely as possible. Whilst immersed in situ, the researchers collect detailed descriptions through field notes and interviews. This provides the thick description necessary for an interested reader to assess the transferability of the findings. Other than the raw data, researchers should also keep records of the research processes. The raw data and the research processes are means for external auditors to assess the dependability and confirmability of the research processes and products. In other words, it is the researcher's responsibility to make available the raw data and make explicit the methodological considerations and decisions. These criteria developed by Guba and Lincoln are still widely accepted for establishing the standards of qualitative research (for example, see Creswell, 1998; Cohen et al., 2000).

This study employed a number of strategies to enhance its trustworthiness. First, the intervention design was about six months, allowing the researcher to have prolonged period of contact with all the participants. During the intervention periods, the researcher constantly monitored the online activities among the teachers and their interactions with their students. It seems fair to claim that the researcher had persistently observed what transpired even though it was only through "virtual presence" in the case of teachers' classroom practices. Second, a multi-sites design was adopted with the collection of multiple sources of data. This provided the necessary means for triangulation of data. Third, the verbatim transcripts of the interviews and the interpretations were subjected to member check. This allowed the researcher to be

corrected by the participants. Fourth, the findings were subjected to peer examination. For example, the pilot study had been written and given to two colleagues for comment. The researcher had also reported the findings through departmental sharing and asked for critical feedback. Peer examination was also applied to the content analysis performed for the online postings. However, the peer examination processes were not systematic since the researcher could not find a critical partner who would read all that had been written. He could only ensure that all findings had been examined by at least two peers, thereby reducing biased interpretation. Fifth, the researcher constantly looked out for negative cases to counter possible personal biases. He had also provided a brief description of himself to make explicit some possible biases in the Introduction. These measures, taken together, should be able to enhance the quality of this study (Cresswell, 1998; Merriam, 1998).

Ethical Issues

It is essential for any research involving human subjects to respect and protect the rights and the welfare of the participants. Following Cohen et al.'s (2000) suggestion, the researcher considered the possible harms that the research process could cause. This study, aimed at exploring teachers' experience of teaching and learning in a KBC, might embarrass the teachers when they were not successful either in their own learning or in implementing the approach in their respective classrooms. There was also a possibility of probing into the teacher's personal life since inadequate participation in the online environment might be due to some family problems. As for reporting of data, negative school context such as unsupportive superiors reported by the teachers might create problems for the teachers in the school. In view of these, an informed consent approach (see Addenda 4) was adopted and the findings were reported using pseudonyms. It was made clear to the participants during the negotiation for access and in the consent form that participation was voluntary and it will not affect their grades. They had the right to pull out from the research anytime for whatever

reason. This was done to prevent the participants from the feeling of being coerced to take part in this research as I was their module instructor. All participants had agreed in writing to take part in this study. Verbatim transcriptions and the findings of this thesis were also made available to the participants via e-mail.

In summary, this chapter has described the intervention designed to facilitate TPD for the purpose of actualizing Engaged Learning. Information about how the T-KBC was implemented has also been outlined. To investigate how teachers collaborate to build knowledge in a CSCL environment and what teaching and learning in that environment meant to them, the researcher argued that a qualitative case study approach was most promising and appropriate. The following chapters will present the findings in fuller detail.

Chapter 4

Findings and Discussion for Online Content Analysis

This chapter focuses on answering the first research question as follows:

- How do teachers build knowledge collaboratively in a KBC?
    - How actively do the teachers participate and interact socially in a KBC?
    - What are the patterns of interaction among the teachers for the purpose of knowledge construction as reflected through the Interaction Analysis Model (IAM)?

The following sections answer the research questions sequentially. The findings are compared with the pilot study (Chai & Khine, accepted) and recent empirical studies to help the researcher in making sense of the data. Possible explanations and interpretations of the phenomena generated will also be discussed within each section. In reporting and discussing the results for the knowledge building dimension, direct quotations were lifted from the database with the phase codes revealed. This was done to increase reliability (Denzin, 2000) and to allow the reader to formulate his/ her personal interpretations (Stake, 2000). The researcher will attempt to illustrate the processes involved in in-depth knowledge building among the teachers. This is important as it is one of the gaps identified in CSCL (Stahl, 2004).

Teachers' Participation Patterns in T-KBC

The numbers of notes created and the numbers of notes read were the two indicators selected for the examination of the extent of participation. Table 7 documents the data for these two areas. To provide a more complete analysis, the number of words used in each of the teachers' notes was checked by the word count function in the Microsoft Word programme. On average, the database grew by 26 notes per week with each teacher contributing a mean of 3.7 notes per week. The range is from 1.7 notes to 8.1 notes. The number of words written by each teacher per week is about 425.

Table 7:

Participation Patterns of the Teachers

Teacher's Pseudonym	Total number of notes posted	Number of notes posted per week	Number of words written	Average number of words per note	Percentage of notes read
Ian	65	2.7	9401	144.6	73%
Karen	114	4.8	12926	113.4	79%
Sarah	88	3.7	7099	79.8	43%
Nadia	71	3.0	8371	117.9	86%
Nora	40	1.7	4678	117.0	45%
Zoe	53	2.2	6488	122.4	40%
Sue	194	8.1	22452	115.7	98%
Total	625	26.0	71415		
Mean/teacher	89.3	3.7	10202	113.9	66.3%

Although it is difficult to make exact comparison with other studies because of the lack of contextual information, the results seemed to suggest that the participation rate was relatively high. Hara et al. (2000) reported an average of one note per week per postgraduate student with a length of about 300 words in their studies. Guzdial and Turns's (2000) study of undergraduate online interactions yielded a result of about one note for every two weeks. Schellens and Valcke (2005) reported coding of 1428 messages for analysis for 80 students studying "Instructional Sciences" in a time span of 12 weeks. The average was about 1.48 messages per week per student (a posting can be separated into several messages). No data were provided for the length of posting. In Singapore, Khine, Yeap and Tan (2003) investigated pre-service teachers' participation rate in an online environment for discussion of classroom management issues. They reported an average of 1.5 messages per week. In the

pilot study of the T-KBC, an average posting of 2.33 messages per week with about 350 words written was obtained. Based on these comparisons, the in-service teachers in this study (both for the pilot and present study) should be regarded as active participants in the online environment.

As studies of practising teachers' collaborative online interaction for professional development are rare (Zhao & Rop, 2001), the researcher could only identify two empirical studies that analyzed specifically teachers' online participation in formal learning setting. Poole (2000) analyzed the participation of 14 practising teachers in a postgraduate course. She reported a total of 1040 messages posted by these teachers across 15 weeks, with an average of 14 lines per message. 9% of the messages were non-academic. Based on this information, it is estimated that her participants posted on average 4.4 on-task messages per week, which seemed likely to be of a higher participation rate than the present study. Jin (2005) analyzed the participation of 18 practising teachers and reported 496 on-task messages for a semester long course. Based on this data, her participants' average weekly posting was around two messages. Jin evaluated that 84% of her participants' messages were of proficient or exemplary quality. A provisional implication that could be drawn from the present study and that of Poole's and Jin's studies is that it is possible to engage practising teachers to be active participants despite their busy lifestyle. Could it be that practising teachers, as adult learners and professionals with abundant experiences who are constantly dealing with learning problems without much community support (Little, 1990), appreciate and take up the collaborative opportunities more readily than other learners? This is of course a conjecture that is way beyond what the present study could substantiate. Many variables could impact on the participation rate of online interaction for teachers. The cultural norm of the teaching profession as an isolated and individualistic practice is one variable that could influence participation. Other variables include group dynamics in the social dimension; teachers'

attributes in the personal dimension; and the interface and pedagogical designs that constitute the technological dimension in a broader sense (Zhao et al., 2002). The following sections will explore these dimensions further.

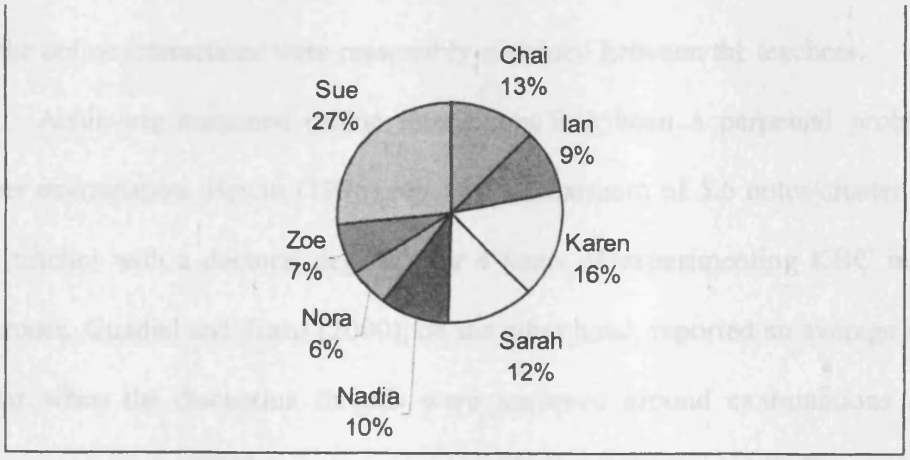
Within the social dimension, the role of the facilitator is one key factor that needs to be studied. The facilitator/ researcher for this study posted 99 notes in total with an average of 117 words per note. He contributed higher than the mean number of notes contributed by the teachers. A further search was performed on the database using the Analytic Toolkit® to find out how many responses the facilitator generated. There were 164 notes that were direct responses to the facilitator's notes, accounting for 22.6% of the total number of notes. For the pilot study, the facilitator's postings generated direct responses that accounted for 19% of the total number of notes. It seems that the facilitator's active participation had helped to promote active participation among the participants.

It is not unusual for facilitator to participate actively. In Hara's study, the facilitator's average posting is twice (2.1 notes/ week) that of the students. Guzdial and Turns (2000) also reported that about 20% of notes in databases were teachers' contributions in their study. However, the question of how active should a facilitator be is far from clear. Mazzolini and Maddison (2003) studied the relationships between instructors and students' rate of postings and how the instructor's rate of posting affected the discussion thread length. The results suggested that instructor's rate of posting was not related to students' posting rates. However, the instructor's rate of posting was negatively correlated to the discussion thread length. This implies that the instructor might close down discussion prematurely if they intervened with the situation too often. Active participation by the facilitator is crucial in developing and sustaining discussion among learners (Wallace, 2003) perhaps at the beginning stage where the facilitator is modelling appropriate behaviours in the online environment. It should then fade away as the participants take ownership of the knowledge co-construction processes.

Adopting such a stance is a recommended strategy for constructivist teaching as it encourages learners' active construction of understanding (Jonassen, 2000; Brooks, 2002). In the same light, facilitators should also confine their communicative acts towards extending the discussion rather than providing expert answers (Collison, Elbaum, Haavind & Tinker, 2000).

The results of this study also imply that the facilitator could not dominate the discourse since about 80% of interactions were peer-to-peer interactions. One rationale of employing CSCL in classroom is to break the typical "three turns" discourse structure of teacher initiates, student responds and teacher evaluates (Scardamalia & Bereiter, 1996). The results seem to support Scardamalia and Bereiter's contention that the KBC democratized learning environment for the learners. Figure 6 below shows the distributions of notes created in the database. Although the percentage of note creation over the total number of notes ranged from 6 % to 27%, it seems fair to say that no one dominated the discussion. It seems to provide further evidence to support that in a CSCL environment, learners are given ample opportunities to participate actively in the process of knowledge construction (ibid).

Figure 6. Distributions of notes creation in the T-KBC.



The average percentage of notes read for this study is 66%. This should be a heartening result given that teachers are usually busy people who have to deal with numerous demands on their time. To examine the relationship between the writing and reading of notes,

a correlation coefficient of 0.64 (0.44 for the pilot) was obtained through computing the correlation between the ranked order of the teachers for writing and reading of notes. The result suggests that there is a moderate correlation between these two forms of participation. However, given the small sample size of this study, further research is needed to clarify the relationship between these two forms of participation.

Dividing the total number of notes by the total number of clusters yields the average length of threads. This study made use of explicit links of notes created through the built-on functions of KF™ by the teachers and did not examine the possible implicit links between the notes or the note clusters. There are 45 unconnected notes in the database and 73 clusters of connected notes. The unconnected notes are considered as a note cluster each, giving the total number of note clusters to be 118. There are 724 notes (including the facilitator's notes) in total. The average length of threads for this study is therefore computed (724 divided by 118) to be 6.14. The largest number of notes in a cluster for this study contained 78 notes. The result implies that for every note posted, it received an average of five to six responses. Given that each posting was about 114 words in length, it was estimated that a participants who posted a note could receive 700 words of built-on response or feedback. This result suggests that the online interactions were reasonably sustained between the teachers.

Achieving sustained online interactions has been a perpetual problem that needs further examination. Hewitt (1996) reported a maximum of 5.6 notes/cluster result achieved by a teacher with a doctoral degree after 4 years of experimenting KBC in an elementary classroom. Guzdial and Turns (2000), on the other hand, reported an average of 7.2 notes per cluster when the discussion threads were anchored around examinations and homework assignments in a CSCL environment entitled CaMILE. CaMILE provides procedural facilitation such as metacognitive prompts that are similar to KF™. Based on the studies conducted, Guzdial and Turns argued that proper interface design and proper anchors would

promote in-depth discussion. However, it seemed that Guzdial and Turns's participants were still low in participation since their rate of posting under these circumstances was 0.7 notes per student per week.

Based on the above results and the broad comparison, the participation rate of the T-KBC seems encouraging. Three possible factors seemed to support the encouraging results. First, KF is one of the well-researched platforms that had gone through multiple iterations of design since the earlier version of Computer-supported Intentional Learning Environment (CSILE) (Miyake & Koschmann, 2001). The interface design provides procedural facilitation that prompts users to contribute to the discussion thread in various ways. This provision helps to foster sustained online discussion (Guzdial & Turns, 2000). Second, the design of the T-KBC was based generally on social constructivist and adult learning theories that emphasize learner empowerment. The teachers identified the problems they wanted to discuss and solve from their teaching experience. The problems were therefore authentic and relevant to them. Open-ended course comments such as "covers areas which are very relevant"; "a lot of discussions on relevant issues" provide some support for this interpretation. Authenticity is one of the important pedagogical principles for online learning and it has been reported to promote active participation (Scardamalia, 2002; Jin, 2005). Third, it seems appropriate to acknowledge that the facilitator of this study, who is also the researcher, was rated highly as a trainer. He consistently received an overall rating of 3.7-3.8 out of a total four points. The pilot study was his second attempt on the T-KBC and the main study was his third attempt. He would have accumulated some experiences useful for promoting active and sustained participation. He could also empathize with the teachers since he had been in the field for seven years and started experimenting with the T-KBC almost immediately after he left his teaching post in a secondary school. These qualities are important for the actualization of what Reiman (1999) conceptualized as the taxonomy of guided written reflections. The

facilitator empathized effectively with the teachers' comments about the problems they faced but he also consciously linked them to theories that could lead to some solutions. The following is an example quoted directly from the KF database. It illustrates how the facilitator tried to link a teacher's comment on classroom environment as not conducive for promoting in-depth thinking to the idea of KBC.

Fostering idea friendly environment for thinking to blossom

You seem to be saying that your observations are that students do think but they seldom articulate their thinking because of an hostile environment co-constructed by the whole education system that does not value "naive" ideas. If that is the case, it is important for us as teachers to create an "idea friendly" environment. This includes establishing a new social norm. I think the principle of improvable idea as mentioned by Scardamalia (2002) is link to this. This also seems to be an area that our community has to design some practical strategies to overcome as we foster KBC in the classrooms.

Note ID 386, Chai, Phase 3f

The factors highlighted above would also influence other results obtained for the social and knowledge building dimensions of the T-KBC that will be discussed next.

The Social Dimension of the T-KBC

Table 8 and Table 9 below show the case-by-case matrix of "Who built-on whose" and "Who read whose" notes as obtained from the Analytic Toolkit®. Reading off from the left to the right, the numbers shows how many times the teachers whose names appeared in the left column built-on or read the notes created by the teachers whose names appeared on the top row. These tables provide information on who is/ is not interacting with whom, thereby allowing the researchers to study how established the community was.

The density of the network in term of participants building on each other's notes was computed using social network analysis. Scott (2000) defined social network density as "the extent to which all possible relations are actually present" (p. 32). The density is therefore obtained by dividing the number of actual linked connections by the total number of possible connections. Since the computation does not require the connection to be reciprocal, any connection that links two participants will be considered as an actual connection. Based on these premises, the density in Table 8 was computed to be 1. The density of the pilot study was computed to be 0.67. Lipponen et al. (2003) considered a density of 0.39 from his study as high. They had 12 participants. The density of social network for the T-KBC was comparatively high for both the pilot study and the main study. This is especially true for the main study since every participant built on at least one note of all the rest of the participants. Furthermore, the relationship was bi-directional. It is also interesting to note that the facilitator received most responses although his contribution was just above the mean. This implies that although he was not dominating the discussion, he seemed to be considered the centre of attention for writing responses by the participants. It also seemed to imply that the participants might still perceive the facilitator as a source of knowledge.

Table 8

Who built-on whose notes?

	Chai	Ian	Karen	Nadia	Nora	Sarah	Sue	Zoe
Chai	--	6	11	9	5	13	22	4
Ian	16	--	9	5	1	5	13	3
Karen	27	8	--	10	3	13	14	7
Nadia	19	3	6	--	2	8	12	3
Nora	13	3	4	5	--	4	6	3
Sarah	24	4	12	11	4	--	7	5
Sue	53	19	30	23	9	23	--	15
Zoe	12	3	9	4	3	9	8	--
Total	164	46	81	67	27	75	82	40

Table 9 below shows the connections between the participants in terms of reading patterns. As can be clearly seen, everyone was connected to every other participant bi-directionally and they read at least 15 notes from another person. The social network density for reading is therefore a perfect one. The result of the pilot study was also one.

Table 9

Who read whose notes?

	Chai	Ian	Karen	Nadia	Nora	Sarah	Sue	Zoe
Chai	--	64	114	72	40	88	189	47
Ian	76	--	86	47	28	59	131	30
Karen	79	51	--	59	30	77	128	32
Nadia	85	56	97	--	31	80	166	34
Nora	50	27	38	28	--	42	83	22
Sarah	37	15	45	34	20	--	49	16
Sue	90	66	108	71	38	85	--	51
Zoe	29	25	38	26	25	44	45	--
Total	446	304	526	337	212	475	791	232

Based on these findings, it seems that the teachers were well connected with one another, indicating that the community was well established. The T-KBCs (both the pilot and the main studies) were relatively conducive environments for collaborative knowledge building since the teachers were more likely to feel supported. There are four possible reasons for achieving this dense network. Firstly, the T-KBC was conceptualized as the single pedagogical approach that stretched across 24 weeks for three different topics related to IT integration. This would allow ample time for the teachers to build relationships and understand each other to some extent. This was designed to overcome the weakness of

fragmented course structure common to both teacher education curriculum and TPD (Wideen et al., 1998; Grossman et al., 2001). Teacher educators have emphasized the importance of allocating sufficient time for the in-depth reflection and understanding to emerge (Wilson & Berne, 1999; Cochran-Smith & Lytle, 1999). Feiman-Nemser (2001) postulated a time frame of at least six months for change in beliefs to happen. The 24 weeks time frame for the T-KBC was the best the present researcher could secure within the larger context of the Advanced Diploma programme.

Secondly, 50% of the course was conducted in a face-to-face setting. The researcher observed that during break times, the teachers frequently shared their stories from their own schools and talked about their problems. Informal sharing and having a shared history are both believed to be vital for fostering social cohesion within a community (Kreijns, Kirschner, & Jochems, 2003). It helped to establish the trust among the participants for them to share and comment on each other's personal knowledge, practices and beliefs. Thirdly, the number of participants was small and this helped in promoting mutual connections (Lipponen et al., 2003). The same level of group cohesiveness might not be achievable if the group was larger. It is also worth noting at this point that there were only three notes that were off task in the two databases (i.e. the pilot and the main study). One note requested for sale information of a certain IT product brought up during discussion, the other commented on the facilitator's effort of synthesizing emerging themes through mind map and the last was an unfinished note. This shows that the teachers were highly task-oriented when they were interacting online. The highly task-oriented nature of the online interactions should not be surprising given the face-to-face sessions and the teachers' shared history of working together. Fourthly, the facilitator's role in fostering social cohesion should also be recognised (Wallace, 2003). During the intervention, the facilitator joined in the small talks among the participants and shared his experiences. This could have helped to foster a cohesive community.

The results thus far seemed to be quite positive. The participants were active and the discussion was sustained. There was also broad participation from all participants and they seemed to form a cohesive community. However, the results of the pilot study indicated that broad and active participation did not result in in-depth discussion. 60% of the interactions were coded to be at phase 1 of the IAM, which were mere sharing and exchanging information. The average thread length was 3.47, implying that for every note posted, it received two to three responses. This result suggests that the discussions were not adequately sustained (Lipponen et al., 2003).

The preceding analyses of the online interactions were done through quantitative data such as average thread lengths and number of postings. In the next section, the online interactions were analyzed through qualitative content analysis to further substantiate the results obtained thus far.

The Knowledge Building Dimension

Gunawardena's model of interaction analysis (IAM) was applied for the coding of the online interactions. The basic unit of analysis was a note. The results of the coding are presented through a bar chart in Figure 7 for the individual codes and through a pie chart in figure 8 for the five phases.

Figure 7. Distributions of individual phase codes in the T-KBC

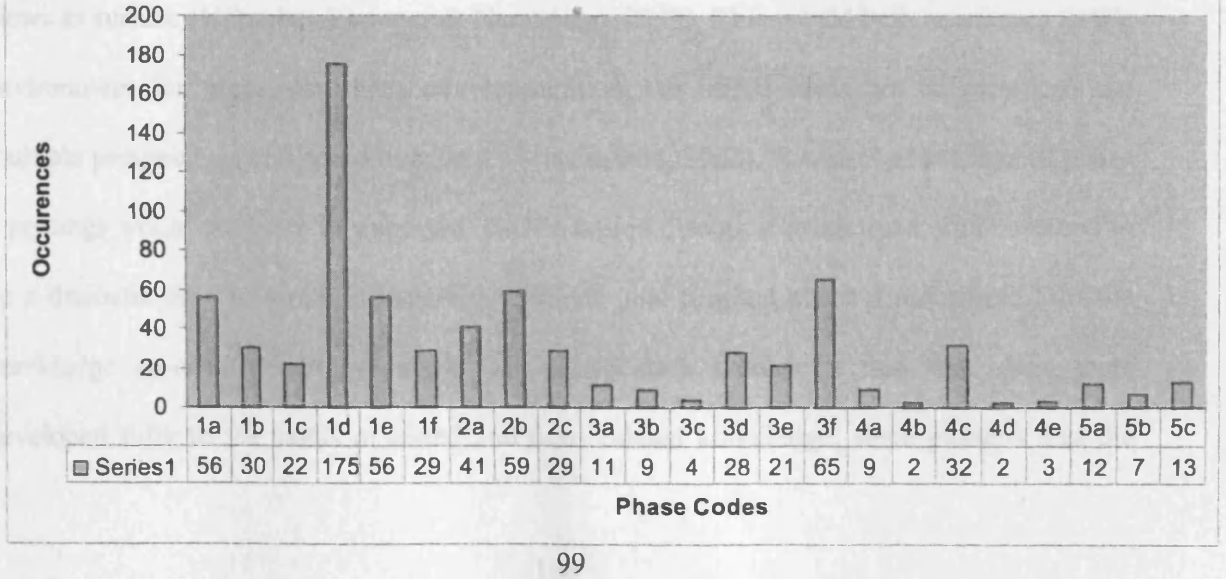
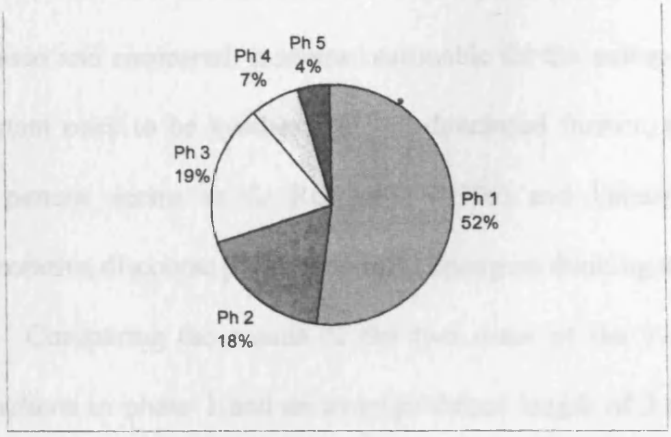


Figure 8. Distributions of interaction phases in the T-KBC.



As illustrated by the preceding bar chart and the pie chart, more than 50% of the online interactions were coded within phase 1, i.e., sharing and comparing information. The results of the pilot study were 60% (Ph 1); 20% (Ph 2); 13% (Ph 3); 4% (Ph 4); 3% (Ph 5) respectively. Within phase 1, asking/answering clarifying questions was the most common form of interaction. Phase 1 interactions as defined by the IAM were knowledge sharing and comparing activities. Strictly speaking, they were not the knowledge co-construction processes yet. They were the precursors to knowledge building activities (Gunawardena et al., 1997; Hendriks & Maor, 2004). As phase 1 postings were the initial articulations of ideas, it should be appropriate to encourage as many responses as possible so as to allow diverse views to surface (Hübscher-Younger & Narayanan, 2003). This would help to create a fertile environment for progressive idea development as the initial ideas are subjected to the multiple perspectives that could bear on it (Scardamalia, 2002). A higher percentage of phase 1 postings would therefore be expected. As the online discourse progressed, there seemed to be a dramatic drop in terms of idea developments that reached phase 4 and phase 5 of the knowledge co-construction processes. The implication would be that few ideas were developed fully to the status of tested and consolidated knowledge, since phase 4 was the

stage for testing ideas and phase 5 was devoted to summarization, application and reflection. The seemingly converging pattern of knowledge building discourse should be an expected phenomenon. Idea creation and refinement processes are emerging processes. As ideas were discussed and compared, it seems reasonable for the unimportant ones to be dropped and the important ones to be synthesized and developed further, thereby resulting in convergence. This pattern seems to fit Roschelle (1996) and Harasim's (2000) description of how collaborative discourse progresses from divergent thinking to convergent thinking.

