SOCIAL CONSTRUCTION OF KNOWLEDGE IN A PROBLEM-BASED LEARNING SETTING

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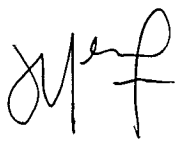
Witness's Signature  Date: 10/9/2014

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ABSTRACT

The objectives of the study were: (1) To investigate the process of social construction of knowledge in a PBL setting, and (2) To investigate the impact of the essential features of PBL in supporting or hindering the process of social construction of knowledge. Using a case study approach (Merriam, 2009), this study analysed the discourse of three PBL participants enrolled in a master's program in a public university. Through an iterative process, Gunawardena et al.'s (1997) Interaction Analysis Model was modified (mIAM) to analyse the emerging data which represented the different phases of interaction in the process of social construction of knowledge. All the six phases of mIAM emerged in the discourse between the PBL participants, indicating that the social construction of knowledge was in action and the participants had gone through a substantive constructivist learning experience. The detailed examination of the PBL discourse also contributed to a deeper understanding of how certain essential features of PBL (Dolmans et al., 2005) which supported or hindered the process of social construction of knowledge. The significance of this study lies in the model that emerged - mIAM. The phases of interaction in mIAM can be useful in examining the process and extent of social construction of knowledge. It can also serve as a basic framework for PBL facilitators to guide their facilitation decisions to advance the PBL discourse into deeper phases of social construction of knowledge.

ABSTRAK

Tujuan kajian ini ialah untuk (1) menyiasat proses pembinaan pengetahuan secara sosial dalam konteks PBL, (2) menyiasat impak unsur-unsur utama PBL dalam menyokong dan menghalang proses pembinaan pengetahuan secara sosial. Kajian ini menggunakan pendekatan kajian kes (Merriam, 2009) and menganalisa wacana tiga peserta PBL yang belajar dalam program sarjana di sebuah universiti awam. Melalui proses lelaran, model analisa interaksi Gunawardena et al., (1997) diubah suai (mIAM) untuk mengkaji data-data yang muncul dalam bentuk fasa-fasa interaksi proses pembinaan pengetahuan secara sosial. Kesemua enam fasa mIAM muncul dalam wacana antara peserta-peserta PBL. Ini menunjukkan bahawa pembinaan pengetahuan sacara sosial berlaku dan peserta-peserta tersebut telah mengalami satu pembelajaran konstruktivis yang mendalam. Pemeriksaan terperinci wacana PBL membawa pemahaman yang lebih mendalam tentang unsur-unsur PBL (Dolmans et al., 2005) yang menyokong atau menghalang pembinaan pengetahuan secara sosial. Kepentingan kajian ini terletak pada model analisis yang muncul iaitu mIAM. Fasa-fasa interaksi mIAM boleh digunakan untuk menyiasat proses and takat pembinaan pengetahuan sacara sosial. Ia juga boleh digunakan sebagai kerangka asas untuk pembimbing PBL untuk memajukan wacana PBL ke fasa-fasa yang lebih lanjut dalam pembinaan pengetahuan secara sosial.

DEDICATION

To my parents

whose trust and love remain my source of inspiration.

ACKNOWLEDGEMENTS

The writing of this thesis has been a most rewarding experience, and there are many people for whom I am greatly thankful.

To my dear wife Li-Cheng, children Yi-Zhong, Yi Qian and Yi Ming, thank you for your untiring support, encouragement and patience throughout the duration of this course. Your selfless love reminds me of what is truly important in life.

To my incredibly generous and supportive supervisor, Dr. Tee Meng Yew, thanks for the countless number of stimulating discussions which made this journey of learning so inspiring.

Finally, I thank God for His timely guidance. To Him be the glory.

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LIST OF SYMBOLS AND ABBREVIATIONS

IAM	Interaction Analysis Model
mIAM	modified Interaction Analysis Model
ICT	Information and Communication Technology
IDEAL	Identify, Develop, Explore, Anticipate, Learn
PBL	Problem-Based Learning
SKPM	Standard Kualiti Pendidikan Malaysia
SQSS	Smart School Qualification Standard
TPACK	Technological, Pedagogical and Content Knowledge
TPC	Technological, Pedagogical, Content knowledge

LIST OF APPENDICES

CHAPTER 1: INTRODUCTION

The world today is well connected and fast changing. The internet technology and the proliferation of mobile devices have radically transformed the way we interact with one another and with our environment. Communication is instant. Information becomes easily accessible. The world has become a borderless entity as information and communication flow freely across countries and continents. These changes bring enormous impact on every aspect of life and society: they alter the ways we connect with each other; they shape the political landscapes of countries; they affect how businesses are run; they transform the learning spaces of students; and these changes are happening at an unprecedented rate. As a result, we are being confronted with real world problems or issues which are constantly changing and increasingly complex as information becomes easily accessible.

To deal effectively with such real world problems, we need to develop learners who are not only knowledgeable but more importantly, learners who have the capacity and skills to address complex, ill-structured problems and engage in life-long learning (Hmelo-Silver, 2009). Education in the 21st century must provide students with learning contexts and processes through which meaningful and real world problems are addressed. As such, learning is no longer a transmission of information from the teacher to the student. Instead, learning needs to be active and to facilitate participants in constructing their own understanding of the world around them through meaningful and productive interactions with their surrounding environment. In short, a new paradigm of learning is needed.