Comparing the results of the two cases of the T-KBC, the pilot case has 60% of interactions in phase 1 and an average thread length of 3.47 while the main study has 52% phase 1 interactions and an average thread length of 6.14. It seems obvious that the latter reflects a more ideal state of affairs for the T-KBC. As the course structures were similar for both cases and they were implemented within the same period of time in the school calendar, the differences between the two cases seemed unlikely to be due to course structure or sudden increase in demands of work. In fact, during the main study, the teachers were more pressurized since they had to do one more module of the Advanced Diploma due to some administration lapse in scheduling the modules within the same period of time. It seemed that a feasible explanation would be that the main case study was constituted by a smaller group of teachers who had managed to establish a more collegial community (see Table 8 and Table 9).

It was observed by the researcher that natural pairing of participants for the implementation of student KBC projects occurred for the teachers in the main study. The teachers paired up according to the subject they taught and geographical proximity. Sue and Nadia were teaching English, Mathematics and Science in lower primary schools located in the same area. Nora and Zoe both taught Malay language in the east zone of Singapore. They helped each other in filling up the gaps when one could not attend the face-to-face sessions.

Sarah and Karen taught same level subjects in the same school. They were closed friends before they joined the course. These pairs shared the same databases classroom implementation (i.e. the students logged on to the same web address) and formulated similar themes for their respective classes. Ian was the only male teacher and he operated alone. However, that did not seem to affect his participation in the T-KBC. The same cohesion could not be ascribed to the participants of the pilot study as reflected by the social networked analysis. The researcher also observed that the teachers worked individually for their own projects although they were encouraged to work in pairs. The social climate of a KBC is an important dimension for the creation of idea friendly environment (Scardamalia, 2002). This could have caused the differences in the knowledge building dimension between the two cases.

Comparing the results of the T-KBC with other recent studies, it seemed that the T-KBC had produced better results in terms of the percentage of occurrences in higher phases of knowledge building. Gunawardena et al.'s (1997) study obtained a result of 191; 5; 4; 2; 4 postings from Phase 1 to Phase 5 respectively. Her participants were practitioners of online education or graduate students. Hendriks and Maor (2004) examined the interactions that occurred in an online postgraduate unit. The participants were mainly teachers. They reported that the majority of the notes captured by the software WebCT were coded as phase 1 interactions. They did not provide any quantitative data for further comparison. Schellens and Vackle (2005) used IAM to analyze undergraduates' online postings and found 52%; 14%; 33%, 1.2% and 0.4 % from Phase 1 to Phase 5 respectively. Of the 47 notes they examined, Marra et al. (2004) reported a distribution 21%; 34%; 30%; 9%; and 0% from phase 1 to phase 5 respectively. The results of these studies seem to indicate that higher phases of co-construction of knowledge are difficult to achieve (see also Garrison et al., 2001). Reviews of studies on teacher networked-based learning had also yielded similar results (Zhao & Rop,

2001). Possible explanations of the differences in the knowledge building dimensions will be elaborated in the next two paragraphs.

One possible explanation is that the intervention design, i.e. the T-KBC was an appropriate design for the purpose of TPD. Since both the pilot study and the main study seem to produce better results than what were reported in the literature generally, this possibility should not be discounted. As explained in earlier chapters, the T-KBC has incorporated a number of tested principles from recent learning theories. Drawing from the situated perspective of learning (Brown & Duguid, 2000) and recommendations from teacher education researchers (Ball & Cohen, 1999; Cochran-Smith & Lytle, 1999; Grossman et al., 2001), the T-KBC initiated its discussion topics from the problems that teachers faced in practice. This could have contributed to the authenticity of the discourse as the problems identified were likely to be real problems that teachers faced. This interpretation is supported by the fact that for both the pilot and the main study, the largest clusters of notes were notes that dealt with common problems teachers faced in integrating IT into classroom learning. The following quotations showed the two problems posted by the facilitator at the start of the modules that solicited many responses.

> (Schools seem to have different definitions of what is IT integration. Such differences can at times contribute to confusion among teachers. I think it is important that we have a common reference. Can we build this consensus? Attached also is 10 cases of "IT integrated" lesson. Perhaps we can look at them to clarify our thoughts.)

Note 1,Chai, Phase 1e

> (Before we start, let's examine the problems at hand. What are the problems that we face in terms of promoting thinking among students? What do we need to understand?)

Note 357, Chai, Phase 1d

The first question attracted 77 built-on notes while the second question attracted 64 built-on notes for the main study. The broader educational context created by the IT masterplans can help to explain the teachers' prolonged attention on the questions. Both MP1 and MP2 emphasized the use of IT in a student-centred approach to promote higher order thinking (MOE 1997b, 2002). There was also a guideline that 10% of the curriculum should be devoted to IT integrated lessons. The following note quoted from Sarah revealed her disagreement with her school's policy, which was in line with MOE's policy. Such disagreement inevitably caused concerns for Sarah since the IT department would only considered her as fulfilling the policy guideline when she conducted her lessons in the computer laboratory. In Singapore's teaching community, conducting lessons in the computer laboratory is a simplistic but seemingly accepted way of judging if the lessons could be considered as student-centred. It is only in the computer laboratory that students can have a chance to interact personally with the computers.

(a lesson that makes use of any IT tools. It can be teacher-centred or student-centred.)(It must be a lesson that makes use of PC and it should be a lesson conducted in the PC Lab)(To me an IT lesson should be a lesson that make use of the IT tools, it need not be a lesson conducted in a PC Lab) (Rodney Earle (2002) argued that IT should be used to solve a teaching problem. I totally agree with this theory. However I feel that in my school this is not the case. Many of the teachers sometimes use IT for the sake of using it so as to fulfil the requirement by the IT department)

Note 2, Sarah, Phase 2C.

Nadia and Karen shared the same concern as expressed by Sarah. Nadia's note is quoted below. It highlighted the problem of "forcing" teachers to use IT and suggested that teachers' collaboration could help to alleviate the problem.

I agree. My school used to make the teachers count the number of minutes IT is used in teaching. We're glad they eliminated this requirement this year. I think some schools are so influenced with the idea of integrating IT that they forget that it's not possibly to use IT all the time. Having a minimum requirement might not work because it makes the teachers force themselves to use IT for the sake of it so that they can meet the requirement and escape being questioned. It's an unhealthy trend. Maybe as a level, teachers can sit down and decide where IT is suitable for each subject and how it can further enhance teaching and learning. Such synergy might help all parties. At least schools can rest assure that even though IT is not used all the time, it is still conducted effectively at some comfortable point

Note 98, Nadia, Phase 3f

Other concerns that the teachers experienced such as time, expertise, access, resources and support were common to those that had been identified in the literature (Leggett & Persichitte, 1998; Galanouli et al., 2004). It seems that for both integrating IT and promoting higher order thinking among the students, the teachers had a rather strong perception that they were facing the problem of "there's so much to cover and so little time" (Note 384, Zoe, Phase 1d). Their concerns were supported by a recent large scale survey involving 2900 first to third year teachers in Singapore. These two factors were rated as the two main obstacles for IT integration by more than 85% of the teachers surveyed (Hu, Wong, Cheah, Wong, & D'Razario, 2004). Other than these common concerns, the discussion had also led the teachers to identify deeper and broader issues. In particular, they identified teachers' beliefs and school IT culture as two areas that they would research further for their final presentation. Two pairs of teachers worked on the issues of teachers' beliefs (Sue and Nadia; Nora and Zoe) while another pair chose to investigate school culture (Karen and Sarah). Ian chose to share on a learning management system because he believed it could provide solutions to some of

the problems identified. Note 251 and note 256 below show Nadia and Sue working to understand issue about teachers' beliefs.

1. What factors contribute to the belief system of teachers?

2. How teachers' beliefs and practices affect teaching and the use of technology in classrooms.

is that how the teachers perceive their way of teaching is greatly influenced by their depth of expertise and knowledge base and experiences they get as pupils themselves earlier in their lives and as a teacher over the years.

Extrinsic and intrinsic barriers (Ertmer, 1999) often exist in the implementation of technology. Teachers' beliefs in the role of technology may "reduce or magnify" the effects of these barriers (Becker, 1991).

Note 251, Nadia, Phase 2a.

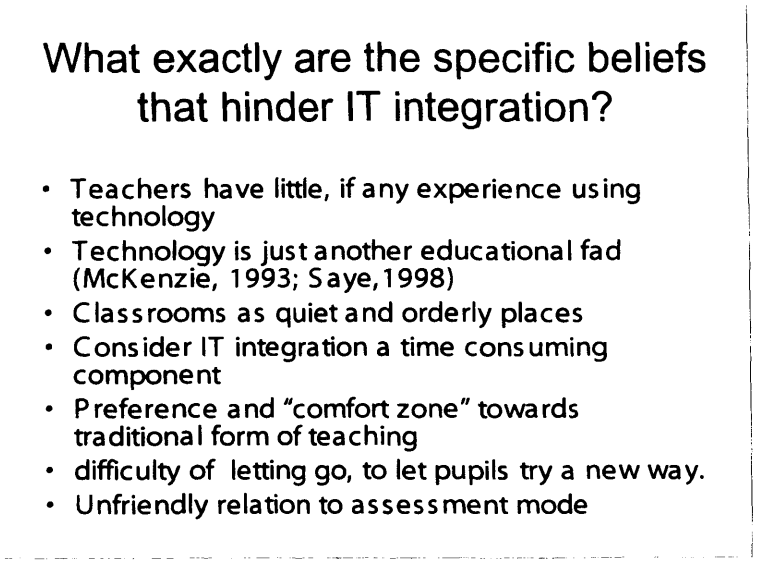
Rokeach (1968) mentioned: "clusters of beliefs about particular entities and situations form attitudes and values and that beliefs, attitudes and values together comprise an individual's belief system"

is that the teacher's upbringing, surroundings, values, opinions, perceptions and attitudes does affect his/her beliefs as well.

Note 256, Sue, Phase 3a.

Both notes above contained references that were beyond the reading given to this group of teachers. Citing information beyond the reading list was common to all the participants in this study. Figure 9 below was one of the PowerPoint slides that Nora and Zoe used for the final presentation. Karen and Sarah's effort in advancing the collective knowledge of the community on school culture is partially captured in Note 263.

Figure 9. A presentation slide on teachers' beliefs.



Many factors must be looked into to create a school culture that supports technology. In addition, lots of planning, implementation and evaluation will be ongoing. Some crucial factors highlighted are:

(1) strong leadership, include the principal and those holding leadership roles

(2) principal's enthusiasm towards IT

(3) teachers' consensus on the goals for adopting technology

(4) involve teachers in decision making

(5) ongoing staff professional development on IT

(6) teachers must take risk and experiment with IT and learn from their mistakes

(7) funding for supports needed by teachers, technically or otherwise

On a personal note, I believe it is possible to create a 'IT culture' in school. Of course, we need to look into many crucial factors, which are interconnected in one way or another. Above all, I think the principal plays the most important role as he is the one who controls the direction in which the school is heading to. The principal must dare to take risk if he supports a 'IT culture' in his school. I believe so far there aren't many successful stories.

Note 263, Karen, Phase 3e.

The notes above seem to contain rather important and comprehensive ideas for school improvement. They also provide some evidence that the teachers were advancing as a community and they contributed to each other's understanding, which is an important goal for KBC (Scardamalia & Bereiter, 1996). It seems also that by respecting adults' need for self-direction; orienting the learning towards problem-centered and organizing the activities in collaborative setting (Knowles, 1990), the teachers were able to adopt a more active stance towards TPD. The results seem to further support Huang's (2002) suggestion that pre-authentication in terms of formulating a problem that the facilitator believes would

interest the participants may not be a good instructional strategy. Gilbert and Driscoll (2002) documented a case study employing online collaborative knowledge building for a postgraduate course. They reported that their problem scenario, planning to set up a charter school, was not regarded by some of participants as authentic. This seemed to result in a failure to establish a collective goal and thus affected the participation. For this study, although the facilitator was familiar with the problems in schools and those reported in literature, he allowed the problems to emerge through discussion based on the teachers' experience. This seems to work better for the in-service teachers. The next quotation from Karen provides support for this interpretation. Further evidence will be provided in the next chapter where the teachers' subjective experiences are reported.

> I am satisfied with the ways we learned in this module. Personally, I feel that it is an interesting way to learn. The lessons are not the lecture type, more of reflections and professional sharing of our practices. I find that the present course is meaningful to me. We have to do readings so as to keep abreast with time and technology. In addition, the research on a particular topic of our interest 'forces' us to do in-depth reading. It makes learning meaningful and interesting.

Note 176, Karen, Phase 5c.

Other than allowing issues to emerge through discussion, two other instructional strategies seemed to have also contributed to the seemingly encouraging results obtained in this study. The first is modelling by the facilitator. Education researchers (Sandholtz et al., 1997; Baylor & Ritchie, 2002) have emphasized the importance of modelling. Other than modelling guided written reflections (Reiman, 1999), the facilitator also created mind maps to consolidate the multiple strands of discussion to provide further direction. Figure 10 shows a mind map constructed by Ian to summarize the discussion on problems about promoting students' thinking and his reading. He had done so without any prompting from

the facilitator because he needed to make sense of the discussion. Ian had also reported applying the technique of highlighting good notes to help students in appropriating good discourse practices in a KBC when he implemented KBC in his school. He appropriated the technique from his learning experience.

The other important strategy applied in the T-KBC was structured reflection. Written reflection on the educative experiences is a tool for one to focus and maximize potential (Reiman, 1999). It acts as a precursor for the reconstruction of what teaching and learning means, thereby enabling a change of beliefs that is essential for the adoption of reformed teaching practices (Dexter et al, 1999; Kwakman, 2003; Butler et al., 2004). In the T-KBC, the teachers were requested to reflect at the end of module one and module three. They were also asked to write reflections on their teaching activities after they had implemented their lesson plans. These reflective notes constituted most of the notes that were coded as phase 5C since teachers usually reported a change in their perspective due to their learning experience. Note 564 is an example quoted from Sue that shows a shift in perspective. Note 274 written by Ian at the end of the first module seemed to reflect his conscious effort in consolidating his understanding and his contemplation on how he could apply what he learnt in his work as a head of department for IT.

> having used KBC as a learning tool in our Adv Dip modules, initially, I felt that it was impossible to adopt this approach to primary school students. Nevertheless, after questioning my theory of 'learning', in the module "Visualizing students' thinking", I began to envision myself adopting the approach as part of my experimentation in getting them to discover more about kites. from my students' postings has made me realize that this approach to teaching helps students to acquire depth and breadth in learning if they have been given the necessary scaffolds.

Note 564, Sue, Phase 5c.

(I have read through a few articles, studies and they are almost similar to what have been posted. (Really almost the same). I will not go into that anymore. I will go into the problem solving mode which is beliefs. However, before we can fully tackle the beliefs of teachers, we need to analyze what causes teachers not to embrace IT.)

(I believe that there are a few reasons and beliefs.

1. Fear that new methods may not be as effective as traditional methods in getting results.
2. Fear of losing control in the lab. This is supported by the ACOT research where the teacher could not stand the noise level initially.
3. Unable to monitor the results of the pupils as most of the computer programmes do not have monitoring facilities unless it is an E-Learning facility that tracks the results.
4. Unable to see what mistakes the children have made in their work and thereby unable to correct the mistakes. Basically, it is not having a "feel" of what the children have done.
5. Teachers do not have the luxury of time to plan proper IT lessons and trying innovative styles of teaching. They also do not have the time to find more resources.
6. "So what if I have very good IT lessons. At the end of the day, my evaluation is based on my class results and not on my IT lessons. I would get called in if my results are not there and get a "D" grade. However, I would not get a "D" grade if I do not conduct IT lessons." Doesn't this sound familiar to many of us?
7. Fear of losing curriculum time when conducting IT lessons using new approaches. This is also reflected as a constraint in the ACOT report.
8. "When the computers breakdown, it will waste my time in the lab."
9. "My Head of Department is also not using IT, so why should I?")

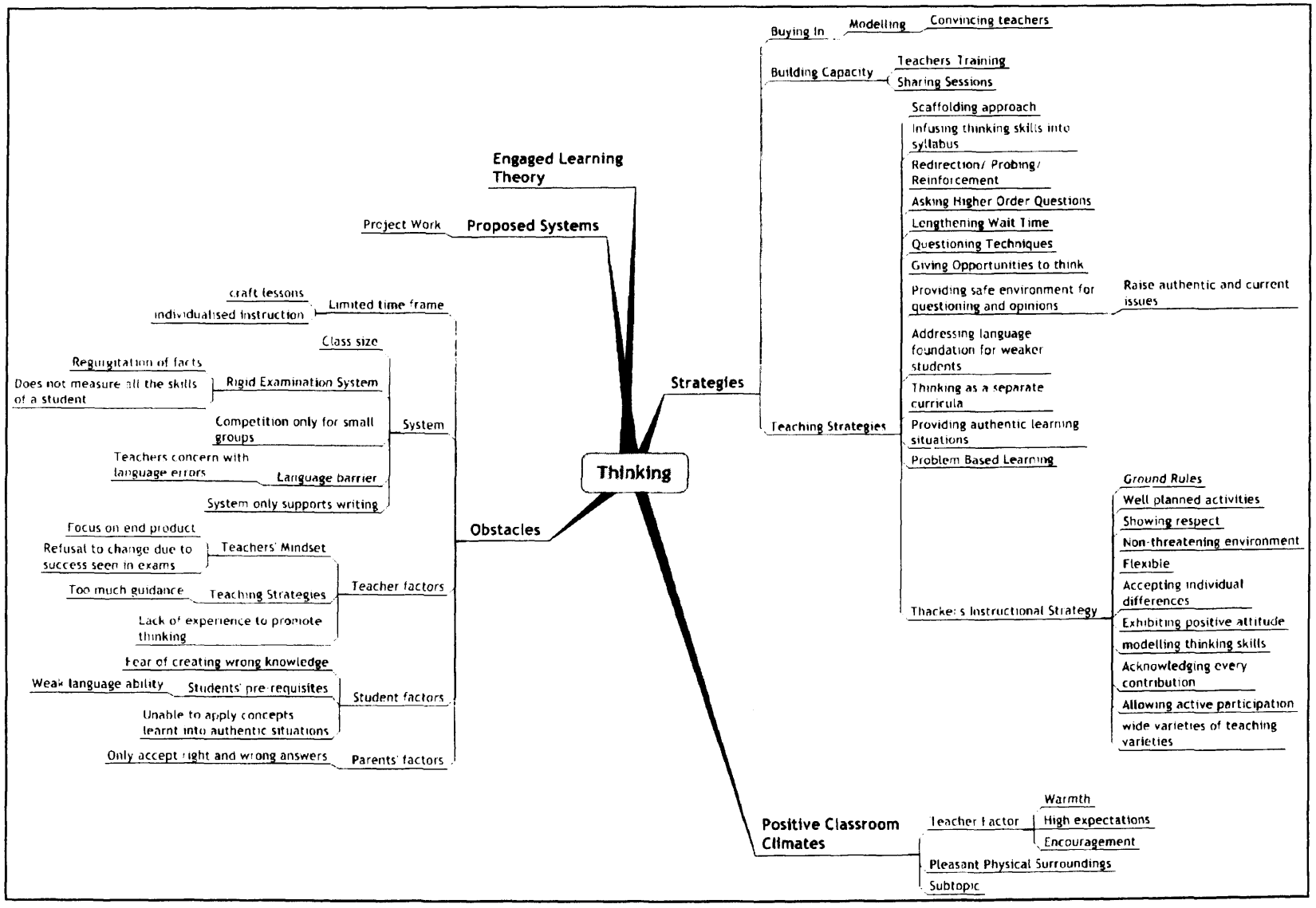
(In my opinion, some of the problems faced by the teachers may or may not be real.)

(Although, I do not have evidence of such thoughts, I would really like to find out if it really is so. This course has really made me think through what is happening. Anyone wants to help me with my thoughts. I would really want to implement a survey to check whether they are really thinking in that manner.)

(If the above beliefs and reasons are true, it is a systemic problem that is inherent in our education system. It requires a multi-pronged approach to address the problems.)

Note 274, Ian, Phase 5c.

Figure 10. Ian's mind map (Attached in Note 476, Phase 5a)



Summary of Chapter 4

From the content analysis performed and reported in the foregoing sections, it seems appropriate to claim that the T-KBC was somewhat successful in engaging the teachers in collaborative knowledge building that had led to better understanding among them. The teachers seemed to be well connected to one another and they had participated actively and contributed to the advancement of knowledge of the community. This is more so for the main study than for the pilot study. Possible factors that could have contributed to the advancement of the T-KBC included having a group of committed teachers who happened to be able to work well with each other; adequate time allocation; a facilitator who is experienced in facilitating this form of learning and a pedagogical model that was built on appropriate learning theories. These factors interact in a complex manner that is beyond the effort in the present study to explicate further and they certainly warrant further studies. All four factors seem necessary for the success of the T-KBC. The T-KBC model seems to be the only factor that is under the control of a facilitator who wishes to employ it. It seems that the other three factors are likely to be beyond the facilitator's control. In a TPD context where teachers sign up for the courses of their choice, it is hard to control the group composition and have the "right mix" of learners readily available. The commitment towards knowledge construction from teachers may also be a barrier to success. It has been reported that some teachers and students would rather play the role of passive recipients and thus rated this way of learning negatively (see Gilbert & Driscoll, 2002; Yuen, 2003). Having an extended period to learn and apply a particular pedagogical model does not seem to be a norm in most teacher colleges (Wideen et al., 1998). Facilitation skills took a long time for this researcher to develop and facilitating is a very time consuming process. This study therefore has raised more questions in the researcher's mind than providing answers for the call of reform that is rampant in

Singapore. In the next chapter, the researcher will report the subjective meanings that the participating teachers attributed to their experiences of teaching and learning in a KBC.

Chapter 5

Teachers' Accounts and Discussions

In this chapter, the teachers' accounts obtained through the interviews and online postings were documented, compared, connected to the relevant literature and discussed. The following research questions provided the foci for the subsequent analyses:

- What are the teachers' reported epistemological beliefs and their reported beliefs about computers in education?
    - What are the teachers' reported prior beliefs about knowledge and knowing?
    - What are the teachers' beliefs about learning, teaching and technology?
- How do teachers reportedly perceive teaching and learning in a KBC?
    - How do the teachers reportedly perceive learning in a KBC?
    - How do the teachers reportedly perceive teaching in a KBC?
    - What are the perceived changes that teachers reportedly experienced as a result of teaching and learning in a KBC?

The findings were reported in the form of assertions supported by quotes from the transcripts and the notes from the KF databases. All assertions made pertained only to this case study although they might inform the reader about a more general situation. The categorizations of the teachers' beliefs and their perceptions about teaching and learning in a KBC were at times not as clear and clean as the researcher would have expected. Epistemological beliefs are fuzzy in nature (Schommer-Aikins, 2004). The interviews were more like "conversations and co-constructed discourse events" (Block, 2000, p. 758). Respondents went through their lives differently and they talked about them in different ways. At times, the researcher had missed out on collecting "squarely" comparable data. This is a limitation of the researcher who was the research instrument. In other words, the interviews provided rich but idiosyncratic data that defied preconceived categories.

Assertion 1: The teachers held a range of epistemological positions that were more or less relativist in orientation.

Drawing from the developmental perspective, all seven teachers from the main study seemed to hold a range of epistemological beliefs that stretched from multiplicity to that of relativism (Perry, 1970, see Table 3, page 31). None of the teachers was in the stage of dualism where everything could be classified as either right or wrong. They all seemed to be well aware that truth is evolving and knowledge claims can change as new evidence is being discovered. In the following quote, Nora expressed her view that scientific constructs were possible explanations that could be overturned.

> Scientists can ultimately discover the truth... I think maybe to a certain extent this statement is true. But I don't think scientists can actually really discover the truth... presently, scientists have made a lot of improvements. They do research and they come out with all those theories which can help us to explain about what are happening so far. But it might not be the true theories. Because these are just what they have constructed but not necessarily the truth... that's why I say to a certain extent. I don't think scientists can ultimately find the truth.

The other teachers also reported a similar notion of knowledge as evolving. For example, Sarah reported that, "The truth now is the truth now. You won't know whether the truth will still be the truth in the future." Ian cited the typical example that the earth was once conceived as flat but later proven to be spherical. This result was within the researcher's expectation. Since all the teachers had completed their tertiary education, they should be aware that many "truths" have been replaced by better understanding. Fox (2001) postulated that the notion of evolving truth is common knowledge among the general educated public. In Schraw and Olafson's (2002) study, none of the 24 participating teachers could be classified

as realists, whom they defined as teachers who believed in the existence of a body of fixed knowledge that learners should acquire.

The stage of multiplicity is different from the stage of relativist in that the former treats uncertain knowledge as exceptional while the latter treats certain knowledge as exceptional (Hofer & Pintrich, 1997). This distinction posed some difficulties for the researcher in terms of distinguishing who among the participants were more relativistic than the others. All participants disagreed with the statement that "Scientists can ultimately discover the truth" to a certain extent but it was not clear how extensive was that disagreement. Responses such as "maybe some but not all" (Zoe) and "I don't think I agree totally" (Nadia) indicated that both were relativistic. However, the elaborations following them did not allow the researcher to distinguish whether or not the teachers viewed fixed knowledge as exception. The degree to which they were inclined towards the relativistic beliefs seemed to differ when one considered the teachers' level of consciousness about epistemological issues and their views about themselves as knowledge constructors.

It seemed more likely that Zoe and Nora were in the multiplicity stage, or in White's (2000) terms, departing absolutist, while the other teachers were more consciously relativistic. Both Zoe and Nora revealed that they had not consciously considered epistemological issues prior to the first interview. When the researcher asked Nora when she began to develop the relativistic stance, her reply was "when you asked me". She further elaborated that "if you were not to ask me, I would not really think about it." There was another incident that seemed to corroborate the researcher's assessment. When the researcher asked her how she would respond if the experts disagreed, part of her responses was as follows:

> To personally construct or to follow? Hmm...I think I belong to the category that I will be the follower, based on majority. But of course I will think whether what I am going to follow is really the correct thing to follow or not, especially at this point of

time, whereby I can really know how to judge and analyze thing. Maybe I will be more open-minded; I will be thinking more about whether what the majority thinks is right or wrong.

When the researcher alleged that what she was doing was constructing her knowledge about this matter, she responded, "Ah...correct. Yah, come to think of it." This seemed to reflect that she was not conscious of her active role as a knower. Within this short quote, it also appeared that she was changing her stance as a knower from accepting what the majority says to constructing her own understanding. It implies that the interview questions had helped her see herself as a knower. This could mean that she did not perceive as problematic what she had received or she did not experience severe controversial situations that compelled her to reflect on epistemological issues (Schraw & Olafson, 2002) prior to the interview.

The quoted interactions between the researcher and Zoe below provided some indicators on Zoe's epistemological development.

R: Now? Let's say we refer back to Newton's law? It is today's truth. Do you think it will become tomorrow's fiction?

Z: What does it mean by tomorrow's fiction?

R: Meaning it is not true.

Z: Not true at all? It could be if another scientist finds different way.

R: You have only come to think about this when I ask you this question?

Z: Yah.

R: If not, you hold that as the truth.

Z: Yes.

R: When you teach, you pass that down as the truth?

Z: Yes.

Zoe again disclosed that she had been accepting the "facts" unquestioningly when the researcher asked her about how she could know whether or not a person is an expert. Her response was that she had "never thought of that". She had also reported that she saw "knowledge as like okay your textbook stuff. Whatever the students have to learn, that is the knowledge that you have to give, to pass on." She claimed that none of her teachers and her professors had discussed epistemological issues with her. The above quotes, taken together, seemed to imply that she had not consciously challenged the source of knowledge that she had received although she knew that knowledge is evolving. She seemed to be in the stage of transitional knowing (Baxtor Magolda, 2004) where uncertainty had just set in.

As a learner, Nora believed that "on very few occasions, I don't think I really construct my own knowledge." She seemed to classify knowledge construction as an activity performed by experts in some field rather than a way people come to know. The role of expert for her is revealed in the following quote.

> The role of the expert is to...pass on. Expert is the person who knows about the knowledge and the topic, right? Their role is to pass on what they know to those who want to know and those who don't know.

Zoe also reported that, "I think an expert knows everything about something in that field... When we ask some questions in that area, they are able to answer us." Inferring from these quotes, it seemed that they both accorded very high status to the expert and saw the expert as the authoritative source of knowledge. When their reports were compared with the other participants, it seemed that the other participants projected a stronger sense of self as knower. For example, when Nadia described the role of experts in her learning, the authority of experts seemed to be less emphasized and the importance of the self as a knowledge constructor was brought forth.

They're like books, I think. Like you listen to them or you follow them. But you cannot like gain what you want to know solely on experts. Of course you still have to find out more go and search somewhere else for what is it that you want to find out. Experts... Because we believe that they know what they're saying. They know what they're doing, so you look to them like some sort of guide.

Nadia related the importance of making personal judgments when one left the teacher preparation institute and entered into the field of practice, i.e. the real school.

This was what I learned (in teacher college) but when you're dealing with people personally, it's very different. You can read about it but when you apply it sometimes you have to make a lot of judgment. You have to feel your actions; you have to really think through.

Confronted with the situational question about experts disagreeing with each other, Sarah responded, "I believe what I believe." This rather direct and subjective response seemed to indicate that like Nadia, she recognized the importance of self as an epistemic agent. She also appeared to be a rather confident knower. She further elaborated her stance in the following quote.

How confident? If I don't believe B and B is not believing what I believe, it's like why should I follow B? No point! Even if what I believe might not be the universal truth at least I'm comfortable with my thinking...

Both Sarah and Nadia projected "subjective knowing" (Belenky et al., 1986) as their way of dealing with controversial situations. Karen seemed to be less subjective in the similar situation and she would attend to the evidence bearing on the assertions.

If they disagree, there must be some basis of this disagreement. What I'll think is I'll respect their decisions as long as the two of them can come up with evidence... I

won't choose (sides) because normally it's like for this type of study you have to base it on evidence.

Karen did not appear to emphasize her role as a knower. Although she reported that "professionally and academically to challenge the rest ..... actually is still not within my means", Karen's responses seemed to be a deliberated reaction. In other words, it seemed that she had considered such epistemological issues and had resolved it at least for herself by trusting the established procedures of publication in academia. Such response would be classified as procedural knowing according to Belenky et al.'s (1986) scheme. The next quote illustrates her resolution.

> So long as they have experimental studies and I trust them. I think that in the professional community they have many tests, many experimental studies before they can publish the findings. I would accept their findings as to what I have learnt at that time.

Among the participants, Sue and Ian seemed to be epistemologically more relativistic than their peers were. Knowing, for Sue, was not a matter of receiving knowledge from the authority. For her, what she knew was a result of pursuing her interest and building "upon the prior knowledge" and "everyday life experiences". Anyone and everyone are entitled to the claim of knowledge.

> As long as there is a person who is cognizant about a particular problem, or a particular area of interest, and he's willing to explore on that so-called interest, or that so-called problem, he might be able to discover the truth as well. It all depends on the individual. I mean if you think that only scientists can discover the truth, then I'll disagree with that because there are people who are not scientists but they have the so-called period of wanting to try things and they want to challenge themselves. They might also be able to discover the truth.

Given that knowledge was no longer held exclusively by the experts, the role of experts in instructional settings was to her that of facilitators "rather than providing me with all the facts." The relationships between the learners and the experts are illustrated in following quote.

> The learners have to do the groundwork, rather than trying to get all the inputs from the experts. The experts will be there to answer certain questions, which I feel that the learners might not be able to find. Then again, the experts might not be able to answer all the questions.

Sue's epistemological stance seemed to have set her apart from the traditional role of teacher as expert or the authority source of knowledge. She readily admitted that sometimes her students have better knowledge and "if the student is better than me, I learn from the student".

Among the participants, Ian seemed to be the only teacher who had reached the stage of committed relativism. He seemed to have carefully considered some philosophical issues. The following interactions provide a glimpse of his epistemological stance.

> R: Some people think that scientists can ultimately discover the truth, what do you think?
>
> I: Scientists cannot. The question is... first define truth.
>
> R: Yah.
>
> I: Define truth.
>
> R: Scientific truth.
>
> I: Scientific truth? They can never. Certain people cannot distinguish...in philosophy there is this concept about truth. It caused a lot of fall of theories actually. Question is they came out with a new philosophy which is called verification. For example numbers are infinite. However, numbers are infinite does not mean that the calculators

cannot be used. You just have to test one plus one plus one and the answer is three. You have verified that the calculator is working. It is a question of verification.

R: Okay. Good point. So your point is you cannot grasp the whole but you can know roughly where?

I: It's more of verification. You put up an assumption and you verify the assumption. Like numbers are infinite. You can never know what the final number is but that does not stop you from using like the calculator.

The above quote seems to imply that although truth cannot be arrived at, it does not follow that everything is therefore relative. One can test and verify certain assumptions and act according to the verification. The next quote provides further corroborating data on Ian's relativistic understanding of situations and yet absolutely committed stance to certain values.

R: Do you agree when someone says that there is no right answer, anybody's opinion is as good as another?

I: Wrong. I do not agree. There are certain things that I would say are definitely right. Maybe I give an example of...there are things that are relative. The question is how you perceive it. For example, some people tend to say that when you get cancer... cancer is evil. But that...is it evil or is it bad is questionable. It is relative. I remember that I knew about this doctor. Famous cancer doctor, when he operates on patients, he was so inhuman. When you look at all his proceedings, they were inhumane. But when he contracted cancer himself, he began to realise the pain of cancer. He became a patient. When he was finally cured, the cancer actually did him good.

R: You saw it as contextual?

I: Contextual. But there are certain things that are of absolute values. For example, killing a person.

R: Thou shall not kill?

I: It's a command. That value can be verified by the impact that it has. For example, let's look at the impact that it creates on people. Pain. Negative connotations all come out from it.

R: Death?

I: Yah, death. So there are absolute values. There are certain things that I believe that are still absolute.

In summary, the seven participants of this study seemed to hold a range of epistemological beliefs with Nora and Zoe at the multiplicity end of the continuum and Ian at the committed relativist end. The rest of the participants seemed to be relativist, with Sue showing the most relativistic stance. Although the sample of this study was small, the distribution seemed to parallel Brownlee's (2001) study where most teachers were at the relativist stage (see also Sutton et al., 1996; White, 2000; Chan & Elliot, 2004). None of the participants were holding the naïve view that knowledge is certain. The distribution also seemed to agree with a recent questionnaire survey (N=660) of local pre-service teachers (Chai & Lourdusamy, in press). However, further studies involving more practising teachers and through appropriate sampling are required to verify the distribution of teachers' epistemological beliefs.

Studies on the effect of epistemological beliefs on learning indicated that sophisticated epistemological outlooks were associated generally with deeper and better learning at school children's level (see Schommer, 1990; Qian & Alvermann, 1995; Mason & Boscolo, 2004; Schraw & Sinatra; 2004). It has also been pointed out that beliefs influence how and what teachers learn when they were learning to teach (Richardson, 1996). To a certain extent, the teachers' participation pattern in KF, in terms of the number of words written, matched their epistemological profiles (see Table 7). Nora and Zoe participated less in the online discussion while Sue and Ian ranked 1 and 3 in terms of words written. Sue read

98% of the notes while Ian read 73% of them. Both Nora and Zoe read less than 50% of the notes. It seemed that their commitment to active learning was not quite the same, which could imply that epistemological beliefs not only affected students' learning but also teachers' learning. Although the teachers (Nora and Zoe) claimed that they were impeded by contextual factors such as family commitment (Nora) and personal sickness for two to three weeks (Zoe), and these factors do affect participation, they might also be more used to receiving rather than co-constructing knowledge. When their situations were compared with Ian's situation who was a Head of Department and a father of three young children, it seemed that Ian's schedules were tighter and yet he was more active. In other words, to attribute the differences in participation as solely due to contextual reasons does not seem to be an adequate explanation. It seems that there is a possibility that the teachers' epistemological stance, especially their confidence as a knower, could affect their participation level. This is an important issue because if the teachers themselves cannot participate productively in a CSCL environment due to their epistemological positions, it is difficult to see how they could help schoolchildren in doing so. More extensive research is needed to verify this claim.

In the following assertions, relationship between epistemological beliefs and beliefs about teaching, learning and technology will be examined. It seems that they are related and the general patterns of the interrelationships seem to confirm the present profiles. However, before examining the relationships between the beliefs, the next assertion postulates the possible factors that seem to have contributed to the teachers' epistemological outlook.

Assertion 2: The personal histories of the teachers in terms of education and their religious backgrounds seem to be related to the teachers' epistemological beliefs.

It has been postulated that teachers' beliefs are largely the outcomes of schooling and personal experience (Van den Berg, 2002; Albion & Ertmer, 2002; Goodson, 2003; Richardson, 2003a). At the beginning of the first interview, the participants were therefore

asked to share their most significant learning experience. Most of the participants reported their formal learning experiences in schools. Ian was the only one who reported his conversion from Christianity to Islam as a significant learning experience. When the teachers' experiences were compared, it seemed to parallel the teachers' epistemological beliefs.

Nora and Zoe reported obtaining good grades in mathematics, a subject that both of them were struggling with at secondary school, as their most significant learning experience. For both of them, it seemed that the main factor that contributed to the positive and memorable learning experience were the positive teachers' attributes rather than the teaching methods. Nora described the mathematics teacher as encouraging, fun-loving, understanding and creative in his teaching. Zoe described hers as "full of zest" and encouragement. However, Nora also described her teacher as "he still taught us in the traditional method like memorize formula... At that time, it (mathematics) was taught in such a way that it was not connected to everyday life." Zoe described her teacher as giving more examples and guidance in analysing problem sums. Neither of them reported any incident that could have stimulated them to reflect on the nature of knowledge. It seemed possible that both teachers had moved through schools that adopted mostly teacher-centred pedagogy without any incentive to re-consider alternative views of knowledge, learning, or teaching.

Sarah, Karen and Nadia's reports of schooling experiences did not anchor around teachers. Nadia described her secondary school days as time when she assessed her strengths and weaknesses through the examination results and decided where to head. Sarah said, "I learn very well by rote learning" and gave the examples of being successful in A level mathematics by massive drill-and-practices on the past years' questions. Karen seemed to have adopted a passive learner's role where most of the time "the teacher just teaches from

the text" and "you just tell me and I just follow". However, Karen was conscious that as she progressed, she was tasked to do more learning herself.

> When I went to JC (junior college), they expected me to be more independent in the sense that you have to go and research on your own. So that's why I think the independent learning only comes during my JC years. And, of course, university.

Sarah reported that her first independent learning experience was when she attempted to learn the Principles of Account in secondary three. She discovered that she could do it on her own. Nadia repeatedly mentioned, "learning comes a lot on my own" and gave examples of how she had managed to learn about soccer and webpage design tools by herself. In recalling their experiences, these three teachers seemed to recall experiences that they at least assumed some active and constructive role as learners. Based on these comparisons, it seemed that some forms of independent learning are beneficial in shaping the learner's identity as a knower.

Another possible explanation that could have contributed to the differences between the teachers' epistemological positions seemed to be their level of consciousness concerning their personal experience. These teachers went through more or less the same education system. It is difficult to imagine that Nora and Zoe were not given assignments that required them to do some research in the junior college or the initial teacher education. It is more likely that they were involved in some research but they did not see the significance of the experience due to a number of possible reasons. It could be that the teachers did not scaffold them to reflect on the experience; they treated active knowledge construction as any other activities or that the experience was not strong enough to create cognitive dissonance. Reflection upon experience is necessary in promoting better sense-making (Dewey, 1938). Nora and Zoe's accounts remind educators of a dimension that could be easily ignored when skills and knowledge dominate the educator's field of vision (Deng, 2004).

For Sue and Ian, their learning experiences were atypical. Their experiences seemed unpleasant but beneficial for fostering an epistemological outlook that could better enable them for reform. They appeared to be conscious of their learning experiences and had reflectively drawn from the experiences some different ingredients that set them apart from the others.

Sue reported that she did well for her secondary school examination under the guidance of good teachers whose teaching strategies centred on good presentation, supported by rigorous drill-and-practice. However, the learning strategies formed by such teaching practice did not help her in her pre-university study. In her words, "I tend to apply similar methods as to how I actually achieved my distinctions in O levels. After a year I realised that it's not supposed to be that way because in college it's more of application, you must understand".

Although she passed her "A" level, Sue had to join the Polytechnic instead of progressing directly to the university. The learning in the Polytechnic introduced to her another mode of learning that she believed to be more beneficial to her.

> It's more of project work. I feel that I am a better learner. I learned more things and I did group works with my friends. I thought I like this kind of learning when I compared it to college. I feel that as a polytechnic student, I learned more things than when I was in college.

The alternative mode of instructions provided by the polytechnic seemed to drive Sue's epistemological development. She reportedly preferred being a more active learner and was confident that it could lead to better learning. As for Ian, his learning experience had been beneficial due to the scaffolding provided by a teacher who seemed to have extensive philosophical training.

During one phase of my life, I was on the crossroads of two religions and I actually went to do quite detail research on which particular faith is it that I want to accept... There was a lot of discussion and interactions between my current teacher and me. He actually forced me to think about my own perceptions..... So, at that time both of us actually presented facts... We are on opposite grounds... both of us actually talked about it, debated about it, but at the same time kept an open mind about each other's view. We questioned each other's understandings, or each other's stand. And this was usually supported by research findings from encyclopaedias, neutral sources. Because during that time I did not trust just from a source that belonged to a certain faith so what I did was during that time when he posed questions regarding the faith, I would be forced to go into neutral sources like encyclopaedias to verify what he said, just to support the findings... Different authors have different views, different perceptions. So you gather all these evidences, and you piece together, part by part, to see whether it coincides ... there's conflicting evidence on this, so there's the question of which is more likely. You have to weigh the two views carefully ...

The outcome of this experience was that "I learned not to take a statement as a fact. Actually, from then on, there was a change in the way I think."

Ian and Sue's accounts indicated the importance of having a substantial learning experience that encourages the learner to construct their own understanding. In Ian's case, it further indicated that having a critical interlocutor enhances the transformative power of the experience. Reflexively, it also seems to point out what might be lacking in Singapore's teacher education, namely, substantial experience in constructing one's knowledge and reflecting upon such experiences from an epistemological perspective. The absence of such a substantial learning experience has been identified as a problem in the curriculum for teacher preparation courses (Hofer, 2001; Tatto & Coupland, 2003; Deng, 2004).

Ian's experience highlighted a dimension of knowing that was frequently referred to in Perry's (1970) work but seemingly reported in the literature pertaining to teachers' beliefs as reviewed by the researcher. Religious beliefs seemed to have an important influence on the participants' epistemological beliefs and vice versa. Nora revealed that she was "more to the traditional Muslim". Her statements about her religious upbringing seemed to have shaped her epistemological beliefs. In her words, "(Knowledge) Given to me. I accept. Religion is like that, I think most of the time. We accept, we don't question. Some do." While she acknowledged that questioning the process of knowing of the religious teachers can lead to problems of different interpretations, she maintained her conservative stance. Zoe had mentioned that some scientific "truth" was undesirable from the perspective of their faith and Nadia doubted "truth" that was not balanced by religious perspective. The researcher did not pursue this further since it was not the focus of this study and it is a sensitive area.

Assertion 3: There seemed to be a closer relationship between the teachers' epistemological beliefs and their beliefs about learning. The relationship between the teachers' epistemological beliefs and their beliefs about teaching appeared to be mediated by other factors such as teachers' beliefs about students' readiness and what they perceived as important in the school context that they were in. The teachers' use of computers, on the other hand, seemed to be more congruent with their beliefs about teaching.

The teachers' epistemological positions seemed to be related to their beliefs about how learning occurs and how should students learn. For Ian and Sue, learning seemed to be more of a process of constructing personal understanding and problem solving. Ian reported that he learned through solving problems. As mentioned earlier in his account, research seemed to be important for learning. He reported that he would consider a person as having learned something when "they've considered actually all possible and allowed research on it." Sue's report indicated that she seemed to believe rather strongly that learning should be

active and constructive. For her, learning should involve experiencing, making use of multiple resources and going beyond understanding textbook content.

> I feel that learning involves, it's not purely from text, from what you have read from the textbook. It involves exploration, self-discovery. For example, if I want to find out more on perhaps the characteristics of one type of insect, it would be useful if I actually try to catch that particular insect, try to look at the actual insect itself. In a way it's like you see the real thing, and then you try to find out more facts about it, that's what I would define as meaningful learning.

As for collaboration, she emphasized its importance on several occasions as it helps to develop students' social skills. She seemed to believe strongly in cultivating students who can share with each other "so that later on when they go on to their working life, they are not only able to work but they are able to work together as a team." Her emphasis on collaborative learning seemed to arise from her perception that the students she was teaching were "more self-centred and they feel that their friends are always competitors". Ian also seemed to share the observation that high achievers were less inclined to co-operate. He reported that he valued student-centred project works. In his words, it help students to learn "how do you go about accepting each other; how do you value others' opinion. All these are values." Incidentally, both of them supported collaborative learning for its value in promoting students' character development rather than the notion of community as a site and resource of learning (see Lave & Wenger, 1999). This may indicate an aspect of learning that teacher educators need to emphasize.

Based on the above, it seemed that Sue and Ian believed that learning should be active, constructive and collaborative. Such a conception of what learning should be seemed rather congruent with what reformers and the local policy makers have advocated (see Jones et al., 1995; Jonassen, 2000; MOE, 2002). However, the researcher also discovered some

inconsistencies between what they have advocated as ideal learning and their reports on their teaching practices. This will be elaborated after other participants' beliefs have been presented.

Nora, Sarah and Zoe's beliefs about learning seemed to be more inclined towards conventional view of learning as gaining more knowledge and new knowledge. As examples, the following quotes from Nora and Zoe and a note from Sarah are given below.

> Learning means getting knowledge about things that we do not know. The knowledge that I get is mostly from...school. School is one of the major contributing factors. (Nora)
>
> You learn to gain knowledge. You will improve or discover your own talent and skill. Learn something new that can be related to your life in future. (Zoe)
>
> (Learning is about role modelling after someone whom I think is right. It is also about gaining more knowledge in aspects that I already know or gaining new knowledge in aspects that I have no knowledge at all. Learning should allow me to be corrected too.) (Sarah)

However, it would be inaccurate to portray Nora and Zoe simplistically as only holding onto a narrow view of learning as receiving knowledge. The following notes written by Zoe and Sarah before the first interview illustrate the point.

> (of students learning is whereby the students are able to widen their knowledge horizon meaningfully, able to think and answer critically and creatively. They learn using different types of mediums such as IT, print and non-print, regardless whether its student or teacher-centred...) (Zoe)
>
> (Engaged learning requires students to be involved and to explore and to search for knowledge on their own. They are usually given the necessary help so that they are able to explore on their own. They do not start with nothing in hand. The

teacher should also always be around to give any support when students face any problem.) (Sarah)

These postings seem to highlight that the teachers were aware that there are other ways and dimensions of learning. Given that they were likely to be familiar with much of the rhetoric of the local reform initiatives such as those delineated in chapter one (see page 2, MOE, 1997 to MOE 2004), these postings may or may not reflect the teachers' beliefs. Posting notes into KF is a public act (at least within the community) and it seems safer to speak the official language in public. Whatever the case, representing the teachers as being ignorant about the knowledge construction dimension of learning is unlikely to be fair. It appeared to the researcher that the knowledge acquisition dimension was more prominent for these three teachers.

When Karen or Nadia talked about learning during the interviews and in the database, they both seemed to emphasize more on learning as meaning making as indicated by the next two postings.

(is pupils are able to make meaning of what they have learnt in class (isolated info.) and try to apply it in other circumstances...They must see the connection between what they have learnt and how it benefits them in the real world. It is important that pupils are given opportunities to bridge school learning with learning in other settings.) (Karen)

(I believe learning takes place when the learners can make sense of what is being taught and being aware of how it becomes relevant in the future. If pupils learn for the purpose of passing exams and later discard the knowledge because they don't see the relevance, then no effective learning has taken place... We have to consciously help them to be aware that what they learn in school can be used in daily activities or in the future.) (Nadia)

Based on the postings alone, the researcher would not be confident to assert that their beliefs about learning are qualitatively different from those of Nora, Sarah and Zoe. Karen did express that "Rote learning will help a student to a certain extent", implying that she could be comfortable with the belief of learning one form of knowledge acquisition. Further indicators were drawn from how these teachers talked about student-centred learning. All of them reportedly support student-centred learning. However, in supporting their stance, Nora and Zoe did not quote substantially concrete experiences either from their personal learning experiences or their teaching experiences. Sarah explicitly stated that she did not implement student-centred learning because she lacked the confidence in students' ability. In her words, "how much can they learn on their own?" This seems to imply that Sarah perceived her students as not being ready (see Kang & Wallace, 2005). Karen, however, had started to experiment with students creating their own PowerPoint presentation based on the mini projects, and she "was quite impressed that most of them are able to come up with the final product. Even when the presentations are not very impressive, I think it's a good beginning." Nadia, on the other hand, seemed to have incorporated student-centred learning in her classroom (see later).

In summary, the teachers' beliefs about learning seem to vary along the dimension of knowledge acquisition and knowledge construction. The pattern seemed to match their epistemological beliefs generally. However, it appears that none of them held one type of beliefs exclusively. In the following paragraphs, their beliefs about teaching and IT, with some references to their reported teaching practices and use of technologies, are delineated. It seemed that in terms of teaching, contextual considerations were more important than personal beliefs in shaping their teaching practices.

Four teachers (Nora, Zoe, Sarah, Karen) articulated that teaching is a process of "imparting knowledge" among students. Nora's note below is an example of the teachers' belief.

> (My theory about teaching and learning is to impart the knowledge that is required of the pupils according to the specific levels they are in. Pupils have to be able to understand what is being conveyed to them during the teaching process. It is a 2-way process that involves the "transmission" of knowledge from teachers (teaching) to pupils (learning).)

Inferring for the term "imparting knowledge", these teachers seemed to believe that knowledge could be transmitted from the teachers to the students. All four teachers also admitted that they adopted a teacher-centred pedagogy most of the time. Their reported teaching practices also seemed to corroborate their reported beliefs. For example, Sarah viewed her duty as covering the syllabuses and reported that, "I will deliver whatever that is required." She elaborated further that unless "I am very sure that after removing this time for student-centred activity, I will still cover my syllabus", she would not implement student-centred learning. Sarah's account seemed to be a good illustration of perceptual control theory (Zhao & Cziko, 2001). By implementing student-centred learning, the teacher perceived a threat to fulfilling her goal of completing the syllabuses.

The other three teachers also reported that they adhered to the syllabi closely and based their teaching on the textbooks. Assessments were reported to be in-class questioning for correct answers and tests and examinations at the end of the semesters. Among these four teachers, Sarah was conscious that her teaching practice was not congruent with her epistemological beliefs and admitted that she taught "absolute truth". The reason for her was "the system makes us do so". Since the teachers adhere to syllabi and textbooks, it seems that one possibly simple and effective way to tweak their practices would be for the local

education curriculum planners to conceptualize and write the curriculum in a more relativistic manner. Textbooks should also present a more relativistic and historically evolving view of today's truths.

Although the teachers also reported that some group work was incorporated in their classroom activities, they acknowledged that that is not the main activities in their classroom. Based on their reports, they seemed to adopt more of traditional classroom practices (see Brooks, 2002). These descriptions are congruent with a large scale study of local classroom teaching practices (Deng, 2005; Liu et al., 2004). It is also important to note that these teachers seemed to be evolving as they were attending the modules offered in the Advanced Diploma course. Karen's note below illustrates how her concept of teacher's role was changing from knowledge dispenser to that of facilitator.