One paradigm of learning that has been found to harness the capacity and skills needed to prepare learners for future learning and engagement with real world novel and complex problems is Problem-Based Learning, or PBL (Schmidt, 1983; Dolmans et al., 2005). PBL is an instructional approach whereby students learn through facilitated problem solving (Hmelo-Silver, 2004; Barrow, 2000). It integrates small group interaction, inquiry, self-directed learning into a learning environment through which the learners are actively constructing new knowledge and understanding. Since its early inception in the mid 1960's as an innovative educational approach in medical education, PBL has been presented as an alternative educational strategy that could produce better critical thinkers (Kek & Henk, 2011), better problem solvers, highly motivated and self-directed learners (Norman & Schmidt, 1992). A study conducted by Rotgans & Schmidt (2011) indicated that students' cognitive engagement increased significantly and consistently over the course of a PBL process. Such transforming advantages, echoing societal needs and aspirations about learning, have brought about a growing interest in PBL in many institutions of higher learning (Hmelo & Ferrai, 1997; Savery & Duffy, 1995). Indeed, PBL has been adopted by many medical schools worldwide (Norman & Schmidt, 1992) and in a wide variety of educational settings (Hmelo-Silver, 2009; Gijbels et al., 2006; Boud & Feletti, 1997).

1.1 Statement of problem

As an educator in an institute of higher learning, I have had, in several occasions, the opportunities to facilitate the process of PBL learning as well as to be an observer in the PBL classes. In most of these PBL sessions, I was fascinated by the outcomes of the PBL process in that there seemed to be no obvious indicators or reasons as to why and how a certain PBL session would turn out to be successful or otherwise. This seemingly unpredictable nature of

the PBL outcomes was, interestingly, consistent with the PBL research findings.

The research to compare PBL with conventional curricula has yielded inconclusive findings in that some studies reported positive findings, some negative findings and some neutral findings (Mamede et al., 2006; Colliver, 2000; Azer, 2000). Norman and Schmidt (2000) reasoned that PBL is a complex and multi-factorial environment and as such the effects of PBL are inevitably influenced by a myriad of unexplained variables which make it impossible to attribute success or failure based solely on the PBL intervention. They stressed that trials of PBL interventions for an entire course are a waste of time and resources because a pure or uniform PBL intervention does not exist.

Norman and Schmidt's (2000) arguments may help to explain the seemingly unpredictable nature of the PBL outcomes. Their findings also underscore the need to understand the PBL process within a useful theoretical framework that could extend our understanding of how and why the PBL process works. The basic theoretical underpinnings may be found in constructivism. A number of key PBL researchers have pointed out the clear link between Constructivism and the practice of PBL as an instructional approach. For instance, Hendry et al. (1999) gave a detailed analysis of the various variables in the practice of PBL and concluded that all the key variables in PBL can be incorporated in the constructivist theory of learning. Schmidt et al. (2000), in their review of the research on the factors affecting small group tutorial learning, observed that students in the PBL settings were constantly engaged in constructing theories about the real world, represented by the real world problems presented in the PBL process. Savery and Duffy (2001) had argued that the practice of PBL is clearly associated with constructivist thinking. They pointed out that PBL is consistent

with the primary underpinnings of constructivism in that in the PBL process, (1) students are actively involved in constructing their own understanding and meaning of reality through tacking complex, real life problems; (2) the problem presented in a PBL context is often complex and ill structured, that is, it has no single right answer and the perimeters of the problem is less defined (Hmelo-Silver 2004) and it acts as a cognitive puzzlement and/or conflict to stimulate learning; and (3) the group interactions provide a rich social environment and mechanism for students' understanding to be tested and challenged. The differing views and perspectives within the group provide a strong stimulus for social negotiation and knowledge construction. Pelech (2008) argued that PBL is an effective platform for delivering the constructivist philosophy in that it consolidates many of the constructivist practices when PBL participants work through the ill-defined, real life problems by generating hypothesis, identifying learning issues and finding resolutions to those problems. Dolman et al. (2005) have suggested that the practice of PBL is based on the insights that learning should be contextual, collaborative and constructivist in nature, an argument which is in line with Constructivism.

Despite all these claims, research-based evidence that focuses on the processes of social construction of knowledge in PBL settings is thin. Indeed, direct explorations of the processes of knowledge construction in PBL settings are not well documented (Hmelo-Silver and Barrows, 2008). In addition to that, there seems to be a lack of a clear and coherent theoretical construct that guide the investigation of the process of social construction of knowledge in PBL settings. In a number of past studies, researchers looked at emerging indicators in the process of collaborative construction of knowledge in PBL groups. For instance, Norman and Schmidt (1992) in their review of literature concluded that group discussions in PBL

promoted the activation of prior knowledge and elaboration which stimulated students towards the constructive and collaborative processes which affected learning positively. De Grave et al. (1996) investigated the cognitive processes during the problem analysis phase in the PBL cycle and showed that the students' cognitive conflicts about the subject matter led to conceptual change in the students. Visschers-Pleijers et al. (2004) reported on the presence of elaboration and co-construction as individuals in the group engaged in questioning, reasoning and solving cognitive conflicts. These studies highlighted the different kind of cognitive interactions that occurred in the PBL discourses. However, they did not attempt to integrate these cognitive interactions from different aspects of analysis to provide a more coherent understanding of how these interactions impacted the process of social construction of knowledge. For instance, Visschers-Pleijers et al. (2004) detected the presence of elaboration and co-construction in three separate aspects of the group interactions, namely questioning, reasoning and conflict. However, the study did not investigate how the cognitive interactions in these three aspects of the analysis worked together to advance the overall social construction of knowledge. Hence, they provide very little insight into theorizing how these cognitive interactions help advance the process of social construction of knowledge throughout the whole PBL process. As Hmelo-Silver and Barrows (2008) rightly pointed out that many of these studies focused only on tiny segments of the PBL meetings and did not integrate the different levels of analysis needed to fully understand the process of collaborative knowledge building. Consequently, various PBL researchers have argued that future research be based on the theoretical concepts underlying PBL so that we can better understand how PBL work or does not and under which circumstances (Dolmans et al., 2005; Mamede et al., 2006; Hmelo-Silver, 2009). Hmelo-Silver and Barrows (2008), in an attempt to understand the contributions of the expert facilitator as well as the students in advancing

the process of collaborative knowledge building in a PBL group, did a detailed analysis of the PBL interactions using the theoretical work on discourse moves that enable the knowledge-building process. They demonstrated that different kinds of questions and statements contributed by the facilitator and the students helped advance the process of collaborative knowledge building. As the group progressed in their discourse of the problem, the causal explanations became more coherent and there was a deeper and richer understanding of the problem situation. The study has shed some light on the kind of discourse moves which advance the process of collaborative knowledge building in a PBL setting.

As such, this study aimed to advance the kind of work done by Hmelo-Silver and Barrows (2008). Specifically, this study sought to describe and understand the phases of social interactions that lead to the social construction of knowledge in a PBL setting. This aspect of the study focused on examining the process of social construction of knowledge and was guided by major constructs of social constructivist framework emerged from studies such as Gunawardena et al. (1997) and Stahl (2000). These constructs include the sharing of information, cognitive dissonance, social negotiation, testing of new understanding and knowledge, and the emergence of social artifacts and their respective cognitive activities that are manifested in the PBL discourse. Additionally, the study also identified elements in the PBL setting which supported and hindered the process of social construction of knowledge. In doing so, the study sought to provide a deeper understanding of how the social construction of knowledge occurred in the PBL setting and identified the specific elements in the PBL setting which have impacted the process of social construction of knowledge.

1.2 Objectives of the study

In this study, the process of social construction of knowledge is investigated in the context of the students' development of the technological, pedagogical and content knowledge (TPACK).

According to Koehler and Mishra (2005), effective teaching with technology requires the integration of technological, pedagogical and content knowledge to produce context specific strategies and representations. This entails a good and critical understanding of the mutually reinforcing relationships between technological, pedagogical and content knowledge. To cultivate a deep understanding of TPACK, students need to have a good understanding of the individual components of TPACK and how these components interact and produce transactional relationships in a specific educational context. In other words, good teaching with technology for a specific situation is complex and multi-dimensional (Koehler and Mishra, 2007). It requires a nuanced understanding of the complex interplay of TPACK in order to produce meaningful learning strategies for a given real life learning context.

In the context of this study, the participants are given the opportunities to focus on a complex, real life problem of practice they seek to address. In the process, the participants learn to construct their own understanding of TPACK and its applications to a specific educational problem the participants had decided to work on.

This study has the following objectives: (1) To investigate the process of social construction of TPACK as it occurred in the PBL setting, and (2) To investigate the impacts of the essential features of PBL in supporting or hindering the process of social construction of knowledge.

1.3 Definitions of terms

1.3.1 The process of social construction of knowledge

From the constructivist viewpoint, the construction of knowledge occurs when learners begin to develop a new understanding or interpretation of the world. This entails a reorganization of the learner's cognitive schema when existing schema can no longer accommodate the new experience (Piaget, 1977). In social construction of knowledge, the development of new knowledge is stimulated and shaped by transformative social discourses. This is based on Vygotsky's (1978) view of social constructivism whereby learning is situated in social-cultural environment and the individual plays an active role in co-constructing new knowledge in interaction with others. According to Gunawardena et al.'s (1997) Interaction Analysis Model (IAM), there are distinct and identifiable cognitive operations that help advance the phases in social construction of knowledge. In this study, the social processes which emerged in the modified version of the Interaction Analysis Model (mIAM) consist of six phases of interactions which help advance the process of social construction of knowledge and these six phases include (1) sharing of information, (2) exploration of an opinion or hypothesis, (3) discovery and exploration of dissonance or inconsistency among ideas, concepts or statements, (4) negotiation of meaning or co-construction of knowledge, (5) testing and modification of proposed synthesis or co-construction, and (6) agreement statements and/or applications of newly constructed meaning (refer to page 73).

1.3.2 Elements in the essential features of PBL

Dolman et al. (2005) argued that though there are many variations of PBL, there are three essential features that characterize the practice of PBL and they are (1) real-life problems being used as a stimulus for learning, (2) tutors function as facilitators to scaffold students' learning and (3) collaborative environment as stimulus for interactions. In this research, these

three essential features of the PBL setting were examined in relation to the social construction of knowledge using the mIAM framework. For each of these essential features, conversational episodes which affected the movement of the PBL discourse based on the mIAM were analyzed. Factors which moved the discourse into more advance phases of mIAM were considered the elements in the PBL setting that support social construction of knowledge. On the other hand, factors which prevented the discourse from moving into more advance phases of mIAM were considered the elements which hinder social construction of knowledge.

1.4 Research questions

The research questions are:

Research question 1: How does social construction of TPACK occur in a PBL setting?

Research question 2(a): What elements in the essential features of a PBL setting support the social construction of knowledge?