> (My [illegible] on teaching is to impart knowledge to the pupils. In modern day, I feel that the role of teachers has changed. Now, teachers become facilitators as pupils have access to the Internet at home. The pupils know more facts than we do. I guess we have to teach them how to analyse and verify information on the net.) (Karen)

The teachers' reports on their use of computers seemed to confirm that they were more didactic in their teaching (see Table 2, Roblyer, 2003; Chen & Hung, 2003). Before the intervention, the teachers employed computers as instructive tools such as using tutorial software or drill-and-practice packages. Another reported use was as presentation tools such as PowerPoint slides to support their lectures. In Zoe's response, it was "PowerPoint and Words, that's all. Before I started this course, it's always like I am using the PowerPoint; it's like teacher-centred things." It seems that Zoe's response can be unpacked as before the course, she had the technical competency in constructing a PowerPoint presentation to deliver the verified and therefore unproblematic knowledge and students are to passively receive the constructed knowledge. She was the one operating the computer rather the students. This

seems to be a rather typical outcome when teachers are well trained in technical skills but not well developed in the pedagogical and epistemological dimensions of using computers for student-centred learning (Pelgrum, 2001; Goodison, 2003; Lim & Hung 2003). They did not exploit the affordances of computers as a tool for students' construction and co-construction of knowledge (Vrasidas & McIssac, 2001), which could problematize the verified knowledge and foster a more dynamic epistemological outlook among students.

Nadia seemed to differ slightly from the four teachers above. This was first reflected in her initial articulation of her belief about teaching as shown below. She seemed to agree less with fixed objectives and curricular.

> (: is that I cannot go into the classroom with the sole objective to complete the syllabus and deliver the lesson planned per se. Teaching has to have an impact on the students' learning. If by the end of the day my students only manage to regurgitate facts without understanding and application, then effective teaching hasn't taken place and learning would have been minimal.) (Nadia)

In Nadia's reported practice, she seemed to prefer interacting with students. She described a lesson where she made use of PowerPoint to present pictures about the Muslim's sacrificial festival and invited students to talk and ask questions about what they saw. Although the same software was used, the slides did not convey packaged knowledge. It stimulated students to talk. Her evaluation of that lesson also seemed to uncover her implicitly constructivist stance (see Brooks, 2002). In her words, "I'm satisfied with the lesson because I got the people to talk about (the festival) and they asked questions based on what they're interested on."

Among the participants, Ian and Sue again appeared to be outstanding. Both of them have advanced computing knowledge. They also appeared to be using IT rather flexibly and innovatively. However, their reported teaching practices seem to differ because Ian perceived

his contexts as not so supportive while Sue seemed to have a very supportive school environment.

On the surface, Ian appeared to adopt didactic teaching practices because of the students that he was teaching. Although Ian did not explicitly state his beliefs about teaching, he stated rather clearly that his goal for his form class was to help them to pass examinations. In other words, he was teaching to the test. The following account reflects the eclectic nature of his teaching approaches based on students' achievements in mathematics.

> First stage, it's more of drilling... it's just drilling (on the four basic operations). It is more behavioural technique. But when it comes to the later part when it is more abstract, it is a mixture of the different theories already. The different theories about the ways to teach. When coming into the third stage, if the very weak ones still cannot understand, then I apply solely behavioural technique of teaching. You see this you do this. But the fast ones, you can start using a lot of constructivist scaffolding. Keep scaffolding their understanding by either real life examples or real life situations.

Ian reported that his class was the weakest in the Primary 6 level. Most of them "never pass mathematics before in their whole life". He had about 10 months to prepare his pupils for the Primary School Leaving Examination. Employing this mixed approach that was coupled with lots of drill-and-practices, Ian proudly reported that most of his students passed mathematics and went on to the secondary schools. Ian's account seemed to be a case of school context inhibiting the actualization of beliefs (Richardson, 2003a). More specifically, it seems to be a case where teacher's perception of student readiness influences the teacher's instructional decision (Kang & Wallace, 2005). However, Ian did not seem to be concerned about the possible inconsistencies between what he believed to constitute knowing and what he was practising in teaching. From the perspective of Perceptual Control theory (Zhao & Cziko, 2001), Ian was acting as a goal-directed agent. He fulfilled what he believed to be his

primary goal first. When the students were ready, he then moved to more constructivist ways of teaching.

Ian elaborated on what he meant by constructivist scaffolding. Exploiting the copy-and-paste and the resize functions of computer, Ian created "electronic models". He performed mathematical operations on the models by pasting more similar shapes or resizing the shapes as instructed by his students based on their understanding of the word problems. He reported that this would usually help the students to discover discrepancies in their thinking. Through such activities, Ian avoided telling the students that they were wrong and helped them to discover what were incorrect in their problem solving processes. This seemed to be an innovative use of technology that the researcher had not come across in the literature. The scaffolding processes he described were akin to what Salomon and Perkins (1998) termed as tutoring, which is characterised by challenging and encouraging interactions. His use of computer, on the other hand, may have reached what Sandholtz and Reilly (2004) described as the invention stage. Further supporting evidences are provided in the next paragraph.

It seemed that it was in the extra-curricular setting when Ian was in-charge of facilitating students' creation of digital art and robotic projects that he adopted the student-centred project-based learning without constraints. In these settings, he would demonstrate some basic technical skills and task students to "go and create something that I did not". He provided feedback, just-in-time help and mediated when conflicts arose within the groups. The outcomes were "they do more marvellous things than me." Ian had brought some of these products to class for sharing.

Sue's view of teaching seemed to be more congruent with her epistemological beliefs and her view on learning. Her goal in teaching was to "develop independent learners" who "will learn for the quest and joy of learning rather than learn for the sake of passing exam"

and "share their knowledge with their friends and peers". She seemed to believe strongly in activity-based lessons that are "dependent on teamwork" and "encourage them to explore things".

> I feel that for kids to learn, they need to have hands-on and activities that are meaningful, that will engage them in order for them to be able to remember whatever that they have actually learnt. And it must be something that is enjoyable.

In her lesson sharing, Sue described a series of lessons anchored by an animated and interactive website that she had created. The following quote illustrates how she realized her beliefs in teaching.

> This lesson is supposed to be in unit one, on My School. So in one of the activity books they are supposed to write down the functions of the various rooms... Then what came to me to try this out was because I felt that the pupils already know, so what's the point of me doing this? I came up with this idea of promoting the Media Resource Library (MRL), which I proposed the name to be Media Magical Island. So it's actually a 3-in-1 kind of thing. It's also for our assembly item, because I'm supposed to have an assembly talk for MRL. Bearing in mind the pupils are actually good pupils, I have actually come up with this reader's theatre. They are able to read, but most of the time they are not able to read with expression. So at the end of the lesson it is hoped that they are able to come up with a script pertaining to Media Magical Island that promotes the Media Magical Island to the school. This also allows them to read the script because reader's theatre you don't memorise, they read, but with expression. It allows them to gain confidence when they're on stage. It was quite a success because at the end of it when I get the people to write the reflections, they actually wrote that they enjoyed and they hoped to have another session.

This account illustrated how she typically made use of her knowledge of the students (they knew about the places but are lacking in reading with expression), the purpose of the curriculum (practising writing about places), school contexts (assembly talk as consequential task) to craft engaging activity-based lessons. Sue's belief of teaching is clearly reform-oriented. Her teaching context also allowed her to practise what she believed in. She reported that the principal had created the "mega" class where all the high achievers were put into one class and assigned her to challenge the students with innovative teaching. She had also reported an incident whereby her principal defended her when one parent expressed her displeasure with Sue's series of mini projects.

While Sue's reported teaching practice seemed constructivist oriented, Sue's account also appeared to emphasize more of the activities aspect rather than the sense-making of the activities. Focusing on activities has been pointed out by researchers as a potential danger which could lead to shallow constructivism (Scardamalia & Bereiter, 2003). Another potential problem with Sue's beliefs was that she seemed to hold an accumulative view of knowledge. For instance, when she talked about the advantage of collaboration, she said, "I always encourage students to find out from their peers because their peers could have more knowledge". She also referenced the strength of problem-based learning as "retain the facts that they have learned." Both instances seemed to imply that she saw knowledge as external information to be acquired. As with Ian, she did not seem to be concerned about such inconsistencies. An alternative explanation for the inconsistencies would be that the participants were expressing relativist views of knowledge because they were aware that the researcher, who was their facilitator/ teacher, was portraying such a view most of the time. However, this seems unlikely since both Ian and Sue had provided consistent accounts across their epistemological beliefs, personal histories, views of learning and their teaching practices. It was only in this aspect that they were providing inconsistent views.

Synthesizing from the above, two important patterns that seemed to be common among the teachers were identified. First, it seemed that none of them would believe that knowledge is not transmittable (von Glaserfeld, 1995) and to varying extent, all of them practised didactic teaching. Perceiving teaching as transmitting knowledge is common among teachers (Wideen et al., 1998; Richardson, 2003a). To construct or to acquire knowledge seemed to be for the teachers a methodological choice within contextual constraints for achieving their goals of helping students to advance to the next grade rather than an actualization of personal epistemological beliefs. In schools, teachers are not held accountable for such inconsistencies. On the contrary, teachers are accountable for students' examination results. As such, the inconsistencies between the teachers' beliefs and their practices reported in the literature (for example, Fang, 1996; Schraw & Olafson, 2002) may only be meaningful to the "theorists". The researcher doubted that the inconsistencies are the teachers' concerns. The teachers' accounts seem to be moving along the logic of perceptual control theory rather than on the plane of philosophical arguments.

Second, all participants reportedly believed that IT can help to make teaching more interesting. For example, Zoe explained that with PowerPoint, "instead of we just convey through text, there is something up there where the children can see and it has animation, all the content in print forms. The children are able to learn better." More importantly, they also recognized that it is important for children nowadays to be familiar with IT (see Demetriadis et al. 2003; Hennessy et al., 2005). In Karen's words, "Totally no technology is not doing justice to the pupils." The positive beliefs that these teachers had towards IT was expected since they had volunteered for the Advanced Diploma course that could last two years. Combining their reports on their beliefs about computers and their use of computers, which has been delineated earlier, it seems that most of the teachers were at an adaptation and

appropriation stage while Ian and Sue could have reached the appropriation stage and moving towards the invention stage (Sandholtz & Reilly, 2004).

Summarizing from assertions 1-3, it seems that the teachers who are more relativistic are also more inclined towards constructivist teaching practice and innovative use of technology. The general relationship between teachers' beliefs and use of computers is similar to those reported in literature (for example, Becker & Ravitz, 1999; Becker 2000). The teachers' beliefs appeared to affect their teaching practices and also their personal learning in the T-KBC (Kagan, 1992; Pajares 1992; Richardson, 1996). However, it appears that the extent of belief manifestation depends on what the teachers perceived as their priorities in terms of goal achievement and their perception of students' readiness (see Lim & Hung, 2003, Demetriadis et al., 2003; Kang & Wallace, 2005). The call for developing teachers' epistemological beliefs seemed therefore to be supported by the present study. Providing opportunities for teachers to construct substantial knowledge and scaffolding teachers' reflection on their knowledge construction experiences seemed to be important for fostering epistemological developments (Prawat, 1992; Windschitl 2003). The T-KBC was designed with such intention. In the next few assertions, the participants' perspectives on their learning experiences in the T-KBC will be elaborated.

Assertion 4: The teachers seemed to be fairly satisfied with their learning experiences in the T-KBC. They reported that they learned more than the usual professional development. It appeared that the T-KBC was perceived by them as promoting active thinking and reflection and to a certain extent collaborative inquiry among them. However, they also perceived room for further improvement in the dimensions of active participation, collaborative knowledge building and depth of discussion.

Before the intervention, none of the teachers reported that they had previous learning experience in a CSCL environment such as the T-KBC. Given this background, six out of

seven teachers described their learning in the T-KBC as either an "eye-opening" experience (Nora, Zoe, Sarah) or an "interesting" experience (Ian, Sue, and Karen). Except for Nadia, the teachers maintained that learning in the T-KBC was different and better than traditional in-service education and training (INSET). They believed that they learned more (see later). Although Nadia described the T-KBC as "time consuming" and "difficult" learning experiences, it seemed that she was not dissatisfied because she was rather happy about her students' progress. Given that most participants were moderately satisfied with their learning in the T-KBC and the overall course evaluation from MOE evaluation was 3.4 out of 4 point scales, the findings was largely comparable to that of the pilot study (Chai, 2004). The teachers seemed to project a preference for the T-KBC over INSET. In the following paragraphs, how the teachers compared the INSET/ traditional workshops and the T-KBC, which gave rise to the teachers' positive and negative experiences, will be delineated.

INSET had been described as after school one-shot and one-way delivery of expert's knowledge to uninformed recipients (Hawley & Valli, 1999; Feiman-Nemser, 2001; Day & Sachs, 2004). Such characteristics were also reported by the participants of this study. For example, Karen described the usual PD courses as "the facilitators would be dictating the whole course and giving you only 1 hour of discussion." For Zoe, "the training part is training, just take it." For Ian, "usually if you go for courses, it is just transmission of knowledge, transmission of information. But you don't get time to think sometime." These descriptions seemed to indicate that INSET in Singapore was not different from those reported elsewhere in the literature in that the teachers reportedly felt that they were treated as passive recipients and it usually does not include many substantial and sustained dialogues (Feiman-Nemser, 2001).

Learning in the T-KBC seemed different for the participants firstly because they perceived that it was more learner-centred, with lesser lecturer's inputs and more knowledge

sharing and co-construction in an open environment. For example, Sue perceived the T-KBC as an environment where "no answer is given to us. We have to do our research, and based on what we have done, try to advance our own knowledge." Nadia reported similar perception that "it's (the T-KBC) very open, so you have to really go all out and substantiate your own learning, which is good." Although the facilitator's main role as Sue perceived it was to "post questions" rather than deliver content knowledge, she seemed to believe she had learned much from the three modules as reflected in the following quote.

> Throughout the online discussion, I learned lots of things. Things on engaged learning, students' motivation, how others (teachers) work on their lesson, their lesson ideas, and what are the problems they encountered. I think it helps us when we want to share with our colleagues back in school. The problems that they had, how they tried to solve the problems, and their learning experiences.

It was in accordance to the principles of adult learning (Knowles, 1990; Huang 2002) and the KBC (Scardamalia, 2002) that the facilitator kept lecturing to the minimum. It seemed that this did not cause the teachers to learn less. In Nora's words, she felt that "we are actually sharing our knowledge together. In a sense that I can learn more, more from each other." When asked to explain further, Nora's reply seemed to indicate that a community of practitioners provides richer resources for learning than lecturer could.

> When we are put into this environment and we are given a topic, then we are forced to talk about whatever we are learning, I find that you know, it's like, much more. Much more to be shared other than just the lecturer share with the pupiis.

Zoe seemed to share Nora's perception when she said that, "through their (her peers') communication and interaction, I am able to learn in a way better. Instead of like just going through the lecture only." Sue and Ian compared PD workshops and insightful lectures with

T-KBC and indicated that they preferred the KBC. The following quote from Sue seems to indicate that she gained a sense of fulfilment of being an active learner in a KBC.

> A lecturer giving an insightful lecture right, whether the students can absorb is one thing. Most of the time, if a lecturer gives a very insightful lecture, the student will just be a passive learner, you just absorb and try to digest it. If you are working in a community of practice, the lecturer usually posts a question and as a community of practice, you will need to get as much knowledge and build on each other's knowledge. In a way, it allows you to be a more reflective thinker, you are able to gain deeper insight when you try to explore and read up more. In a way, when we are online as in online learner, it allows the students to be more active.

The above quotes seem to highlight that the second property of the T-KBC that the teachers appreciated was being in a community. In other words, the teachers seemed to recognize the social affordances of the T-KBC. Learning in a community allowed them to be exposed to the multiple problems and multiple perspectives of seeing and solving problems that they faced in schools (see Kolodner & Guzdial, 1996; Lave & Wenger, 1999; Barab et al., 2001). This initiated the spiral processes of dialogic inquiry (Wells, 1999) and prompted the teachers to think and reflect actively. It seemed that teachers valued such opportunities. All seven teachers claimed that they were engaged in some reflection in the T-KBC. In Nadia's word, "we are reflecting and we are posting". Ian thought that the T-KBC was "very good for learning because it makes you reflect." Sarah posted seven reflective notes in the KF. Karen stated for her, "it really makes you reflect, what you have done, what are your practices." Sue's stance was elaborated earlier. Inferring from these and earlier quotes, it seemed that the teachers believed that they learned more when they were actively constructing and co-constructing their own knowledge in a community. This seemed to provide some supports for the calls for moving TPD towards collaborative inquiry where teachers were treated as co-

constructors of knowledge rather than recipients (Darling-Hammond, 1996; Randi & Corno, 1997).

While all participants in the T-KBC reported that they gained from the multiple perspectives afforded by the community, it seemed that different participants perceived their gains in different ways. Nora and Zoe seemed to be most positive about gaining from their peers' notes rather than the lectures. In Nora words, "sometimes just by reading their comments in the knowledge forum, we actually learn more." Nora elaborated her views in the following quote.

> We read, but their understanding is different from our understanding. They are able to analyze more, and then from there make us realize ...the level of understanding is not only there, there are more to it than what is there that is read.

Zoe shared similar views as Nora and reported having "more ideas". She also said, "I can learn from them whether my opinion is valid or invalid and maybe I need to revise."

The other participants emphasized less on learning from peers. Karen felt that "some of the notes are really thought-provoking" and pointed out that "like Sue, she is very helpful in the sense that she quotes the source and that provides a resource for me to verify." Nadia reported that, "I learn something from everybody" but did not rate learning from peers as substantial. An alternative interpretation could be that Nadia was just being courteous as it is inappropriate for Asian people to be too critical towards their teachers and peers (Hickey, 1998). For Sue, the learning was more like "self-discovery" and learning to appropriate the facilitator's scaffolding techniques. Ian seemed to enjoy the challenges posed by Sue which he thought "it made me think." He also seemed to enjoy the facilitator's feedbacks that were at times "controversial statements that made people think about what they are believing in."

From the above remarks, it seemed that in the T-KBC, the diversity in ideas, abilities and perspectives created multiple ZPDs to some extent whereby the teachers could gain from

each other's contribution (Pea, 1993; Oshima, 1998; Roth, 1999). However, the perceived gains from peers' inputs was greater for those participants who are less knowledgeable in IT and holding on to a more certain epistemological outlook.

Another important property of the T-KBC seemed to be situating teachers' learning in the site of practice (Cochran-Smith & Little, 1999; Ball & Cohen, 1999; Brown and Duguid, 2000). The next quote from Ian illustrates this point.

> In this case because you are always in a community, so it really makes you think back, trying to consolidate whatever you have learnt. At the same time you are applying. And the forum also allows the teachers to voice their opinions, their teaching experience. So they combined theory with application, and they combined their reflection, and also urging each other to think things differently. Because people sometime will put up a different stance.

Ian's words highlighted the importance of an experiential context that was situated in practice. This appeared to be the ground for teachers to synthesize theories and practices through reflection. Sarah's accounts below seemed to reinforce the value of the experiential context.

> To test whether what they (PD instructors) have shared are really working. They can give you very wonderful theory, but it doesn't mean it can apply in your class or in your school. But if you do it, you will know whether it does or doesn't work for you.

Sarah's view was echoed by Nadia in a slightly different tone. Nadia's experience of facilitating students' knowledge building helped to alleviate her concern. In her words, "once you experienced it, then you probably can be more open about it."

Other than linking theory and practice, the double-loop learning system (Salomon & Perkins, 1998) where the teachers experienced PD in a KBC and later facilitate students' knowledge building seemed to ease implementation. Nora considered the learning experience

as important to her in enabling her to implement the KBC in her class. In her words, "It gave me an idea of how I want my pupils to go about doing it when I implement this in class." The experience allowed her to "know what to expect, what to look out for when you actually make use of it one day". Sue formulated and adapted from her learning experience several strategies that she believed were important in creating a KBC. These strategies encompassed laying down ground rules for the online behaviours, modelling question-asking techniques for the pursuit of in-depth understanding, and managing the large number of online postings. The following quote illustrates one strategy that she appropriated.

> I look at how you managed as when you were responding to our notes. Most of the time, before you end, you will create a rise-above note and you will point out the questions that have not been answered. Then you will create a new view. Instead of me summarizing, I got the leaders to summarize.

The final property that emerged from the teachers' accounts pertains to the technological affordances of the T-KBC. It seemed that the teachers appreciate the technological affordance of an asynchronous platform such as KF. They reported that they were able to spend more time to think about the issues. Sue and Zoe's reports below illustrate the point.

> In a knowledge building community, it actually allows me to have sufficient time to think, reflect, and respond to opinions and postings made by peers. (Sue)
>
> It's not real time but at least you have time to think about the questions and you are able to construct your thinking properly and accurately at times. (Zoe)

This technological affordance has been well reported in the literature (for example see Harasim, 2000; Wallace, 2003). However, the affordance of flexible access did not seem to help to reduce the strong perception of time constraint that the teachers faced in the T-KBC. Except for Sue, the other teachers have all mentioned time constraints repeatedly and they

were apparently stressed. The difficulty that teachers faced seemed best illustrated by Nadia's report below.

> We really don't have the time that we ought to, to make the whole learning fruitful. Difficult because we are teaching and studying and we are doing something new at the same time. We are more concerned about what's happening in school so we are always putting this aside.

None of the teachers was relieved of their duties for attending the modules. The time constraints appeared to have impacted the level of participation as shown in the following quote from Nora.

> I would not say (the participation as) intensive because like I was mentioning just now, maybe due to the fact that each and every one of us, we are in-service teachers. We have our own responsibilities. As much as we want to interact, participate everyday in the knowledge building community, sometimes because of time constraint we are not able to do so.

Time constraint was also cited as the reason for insufficient depth in discussion as reported by Sue. Sue said, "Good because there is participation. There is commitment on the parts of the members. In terms of depth, maybe because of constraint, we don't enquire that much of depth."

Incidentally, all but Zoe felt that participation and collaboration could be better. This finding was somewhat different from the findings reported in chapter four (see Figure 7) that was based on the comparisons of results with other reported studies. It seemed that the teachers expected more from their collaborations. Given that more than 50% of the notes were at phase one, and only 18% were phase 2 notes that were explicitly stating disagreement, the teachers' perceptions seem to be closer to reality.

In summary, the teachers viewed learning in the T-KBC as a rather positive experience. Pedagogically, the T-KBC was designed to be learner-centred, experiential and situated in practice, thereby encouraging active thinking in an authentic environment. Socially, it was community based and that afforded multiple ways of seeing (Hung, 1999) that stimulated co-construction of knowledge. Technologically, the asynchronous platform allowed discussion to be extended and recorded (Scardamalia & Bereiter, 1996). These properties interacted and complimented each other to bring about some positive learning experiences among the teachers. Although it seemed that situating learning in practice created the problem of competing demands on teachers' time, the researcher would argue that this seems to be a limitation for all in-service learning if some arrangement of off-loading teachers could not be made.

Assertion 5: The teachers appeared to be rather positive about their experience of facilitating a KBC in their chosen classes. They seemed to be pleased by the students' responses in the KBC. They also seemed to view the KBC as a pedagogical model that could help achieve the local reform initiatives. However, they also have multiple concerns about implementing the model in primary schools.

> They (the students) are very interested, very motivated. And when I read through their thinking process, their sharing, I find that wow! They're actually learning much better from each other, rather than they learn from the normal class. I and my pupils, the one way kind of learning experience. So I think the children enjoy. It's very useful to them. (Nora)
>
> It's really worthwhile. They liked it. They enjoyed it. I enjoyed it and I really learned from them. (Sue)
>
> I was saying the other time that the quality (of students' notes) might not be that good, ... but I am not disheartened at all because at least... they are learning something

new, being exposed to something and going through this learning with their friends... it benefits them, and it's very fine for me. (Nadia)

The above quotes provided a glimpse to the teachers' overall perception of their experiences in facilitating the KBC in their respective classes. Generally, the teachers' experience appeared to be positive. Sarah and Zoe were the teachers who did not state their positive feeling explicitly. However, from the following quotes, the reader should be able to derive some notion of what facilitating a KBC meant for them.

> Once they are engaged, they know how to use this, they find it very interesting. Actually, just a few days ago, one of the students asked me, "Teacher, do we still have the KF account?" I was like "are you sure that you are going to the database?" She told me "it's interesting, I still want to use it." (Zoe)

> It's really the first time that I'm doing this teach less to learn more. I mean, at least I don't teach the kids, they learn on their own, the first time. (Sarah)

From these quotes, it seemed also clear that the teachers were heartened by the students' responses. Reflexively, it may imply that the teachers were concerned about the impact of the innovation in terms of its consequences on the students (Hall & Hord, 2001). Since the consequences seemed positive, it should lead to some changes in teachers' beliefs. This will be reported later.

The generally positive experiences seemed to be the outcome of the teachers' intentional facilitation, which was the focus of the third module. Some of the teachers reported that they experienced some difficulties initially arising from the differences between the orientations of the KBC, namely inquiry-based collaborative learning (Scardamalia, 2002) and that of traditional classroom learning. In other words, there was a distance between the school culture and the innovation (Zhao et al., 2002; Windschitl, 2002). For example, Zoe reported that, "at first it was very difficult because I think you know my students they are

being taught in the traditional way from the beginning... they were very confused. It takes a lot of time." Ian reported that it was "a total disaster during my first three lessons... it's so surprising that they don't know how to analyze things." Karen's report below seemed to reflect the similar problem. It also typified how she and the other teachers managed to overcome the traditional classroom culture.

> They are new towards this kind of learning, very different, so they are a little hesitant to post notes. Even if they make comments to their friends, you will find that it's like 'oh I agree with you', very basic. Then it's only later, I mean, the investigative part, then I'll come in and tell them that when you support someone's idea, you must give facts as well, or where you got information that has similar contents... It is only in the third lesson or fourth lesson... then I see that some of them started to collaborate.

Through the gradual process of scaffolding students' inquiry, the teachers seemed to observe a change in the classroom discourse structure from teacher directed recitations to a more democratized environment. This was an important goal when Scardamalia and Bereiter (1996) designed the KBC. Nora could see that in her class, "they're opening up, especially those smart ones who could not, who do not really contribute their views." In the normal classroom conditions, "when it comes to sharing, if I were to ask them what do you think about this? I would have complete silence". Although the advancement was "they advance from a one liner to maybe 3 or 4 lines", it seemed to be a real improvement worth celebrating for Nora. Zoe also reported similar observation as the next quote illustrates.

> They are able to open up, give ideas, give opinions. I actually have a few students who are really closed up. They don't voice up. Once I have given them the platform to use, they voice up. They gave a lot of opinions and they got scolded by me. I said that you should have done this in class as well, not only in the platform.

In Ian's case, he stated that his students claimed that KBC was different for them as illustrated in the next quote.