Research question 2(b): What elements in the essential features of a PBL setting hinder the social construction of knowledge?

As discussed in the preceding section, there are 3 essential features of a PBL setting and these features include (1) the use of real-life problems as a trigger for learning, (2) the tutor's facilitation to scaffold the learning process and (3) the participants' collaboration in stimulating interactions and learning (Dolmans et al., 2005). In this research, the essential features of the PBL setting were examined in relation to the process of social construction of knowledge. Specifically, question 2(a) and question 2(b) are broken down into the following questions:

Question 2(a)(i): What elements of real-life problem in the PBL setting support the social construction of knowledge?

Question 2(a)(ii): What elements of facilitation in the PBL setting support the social construction of knowledge?

Question 2(a)(iii): What elements of collaborative interactions in the PBL setting support the social construction of knowledge?

Question 2(b)(i): What elements of real-life problem in the PBL setting hinder the social construction of knowledge?

Question 2(b)(ii): What elements of facilitation in the PBL setting hinder the social construction of knowledge?

Question 2(b)(iii): What elements of collaborative interactions in the PBL setting hinder the social construction of knowledge?

1.5 Delimitation of the study

The review of PBL literature has shown that PBL is a multi-factorial environment in that there are various elements in the environment that could affect the quality of PBL group collaborative efforts (Mamede et al., 2006; Dolmans et al., 2005; Schmidt & Moust, 2000; Gijselaers & Schmidt, 1990). A study by De Grave (1996) has also shown that collaborative construction of knowledge was affected by (1) the presence of cognitive conflicts and (2) the quality of the alternative theories proposed as students engaged in formulating tentative hypothesis during the problem analysis phase. As discussed earlier, Hmelo-Silver and Barrows (2008) highlighted the critical roles played by the facilitator as well as the students in advancing the process of knowledge building in a PBL setting. These included the kinds of questions asked and statements made as the facilitator intervened in a timely fashion to

advance the PBL discourse. The students too, contributed to the progress of the discourse by modeling the questions and statements made by the facilitator. As noted above, there are likely to be a myriad of factors or elements that could potentially affect the outcomes of the PBL process and thus the process of social construction of knowledge. This research delimited the investigation of the PBL process to the three essential features of a PBL as argued by Dolman et al. (2005) and examined how these features supported or hindered the process of social construction of knowledge.

1.6 Conceptual framework of the study

The context of this research is the social interactions of participants in an instructional technology course which was conducted in a PBL setting. The main social interaction for the participants in the PBL group happened face-to-face during in-class discussions. Most of these discussions were facilitated by the course instructor while some discussions were conducted without facilitation. Conceptually, the quality of interactions in the PBL sessions is affected by several elements in the PBL environment and this in turn determines how far the social construction of knowledge will advance. Stahl's (2000) model of knowledge building phases was used to frame and focus the initial investigation and coding of the participants' interactions. However, as the data emerged, it became increasingly clear that Stahl's framework lacked the specific and detailed descriptions of the cognitive activities that represented the flow and advancement of the process of social of construction of knowledge. At this point, Stahl's model was replaced by Gunawardena et al.'s (1997) Interaction Analysis Model (IAM) which appeared to have a better functional match with the emerging data. Further analysis of the data indicated that the IAM had to be modified in order to accommodate new cognitive patterns that emerged from the participants' discourse. As can

be seen from the diagram, this was a two way process. The extent to which the AIM was modified was guided by the nature of the social interactions in the group and the modified framework would then be applied as a guide to code the emerging data. The outcome of this iterative process was the modified IAM (mIAM). The levels and the extent to which the social negotiation occurred among the participants were indicated by the phases of interaction in the mIAM. The outcomes of the process of social construction of knowledge were evidenced by the summarization of new knowledge, and the applications of the new knowledge in some forms of cultural artifacts. At the same time, elements in the three essential features of PBL which affected the process of social construction of knowledge were also investigated. The investigation involved the analysis of conversational episodes which advanced or prevented the movements of the discourse based on the phases of interaction in the mIAM and the elements in each of these essential features which supported or hindered the movements of the discourse were identified and articulated. The conceptual framework of this study is represented in Figure 1.1.

1.7 The significance of the study

The purpose of this research was to extend our understanding of how or in what ways the social construction of knowledge occurred in a PBL setting. This study represented an important and one of the few attempts to examine the process of social construction of knowledge outside of medical education and contributed to the research field by providing a more coherent and deeper understanding of how the process of social construction of knowledge advanced through different phases of interactions. Such understanding can inform the training and development of PBL facilitators and equip them with the knowledge and the practical intervention skills to effectively scaffold and advance the process of social

construction of knowledge in the PBL discourse. On top of that, the identification of elements which supported and hindered the process of social construction of knowledge can provide a useful evaluative framework to PBL facilitators by helping them to recognize which of their facilitation strategies or skills that had advanced or hindered the movement of the interaction into deeper phases of the process of social construction of knowledge and hence bring improvement to the quality of PBL process in everyday practice.