> They say it is different because...they really have to elaborate on what they know. They also have to help their friends... they also have to rebuke their friends and they also have to make their stand which they never have to do it before actually.

In Sue's class, there seemed to be a shift from the teacher as the only authoritative source of knowledge to students "teaching" each other. In other words, the students began to assume an active role in constructing and co-constructing knowledge. They were the knowers and they were moving away from relying on the teachers to give them the information (Dalgarno, 2001). Sue shared an incident in the following quote.

> There was once where they have already posted notes, and in class they were talking to each other. 'This is how we supposed to do, not like that'. Because this boy actually found a book in the library and he was trying to explain to this girl 'what you said is not correct. I found new text and it is here'. It is like allowing them to think about it and then they find out on their own.

The change in classroom dynamics was also reflected in the following notes written by some of her primary three students. The theme of inquiry was on "kite".

> Hi all, three main forces control kite flight: lift, gravity, and drag. A kite flies because the lifting force of the wind overcomes both the downward pull of gravity and air resistance to the forward motion of the kite called drag. When kite is fixed in a position to gain lift from the wind, a kite maintains a stand still or stable positive angle. That's all, friends.)

(Firstly, there is no air in space. The moon is above the level of atmosphere. As a result, there is also no wind. Secondly, there is no gravity on the moon. Gravity is used to pull the kite down to the ground. Because of this, the kite will float away. Lastly, a kite needs a person to hold it but on the moon, people fly and will fly away with the kites.)

The concepts that these students were dealing with are in the secondary school syllabi. The students searched for the information, paraphrased it and shared it through the platform. They seemed serious in constructing an explanation for how kites fly. The second note was a response to Sue's probing question "can kites fly on the moon?" Although it contained misconceptions such as there isn't gravity on the moon, the student marked it as opinion, indicating that he was making a conjecture based on what he knew. From these notes, it seemed clear that some of Sue's students did embark on a knowledge quest beyond the curriculum. Sarah and Karen also reported that the information that the students obtained from Internet and reported on KF was sometime beyond the syllabus. Karen was pleased but she did not accept the students' mindless information regurgitation as shown in the next quote.

> Sometimes when they get information, they do not really know what it is so they just present it. So when I fire them: 'what does this word mean', they will be dumbstruck. They don't know what it is. Really, it's a good way of learning, but I think it needs polishing whereby whatever you learn, you must know what it is really... And then after that, of course I told the class to ask, then after that everyone ask: why is this so, what is this, why must you use this...

For the record, Table 10 below provides an overview of the outcomes of the teachers' implementation in respective classrooms. It is obvious that the percentages of notes read by

students were low. How could the students build on ideas when they don't read each others' notes? It is therefore clear that eight weeks' implementation did not create mature KBCs and there is much room for improvement. In the Canadian classrooms, it took years for the teachers to develop the necessary dispositions and skills to establish KBC (see Hewitt, 2001; Caswell & Bielaczyc, 2001; Moreau, 2001). They worked in much more favourable sociocultural and school contexts and the students were from higher income families (K. Bielaczyc, personal communication, November, 2005). The teachers in this case study were 'neighbourhood' schools teaching children from average backgrounds. The contextual conditions the teachers faced will be elaborated in the following paragraphs. The important point to note in this contrast is that the teachers seemed to be quite positive about their teaching experiences and the KBC model (see later) after they had implemented it even when they were facing problems. It also seemed fair to conclude that the outcomes of their implementation were reasonable if not commendable.

Table 10

Overview of the Results of Classroom Implementations

	Nora	Zoe	Karen	Sarah	Nadia	Sue	Ian
Project Theme	Insects	Insect	Circulatory system	Circulatory system	Kite	Kite	National Heroes
Level	P5	P5	P4	P4	P2	P3	P4
Number of students	29	22	43	45	45	63	42
Total number of notes	287	267	284	207	108	474	152
Notes per students	9.9	12.1	6.6	4.5	2.4	7.6	3.6
Percentage of notes read	31%	27%	15%	18%	18%	15%	31%
Percentage of connected notes	87%	84%	86%	64%	75%	74%	90%

Other than the initial difficulties in enculturating the students into the KBC, which the teachers had managed to overcome to some degree, the teachers also reported encountering contextual barriers commonly reported in the literature dealing with IT integration (see Leggett & Persichitte, 1998; Pelgrum, 2001; Tien, 2002; Galanouli et al., 2004). Time was a major concern for all the teachers except Sue. Nora and Zoe said they were unable to have enough sessions in the computer labs because both schools scheduled the teachers' lab session fortnightly. Lab maintenance also denied entry to Zoe for three weeks. She had only one networked computer in her classroom. Sarah and Karen faced problems in connecting to the KF server. This caused long wait time for students to post notes. These teachers also reported that students' home access to the Internet as a barrier for better participation. It seemed that there was a gap between the KBC and the school technological infrastructure

(see page 22, Zhao et al., 2002). When problems of home access arose, it seemed that the social implications of implementing the KBC or other forms of online learning would also be a concern (see also OECD, 2001; Bitter & Pierson, 2002) since it might widen the gaps between the haves and the have nots. Less advantaged students would be deprived of participating in the knowledge building discourse. In other words, the activity system of a classroom may not be supported by the larger sociocultural context (Lim & Hung, 2003).

Another important contradiction that existed between the classroom activity system and the larger sociocultural context reported by teachers was preparing students for examination and preparing students for the knowledge society. Regardless of the outcomes of their implementation or difficulties they faced, the seven teachers and the three teachers from the pilot study (Chai, 2004; see also Chai et al., 2003) reported that the KBC is a useful pedagogical model for students' preparation into the knowledge society. The next quote from Karen, who said, "I think it's (KBC) a must", explained her view.

> When they go into the workforce, it will be globalized... you need this type of collaboration to discover something or for the benefits of mankind. So, it provides a very good opportunity for them to learn. Or else they'll be very closed up, like 背死书 [literally, memorizing dead books] which some of the good classes were being commented on. So there must be a deviation from that. Because they need to reflect on what they have learnt, they need to decide how to use the information. So they have to think, they must understand. So, in a way it also forces them to learn.

Nora, Sarah and Nadia expressed that they believed that the KBC helped to cultivate independent learners through student-centred learning. Nora's view is illustrated below.

I think it is a very beneficial type of learning activity for the pupils because the pupils are the main people here. It's not the teacher like the students getting every thing from the teachers but they are getting the knowledge for themselves with teacher as facilitator, as guide for them.

Other than independent learning, Sue, Ian and Zoe believed that the KBC allowed students to gain a deeper understanding about the subject of inquiry. Sue's statements below provide an illustration.

KBC allows my students to enquire depth and breadth in learning. I felt that since we are doing project work, this is one of the ways to facilitate project work. For project work, the time allocated will usually be once a week for double period. Whereas for this form of learning, they can participate in the discussion daily at their own time.

Sue's words above also implicitly highlighted the importance of having the KF platform. It is through the asynchronous platform that classroom talk can be extended beyond classroom and in-depth and sustained inquiry can be carried out despite the limited time allocated for the curriculum. Although the teachers could see some potentials of KBC in advancing some of the aims of "Engaged Learning" (Jones et al., 1995), they also expressed multiple concerns that they have. Nadia's account below summarizes the potential barriers that teacher faced for broader implementation.

I don't like to say this but we always go back to time, covering of syllabus, and also how the school sees it, whether the school agrees with you using this with your students, the perception... like how the students will react to this, how the parents will react, how the school will react...

Sarah elaborated much on the mismatch between the KBC and the local evaluation system which is based solely on examination. She felt that unless the evaluation system is

changed, the KBC is hardly applicable. She believed that the KBC was good for learning but not for preparing students for examination. In her words,

> If you are daring enough, actually the class can learn on their own. But based on the conditions that the school shouldn't penalize your result... Because I find that no matter how, it's going to affect the grades. So, if grade is not the priority and you are only concerned about the learning processes then it's a good choice to use KBC.

Sarah also reported the pressure that some teachers faced in the local context. "At the end of P6, principal will come and tell you: what have you been doing with your class, why can't your class produce results?" Ian reported similar constraints in the Singapore educational context and added the problem of teachers' competency.

> Schools are just catering to the exam. They look at the paper, they teach the questions. That's all. This platform is good in developing passion for learning. If it is successful; if teachers know how to...the problem is teachers are not trained. Most of the teachers were taught in the traditional method. So the methods of delivery are also more traditional.

Singapore teachers are driven to excel in examinations and they have a culture that is less tolerant towards failure (Koh, 2004). Although some studies adopting experimental design documented significantly better tests results for the KBC group (Scardamalia et al., 1992; Lamon et al., 1994; Scardamalia, Bereiter & Lamon, 1996), a study of this nature has not been replicated locally. It may be needed to provide evidences for teachers and school leaders to be convinced.

In summary, the teachers reported that they had positive experience in facilitating KBC. The satisfaction seemed to be derived mainly from their observations of the students' responses. They were also able to see the connections between the KBC model and the local reform. However, they recognized the distance between the ideal KBC and the sociocultural

and contextual conditions. Without systemic reform, there is a threat that their experience gained both in learning and teaching would be just another experience. Although most of the teachers said that they would teach in a KBC if the school is supportive, only Karen and Sarah are implementing a similar approach because their head of department, who was a participant in the 2003 study (Chai et al., 2003), had planned for it.

Assertion 4 and assertion 5 reported the teachers' experience in learning and teaching in the T-KBC. The experience apparently was an important foundation in facilitating teachers' development. In the next assertion, the teachers' reported changes will be reported.

Assertion 6: The most salient change that the teachers reported was their views about their students. There were also some changes in their view about the teachers' and computers' role in classroom teaching and learning. The changes were conducive for the advancement of local reform.

Changes at knowledge and skills level in terms of acquiring the technical and pedagogical skills for implementing KBC were the basic aims of the modules and they were met as documented in Table 10. The changes reported here are generally changes that are linked to teachers' beliefs. They appeared to be in the direction of supporting reforming teaching practices towards constructivist teaching. However, it seemed also true that the changes were not at the level of transformation. Neither had they reached the core epistemological beliefs of the participants.

The most salient change commonly reported by the teachers was that they began to see their students differently. Earlier quotes from Nora and Zoe in assertion 5 had already indicated that they were pleasantly surprised by the responses of their students, especially those who were silent in class. In Zoe words, "I thought that they are very quiet. They can't be bothered but actually they have been keen. They said that in class they are afraid to voice up." Ian also reported that KBC "is an avenue for quiet pupils to give their viewpoints." Nora

seemed to have formed the view that students can be active contributors of their peers' learning and they have a voice. In other words, they were not blank slates to be written on.

> I see them not only being the group of people who are listening to what I'm saying, listening to my views, but they are listening to each other. They are also you know, giving out what they think about a certain topic. (Nora)

Karen also saw some "hidden potential" among her students. In her words, "some of them can carry out independent learning, and some of them can be very resourceful and some of them can be very committed." Similarly, Sue seemed to have undertaken a re-assessment of her students' abilities and thought that "they are definitely capable of performing better". Nadia was concerned initially that her primary two students were "too young" to handle KBC but her experience changed her view (see earlier). As for Sarah, the following quote shows that although she believed that the learning outcomes is dependent on the type of class, she nonetheless saw all students as capable of learning on their own.

> (It) helps me to realize that you don't have to teach, sometimes they can learn on their own. But there are some setbacks. How much they can learn depends on the quality of the class. So if you are given a weak class, they learn on their own, but their learning will be quite limited. But if you are given a good class, they can explore more.

Prawat (1992) postulated that for teachers to shift towards constructivist teaching, it is necessary that they value students' effort to construct deeper understanding from their incomplete prior knowledge and facilitate such processes. From the above quotes, it seemed that the students' performances had help change the teachers' view about them. Except for Sarah who was concerned about results, the other teachers seemed to express an appreciation of hearing students' voices and seeing "how they have progressed from the beginning" (Nadia). The change in the teachers' view about their students therefore seemed to help the teachers in moving closer to learner-centred constructivist teaching.

Two other changes that were reported by some of the teachers were the change in roles and their changing views of how computers should be used in classrooms. Nora and Zoe expressed that they were "more sure, more comfortable" and had gained "better understanding" (Zoe) of what was meant by facilitating students' learning. Nora's words below seemed to show also that she had changed to emphasize the role of facilitator.

> The roles of a teacher have changed, should change from the normal teacher being the dispenser of knowledge. Now the role of the teacher should be in such a way that it would be, should not give them all the time. We should be facilitating them along, constructing their knowledge. So the role of the teacher must change.

Karen expressed similar beliefs in saying that "you must be a facilitator, you must be also a coach, sometimes a mediator when the group cannot function." The following note from Sarah shows how she reflected on the lesson conducted and planned her next move in guiding students forward. Interestingly, the note reflects Sarah's strong notion of correct ways of doing things.

My sixth lesson reflection

by Sarah

Last modified: 2004, August 05 (13:26:37) by Sarah

1. Students started to do their first research posting, about 10 students came to class not prepared at all. They did not do any research work at all for the past 1 whole week. They spent the posting time doing the research.
2. The students started off not knowing what to post. After showing them an example, they slowly managed to post their findings in a more proper manner.
3. Students are still unable to give the correct reference at the end of their postings. I have taught them the proper manner but they are still unable to do it. I might have to demo 1 more time in my next lesson.
4. Students are still unable to give useful comments on their friends' postings. They are unable to build on their friends' idea. They mainly agree with what their friends have posted. Only 1 group state that they do not understand what their friends have posted, even so this group is unable to state clearly what they have not understood.
5. To conclude, till now the students are still unable to display good KBC skill. They really need a lot more practices and exposure.

Facilitating students' active sense-making is an important constructivist teaching strategy (Desforges, 2000; Brooks, 2002). While implementing the KBC, all teachers reported being engaged in questioning and challenging students' construction and encouraging the students to do so themselves. Treating what students are able to construct as their current developmental level, the questioning and challenging by both teacher and peers are important in extending students' competencies as it scaffolds students toward the higher end of their ZPDs (Vygotsky, 1978).

Associated with the change in the teacher's roles was the change of the role of computers. The role of computer for Nora appeared to change from that of teacher-centred use to that of student-centred use. "It's no longer being used as a presentation tool. It should be used not by the teacher only, but by the pupils themselves." Karen reported that she moved beyond bringing "them to the lab to use the CD-Rom and then let them try the various questions." She believed that "the level of involvement by the students could be increased, by giving them the project-based (tasks)." Zoe seemed also to move in this direction as shown in the next quote.

> Last time … teaching is done by the computer. Now (the children are) learning with the computer. The computer is like helping the children to learn better… Instead of the computer already constructed for them. (Zoe)

The last dimension of change reported by the teachers seemed to be with regards to the syllabus, which is the embodiment of the curricula. Nadia and Sarah's concern about time constraints and syllabi coverage have been mentioned earlier. Ian put it simply as "too much to teach, not enough depth." Nora's view is elaborated below.

> I think the syllabus now is that there are too many things to be taught to our pupils. ..... sometimes, we are rushing in such a way that we could not really see the students' extent of understanding. We don't have enough time to get them to engage in thinking, whereby we can ask the students 'what do you think of the topic?' and they will give their own idea. We have no time to carry out teaching that way. We'll end up rushing through, but what do the children get from it? And then sometimes based on what we're supposed to learn, we really have no time to get the children to really go further.

The above quote illustrated Nora's view on curriculum after facilitating the KBC. Though she and the other teachers might have thought that the syllabus was too much before the intervention, it seemed reasonable to accept that after the KBC experience, this view became more acute. Before the experience, facilitating students' construction of knowledge may be a vague notion that they did not bother about much. After the experience, they were more or less convinced that student-centred constructivist learning could be done and at times, it could be a more meaningful way to learn. However, that could hardly be implemented if the larger environments do not change. Nora's words seemed to point to these important issues about constructivist learning. If students were not given a chance to share their thoughts, how could teachers then facilitate further and better knowledge construction? Without giving time for students to form their own understanding, do students learn? This is directly linked to pedagogical dilemma that Windschitl (2002) elaborated.

Lastly, in terms of epistemological changes, only Nora and Zoe reported some changes in this category. The next quote seemed to sum up Nora's changes holistically from receiving knowledge mostly to greater emphasis on the active role of the knower.

> Before going through this experience, knowledge to me is just about acquiring what I'm supposed to learn from teachers. Teachers teach and children acquire the knowledge. After going through this experience, knowledge does not only come from what is being taught in school. Actually, pupils also can construct their knowledge on their own. They are exposed to knowledge in their daily life. It's just that unconsciously they are not aware of it. To them the knowledge is what I get from school. From the teacher I have the knowledge. Actually, it's already in them. Maybe they need a channel on how to share this knowledge, to give to each other, to articulate this knowledge with others.

Zoe seemed to be broadening her sources of knowledge when she said, "instead of me just looking at the book and the book gives the answer and solutions." Her ways of knowing, as she reported, became "talking face to face or even the online is building up knowledge" and "more to experiencing as well". Interacting with others emerged as an important way of knowing for her.

For the other teachers, the totality of the experience of both teaching and learning in a KBC seemed to reinforce and enrich their originally held epistemological positions. This is a reasonable outcome since their beliefs were more congruent with the underlying beliefs of the KBC.

The changes reported by the teachers were changes that could help them to better realise the aims of the local reform. Similar changes had been reported by Resta et al. (1999) and Yuen (2003) and the pilot study (Chai, 2004). However, the researcher suspects that these changes may not be sustainable because the distance between the school culture and the

KBC seems large (Zhao et al., 2002) and the activity systems of the schools are geared towards producing results (Lim & Hung, 2003). After the modules, few teachers had tried implementing KBC again.

Summary of Chapter 5

Concluding from the six assertions made in this chapter, this case study documented seven teachers' beliefs and their perception of teaching and learning in a KBC. The teachers' epistemological beliefs were more or less relativistic in nature. To some extent, the teachers' epistemological beliefs were related to their beliefs in learning. The relationships between their epistemological beliefs and their teaching practices were however not direct. It seemed that teachers with complex epistemological outlooks reported diverse ways of teaching. The teaching strategies could range from traditional didactic teaching to constructivist teaching depending on their perceived contextual constraints and their goals. Teachers with simpler epistemological outlooks were reporting more on traditional teaching.

After the KBC experience, all teachers reported being better prepared to implement reform oriented teaching as demanded by MP2. Their perceptions about teaching and learning in a KBC were generally positive and they could relate their experience to the reform initiatives. However, they faced problems that were beyond their control. Systemic change is required before they could implement the more ambitious forms of teaching and refine their understanding and pedagogical skills further. In the next chapter, the conclusions and the implications from this case study will be drawn.

Chapter Six

Conclusion and Recommendations

This study began with the aims of designing an appropriate PD model in a CSCL environment to prepare teachers with the necessary skills, knowledge and beliefs for the actualization of MP2. Based on the literature review, it adapted the KBC model for teachers' development, which was named as the T-KBC. Underlying the T-KBC were interlinked learning theories derived from sociocultural perspective, constructivist philosophy, and adult learning theories. Supported by the KF platform that was designed to exploit the technological affordances of IT, the model was implemented for two groups of Singapore schoolteachers. The guiding research questions were as follows:

1. How do teachers build knowledge collaboratively in a KBC?
2. What are the teachers' reported epistemological beliefs and their reported beliefs about computers in education?
3. How do teachers reportedly perceive teaching and learning in a KBC?

In the following paragraphs, the findings for the research questions will be summarized and the implications for practice and future research are drawn. Four main sections form this concluding chapter. Questions 1 and 3 will be discussed first as they seemed more closely related. This is followed by a discussion on Question 2. This chapter will end with some reflective concluding remarks.

Summary and Implications from the Study of Teachers' Online Knowledge Building Activities

With regard to the first research question, the findings indicated that the teachers had participated fairly actively in building each others' understanding in the broad areas of integrating IT into curriculum and implementing the KBC in their classrooms. This is at least a warranted interpretation when the note-writing and reading activities are compared broadly to the empirical studies reviewed. All teachers were well connected to one another in terms of

the links they created by reading and building on their posted notes. On this evidence, the social cohesiveness of the group seems to be good. Comparison with other studies that employed the IAM (Gunawardena et al., 1997) as an analytical model to measure knowledge building discourse also seems to indicate that the T-KBC had obtained reasonably good results in the knowledge building dimension. The documentation of these outcomes should contribute to research effort on practising teachers' collaborative online interaction for professional development since studies in this area are rare (Zhao & Rop, 2001). The descriptions generated by this study should also contribute to the research on CSCL with further analysis of the text-based interactions that could help to achieve a better understanding of CSCL (Hendriks & Moar, 2004; Marra et al., 2004).

As revealed by this case study, three general categories of factors seemed to be important contributors to the rather successful outcomes. The three categories are technological affordances, social affordances and pedagogical designs. Technologically, the asynchronous platform allowed the users to have ample time to think and it extended the discourse beyond the confinement of classrooms and face-to-face settings (Scardamalia & Bereiter, 1996). Extended discussion is very important for co-constructing a better understanding about complex matters. Teachers in traditional classrooms do not have enough time for learners to discuss matter to sufficient depth, let alone to encourage students to reflect on the discussion processes. With the support of asynchronous platform, learners could carefully consider the issues, articulate and perhaps revise their views as they progress (Hara, Bonk, & Angeli, 2000).

In this case study, the time afforded by KF seems to be the major contributor for the average word counts per note to be around 114. It seems that what Rowe (1974) tried to achieve through special training could be achieved quite easily in an asynchronous platform. The text-based nature of the platform kept records of what transpired during the interaction.

This allowed the participants to go through the interaction multiple times. The participants were also able to rejoin the discourse at a later time (see Scardamalia, 2002).

Socially, having a group of participants brought with it multiple perspectives. This created a fertile ground for ideas to be developed and revised. Given that in this case the participants were professional teachers each having their own areas of expertise, epistemological positions and unique way of seeing, the distributed intellectual resources and the multiple zones of proximal developments should stimulate rich discussion (Pea, 1993; Kolodner & Guzdial, 1996; Oshima, 1998; Roth, 1999). In terms of pedagogical design, a number of important principles of learning that were derived from recent theories have been consciously practised or incorporated in the T-KBC. These include situating the teachers' learning in community of practice and the site of practice (see Lave & Wenger, 1999; Darling-Hammond & Sykes, 1999; Barab et al., 2001), adopting a learner-centred constructivist teaching approach (Jonassen, 2000), and double-looped experiential learning (Salomon & Perkins, 1998; Huang, 2002). These learning principles are very important for the emergence of an authentic and, thus, meaningful learning. The outcomes of this study in terms of the online content analysis seem to provide further support to the learning theories and principles outlined. However, it should be noted that the participants of this study are teachers who had committed themselves to a 12-18 months long programme. They were also holding positive attitudes towards IT. This is a case study that documented some possible outcomes given the stated conditions. More case studies under different contextual conditions are therefore needed to provide further verification of the T-KBC model and its underlying learning theories.

Although it was the researcher's original intention to identify a series of notes to illustrate clearly how knowledge building discourse occurred on a turn-to-turn basis, this aim was not achieved. The findings as reflected by the notes quoted in chapter 4 were more of a

general description of how teachers identified problems they faced and how they attempted to understand and solve the problems collaboratively. Providing evidence for effectiveness of CSCL for teaching and learning, especially at the microgenetic level, is an identified gap in the literature of CSCL (Stahl, 2004). It remains an area that needs further research. The present researcher gave up his attempt to analyze the discourse at the microgenetic level because he realized that it would require specialized training in discourse analysis for one to substantiate knowledge claims in this area. In other words, specialized training in linguistics is necessary to do the job adequately. It seems therefore that future attempts to document such evidences should be carried out by collaborative teams of researchers from both the fields of educational technology and linguistics.

The researcher made the claims that the outcomes of the online interactions were reasonably good based on comparison with other empirical studies. As the arguments were being prepared, the question of what constituted quality in terms of learning outcomes became apparently unavoidable. CSCL is an emerging field of study where evidences of substantial learning are still needed (Lipponen, 2002). Consensus on what constitutes good learning in CSCL is yet to be reached. Since teachers are professionals dealing with teaching and learning, this study also drew on the teachers' subjective perceptions of teaching and learning in the KBC to enrich understanding in this area (see also Sandholtz, 2001). The findings obtained for the third research question are summarized below and they seem to strengthen the claims made earlier.

Summary and Implications of Teachers' Perception about Teaching and Learning in a KBC

Generally, the responses of the ten teachers (inclusive of the three teachers in the pilot study) interviewed were positive for their learning in a KBC. The teachers seemed cognizant that they were not taught much but most teachers believed that they learned more. They appeared to appreciate the opportunities to be active and collaborative learners rather than

being treated as passive recipients of information. The explanations provided by them to account for their satisfaction in learning include being in a community, being able to see from multiple perspectives, investigating topics of their choice, experiencing before implementing, and having sufficient time to think and reflect. These explanations seemed to be congruent with the learning principles discussed earlier. This study therefore provides some support to the calls for reforming teacher PD into community-based onsite collaborative inquiries (Ball & Cohen, 1999; Cochran-Smith & Lytle, 1999; Barab et al., 2001; Yamagata-Lynch, 2003b).

From the teachers' perspective, it seems that this form of PD is more meaningful than INSET. One possible design guideline that can be inferred from the teachers' accounts for teacher educators seems to be that in the context of professional development, it would be better for the teachers to identify the problems that they would like to investigate within the broader themes as set out by the modules. In other words, rather than "delivering" the content to the teachers, it might be better to draw the content out from the teachers and facilitate the co-construction of further understanding. This also means that teacher educators should treat in-service teachers as knowledgeable adults who are looking for ways to resolve the dilemmas that they face rather than naïve participants who need information. For example, when dealing with a module that aims at enhancing students' thinking, teacher educators should draw from teachers' experiences on what are the problems that students have in thinking. The potential pitfall of this approach is that the teachers may be more inclined to identify practical problems they are facing and they resolve the problem through practical strategies rather than building an in-depth understanding and theoretical knowledge.

In this study, 52% of the notes were ranked as phase 1 notes according to the interaction analysis model. This means that there was more information sharing than knowledge building interactions. The teachers also seemed more inclined to contribute personal opinions and ideas on practical problem solving. They were not inclined towards

building theories. This is an area where teacher educators have to focus their efforts in order to foster closer and mutually engendering relationships between theories and practices. In other words, it seems necessary for teacher educators to help teachers in understanding the value of building theories.