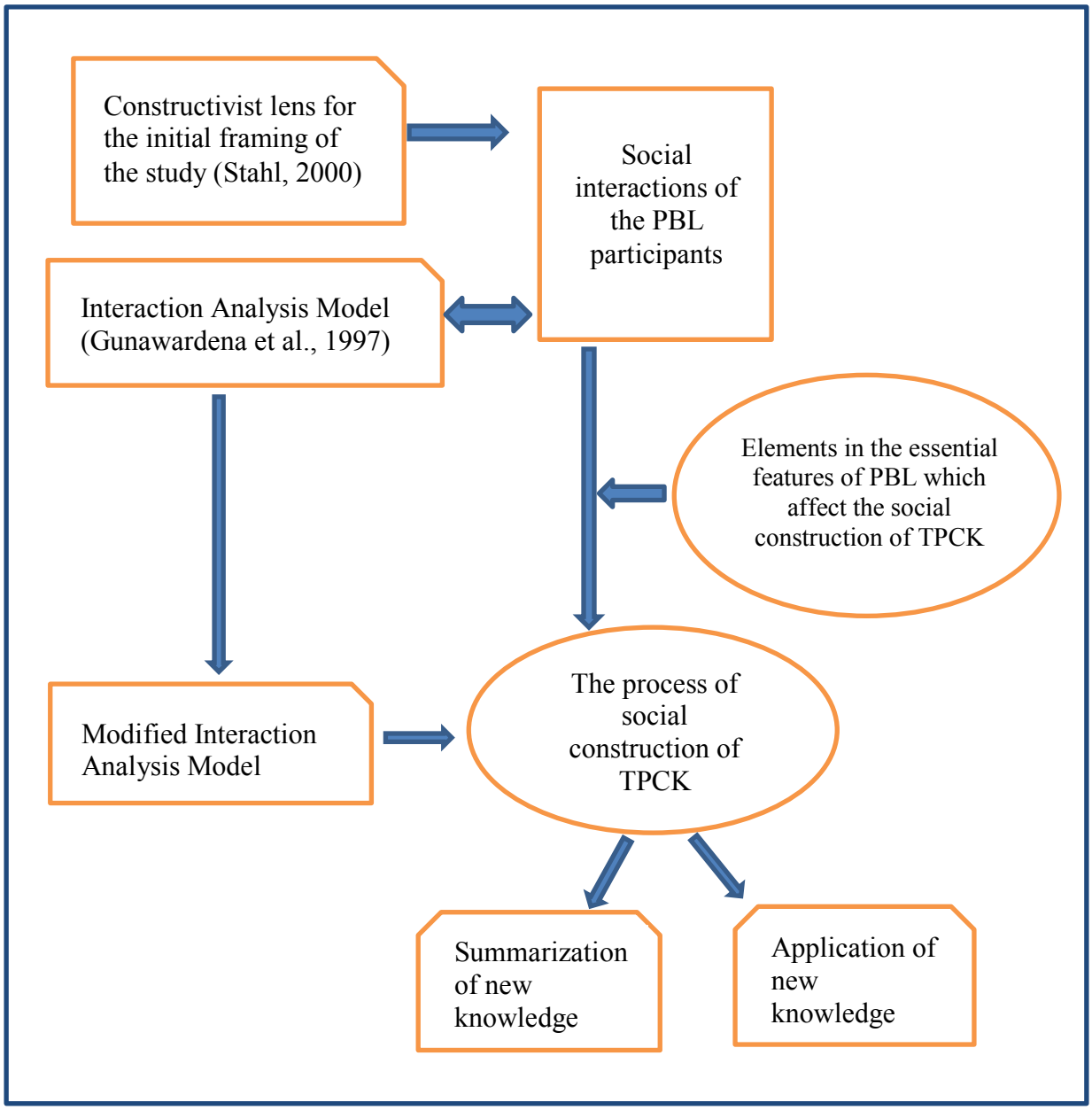

Figure 1.1: The conceptual framework for investigating the process of social construction of knowledge in a PBL setting.

CHAPTER 2: REVIEW OF LITERATURE

PBL was originally introduced as an educational innovation at McMaster University, Canada, in the mid-1960's (Norman & Schmidt, 1992). It was implemented with the aim to replace the traditional lecture-based approach to learning in the medical school to counter the perceived lack of relevance and motivation in the professional and intellectual development of the students (Bridges & Hallinger, 1995; Schmidt, 1995; Hamilton, 1976). In 1974, The Maastricht medical school became the second school after McMaster to introduce the use of PBL in a school-wide manner. It was practiced with a strong emphasis on developing the students' self-directed and problem solving skills. For the first time, students were given the responsibility and freedom to identify their own learning issues and find relevant information to solve real-life, authentic clinical problems (Van der Vleuten et al., 1996).

Since then, PBL has gained popularity and has been presented as a viable alternative to traditional education as it holds the potential to produce students who are able to apply the knowledge they acquired to solve real life problems (Schmidt, 1983). As a result, increasing number of medical schools in other parts of the world began to embrace the practice of PBL (Hendry et al., 1999; Norman & Schmidt, 1999). In recent years, PBL has been implemented in a wide variety of educational settings including the Business Schools (Milter & Stinson, 1994), School of Education (Bridges & Hallinger, 1992; Duffy, 1994), Architecture, Law, Engineering, Chemistry, Social Work (Tan et al., 2000; Boud & Feletti, 1991), Biomedical Engineering (Newstetter, 2006), and a variety of undergraduate disciplines as well as K-12 education and workplace settings (Hmelo-Silver, 2009; Mergendoller et al., 2006; Savin-Baden , 2000).

2.1 The PBL process

The PBL strategy is designed to achieve several important learning goals. According to Hmelo-Silver (2009), the PBL process was intended to help students (1) develop extensive and flexible knowledge base, (2) develop effective problem solving skills, (3) develop self-directed lifelong learning skills, (4) become skilled team players or collaborators, and (5) become intrinsically motivated learners. To achieve such goals, PBL situates learning in the context of real world problems (Barrows, 2000) and the learners are expected to work collaboratively to address the problems.

In a PBL learning cycle, a problem is presented to the students as a trigger for learning prior to any instruction or preparation (Schmidt & Moust, 2000). The students are only equipped with their prior knowledge and experience to begin with. As such, problems in PBL are framed in such a way to stimulate learning rather than to assess the extent to which the students have learned a particular concept or subject that have been taught. Typically the problems are ill-defined, complex and deal with real life situations. For example, Savery and Duffy (2001) reported on the use of actual medical notes on a patient as a typical stimulus for learning in many medical schools. From the outset, the students are required to define and analyze the problem in a small group usually made up of eight to ten students. Students are prompted by the tutor to systematically gather relevant facts and information from the problem presented in order to develop a deeper understanding of the problem. As the students go through this early stage of the PBL cycle, they come up with tentative hypotheses to explain the problem scenarios. Drawing from their prior knowledge and experience, the hypothesis generated may consist of causal mechanism, processes or principles underlying the given phenomena. In doing so, the students are made aware of the knowledge gap

between what they know and what they think they ought to know in order to solve the problem at hand. As a result, a list of learning issues can be formulated by the students for further research through students' independent self-directed learning (Barrows, 1986). During the self-directed learning phase, the students are responsible to gather information that relates to the learning issues. The students are not assigned any texts and they are expected to gather information through a range of resources from sources such as the library and the online databases. They then re-group to share what they have learned independently and reconsider their earlier hypotheses. The same cycle of self-directed learning will be repeated if new hypotheses are formulated and more information is needed to address these new hypotheses in order to fully resolve the problem. The PBL learning cycle is represented in Figure 2.1 (Hmelo-Silver, 2009).

Another key feature in PBL is that learning is facilitated. The PBL discussion is supported by a facilitator who is also known as the tutor (Barrows, 1987). The facilitator serves as an expert learner who models good metacognitive strategies and thinking rather than to provide or disseminate content knowledge (Hmelo-Silver, 2004). The tutor guides the cognitive processes of the group by encouraging students to justify their answers, to comment on others' thinking, to externalize self-reflections and to guide the discussions in subtle but productive ways. In other words, the focus of the tutors is to scaffold the learning process. To do this, the tutors ask probing questions that stimulate deep thinking and reasoning in students. Superficial thinking and vague reasoning do not go unchallenged and the students are constantly being asked to justify their opinions with factual information. By doing so, the students are prompted to organize their knowledge, work through their misconceptions and do this, the tutors ask probing questions that stimulate deep thinking and reasoning in