For the teachers' perceptions of "teaching" in a KBC, again all ten teachers interviewed reported positive experiences, perhaps even more than their learning experiences. The major contributor of their satisfaction seems to be their perception of the students' learning through interaction in a KBC. They also seemed to perceive the KBC as promoting active and collaborative learning among students. To a lesser extent, the students were also assessed to exhibit more critical and creative thinking. This is important because the qualities exhibited are the ones that local and international reforms in education are targeting at (Jones et al., 1995; MOE, 2002).

Despite the teachers' positive experiences, it seems clear from the teachers' accounts that teaching in a KBC involves intensive facilitation work. New norms and orientations towards learning have to be established among the students. Time is needed to foster the new orientations that are geared more towards independent and inquiry-based, student-centred learning. However, the current school system as a whole does not seem to support this form of learning, at least in the sense that there exist obvious contradictions between the activity systems (Zhao et al., 2002; Windschitl, 2002; Lim & Hung, 2003).

On the one hand, schools are expected to produce good examination results. Teachers are assessed according to outputs. To fulfil this demand and for personal professional survival, teachers teach didactically according to the syllabi and drill the students to answer examination questions. On the other hand, the policy makers are also asking the teachers to move away from didactic teaching and create student-centred constructivist learning that involves some form of research. Time is needed for students to construct understanding. In

this study, the tension created by these seemingly opposing demands seems clearly felt by the teachers. The teachers appeared to respond to the tension by cautiously weighing the situation, especially in terms of student readiness and adopt their teaching strategies according to what they perceived as the efficient method to achieve their goals (see Zhao & Cziko, 2001). At times, implementing innovative teaching approaches seems to be perceived as hindering students' ability to perform in examinations (see Demetriadis et al., 2003; Fox & Henri, 2005) and this is usually the decision when the teachers assessed their students as being less able. The implications could be that those perceived to be less able get more didactic form of teaching, which maybe is exactly what they do not need. There may be a need for professional development efforts to address this way of thinking among Singapore teachers.

There is also a need for the education system to evolve in terms of its assessment practices, both for the teachers and the students. Teachers, as well as students, need to be reassured that the teaching and learning processes are as important as the outcomes, if not more important. In essence, more concerted and systemic effort and generative dialogues are needed among all stakeholders of students learning. Teachers' perspectives need to be considered by the policy makers (Goodson, 2003). The policy makers also need to be understood by the teachers. It seems wise for teachers to understand that they need to contribute possible solutions to the problem instead of just shifting the blame to the system. This would reflect a change in the teacher's identity as a knowledge reproducer to that of knowledge producer (Feiman-Nemser, 2001). It also seems that case study of the changes of teachers' identities and how that occurs could be a possible perspective that future research could adopt in understanding teacher professional development in CSCL environment.

The changes that the teachers experienced from teaching and learning in a KBC seem to be that:

a) they were reportedly more receptive about the idea of students as independent learners and knowledge constructors

b) they were reportedly more comfortable with the role of facilitator

c) they were reportedly widening the role of computers in classroom teaching and learning as cognitive tools (see Lajoie, 2000; Jonassen, 2000) and exploiting more of the affordances of IT.

These changes should at least put the teachers at the beginning of the developmental trajectory for the MP2. From Sandholtz and Reily's (2004) framework, the teachers seemed to be moving towards the appropriation stage.

In this study, the teachers were given support throughout the processes by the researcher and amongst themselves. As compared to usual INSET, a longer period of time was devoted to learning, drawing on the learning experience, designing the classroom activities, implementing and reflecting. Without the community support and the preparation work, the teachers might not be able to generate these positive experiences. This study therefore documented a possible PD model to facilitate teachers' development for reform-oriented teaching. The case study seems to argue against conceptualizing professional development activities as short-term workshops targeted at equipping teachers with skills and knowledge without substantial dialogue. In other words, to equip teachers with the necessary skills and knowledge for the initiatives such as the MP2, policy makers need to think about substantial and ongoing in-service collaborative inquiry. Professional learning communities which share the goal of improving practices and the commitment of constructing the means and theoretical supports for actualizing reform should be formed and treated as a form of legitimate and meaningful professional development activity.

This case study should also provide further support to the general claims that CSCL supported by networked technology is a workable form of technology to support changes in

teaching practices in the context of in-service professional development (Zhao & Rop, 2001; Yamagata-Lynch, 2003b; Lipponen et al., 2004). The context of this study was that except for two of the teachers, the rest of them came from different schools. One possible area for future research would be implementing the T-KBC as school-based professional development. Grossman et al. (2001) documented the effects of conducting school-based learning community among teachers and reported the conflicts in work affecting the learning community. Given that it is relatively easy for CSCL to be designed with the capability for anonymous posting, it might resolve some problems that Grossman's team encountered. With CSCL, a school-based community of learners meets face-to-face, online, or online anonymously. It would be interesting to find out how CSCL would change and be changed by the school-based situation. This will allow researchers to find out more on the appropriate settings where CSCL should be employed.

Summary and Implications of Teachers' Epistemological Beliefs

Teachers' beliefs about knowledge, knowing, teaching and learning, and computers were investigated in this study answer to the identified gaps in knowledge both from IT integration perspectives and studies from teachers' beliefs (Ertmer, 1999; Ertmer & Albion, 2002; Schraw & Olafson, 2002; Chan & Elliot, 2004). In the Singapore context (see Deng, 2004; Chai & Lourdasamy, in press) as elsewhere, this area requires much research. This study has therefore contributed to the research in teachers' epistemological beliefs.

The findings of this study indicate that the teachers reportedly held a range of epistemological beliefs that varied along the relativistic continuum. The teachers differed in terms of how relativistic their perception of knowing and knowledge were. Teachers who were less relativistic reported adopting a more traditional view of learning from textbooks and experts while teachers who were more relativistic emphasized more the construction of personal knowledge through multiple sources of knowledge. Their participation patterns in

the online database seemed to be related to their epistemological stance. Teachers who were less relativistic also seemed to be more inclined toward teacher-centred pedagogy while teachers who were more relativistic seemed to adopt more student-centred learning in their classrooms. However, it is important to note that it is a matter of degree rather than exclusive choice of certain teaching or learning strategies. All participants reported learning in traditional ways and teaching in a didactic manner to a certain extent. The strategies adopted are more of contextual choice with reference to the reported beliefs rather than decided by the beliefs. No assertion was attempted to answer the question as how did the teachers' epistemological positions relate to their KBC implementations. To infer any assertion in this area requires the researcher to study teachers' facilitation activities in the student databases based on the students' postings. It could be a meaningful study but it is beyond the scope of the present one. Moreover, the teachers' planning and implementation were more of modelling after the facilitator's and the case studies they performed on local databases from the pilot study and reports from Canada. Their actions in the database may not reflect their epistemological positions.

The present case study seemed to provide some support for the call for developing teachers' epistemological outlook (Ertmer, 1999; Windschilt, 2002). This seems to be at least true for teachers who are holding onto the more traditional view of teaching and learning. This group of teachers was more positive towards IT in education and among them, there are some who need to further develop their epistemological stance. It seems therefore possible that a certain proportion of Singaporean teachers might also be holding similar traditional outlooks (see also Chai & Lourdasamy, in press; Liu et al., 2004). This is an area that requires large scale survey research if the local education authorities want to transform the educational practice. The baseline data generated could help policy makers in setting realistic

targets concerning the achievement of the reform initiatives and making decisions concerning professional development activities.

The framework adopted by this study in investigating teachers' epistemological beliefs was drawn mainly from Perry's work. As the framework adopted a developmental perspective, assessing the teachers' epistemological positions at times seemed to be rather judgemental. The researcher felt quite uncomfortable when he sent the findings to the participants for member checking. There are other ways to assess teachers' epistemological outlooks. One possible framework seems to be Schraw and Olafson's (2002) epistemological worldviews that categorise teachers as realist, contextualist and relativist. Alternatively, a future study could adopt the grounded theory approach to generate other forms of descriptions that could be more informative than the developmental perspectives. In terms of the dimensions of epistemology to be studied, it seems that a broader delineation of epistemology is desirable. Although the nature of knowledge and knowing form the core of epistemology, for research that deals with teaching and learning, other peripherals that are more or less dependent on the core could help researchers to gain a clearer understanding of the teachers' beliefs.

Researching teachers' epistemological beliefs was not a simple task (Pajares, 1992). As the teachers were articulating their beliefs, they were examining them and changing them at the same time. The quote lifted from Nora's transcript (see pp. 117-118) is a case in point. It is potentially threatening to the teachers' sense of self-esteem. This poses a methodological challenge for the researcher when one needs to capture the existing beliefs. As such, when conditions permit, it seems best for researchers to begin with lesson observations and perhaps document review such as studying the lesson plans. This would help the interviews to be grounded in actual events and thus more authentic (Cooper & McIntyre, 1996). For this study, the lesson plans were collected and analyzed before interviews. Observation however was not

conducted due to logistical problems. The researcher suggests that future research should include classroom observations to enhance the confirmability of the study (Guba & Lincoln, 1989).

Another good strategy for obtaining data on teachers' epistemological beliefs would be asking the teachers to complete a questionnaire on their epistemological beliefs. Schraw and Olafson's (2002) epistemic inventory as well as Kitchener, King and Wood's (2000) "Reasoning about Current Issues" both seem to be a good choice of instruments. To assess epistemological beliefs, multiple data collection employing multiple methods is advisable for the researcher to triangulate the results (see also Schraw & Olafson, 2002). In the context of professional development, the questionnaire could be a good initiator since it appears that articulating epistemological beliefs was also not an easy task for the teachers in this study.

Concluding Remarks

This study was conducted in the context of three in-service modules that were aimed at enabling teachers' for the fulfilment of Engaged Learning. The professional development activities were targeted at transforming teachers' beliefs. At the end of this journey, it seems that only two teachers changed their epistemological beliefs. For the other participants, it was more about discovering an approach that was more congruent to their beliefs and the initiatives that they were tasked to achieve. Although the reported changes appeared to be changes that could help advance the cause of Singapore educational reforms, two lingering issues remain. They are the scalability and the sustainability of the T-KBC. The researcher and the teachers spent much time and effort in designing and experimenting with this approach. For the researcher, it took three years to develop the model and the necessary skills to achieve the limited changes among the teachers. The time and effort devoted seem way beyond what a teacher educator could afford in normal teaching circumstances. The professional development was conducted for a small group of seven teachers. If the group

were to be more than 15 teachers, the voluminous postings would be difficult to cope with. However, for teaching practice to change at a nationwide level, it seems clear that many teachers need to have substantial learning experiences in a KBC or similar form of PD. Are there enough teacher educators to affect this change? When the teachers return to their daily teaching, they are likely to be isolated individuals who know about an alternative way to teaching and learning. Pressurized by the sorts of high-stake examinations noted above, could they affect change at their level? How long would that take? In the larger social-cultural context that teachers work, there seems to be a real threat that the teachers could be assimilated back to the mainstream practice of didactic approach.

Despite the preceding remarks, the call for attention to teachers' beliefs in the context of developing teachers' competencies in integrating IT seems warranted (Ertmer & Albion, 2002; Looi et al., 2004). Imagine a group of teachers who see knowledge as a body of fixed and verified facts. They have been taught mostly this way and they have experienced success in treating knowledge as fact to be assimilated. It is hard to imagine how they could value or accept constructivist teaching that could result in students constructing misconceptions. Neither could they scaffold knowledge construction since they have been receiving knowledge passively and as such they lack the experiential knowledge necessary to do it (Windschitl, 2003). In other word, the teachers' stage of epistemological development could function as an invisible ceiling that prevents the teacher from adopting the epistemologically more challenging and ambitious teaching methods. It is therefore important for researchers to further advance research into teachers' beliefs and look for innovative way to further teachers' epistemological outlooks.

References

Albion, P. A., & Ertmer, P. A. (2002). Beyond the foundations: The role of vision and belief in teachers' preparation for integration of technology. *Techtrends, 46*(5), 34-38.

Arvaja, M., Hakkinen, P., Rasku-Puttonen, H. & Etelapelto, A. (2002). Social processes and knowledge building during a small group interaction in a school science project. *Scandinavian Journal of Educational Research, 46*(2), 161-179.

Audi, R. (Ed.). (1995). *The Cambridge Dictionary of Philosophy.* Cambridge, UK: Cambridge University Press.

Ball, D. L., & Cohen, D. K. (1999). Developing practice, developing practitioners: Toward a practice-based theory of professional education. In L. Darling-Hammond & G. Sykes (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 3-32). San Francisco: Jossey-Bass.

Barab, S. A., MaKinster, J. G., Moore, J. A., Cunningham, D. J. & the ILF Design Team. (2001). Designing and building an online community: The struggle to support sociability in the Inquiry Learning Forum. *Educational Technology, Research and Development, 49*(4), 71-96.

Baxtor Magolda, M. B. (1992). *Knowing and reasoning in college: Gender-related patterns in students' intellectual development.* San Francisco, CA: Jossey Bass.

Baxtor Magolda, M. B. (2004). Evolution of a constructivist conceptualization of epistemological reflection. *Educational Psychologist, 39*(1), 31-42.

Baylor, A. L., & Ritchie, D. (2002). What factors facilitate teacher skill, teacher morale, and perceived student learning in technology-using classroom? *Computers & Education, 39*(4), 395-414.

Becker, H. J. & Ravitz, J. (1999). The influence of computer and internet use on teachers' pedagogical practices and perceptions. *Journal of Research on Computing in Education, 31*(4), 356-384.

Becker, H. J. (2000). Findings from the teaching, learning, and computing survey: Is Larry Cuban right? *Education Policy Analysis Archives, 8* (51), Retrieved April 12, 2005, from http: epaa.asu.edu epaa v8n51

Beers, P. J., Kirschner, P. A., Boshuizen, H., & Gijselaers, W. H. (2005). Coercing knowledge construction in collaborative learning environments. In T. Koschmann, D. Suthers, & T. W. Chan (Eds.), *Computer supported collaborative learning 2005: The next 10 years!* (pp. 8-17). Mahwah, NJ: Lawrence Erlbaum.

Belenky, M. F., Clinchy, B. M., Goldberger, N. R. & Tarule, J. M. (1986). *Women's ways of knowing: The development of self, voice and mind.* New York: Basic Books.

Bereiter, C. (1994). Implications of postmodernism for science, or, science as progressive discourse. *Educational Psychologist, 29*(1), 3-12.

Bereiter, C. (1997). Situated cognition and how to overcome it. In D. Kirshner & J. A. Whitson (Eds.), *Situated cognition: Social, semiotic, and psychological perspectives* (pp. 281-300). Hillsdale, NJ: Erlbaum.

Bereiter, C. (2002a). *Education and mind in the knowledge age.* Mahwah, NJ: Lawrence Erlbaum.

Bereiter, C. (2002b). Design research for sustained innovation. *Cognitive Studies, Bulletin of the Japanese Cognitive Science Society,* 9(3), 321-327.

Bitter, G. G., & Pierson, M. (2002). *Using technology in the classroom.* (5th ed.). Boston, MA: Allyn and Bacon.

Block, D. (2000). Problematizing interview data: Voices in the mind's machine? *TESOL Quarterly, 34*(4), 757-762.

Borja, R. R. (2004). Smarts no longer good enough for Singapore students. *Education Week 23*(41), 8.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher, 33*(8), 3-15.

British Educational Communication and Technology Agency (BECTA). (2005). *The Becta review 2005: Evidence on the progress of ICT in education.* Retrieved 1st April 2005 from http://www.becta.org.uk/research/research.cfm?section=1&id=3497

Brooks, J. G. (2002). *Schooling for life: Reclaiming the essence of learning.* Alexandria, VA: ASCD.

Brown, A. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences, 2*(2), 141-178.

Brown, A. & Campione, J. C. (1994). Guided discovery in a community of learners. In K. McGilley (Ed.), *Classroom lessons: Interesting cognitive theory and classroom practice* (pp. 229-270). Cambridge, MA: MIT Press.

Brown, J. S., & Duguid, P. (2000). *The Social life of information.* Boston : Harvard Business School Press

Brownlee, J. (2001). Knowing and learning in teacher education: A theoretical framework of core and peripheral epistemological beliefs. *Asia-Pacific Journal of Teacher Education and Development, 4*(1), 131-155.

Brownlee, J. (2003). Changes in primary school teachers' beliefs about knowing: a longitudinal study. *Asia-Pacific Journal of Teacher Education, 31*(1), 87-97.

Brownlee, J. (2004). Teacher education students' epistemological beliefs. *Research in Education*, 72, 1-17.

Bodgan, R., & Biklen, S. P. (1998). *Qualitative research for education.* (3rd edition). Needham Heights, MA: Allyn and Bacon.

Burns, M., Menchaca, M., & Dimock, V. (2002). Applying technology to restructuring and learning. *Proceedings of CSCL 2002*, Boulder, Colorado, USA. Retrieved Sep 23, 2003, from http://newmedia.colorado.edu/cscl/234.html

Burtis, P. J. (1998). *The analytic toolkit [Computer software]*. Toronto: Knowledge Buidling Research Team, Ontario Institute for Studies in Education, University of Toronto, Canada.

Bushweller, K. (2004). Technology report examines the world. *Education Week, 23*(34), 5.

Butler, D. L., Lauscher, H. N., Jarvis-Selinger, S., & Beckingham, B. (2004). Collaboration and self-regulation in teachers' professional development. *Teaching and Teacher Education, 20,* 433-455.

Caswell, B., & Bielaczyc, K. (2001). Knowledge Forum: altering the relationship between students and scientific knowledge. *Education, Communication & Information, 1*(3), 281-305.

Caswell, B., & Lamon, M. (1998). Development of scientific literacy: The evolution of ideas in grade four knowledge-building classroom. Paper presented at the Annual Meeting of the America Educational Research Association, San Diego,CA.

Chai, C. S. (2004). Teachers' perceptions of teaching and learning in a Knowledge Building Community: A pilot study. *Proceedings of International Conference of Educational Technology*, Singapore, 9th-10th Sep.

Chai, C. S. & Khine, M. S. (in press). An analysis of interaction and participation patterns in an online learning community. *Journal of Education Technology and Society.*

Chai, C. S. & Lourdusamy, A. (in press). Singapore pre-service teachers' epistemological beliefs: A pilot survey. *Journal of Education (Brunei).*

Chai, C. S., Tan, S. C, & Hung , W. L. (2003). Fostering Knowledge Building Communities (KBC) through Computer-supported collaborative learning (CSCL). *Proceedings of Annual HERDSA Conference*, Christchurch, New Zealand. 6th-9th July.

Chan, K. W., & Elliot, R. G. (2004). Relational analysis of personal epistemology and conceptions about teaching and learning. *Teaching and Teacher Education, 20*(8), 817-831.

Charmaz, K. (2003) Qualitative interviewing and grounded theory analysis. In J. F. Gubrium, & J. A. Holstein (Eds.), *Handbook of interview research: Context & method* (pp. 675-694). Thousand Oaks, CA: SAGE.

Chen, D. T. & Hung, D. (2003). Learning theories and IT in instruction. In S. C. Tan, & F. L. Wong (Eds.), *Teaching and learning with technology: An Asia-pacific perspective.* (pp. 77-89). Singapore: Prentice Hall.

Cheong, H. Y. (2001). *Staff development in using information technology for teaching: The management perspective.* Unpublished master's thesis, Nayang Technological University, Singapore.

Cochran-Smith, M., & Lytle, S. (1999). Relationships of knowledge and practice: Teacher learning in community. *Review of Research in Education, 24*, 249-305.

Cohen, D. K. (1988). Teaching practice: Plus ça change. In P. W. Jackson (Ed.), *Contributing to educational change : Perspectives on research and practice.* Berkeley, CA: McCutchan Pub. Co.

Cohen, L., Manion, L. & Morrison, K. (2000). *Research methods in education.* (5th ed.). New York, NY: Routledge Falmer.

Cole, M., & Engeström, Y. (1993). A cultural-historical approach to distributed cognition. In G. Salomon (Ed.), *Distributed cognitions: Psychological and educational considerations.* New York: Cambridge University Press.

Cole, A. L., & Knowles, J. G. (2000). *Researching teaching: Exploring teacher development through reflexive inquiry.* Needham Heights, MA: Allyn & Bacon.

Collins, A. (1999). The changing infrastructure of Education Research. In J. P. Keeves & A. Collins (Eds.), *Issues on Education Research (pp.289-298).* Amsterdam, NY: Pergamon.

Collins, A., Joseph, D., & Bielaczyc, K. (2004). Design research: Theoretical and methodological issues. *Journal of the Learning Sciences, 13* (1), 15-43.

Collison, G., Elbaum, B., Haavind, S. & Tinker, R. (2000). *Facilitating online learning: Effective strategies for moderators.* Madison, WI: Atwood Publishing.

Cooper, P., & McIntyre, D. (1996). *Effective teaching and learning: Teachers' and students' perspectives.* Buckingham, UK: Open University Press.

Creswell, J.W. (1998). *Qualitative inquiry and research design: Choosing among five traditions.* Thousand Oaks, CA: SAGE.

Dalgarno, B. (2001). Interpretations of constructivism and consequences for computer assisted learning. *British Journal of Educational Technology, 32*(2), 183-194.

Day, C. (1999). *Developing teachers: The challenges of lifelong learning.* London, UK: Falmer.

Day, C. & Sachs, J. (2004). Professionalism, performativity, and empowerment: Discourse in the politics, policies and purposes of continuing professional development. In C. Day & J. Sachs (Eds.), *International handbook on continuing professional development of teachers.* (pp. 3-33). Maidenhead, UK: Open University Press.

Darling-Hammond, L. (1996). The quiet revolution: Rethinking teacher development. *Educational Leadership, 53*(6), 4-10.

Darling-Hammond, L. & Sykes, G. (eds.) (1999). *Teaching as the learning profession: Handbook of policy and practice.* San Francisco: Jossey-Bass

Demetriadis, S., Barbas, A., Molohides, A., Palaigeorgiou, G., Psillos, D., Vlahavas, I., Tsoukalas, I., & Pombortsis, A. (2003). "Cultures in negotiation": Teachers' acceptance/resistance attitudes considering the infusion of technology into schools. *Computers & Education, 41*(1), 19-37.

Deng, Z. (2004). Beyond teacher training: Singaporean teacher preparation in the era of new educational initiatives. *Teaching Education, 15*(2), 159-173.

Deng, Z. (2005). Teacher education. In J. Tan, & P. T. Ng (Eds.), *Shaping Singapore future* (pp. 123-136). Singapore: Prentice Hall.

Denzin, N.K. (2000). The practices and politics of interpretation. In N, K. Denzin, & Y. S. Lincoln (Eds.), *Handbook of qualitative research.* (pp. 897-992). Thousand Oaks, CA: Sage Publications

Desforges, C. (2000). Learning. In B. Moonb., Ben-Peretz, M. & S. Brown (Eds.), *Routledge International Companion to Education* (pp. 65-84). London, UK: Routledge.

Dewey, J. (1938). *Experience and education.* New York, NY: Touchstone.

Dexter, S. L., Anderson, R. E. & Becker, H. J. (1999). Teachers' views of computers as catalysts for changes in their teaching practice. *Journal of Computing in Education, 31*(3), 221-239.

Drever, E. (1995). *Using semi-structured interviews in small-scale research: A teacher's guide.* Glasgow, UK: Scottish Council for Research in Education.

Drucker, P. (2001). The next workforce. Retrieved 17 Feb 2005 from http://www.druckerarchives.net/data/html/pop_article3.htm

Dwyer, D. C. (2002). Since computer came to school. *Educational Technology, 42*(1), 17-18.

Earle, R. S. (2002). The integration of instructional technology into public education: Promises and challenges. *Educational Technology,* 42(1), 5-13.

Eisner, E.W. (1998). *The enlightened eye: Qualitative inquiry and the enhancement of educational practice.* Upper Saddle River, NJ: Prentice-Hall.

Engeström, Y. (1993). Development studies of work as a testbench of activity theory: The case of primary care medical practice. In S. Chaiklin, S. & J. Lave (Eds.), *Understanding Practice: Perspective on activity and context.* Cambridge, U.K.: Cambridge University Press.

Ertmer, P. A. (1999). Addressing first- and second-order barriers to change: Strategies for technology integration. *Educational Technology, Research and Development,* 47(4), 47-61.

Ertmer, P.A. (2003). Transforming teacher education: Visions and strategies. *Educational Technology, Research and Development, 51*(1), 124-128.

Fang, Z. (1996). A review of research on teacher beliefs and practices. *Educational Research, 38*(1), 47-65.

Feiman-Nemser, S. (2001). From preparation to practice: Designing a continuum to strengthen and sustain teaching. *Teachers College Record, 103*(6), 1013-1055.

Flick, U. (2002). *An introduction to qualitative research.* London, U.K.: SAGE.

Fontana, A. & Frey, J. H. (1994). Interviewing: The art of science. In N. K. Denzin & Y.S. Lincoln (eds.). *Handbook of qualitative research* (pp. 361-377). Thousand Oaks, CA: SAGE.

Fox, R. (2001). Constructivism examined. *Oxford Review of Education, 27*(1), 23-35.

Fox, R., & Henri, J. (2005). Understanding *Teacher* Mindsets: IT and Change in Hong Kong Schools. *Journal of Educational Technology & Society, 8* (2), 161-169.

Fullan, M. (2001). *The new meaning of educational change.* (3rd ed.). New York, NY: Teachers College Press.

Garrison, D. R., Anderson, T., & Archer, W. (2001). Critical thinking, cognitive presence, and computer conferencing in distance education. *American Journal of Distance Education, 15*(1), 7-23.

Galanouli, D., Murphy, C., & Gardner, J. (2004). Teachers' perceptions of the effectiveness of ICT-competence training. *Computers & Education, 43* (1/2), 63-79.

Gilbert, N. J., & Driscoll, M. P. (2002). Collaborative knowledge building: A case study. *Educational Technology, Research and Development, 50* (1), 59-79.

Gess-Newsome, J., Southerland, S. A., Johnston, A., & Woodbury, S. (2003). Educational reform, personal practical theories, and dissatisfaction: The anatomy of change in college science teaching. *American Educational Research Journal, 40* (3), 731-767.

Gill, M. G., Ashton, P. T., & Algina, J. (2004). Changing preservice teachers' epistemological beliefs about teaching and learning in mathematics: An intervention study. *Contemporary Educational Psychology, 29*(2), 164-185.

Goodison, T. (2003). Integrating ICT in the classroom: A case study of two contrasting lessons. *British Journal of Educational Technology, 34*(5), 549-566.

Goodson, I. F. (2003). *Professional knowledge, professional lives: Studies in education and change.* Maidenhead, UK: Open University Press.

Grossman, P., Wineburg, S., & Woolworth, S. (2001). Toward a theory of teacher community. *Teacher College Record, 103,* (6), 942-1012.

Guba, E. & Lincoln, Y.S. (1989). *Fourth generation evaluation.* Newbury Park, CA: Sage Publications.

Gunawardena, C. H., Lowe, C. A. & Anderson, T. (1997). Analysis of a global online debate and the development of an interaction analysis model for examining social construction of knowledge in computer conferencing. *Journal of Educational Computing Research 17*(4), 397-431.

Guzdial, M., & Turns, J. (2000). Effective discussion through computer-mediated anchored forum. *The Journal of the Learning Sciences, 9*, 4, 437-469.

Hall, G. E. & Hord, S. M. (2001). *Implementing change: Patterns, principles and potholes.* Needham Heights, MA: Allyn & Bacon.

Hara, N., Bonk, C. J. & Angeli, C. (2000). Content analysis of online discussion in an applied educational psychology course. *Instructional Science, 28,* 115-152.

Harasim, L. (2000). Shift happens: Online education as a new paradigm in learning. *Internet and Higher Education, 3,* 41-61.

Hashweh, M. Z. (1996). Effects of science teachers' epistemological beliefs in teaching. *Journal of Research in Science Teaching, 33* , 47-63.

Hashweh, M. Z. (2003). Teacher accommodative change. *Teaching and Teacher Education 19* (4), 421-434.

Hawley, W. D., & Valli, L. (1999). The essentials of effective professional development. In L. Darling-Hammond & G. Sykes (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 127-151). San Francisco: Jossey-Bass.

Haynes, P., IP, K., Saintas, P., Stanier, S., Palmer, H., Thomas, N., et al., (2004). Responding to technological change. *Active Learning in Higher Education, 5*(2), 152-165.

Hendriks, V., & Maor, D. (2004). Quality of students' communicative stragegies delivered through computer-mediated communications. *Journal of Interactive Learning Research, 15*(1), 5-32.

Hennessy, S., Ruthven, K., & Brindley, S. (2005). Teacher perspectives on integrating ICT into subject teaching: Commitment, constraints, caution, and change. *Journal of Curriculum Studies, 37*(2), 155-192.

Henri, F. (1992). Computer conferencing and content analysis. In A. R. Kaye (Ed.), *Collaborative learning through computer conferencing* (pp. 117--136). Berlin, Heidelberg: Springer-Verlag

Hewitt, J. (1996) *Progress toward a knowledge-building community.* (Doctoral dissertation, University of Toronto, 1996). (Umi No. AAT NN11743)

Hewitt, J. (2001). From a focus on tasks to a focus on understanding: The cultural transformation of s Toronto classroom. In T. Koschmann., R. Halls, & N. Miyake (Eds.), *CSCL 2: Carrying forward the conversation* (pp. 11-42). Mahwah, N.J.: Lawrence Erlbaum.

Hickey, M. G. (1998). "Back home, nobody does that": Immigrant students and cultural models of schooling. *Social Education, 62*(7), 442-427.

Hmelo-Silver, C.E. (2003). Analyzing collaborative knowledge construction: Multiple methods for integrated understanding. *Computers & Education, 41*(4), 397-420.

Hofer, B. K., & Pintrich, P.R. (1997). The development of epistemological theories: Beliefs about knowledge and knowing and their relation to learning. *Review of Educational Research, 67*(1), 88-140.

Hofer, B. K. (2001). Personal epistemology research: Implications for learning and teaching. *Journal of Educational Psychology Review, 13*(4), 353-383.

Hogan, K. & Pressley M. (1997). Becoming a scaffolder of students' learning. In K. Hogan. and M. Pressley (Eds.), *Scaffolding student learning: Instructional approaches and issues,* (pp. 185-192). Cambridge, MA: Brookline Books.

Holt-Reynolds, D. (2000) What does the teacher do? Constructivist pedagogies and prospective teachers' beliefs about the role of a teacher. *Teaching and Teacher Education 16*(1), 21-32.

Hoogveld, A. W. M., Paas, F., & Jochems, W. M. G. (2003). Application of an instructional systems design approach by teachers in higher education: individual versus team design. *Teaching and Teacher Education, 19*(6), 581-590.

Howell-Richardson, C. & Mellar, H. (1996). A methodology for the analysis of patterns of participation within computer mediated communication courses. *Instructional Science, 24*, 47-69.

Hu, C., Wong, A., Cheah, H. M., Wong, P., & D'Rozario, V. *Effectiveness of NIE's IT teacher training programme: Have we prepared them enough?* (Academic Research Fund Report 18/01). Nayang Technological University: Singapore.

Huang, H. (2002). Toward constructivism for adult learners in online learning environments. *British Journal of Educational Technology, 33*(1), 27-37.

Huffman, D. & Kalnin, J. (2003). Collaborative inquiry to make data-based decisions in schools. *Teaching and Teacher Education, 19*(6), 569-580.

Hung, D. (1999). Activity, apprenticeship, and epistemological appropriation: Implications from the writing of Michael Polanyi, *Educational Psychologist*, *34*(4), 193-205.

Hung, D. (2003). An overview of IT developments in the Asia-Pacific region. In S. C. Tan, & F. L. Wong (Eds.), *Teaching and learning with technology: An Asia-pacific perspective.* (pp. 8-16). Singapore: Prentice Hall.

Hung, D. & Chen, D. (2003). A proposed framework for the design of a CMC learning environment: Facilitating the emergence of authenticity. *Education Media International. 40*(1), 7-13.

Hudson, J. M. & Bruckman, A. S. (2004). The bystander effect: A lens for understanding patterns of participation. *The Journal of the Learning Sciences, 13*(2), 165-195.

Hübscher-Younger, T. & Narayanan, N. H. (2003). Authority and convergence in collaborative learning. *Computers & Education, 41*(4), 313-334.

Jin, S. H. (2005). Analyzing student-student and student-instructor interaction through multiple communication tools in web-based learning. *International Journal of Instructional Media, 32*(1), 59-67.

Järvelä, S. & Häkkinen, P. (2002) Web-based cases in teaching and learning – the quality of discussions and a stage of perspective taking in asynchronous communication. *Interactive Learning Environments, 10* (1), 1-22.

Jonassen D. H. (2000). *Computers as Mindtools for schools* (2nd ed.). Upper Saddle River, NJ: Prentice-Hall.

Jonassen, D. H. (2002). Learning as activity. *Educational Technology, 42*(2), 45-51.

Jones, B. F., Valdez, G., Nowakowshi, J., & Rasmussen, C. (1995). *Plugging in: Choosing and using educational technology.* Washington DC: Council for Educational Development and Research, North Central Regional Educational Laboratory.

Johnson, E. B. (2002). *Contextual teaching and learning: What it is and why it's here to stay.* Thousand Oaks, CA: Corwin Press.

Kagan, D. M. (1992). Implications of research on teacher belief. *Educational Psychologist, 27*(1), 65-90.

Kaartinen, S., & Kumpulainen, K. (2002). Collaborative inquiry and the construction of explanations in the learning of science. *Learning and Instruction, 12*, 189-212.

Kane, R., Sandretto, S., & Heath, C. (2002). Telling half the story: A critical review of research on the teaching beliefs and practices of university academics. *Review of Educational Research. 72*(2), 177-228.

Kang, N. & Wallace, C. S. (2005). Secondary science teachers' use of laboratory activities: Linking epistemological beliefs, goals, and practices. *Science Education, 89*(1), 140-165.

Kelchtermans, G. (2004). CPD for professional renewal: Moving beyond knowledge for practice. In C. Day & J. Sachs (Eds.), *International handbook on the continuing professionaldevelopment of teachers.* (pp. 217-238). England, Maidenhead: Open University Press.

Khine, M.S., Yeap, L. L., Tan, C. L., (2003). The quality of message ideas, thinking and interaction in an asynchronous CMC environment. *Education Media International, 40*(1/2), 115-126.

Kitchner, K. S., King, P., & Wood, P. (2000). *Reasoning about Current Issues Test.* (Available through personal contact with Authors)

King, K. P. (2002). Educational technology professional development as transformative learning opportunities. *Computers & Education. 39*(3), 283-297.

King, P. M., & Kitchener, K. S. (1994). *Developing Reflective Judgement.* San Francisco, CA: Jossey-Bass.

King, P. M., & Kitchener, K. S. (2004). Reflective judgement: theory and research on the development of epistemic assumptions through adulthood. *Educational Psychologist, 39*(1), 5-18.

Knowles, M. S. (1990). *The adult learner: a neglected species.* (4th ed.). Houston: Gulf Pub.

Knight, P. (2002). A systemic approach professional development. *Teaching and Teacher Education. 18*(3), 229-241.

Koh, A. (2004). Singapore education in "New Times": Global/local imperatives. *Discourse: Studies in the Cultural Politics of Education, 25*(3), 335-349.

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development.* Englewood Cliffs, N.J.: Prentice-Hall.

Kolodner, J., & Guzdial, M. (1996). Effects with and of CSCL: Tracking learning in a new paradigm. In T. Koschmann (eds.). *CSCL: Theory into practice of an emerging paradigm* (pp. 307—320). Mahwah, NJ: Lawrence Erabaum.

Koschmann, T. (Ed.). (1996). *CSCL: Theory and practice of an emerging paradigm*. Mahwah, NJ: Lawrence Erlbaum Associates.

Koschmann, T., Hall, R., & Miyake, N. (Eds.), (2002). *CSCL2: Carrying forward the conversation*. Mahwah, NJ: Lawrence Erlbaum Associates.

Kraft, N.P. (2002). Teacher research as a way to engage in critical reflection: A case study. *Reflective Practice,* 3(2), 175—189.

Kreijns, K., Kirschner, P. A., & Jochems, W. (2003). Identifying the pitfalls for social interaction in computer-supported collaborative learning environments: A review of the research. *Computers in Human Behaviour, 19*(3), 335-353.

Kvale, S. (1996). *Interviews: An introduction to qualitative research interviewing.* Thousand Oaks, CA: SAGE.

Kwakman, K. (2003). Factors affecting teachers' participation in professional learning activities. *Teaching and Teacher Education, 19*(2), 149-170.

Laat, M., & Lally, V. (2003). Complexity, theory and praxis: Researching collaborative learning and tutoring processes in a networked learning community. *Instructional Science,* 31, 7-39.

Lajoie, S. (Ed.). (2000). *Computers as cognitive tools, volume two: No more walls: Theory change, paradigm shifts, and their influence on the use of computers for instructional purposes.* Mahwah, NJ: Lawrence Erlbaum Associates.

Lampert, M. & Ball, D. L. (1999). Aligning teachers education with contemporary K-12 reform visions. In L. Darling-Hammond & G. Sykes (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 3-32). San Francisco: Jossey-Bass.

Lamon, M., Secules, T., Petrosino, A.J., Hackett, R., Bransford, J.D., & Goldman, S.R. (1994). Schools for thought: Overview of the international project and lessons learned from one of the sites. In L. Schauble & R. Glaser (Eds.), *Contributions of instructional innovations to understanding learning.* Hillsdale, NJ: Lawrence Erlbaum.

Lamon, M., Reeve, R., & Caswell, B. (1999). Finding theory in practice: Collaborative networks for professional learning. Paper presented at the annual meeting of the American Educational Research Association, Montreal. Retrieved 14 Oct 2002 from http: ikit.org abstract finding_theory.htm

Lamon, M., Reeve, R., & Scardamalia, M. (2001, April). Mapping learning and the growth of knowledge in a Knowledge Building Community . Paper presented at the annual meeting of the American Educational Research Association, Seattle, WA.

Lau, S. (Ed.). (1996). *Growing up the Chinese way: Chinese child and adolescent development.* Hong Kong: The Chinese University Press.

Lave, J., & Wenger, E. (1999). Legitimate peripheral participation in the communities of practice. In R. McCormick, & C. Paechter (Eds.), *Learning and knowledge.* (pp. 21-35). Thousand Oaks, CA: SAGE Publication.

Lee, O., & Yarger, S. J. (1996). Modes of inquiry in research on teacher education. In J. Sikula, T.J. Buttery, & E. Guyton (Eds.), *Handbook of research on teacher education,* (2nd ed.) (pp. 14-38), New York, NY: Macmillan.

Leggett, W. P., & Persichitte, K.A. (1998). Blood, sweat, and tears: 50years of technology implementation obstacle. *Techtrends, 33* (Apr/May), 33-36.

Lehtinen, E., Hakkarainen, K., Lipponen, L., Rahikainen, M., & Muukkonen, H. (1999). *Computer-supported collaborative learning: A review of research and development* (The J.H.G.I. Giesbers Reports on Education, 10). Netherlands: University of Nijmegen, Department of Educational Sciences.

Li, Q. (2004). Knowledge building community: Keys for using online forums. *Techtrends, 48*(4), 24-28.

Liu, Y., Kotov, R., Rahim, R. A., & Goh, H. H. (2004). Chinese language pedagogic practice: A preliminary snapshot description of Singapore Chinese language classrooms. Retrieved 29 Aug 2005 from http: www.crpp.nie.edu.sg course view.php?id=254

Lim, C. P., Pek, M. S., & Chai, C. S. (accepted). Classroom management issues in ICT-Mediated learning environments. *Journal of Multimedia and Hypermedia.*

Lim, C. P. (2001). Object of the activity systems as a major barrier to the creative use of ICT in schools. *Australian Journal of Educational Technology, 17*(3), 295-312.

Lim, C. P. & Hung, D. (2003). An activity theory approach to research of ICT integration in Singapore schools. *Computers & Education, 41*(1), 49-63.

Lim, C. P. & Tay, L. Y. (2003). Information and communication technologies (ICT) in an elementary school: Student's engagement in higher order thinking. *Journal of Multimedia and Hypermedia, 12*(4), 425-451.

Lim, C. P., Teo, Y. H., Wong, P., Khine, M. S., Chai, C. S., & Divaharan, S. (2003). Creating a conducive learning environment for the effective integration of ICT: Classroom management issues. *Journal of Interactive Learning Research, 14*(4), 405-423.

Lim, C. P. & Chai, C. S. (2004). An activity-theoretical approach in Singapore schools: Orienting activities and learner autonomy. *Computers & Education, 43*(3), 215-236.

Lim, H, M. (2003, Sep 13). *Lianhe Zaobao.* Retrieved September 19, 2003, from http://www.zaobao.com/sp/sp023_130903.html

Lincoln, Y. S., & Guba, E. G. (1985). *Naturalistic inquiry.* Beverly Hills, CA: Sage Publications.

Lipponen, P. (2002, Jan). Exploring foundations for computer-supported collaborative learning. *Proceedings of CSCL 2002*, Boulder, Colorado, USA. Retrieved Sep 23, 2003, from http://newmedia.colorado.edu/cscl/31.html

Lipponen, L., Rahikainen, M., Lallimo, J., & Hakkarainen, K. (2003). Patterns of participation and discourse in elementary students' computer-supported collaborative learning. *Learning and Instruction, 13* (2003), 487-509.

Lipponen, L., Hakkarainen, K., & Paavola, S. (2004). Practices and orientations of CSCL. In J. Strijbos., P. A. Kirschner, R. L. Martens (Eds.), *What we know about CSCL: And implementing it in higher education.* (pp. 31-50). Norwell, MA: Kluwer Academic.

Looi, C. K., Hung, D., Bopry, J. & Koh, T. S. (2004). Singapore's Learning Sciences Lab: Seeking transformations in ICT-enabled pedagogy. *Education Technology, Research and Development, 52*(4), 91-115.

Luke, A., Freebody, P., Lau, S. & Gopinathan, S. (2005). Towards research-based innovation and reform: Singapore schooling in transition. *Asia Pacific Journal of Education, 25*(1), 5-28.

Mandinach, E. B., & Cline, H. F. (2000). It won't happen soon: Practical, curricular and methodological problems in implementing technology-based constructivist approaches in classroom. In S. Lajoie (Ed.), (2000). *Computers as cognitive tools, volume two: No more walls: Theory change, paradigm shifts, and their influence on the use of computers for instructional purposes.* (pp. 377-395). Mahwah, NJ: Lawrence Erlbaum Associates.

Mahizhnan, A. (2000). Singapore. *Southeast Asian Affairs*, 2000, 276-281.

Marra, R. M., Moore, J. L., Klimczak, A. K. (2004). Content analysis of online discussion forums: A comparative analysis of protocols. *Education Technology, Research and Development, 52*(2), 23-40.

Martínez, A., Dimitriadis, Y., Rubia, B., Gómez, E., de la Fuente, P. (2003). Combining qualitative evaluation and social network analysis for the study of classroom social interactions. *Computers & Education, 41,* 353-368.

Mason, L., & Boscolo, P. (2004). Role of epistemological understanding and interest in interpreting a controversy and in topic-specific belief change. *Contemporary Educational Psychology, 29*(2), 103-128

Mazzolini, M., & Maddison, S. (2003). Sage, guide or ghost? The effect of instructor intervention on student participation in online discussion forums. *Computers & Education, 40*(3), 237-253.

Merriam, S.B. (1998). *Qualitative research and case study applications in education.* San Francisco, CA: Jossey-Bass.

Messina, R. (2001). Intentional learners, cooperative knowledge building, and classroom inventions. Paper presented at the annual meeting of the American Educational Research Association, Seattle, WA.

Ministry of Education, Singapore, (1997a). Opening of 7th international conference on thinking. Retrieved, Mar 8, 2003: http://www1.moe.edu.sg/speeches/1997/020697.htm

Ministry of Education, Singapore, (1997b). Masterplan for IT in Education. Retrieved Jul 25, 2003, from http://www1.moe.edu.sg/ireducation/masterplan/summary.htm .

Ministry of Education, Singapore, (2001). Project work to be included for university admission in 2005. Retrieved 24 Feb 2005 from http://www1.moe.edu.sg/press/2001/pr20062001.htm

Ministry of Education, Singapore, (2002). Masterplan II for IT in Education. Retrieved Jul 25, 2003, from http://www.moe.gov.sg/edumall/mp2/mp2_overview.htm

Ministry of Education, Singapore, (2004a). Press releases: Singapore tops the trends in international mathematics and science study. Retrieved 17 Feb 2005 from http://www.moe.gov.sg/press/2004/pr20041214.htm

Ministry of Education, Singapore, (2004b). Strategies for Active and Independent Learning. Retrieved July 6, 2005 from http://www.moe.gov.sg/press/2004/pr20040325.htm

Ministry of Education, Singapore, (2004c). *The next chapter: Innovation and Enterprise.* Singapore: MOE.

Ministry of Education, Singapore, (2004d). Masterplan for IT in Education: 1997-2002. Retrieved 17 Feb 2005 from http://www.moe.gov.sg/edumall/mpite/

Miyake, N. & Koschmann, T. (2001). Realizations of CSCL conversations: Technology transfer and the CSILE project. In T. Koschmann., R, Halls., & N, Miyake (Eds.), *CSCL 2: Carrying forward the conversation.* (pp. 1-10). Mahwah, NJ: Lawrence Erlbaum.

Moreau, M. J. (2001). Knowledge building pedagogy and teacher change: One teacher's journey. Paper presented at the annual meeting of the American Educational Research Association, Seattle, WA.

National Research Council (NRC), (2000). *How people learn: Brain, mind, experience, and school.* Washington, DC: National Academic Press.

Organisation for Economic Co-operation and Development (OECD) (2000). *Literacy in the information age.* France, Paris: OECD.

Organisation for Economic Co-operation and Development (OECD) (2001). *Learning to change: ICT in schools.* France, Paris: OECD.

Office for Standard in Education (Ofsted) (2004). *ICT in schools 2004: The impact of government initiatives five years on.* Retrieved 12th Dec 2004 from http://www.ofsted.gov.uk/publications/index.cfm?fuseaction=pubs.displayfile&id=3652&type=pdf

Oshima J. (1998) Differences in knowledge-building between two types of networked learning environments: An information analysis. *Journal of Educational Computing Research, 19*(3), 329-351.

Pajares, M.F. (1992). Teachers' beliefs and educational research: cleaning up a messy construct. *Review of Educational Research, 62*(3), 307-332.

Patton, M. Q. (1990). *Qualitative evaluation and research methods.* Newbury Park, CA. : Sage Publications.

Pea, R. D. (1993) Practices of distributed intelligence and designs of education. In M. Cole, & Y. Engeström (Eds.), *Distributed Cognition: Psychology and educational considerations*, Cambridge University Press

Pelgrum, W. J. (2001). Obstacles to the integration of ICT in education: Results from a worldwide educational assessment. *Computers & Education, 37*(3), 163-178.

Perry, W. G. (1970). *Forms of intellectual and ethical development in the college years: A scheme.* New York: Holt, Rinehart and Winston.

Poole, D. M. (2000). Student participation in a discussion-oriented online courses: A case study. *Journal of Research on Computing in Education, 33*(2), 162-177.

Popper, K. R. (1965). *Conjectures and refutations: The growth of scientific knowledge.* New York, NY: Harper & Row.

Prawat, R. S. (1992). Teachers' beliefs about teaching and learning: A constructivist perspective. *American Journal of Education, 100* (3), 254- 305.

Pring, R. (1999). Reflecting on the reflective practitioners. In A. Chen., & J. V. Maanen (Eds.), *The reflective spin: Case studies of teachers in higher education transforming action* (pp. 3-14). Singapore: World Scientific Publishing.

Putnam, R. T. & Borko, H. (2000). What do new views of knowledge and thinking have to say about research on teacher learning. *Educational Researcher, 29*(1), 4-15.

Qian, G. & Alvermann, D. E. (1995). Role of epistemological beliefs and learned helplessness in secondary school students' learning science concepts from text. *Journal of Educational Psychology, 87*(2), 282-292.

Qian, G. & Alvermann, D. E. (2000). Relationship between epistemological beliefs and conceptual change learning. *Reading and Writing Quarterly, 16,* 59-74.

Randi, J. & Corno, L. (1997). Teachers as innovators. In B.J. Biddle, T. L. Good, & I. F. Goodson (Eds.), *International handbook of teachers and teaching* (pp. 1163-1221), Dordrecht, Boston: Kluwer Academic Publishers.

Reiman, A. (1999). The evolution of the social roletaking and guided reflection framework in teacher education: Recent theory and quantitative synthesis of research. *Teaching and Teacher Education, 15* (6), 597-612.

Reeves, T.C. (1999). A research agenda for interactive learning in the new millennium. Ed-media 99 Keynote address paper. Retrieved 12/9/2002, from http://it.coe.uga.edu/~treeves/EM99Key.html .

Resta, P., Christal, M., Ferending, K. & Puthoff, A.K. (1999). CSCL as a catalyst for changing teacher practice. *Proceedings of the Computer Support for Collaborative Learning (CSCL) 1999 Conference* , Dec. 12-15, Stanford University, Palo Alto, California. Retrieved Oct 1, 2003, from http://newmedia.colorado.edu/cscl/WW347.HTM

Roblyer, M. D. (2003). *Integrating educational technology into teaching.* (3rd ed). Upper Saddle River, NJ: Pearson Education.

Roschelle, J. M. (1996). Learning by collaborating: Convergent conceptual change. In T. Koschmann (Ed.), *CSCL: Theory and practice of an emerging paradigm.* (pp. 209-248). NJ: Lawrence Erlbaum

Roschelle, J. M., Pea, R. D., Hoadley, C. M., Gordin, D. N., & Means, B. M. (2000). Changing how and what children learn in school with computer-based technologies. *The future of Children and Computer Technology, 10*(2), 76-101.

Roth, W. (1999). Authentic school science. In R. McCormick, & C. Paechter (Eds.), *Learning and knowledge.* (pp. 6-20). Thousand Oaks, CA: SAGE Publication.

Rowe, M. B. (1974). Wait-time and rewards as instructional variables, their influence on language, logic, and fate control: Part one-Wait-time. *Journal of Research in Science Teaching, 11*(2), 81-94.

Russell, M., Bebell, D., O'Dwyer, L. & O'Connor, K. (2003). Examining teacher technology use: Implications for preservice and inservice teacher preparation. *Journal of Teacher Education, 54*(4), 297-310.

Richardson, V. (1996). The role of attitudes and beliefs in learning to teach. In J. Sikula., T. J. Buttery., & E. Guyton (Eds.), *Handbook of research on teacher education* (2nd ed.) (pp. 102-119). New York, NY: Macmillan Library Reference USA.

Richardson, V. (2003a). Preservice teachers' beliefs. In J. Raths, & A. C. McAninch (Eds.), *Teacher beliefs and classroom performance: The impact of teacher education.* (pp. 1-22). Greenwich, Connecticut: Information Age Publishing.

Richardson, V. (2003b). The dilemmas of professional development. *Phi Delta Kappan, 84*(5), 401- 406.

Salomon, G. & Almog, T. (1998). Educational psychology and technology: A matter of reciprocal relations. *Teacher College Record, 100*(2), 222-241.

Salomon, G. & Perkins, D. N. (1998). Individual and social aspects of learning. *Review of research in education. 23,* 1-24.

Sandholtz, J. H., Ringstaff, C., & Dwyer, D. C. (1997). *Teaching with technology: Creating student-centered classrooms.* New York, NY: Teachers College Press.

Sandholtz, J. H. (2001). Learning to teach with technology: A comparison of teacher development programs. *Journal of Technology and Teacher Education. 9*(3), 349-374.

Sandholtz, J. H. (2002). Inservice training or professional development: contrasting opportunities in a school/university partnership. *Teaching and Teacher Education, 18*(7), 815-830.

Sandholtz, J. H., & Reilly, B. (2004). Teachers, not technicians: Rethinking technical expectations for teachers. *Teachers College Record, 106* (3). 487-512.

Scardamalia, M., Bereiter, C., McLean, R., Swallow, J., and Woodruff, E. (1989). Computer supported intentional learning environments, *Journal of Educational Computing Research 5*(1), 51-68.