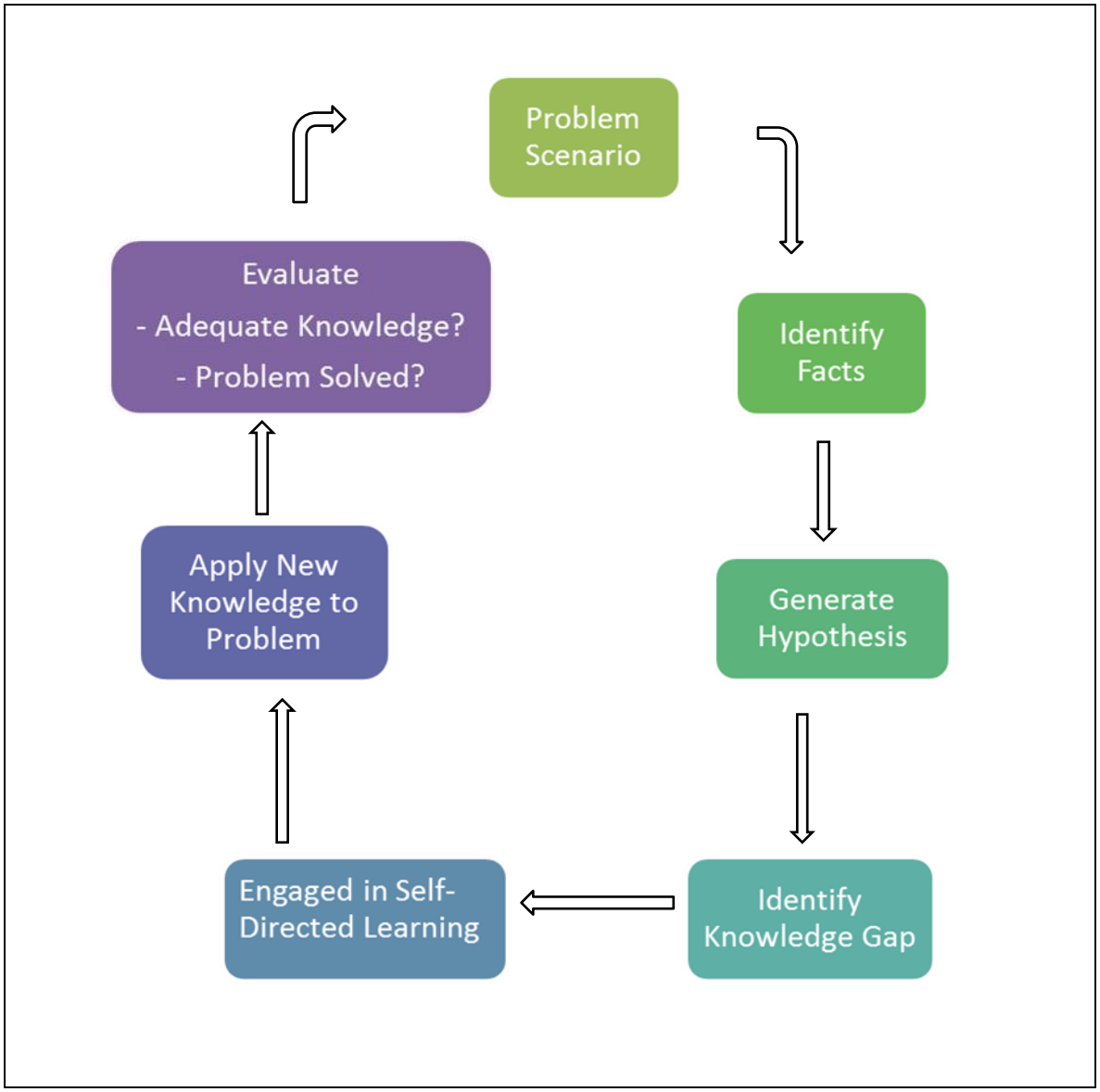

Figure 2.1 The PBL cycle (Hmelo-Silver, 2009)

students. Superficial thinking and vague reasoning do not go unchallenged and the students are constantly being asked to justify their opinions with factual information. By doing so, the students are prompted to organize their knowledge, work through their misconceptions and come to a better understanding of the subject matter being studied (Schmidt and Moust, 2000). Gradually, as the students acquire the skills of an expert learner, the tutor would scaffold less and the students would assume greater role in facilitating the learning process in the group.

Barrows (1996), pointed to a core model of PBL in which six general characteristics can be identified, namely, (1) learning is student-centered, (2) learning is facilitated in a small group, (3) the tutor functions as a guide, (4) real life problems are the starting point for learning before any preparation or study has occurred, (5) the skills and knowledge that are required to solve the problems are acquired in context and (6) new information is gathered through self-directed learning. Dolmans et al. (2005) asserted that there are three characteristics which are considered essential to the PBL process. These include (1) problems as stimulus for learning. They pointed out that in PBL, problems are the driving force behind students' learning and are used to foster the construction of knowledge, (2) tutors as facilitators. The role of the tutors is not to transmit knowledge but to keep the learning process going by encouraging specific kinds of cognitive activities among the PBL participants. (3) Group work as stimulus for interactions. In PBL, students work collaboratively to stimulate each other's thinking and to co-construct solutions to the problem. Additionally, this provides an environment for team effort and may help students to become better collaborators. These essential or core PBL characteristics can serve as a useful guide to identify if a particular new learning environment is PBL. As the practice of PBL as an educational approach gains wider acceptance it's likely the PBL process may be applied with varying degree of modification in different educational settings. As rightly pointed out by Hmelo-Silver (2009), it is unlikely that the medical school model of PBL could be adopted by other educational contexts without any modifications or adaptations to the local contexts. There could be a variety of reasons why such modifications are necessary. For instance, due to the economy of scale, the practice of a dedicated tutor for each PBL group may not be possible for some courses where the number of student enrolment are high. In such a situation, some modifications to the process of facilitation may be necessary.

In this research, an improvised PBL will be used. Bransford & Stein's (2002) IDEAL model will be used to guide the classroom planning and management. The improvised PBL has several key features that overlap with the general characteristics of PBL as outlined by Barrows (1996) in that the problems addressed will be authentic, complex and facilitated through a combination of collaborative, iterative and self-directed activities.

2.2 The philosophical foundation of PBL

PBL is underpinned by Constructivism. Constructivism is a philosophical view that deals with the questions of how we come to understand or know something (Dewey, 1938; Vygotsky; 1962). In the context of PBL where learning is situated in the collaborative efforts of the participants, Vygotsky's (1978) proposition of socio-historical constructivism is of particular interest here. According to Vygotsky, learning is a continual movement from the current intellectual level to a higher level stimulated by social interaction and influenced by the social and cultural context over which the interaction happens. In this position, meaning emerges from our interpretations of the social experiences as we go through the cognitive processes such as elaboration, explanation and negotiation when confronted with diverse or differing viewpoints from others. These interpretations of meaning in turn form the knowledge base which gives rise to our individual understanding of the external world (Jonassen, 1991). In other words, the mechanism that compels the construction of knowledge is social interaction. Another prominent idea that emerges from Vygotsky's theory of social constructivism is the zone of proximal development. Zone of proximal development argues that novice learners develop their potential to learning through the modeling of an expert learner. In other words, before we can perform a particular task we have to learn the skills from the proximal presence of an expert. As the novice's skills develop, the expert will

progressively curtail his or her involvement, leading to the novice assuming the role of the expert. The idea of proximal development is evident in the PBL process in that the facilitator serving as an expert learner, model the problem solving and self-directed learning skills to the PBL participants during the early stages of the PBL process. The facilitator then progressively fades his or her scaffolding as students become more experienced with the PBL process leading to the students assuming the questioning role of the facilitator (Hmelo-Silver, 2009).