Scardamalia, M., Bereiter, C., Brett, C., Burtis, P. J., Calhoun, C., & Lea, N. S. (1992). Educational applications of a networked communal database. *Interactive Learning Environment, 2*(1), 45-71.

Scardamalia, M. & Bereiter, C. (1994). Computer support for knowledge-building communities. *The Journal of the Learning Sciences, 3*(3), 265-283

Scardamalia, M., Bereiter, C., & Lamon, M. (1994). The CSILE project: Trying to bring the classroom into world 3. In K. McGilly (Ed.), *Classroom lessons: Integrating cognitive theory and classroom practice* (pp.201-228). Cambridge, MA: Bradford Books/MIT Press.

Scardamalia, M. & Bereiter, C. (1996). Computer support for knowledge-building communities. In T. Koschmann (Ed.), *CSCL: Theory and practice of an emerging paradigm.* (pp. 249-268). NJ: Lawrence Erlbaum

Scardamalia, M., & Bereiter, C. (1999) Schools as knowledge-building organizations. In D. Keating & C. Hertzman (Eds.), *Today's children, tomorrow's society: The developmental health and wealth of nations* (pp. 274-289). New York: Guilford.

Scardamalia, M. (2000). Can school enter a knowledge society? In M. Selinger (Ed.), *Proceedings of educational technology and the impact on teaching and learning: A global research forum,* London, England

Scardamalia, M. (2002). Collective cognitive responsibility. In B. Smith (Ed.), *Liberal education in the knowledge age.* Chicago: Open Court.

Scardamalia, M. & Bereiter, C. (2003). Knowledge Building. In J. W. Guthrie (Ed.), *Encyclopedia of Education* (2nd ed.) (pp. 1370-1373). New York: Mcamillan Reference, USA.

Schellens, T. & Valcke, M. (2005, in press). Collaborative learning in asynchronous discussion groups: What about the impact on cognitive processing? *Computers in Human Behaviour. 21*(6), 957—976.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. *Journal of Educational Psychology, 82*(3), 498-504.

Schommer, M. (1993). Epistemological development and academic performance among secondary students. *Journal of Educational Psychology, 85*(3), 406-411.

Schommer, M. (1994). Synthesizing epistemological belief research: Tentative understandings and provocative confusions. *Educational Psychology Review, 6*(4), 293-319.

Schommer-Aikins, M., Mau, W. Brookhart, S., & Hutter, R. (2000). Understanding middle students' beliefs about knowledge and learning using a multidimensional paradigm. *The Journal of Educational Research, 94* (2), 120-127.

Schommer-Aikins, M., Duell, O.K., & Barker, S. (2003). Epistemological beliefs across domains using Biglan's classification of academic disciplines. *Research in Higher Education, 44*(3), 347-366.

Schommer-Aikins, M. (2004). Explaining the epistemological belief system: Introducing the embedded systemic model and coordinated research approach. *Educational Psychologist, 39*(1), 19-29.

Schraw, G. & Sinatra, G. M. (2004). Epistemological development and its impact on cognition in academic domains. *Contemporary Educational Psychology, 29*(2), 95-102.

Schraw, G. & Olafson, L. (2002). Teachers' epistemological world views and educational practices. *Issues in Education 8*(2), 99-149.

Scott, J. (2000). *Social network analysis: A handbook.* (2nd ed.). Thousand Oaks, CA: SAGE.

Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher, 27*(2), pp. 4-13.

Selwyn, N., Dawes, L., & Mercer, N. (2001). Promoting Mr. Chips: The construction of the teacher/ computer relationship in educational advertising. *Teaching and Teacher Education, 17*(1), 3-14.

Silin, J. G. & Schwartz, F. (2003). Staying close to the teacher. *Teacher College Record, 105*(8), 1586-1605.

Sin, M. L. (2002). *A study of the conditions that facilitate teachers' effort in integrating information technology into curriculum.* Unpublished master's thesis, Nayang Technological University, Singapore.

Sinatra, G. M., Southerland, S. A., McConaughy, F. and Demastes, J. (2003.) Intentions and beliefs in students' understanding and acceptance of biological evolution. *Journal of Research in Science Teaching 40* (5), 510–528.

Sprinthall, N. A., Reiman, A. J., & Theis-Sprinthall, L. (1996). Teachers professional development. In J. Sikula, T. J. Buttery, & E. Guyton (Eds.), *Handbook of research on teacher education* (2nd ed.) (pp. 666-695). New York, NY: Macmillan.

Stahl, G. (2001). Rediscovering CSCL. In T. Koschmann., R, Halls, & N, Miyake (Eds.), *CSCL 2: Carrying forward the conversation* (pp. 169-181). Mahwah, NJ: Lawrence Erlbaum.

Stahl, G. (2002). Contributions to a theoretical framework for CSCL. *Proceedings of CSCL 2002*, Boulder, Colorado, USA. Retrieved Sep 23, 2003, from http: newmedia.colorado.edu cscl 81.html

Stahl, G. (2004). Building collaborative knowing: Elements of a social theory of CSCL. In J. Strijbos., P. A. Kirschner, R. L. Martens (Eds.), *What we know about CSCL: And implementing it in higher education.* (pp. 53-86). Norwell, MA: Kluwer Academic.

Stake, R. E. (2000). Case study. In N, K. Denzin, & Y. S. Lincoln (Eds), *Handbook of qualitative research.* (pp. 435-454). Thousand Oaks, Calif. : Sage Publications

Strauss, A. & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques.* Newbury Park, CA: Sage.

Sutton, R. E., Cafarelli, A., Lund, R., Schurdall, D. & Bichsel, S. (1996). A developmental constructivist approach to pre-service teachers' ways of knowing. *Teaching and Teacher Education, 12*(4), 413-427.

Sykes, G. (1999). Teaching and student learning: Strengthening their connection. In L. Darling-Hammond & G. Sykes (Eds.), *Teaching as the learning profession: Handbook of policy and practice* (pp. 151-180). San Francisco: Jossey-Bass.

Tan, C. (2005). Driven by pragmatism: Issues and challenges in an ability-driven education. In Tan, J. & Ng, P. T. (eds.). *Shaping Singapore future* (pp. 5-21). Singapore: Prentice Hall.

Tan, J. (2002). Education in the early 21st century: Challenges and dilemmas. In D. da Cunha (Ed.), *Singapore in the new millennium: Challenges facing the city-state* (pp. 154-186). Singapore: Institute of Southeast Asian Studies.

Tan, S. C., Hung, D., Looi, C. K., & Chai, C. S. (2004). Changing epistemology of pre-service teachers in a blended constructivist learning environment – A case study. In S.C. Tan (ed.). *Fostering Scientific Inquiry through Computer-Supported Collaborative Learning* (Research Rep. EP 1/01 TSC), (pp. 94-107), Nayang Technological University, Singapore.

Tatto, M. T., & Coupland, D. B. (2003). Teacher education and teachers' beliefs: Theoretical and measurement concerns. In J. Raths, & A. C. McAninch (Eds.), *Teacher beliefs and classroom performance: The impact of teacher education.* (pp. 99-122). Greenwich, Connecticut: Information Age Publishing.

Tiene, D. (2002). Exploring current issues in educational technology using a problem-based approach to instruction. *Educational Technology,* 42(1), 14-22.

Tripps, D. (2004). Teachers' networks: a new approach to the professional development of teachers in Singapore. In C. Day & J. Sachs (Eds.), *International handbook on the continuing professional development of teachers* (pp. 191-216). England, Maidenhead: Open University Press.

Tsai, C. C. (2001). Collaboratively developing instructional activities of conceptual change through the Internet: science teachers' perspectives. *British Journal of Educational Technology, 32*(5), 619-622.

Tsu, G. (2000). *Concerns-based adoption model (CBAM) development profile of teachers in the IT masterplan implementation.* Unpublished master's thesis, Nayang Technological University, Singapore.

van Aalst, J. & Chan, C. (2001). Beyond "sitting next to each other": A design experiment on knowledge building in teacher education. *Proceedings of Euro-CSCL 2001,* Maastricht University, The Netherlands. Retrieved Jan 2005, from http://www.ll.unimaas.nl/euro-cscl/Papers/1.doc

van Bruggen, J. M., Kirschner, P. A. & Jochems, W. (2002). External representation of argumentation in CSCL and the management of cognitive load. *Learning and Instruction, 12,* 121-138.

Van den Berg, R. (2002). Teacher's meaning regarding educational practice. *Review of Educational Research, 72*(4), 577-626.

van Maanen, J. (1999). Case studies: Why now, more than ever, cases are important. In A. Chen., & J. V. Maanen (Eds.), *The reflective spin: Case studies of teachers in higher education transforming action.* (pp. 25-44). Singapore: World Scientific Publishing.

van Zee, E. Lay, D., & Roberts, D. (2003). Fostering collaborative inquiries by prospective and practicing elementary and middle school teachers. *Science Teacher Education, 87*(4), 588-612.

von Glasersfeld, E. (1995). *Radical constructivism: A way of knowing and learning.* London, UK: Falmer Press

Vrasidas, C. & McIsaac, M. S. (2001). Integrating technology in teaching and teacher education: implications for policy and curriculum reform. *Education Media International, 38*(2), 127-132.

Vygotsky, L. S. (1978). *Mind in society.* Cambridge, Massachusetts: Harvard University Press.

Wallace, R. M. (2003). Online learning in higher education: a review of research on interactions among teachers and students. *Education, Communication & Information, 3*(2), 241-280.

Wegerif, R. & Mercer, N. (1997). Using computer-based text analysis to integrate qualitative and quantitative methods in research on collaborative learning. *Language and Education, 11*(4), 271-286.

Wells, G. (1999). *Dialogic inquiry: Toward a sociocultural practice and theory of education.* New York, NY: Cambridge University Press.

Wettasinghe, C.M. (2002). *A descriptive study of the change and learning patterns of Singapore government primary school teachers in relation to the integration of information technology in education.* Doctoral dissertation, The George Washington University. UMI Publication Number: AAT 3045494

White, B.C. (2000). Pre-service teachers' epistemology viewed through perspectives on problematic classroom situations. *Journal of Education for Teaching, 26*(3), 279-305.

Wideen, M., Mayer-Smith, J., & Moon, B. (1998). A critical analysis of the research on learning to teach: Making the case for an ecological perspective on inquiry. *Review of Educational Research, 68*(2), 130-178.

Windschitl, M. (2002). Framing constructivism in practice as the negotiation of dilemmas: An analysis of the conceptual, pedagogical, cultural, and political challenges facing teachers. *Review of Educational Research, 72*(2), 131-175.

Windschitl, M. (2003). Inquiry projects in science teacher education: What can investigative experiences reveal about teacher thinking and eventual classroom practice? *Science Education, 87*(1), 112-143.

Williams, M. D. (2003). Technology integration in education. In S. C. Tan, & F. L. Wong (Eds.), *Teaching and learning with technology: An Asia-pacific perspective.* (pp. 17-32). Singapore: Prentice Hall.

Wilson, S. M., & Berne, J. (1999). Teacher learning and the acquisition of professional knowledge: An examination of research on contemporary professional development. *Review of Research in Education, 24,* 173-209.

Wong, P. (2003). Teacher's role in technology integration. In S. C. Tan, & F. L. Wong (Eds.), *Teaching and learning with technology: An Asia-pacific perspective.* (pp. 34-41). Singapore: Prentice Hall.

Wong, P., & Wettasinghe, M. (2003). Managing IT-based learning environments. In S. C. Tan, & F. L. Wong (Eds.), *Teaching and learning with technology: An Asia-pacific perspective.* (pp. 42-59). Singapore: Prentice Hall.

Woodruff, E. & Brett, C. (1999). Collaborative knowledge building: Preservice teachers and elementary students talking to learn. *Language & Education 13* (4), 280-302.

Yamagata-Lynch, L.C. (2003a). Using Activity Theory as an analytic lens for examining technology professional development in schools. *Mind, Culture and Activity, 10*(2), 100-119.

Yamagata-Lynch, L.C. (2003b). How a technology professional development program fits into teachers' work life. *Teaching and Teacher Education, 19*(6), 591-607.

Youn, I. (2000). The culture specificity of epistemological beliefs about learning. *Asian Journal of Social Psychology,* 3, 87-105.

Yuen, A. (2003). Fostering learning communities in classrooms: A case study of Hong Kong schools. *Education Media International, 40*(1/2), 153-162.

Zhao, Y. (1998). Design for adoption: The development of an integrated web-based education environment. *Journal of Research on Technology in Education, 30*(3), 307-328.

Zhao, Y., & Cziko, G. A. (2001). Teacher adoption of technology: A perceptual control theory perspective. *Journal of Technology and Teacher Education, 9*(1), 15-30.

Zhao, Y., & Rop, S. (2001). A critical review of the literature on electronic networks as reflective discourse communities for inservice teachers. *Education and Information Technologies, 6*(2), 81-94.

Zhao, Y., Pugh, K., Sheldon, S. & Byers, J. L. (2002). Conditions for classroom technology innovations. *Teacher College Record, 104*(3), 482-515.

Zhao, Y., Alvarez-Torres, M. J., Smith, B., Tan H. S. (2004). The non-neutrality of technology: A theoretical analysis and empirical study of computer mediated communication technologies. *Journal of Educational Computing Research, 30*(1), 23-55.

Appendix 1

Interaction Analysis Model for examining social construction of knowledge in computer conferencing (Adapted from Gunawardena et al. 1997, p. 414)

Phase 1: Sharing/Comparing of Information	
A. A statement of observation or opinion (or belief or an idea)/ (Sharing of factual information) Note 85 Learn & Relearn by Sue [2004, January 10] (is that in order for IT to be integrated effectively into the school curriculum, teachers should first be more receptive to changes and also willing to learn and relearn with the intention of reaching for the "blue skies" to enhance teaching and learning.)	1a
B. A statement of agreement from one of more participants Note 230 Social Interaction is important by Sarah [2004, February 01] (I agree with the point that we must never sacrifice social interaction. Social interaction is the base of all learning. If it is sacrificed because of IT then I feel that learning has lost some of its purpose.)	1b
C. Corroborating examples provided by one of more participants Note 419 Similar Experience by Ian [2004, August 26] (I agreed with Karen. My project group faces a similar problem. They do not have computers to access at home and it thereby limited their knowledge expansion. I only meet once a week and that is the only time I have with them...)	1c
D. Asking and answering questions to clarify details of statement Note 9 ZPD by Sue [2004, February 02] (Isn't that ZPD OR Zone of Proximal Distribution?) Note 10 ZPD is not performance gap by Chai [2004, February 04] ZPD is a Vygotskian concept that refers to Zone of proximal development, not distribution. It is about the developmental stage. The difference between the current state of ability and the maximum performance the learner can reach with scaffolds	1d

from more able peers or expert is the ZPD. Instructional problem is a different concept. The desire performance level is stipulated by some authority such as MOE or the manager of a company. It is not something that is decided by the learners' internal state of development. It is about performance, what people are doing, not ability.	
E. Definition, description, or identification of a problem Note 22 Students' Centred Lessons? by Karen [2004, January 14] (is that most of the time, IT lessons in class tend to be teacher-centred. It is only when the pupils are in the laboratory, then the lessons are student-centred. Student-centred lessons are mostly lessons where they attempt the activities on CD. The CD-Roms available in the market do not really tailor to the need of the pupils. To come up with a student-centred lesson by ourselves is too time consuming. That is why some teachers may not want to waste their time in the lab.)	1e
F. (Sharing of reflective summary from readings/ sharing of draft lesson plan) Note 209 Extrinsic & Intrinsic Barriers by Nadia [2004, January 24] (In order to IT to be implemented well, teacher has to view it positively. While I'm sure many are comfortable already, there are many who are still skeptical to the use and benefits of IT.) (This skepticism can be due to barriers. Ertmer (1999) - as mentioned in Rodney's article has grouped these barriers into extrinsic and intrinsic ones. It is eye-opening to realize that these barriers are so evident in some of our beliefs. We grumble at the (extrinsic barriers) lack of time to prepare, the support we get from schools as well as access time due to urgency to complete syllabus. But the bigger challenge is to eliminate our intrinsic barriers of attitudes, beliefs, practices and resistance. Ertmer continued to say that "even if the first-order barrier are removed, teachers would not automatically use technology")	1f

Phase 2: The discovery and exploration of dissonance or inconsistency among ideas, concepts or statements/ (Discovery of gaps in understanding or areas for improvements among ideas or concepts)	
A. Identifying and stating areas of disagreement/ gaps in understanding Note 205 Grades VS Knowledge by Zoe [2004, February 28] (Parents are more concerned with grades because our educational hierarchy requires that. If we look in our Singapore and some other countries system, the higher your educational level, you'll get better paid jobs. Our standard of living is very high. Thus, parents tend to think grades will help their kids to achieve better life in future.) (whatever it is, we teachers have to put their thoughts aside for a minute. We cannot be solely based on book learning. We need to widen the children's horizon of learning and knowledge. Just learning from book and for grades, does not help the child to be more creative, innovative and motivated learner. There's a lot to know in the world out there. IT can help to lighten our load as a deliver of knowledge.)	2a
B. Asking/ answering questions to clarify the source and extent of disagreement Note 478 Varying personalities by Nadia [2004, June 25] (is it is possible for pupils to be engaged silently? They might not be forthcoming in asking questions, but they absorb. You can tell their understanding, say through their written reflections, for example.)	2b
C. Restating the participant's position and possibly advancing arguments or considerations in its support by references to the participant's experience, literature, formal data collected, or proposal of relevant metaphor or analogy to illustrate point of view. Note 103 A subtler approach, please.... by Nora [2004, January 31] (Personally I feel that usage of IT should not be forced. Though it is necessary for teachers to use IT, it should be subtly woven into their daily work in school.)	2c

(My school principal successfully achieved 100% usage of IT even by the "more experienced generation" teachers by creating a certain amount of communication via email. Though this might be of the simplest form of usage of IT, it is indeed an achievement to see those "technology-fear" group of teachers able to email on their own without requesting help from the more "IT savvy" generation of teachers.)	
Phase 3: Negotiation of meaning/ co-construction of knowledge	
A. Negotiation or clarification of the meaning of terms Note 285 Some queries by Ian [2004, January 31] (Perhaps, I have misunderstood the concept of Constructivism. Maybe, mine was more of a scaffolding approach which is a sub component of the constructivist approach. A few questions in mind 1. Must Constructivist approach have a real life problem? 2. Isn't the problem sum a real life problem? 3. Must it always be student centred? Can a weak class like the EM3 have a modified approach?) (I believe that my lesson has the following elements 1. Making sense of something - During the whole lesson, you will notice that I am always asking questions to lead them to the answer. Whenever, there is a misconception, I would show them the processes via visualisation through PowerPoint. Answer was not given to them but allowing them enough room to think what is happening when they execute an operation. 2. Pupils were prompted with relevant structured questions to derive the final model. While the computer operator is me, the teacher, input is solely from the pupils. Can this be considered a modified student centred approach?)	3a
B. Negotiation of the relative weight to be assigned to types of argument Note 15 2nd Concern by Sue [2004, January 22] (General comments In "Technology Integration in education", Michael D Williams defines technology integration as " the use of learning technologies to introduce, reinforce, supplement and extend skills". This simply means that as long as IT is integrated into the curriculum, the issue of whether it is a student-centred or	3b

a teacher-centred is a second concern. The main concern here is whether a teacher could make use of IT as a tool to enhance learning and teaching.)	
C. Identification of areas of agreement or overlap among conflicting concepts Note 166 Over emphasis by Nadia [2004, February 05] (I do agree that maybe there could be an over emphasis on IT. Like I said earlier, some schools / teachers can be over-influenced with the need to use IT that they probably over-use it. If to successfully integrate IT means reducing the quality time in proper teaching or drilling, then it can be hazardous. But then again, I haven't heard of schools being worse off when they focus on IT. If this is true, then MOE should be alarmed.)	3c
D. Proposal and negotiation of new statements/ideas embodying compromise, co-construction Note 487 Motivating Forces by Karen [2004, June 05] (Students are motivated by both intrinsic and extrinsic factors.) (An independent learner will be motivated to learn by himself. His reward will be intrinsic such as satisfaction obtains from in-depth understanding of a subject area.) (Some learners need to be motivated by extrinsic factors such as rewards in the forms of tokens. They do not have the self motivation to learn new things. They need a carrot to lead them on.) I believe both intrinsic and extrinsic factors play their parts in motivating students to learn.	3d
E. Proposal of integrating or accommodating metaphors, analogies, models Note 197 Learning Theories and IT by Sarah [2004, January 20] I strongly feel that each theory has its usefulness. It is not right to say which is best or which is useless. Different theory should be applied to different teaching style and situation. The quality and learning ability of the learners will also affect our decision as to which theory to adopt. I think if IT is to be integrated into the lessons, then all theories should be used at the different stages of the IT lessons or maybe all theories need to be applied in	3e

order to conduct a better IT lessons…….	
F. (Proposal of possible solutions to identified problem) Note 606 Nora and Zoe's Prescribed Solutions by Nora [2004, July 03] 1. Group students according to their abilities - Teacher comes into class with prior knowledge of different pupils' abilities. The amount of scaffolding provided will depend on the different ability group. 2. Appoint those high ability pupils to be buddies to those lower ability pupils. They can help to provide support to their partners. 3. Quote:- Thinking aloud by the teacher and more capable students provided novice learners with a way to observe "expert-thinking" usually hidden from the student. This is to tackle the issue of passive learners. 4. We need to regulate the amount of scaffolds. This is to enable us to realise when we need to give more or less or no scaffolds.	3f
Phase 4: Testing and modification of proposed synthesis or co-construction	
A. Testing the proposed synthesis against "received fact" as shared by participants and/or their culture Note 450 Share the same view by Sarah [2004, July 13] (If teachers teach their classes most of the subjects they have more time to 'play' around with and thus the chances of experiencing success might be greater. At present I am facing this problem. I only teach my class English, Maths and Science thus I do not have other time to 'play' around with. In order to embark on KBC, I do it outside teaching time, which means the students come earlier. To be very frank, how many teachers are willing to come to school earlier just to do KBC? Just wondering will I do that if it is not for this course that I am taking.)	4a
B. Testing against existing cognitive schema/ (or literature) Note 268 Support by Sue [2004, March 04] (is that principals are generally supportive on IT though it may not be their top priority. Then again, the heads of departments also have to take the initiatives to model as well as support IT integration. Perhaps, if every dept stress on IT, then, it would be easier to slowly integrate it into the school curriculum.)	4b

(being that to integrate IT effectively, the process has to be contextual developmental and not too sudden, causing "fear" amongst teachers who are non-IT-savvy.) (was clearly stated in ACOT findings that teachers are more willing to accept IT when they have undergone the 5-stages of evolution, namely, the entry, adoption, adaptation, appropriation and invention stage.)	
C. Testing against personal experience Note 572 Time vs. Outcome by Karen [2004, August 26] (I did spend at least 1 hour each week to do the KF. It is time consuming definitely, but the pupils are engaged in their work, at least the majority.) (My Reporting Officer observed the lesson and commented that the pupils knew what they were doing and they were engaged in their work. Another teacher commented that she was impressed with the pupils' IT skills and she learnt from them as she watched them carry out their investigative task.) (There is always a learning opportunity for the pupils in any learning environment. Time is always a factor that most teachers are concerned about. When there is a content reduction in primary school education, teachers may have more time to try out KF and realise its merits. They may be surprise by what some pupils can produce. At the same time, for the less fortunate pupils, it will be a great learning experience for them.)	4c
D. Testing against formal data collected Note 168 IT works- it just depends on Usage by Ian [2004, January 16] (.....I use IT almost everyday for teaching and learning. My class 6 EM3 - entry behaviour was 28 U grades, 5 Grade 4, 1 Grade 3 and 1 Grade 2. At PSLE, it was at 7 grade 2, 5 grade 3, 9 grade 4 and only 14 U grades. Another supporting evidence is our P4 Maths results. We embarked on P4 Maths E-Learning programme. The whole level entry of Band 1 is only at 20.65% (57 pupils). At streaming, it was at 51.09% (141 pupils achieving B1). Of course, this must be supported with other pedagogical aspects and methods.)	4d
E. Testing against contradictory testimony in the literature Note 42	4e

Counter evidences by Chai [2004, January 28] (However, in the article that "Changing how and what children learn in school with computer-based technology", the authors conclude that research results is to date inconclusive. The key of effectiveness lies in teacher training, matching students and subject to relevant computer application and sound pedagogy.)	
Phase 5: Agreement statements/ applications of newly-constructed knowledge	
A. Summarization of agreements/ (outcomes of discussion) Note 280 Beliefs & culture by Sue [2004, March 04] ..... (is that "teachers' beliefs" and "the school culture" can never be separated.) (is that the 2 factors affect each other and have great impact on whether IT could be integrated effectively in a school) (from ACOT-"Implementing change in education must include changing teachers' practices and beliefs. This does not mean abandoning beliefs but gradually replacing them with more relevant beliefs shaped by experiences in an altered context. And it is this altered context that may make the difference. When teachers work with colleagues and administrators who actively support fundamental change, there is far greater opportunity for successful growth of new beliefs and practices.")	5a
B. Applications of new knowledge Note 184 General Reflections by Ian [2004, March 05] (I have really learnt a lot in this course. It really changes my perception of many things. Mr Chai has really brought out many issues which I believe are critical to the success of MP2. However they are really difficult challenges which cannot be resolved by just a single method. I am currently working on a few issues affecting the school right now using what I have learnt. A webquest project will be implemented soon for a level. Hope that I have some time to inform you all.)	5b
C. Metacognitive statements by the participants illustrating their understanding that their knowledge or their ways of thinking (cognitive schema) have changed as a	5c

result of the conference interaction Note 692 A new learning experience by Karen [2004, September 02] (*Opinion* I did have my share of concern on whether my pupils would benefit from such learning experience. As educators, I guess we are supposed to try out different teaching strategies and identify the learning styles of our pupils.) (*Conclusion* I was glad that my class enjoyed the learning experience and there was some level of epistemic agency found in KF. From the experience, I find that my pupils have to be more open and give more ideas to one another. As this was the first attempt at KF, there was still a lot of things our pupils have to learn. We could not expect them to create wonder overnight. The good thing is at least we are trying and still trying.)	