2.3 Effectiveness and outcomes of PBL

The research trend to compare PBL with conventional, lecture-based curricula has led to some interesting debate in literature. In their review article, Norman and Schmidt (1992) concluded that there were "small or negative differences between the overall knowledge or competence of students trained by PBL and by conventional curricular". However, there was initial evidence pointing to better retention of knowledge and learning skills for PBL students. Review by Albanese & Mitchell (1993) showed that PBL students performed as well and sometimes better on clinical examinations and faculty evaluations compared to traditional medical students. However, their review also concluded there were potentially important gaps in PBL graduates' knowledge base and expert reasoning skills. Vernon and Blake (1993), in their review of evaluative research published from 1970 through 1992, drew the following conclusions: (1) There was no significant difference between PBL and traditional approach on tests of factual and clinical knowledge, (2) Students from the traditional approach performed significantly better than their PBL counterparts on the National Board of Medical Examinations Part I Examination (NBMEI), (3) On outcomes that were less frequently researched (e.g. faculty attitudes, student mood, class attendance,

academic process variables), results generally supported the superiority of PBL approach over more traditional methods. Berkson (1993) in his review of literature published before 1992, had examined the effectiveness of PBL curricular over traditional methods in areas such as students' motivation, development of problem solving skills and acquisition of content knowledge, drew the conclusion that 'graduates of PBL are not distinguishable from their traditional counterparts'. Additionally, they pointed out that the practice of PBL can be stressful for students and faculty and that the cost of implementing PBL was unrealistically high. The review by Smits et al. (2002a) indicated that there was no consistent evidence to show that PBL is more superior to other educational strategies in improving doctors' knowledge and performance.

More recent reviews on the effectiveness of PBL also yielded mixed or inconclusive results. Colliver (2000), in his review of eight studies aimed at examining the effectiveness of PBL over traditional curricula, concluded that the literature either did not provide convincing evidence that PBL improved the content knowledge or clinical skills of students, or did not show significant improvement to justify the considerable resources needed to run a PBL course. Newman (2003), working with a review group in a pilot systematic review and meta-analysis using strict inclusion criteria, found that the results were mixed. In assessing the accumulation of knowledge, it was reported that out of the 39 effects studied, 16 favors the PBL intervention and 23 the control group. In measuring the improvement in practice (e.g. attitude toward practice), study by Moore at al. (1994) showed that the result favors PBL group. Of the seven effects reported by Lewis and Tamblyn (1987), two favor the PBL group. Of the nine effects reported by Grol et al. (1989) only one favors the PBL intervention group. Mamede et al. (2006) drew a similar conclusion in their studies to compare the effectiveness

of PBL as an educational intervention with conventional curricula in that the studies have yielded inconclusive results.

However, there are other studies which support the positive effects of PBL. For example, research by Distlehorst & Robbs (1998) showed that PBL students performed better in clinical assessment compared to students who were from traditional curriculum. Study by Birgegard & Lindquist (1998) demonstrated that PBL fostered critical thinking and students showed improved in attitudes. An interesting meta-analysis was conducted by Walker & Leary (2009) in which 47 PBL comparative outcomes outside the fields of medical education and allied health were used. These disciplines included teacher education, social science, business, science and engineering. This represents the first attempt to synthesize the results across various disciplines other than those in medical and related fields. The analysis showed that across almost all of these disciplines, PBL students did either as well or better than their lecture-based counterparts. PBL students from social science and teacher education in particular performed significantly better than those from the conventional curricular.

These conflicting and inconclusive results on the effectiveness of PBL as an educational strategy have prompted some researchers to suggest that the methods used for the evaluation were in most cases inappropriate and not congruent with the broader aim of PBL. For example, Van der Vleuten et al. (1996) pointed out the use of the regular multiple choice questions (MCQ) as an instrument for assessing the achievement of PBL students is inconsistent with PBL principles as most MCQ used tended to measure the lower taxonomic levels of knowledge of the students. In addition to that, they observed that the traditional MCQ tests caused the students to study to the tests. This had a negative effect on student

learning as they tended to adopt rote memorization to prepare for the test rather than to fully immersed in the PBL learning cycle. Hence, they suggested that new assessment tools or methods must be specifically designed for the PBL context. In a similar fashion, Gijselaers and Schmidt (1990) argued that if one intends to discover if an innovative educational method such as PBL works, it becomes necessary to evaluate the program based on its objectives. They pointed out that the classical approaches for measuring students achievement are concerned mainly with the achievement of content knowledge and tend to ignore the influence of the learning process and context in shaping the final outcomes of the learning experience. Following the ideas of Cooley and Lohnes (1976), they posited that learning process in the classroom is complex and there are multiple variables and the interplay of these variables has a significant influence on the outcome of the students' learning process. They developed and designed a causal model of evaluation study that assessed the causal relationships between the relevant variables and the outcomes in the PBL learning process.

The complex interplay of multiple variables was an idea that resonated with several other PBL researchers and some research in that direction was carried out to explore the relationships between the outcomes of the learning process and the various relevant variables in the PBL environment. Accordingly, some researchers argued that the trials of curriculum level interventions are quite pointless as PBL is a complex and multi-factorial learning environment and should not be treated as a uniform or pure intervention (Norman & Schmidt, 2000). In a complex and multiple variable environment such as PBL its effects on the outcomes of learning are affected by the complex interplay of these diverse variables, as a result of which it is impossible to attribute success or failure solely on the intervention. As rightly asserted by Faidley et al. (2000), PBL is "a sophisticated design that requires attention

to learner and to teacher, to content and to context."

Schmidt and Gijselaers (1990) studied the various elements in the PBL environment and came out with a theory of PBL that was based on the complex interplay of three distinct categories of variables, namely, the input variables, the process and the outcome variables. The input variables were the students' prior knowledge, the block-book (i.e. the PBL problem) and tutor behavior. It was argued that the input variables would impact the process variables of study time and group functioning and this would in turn influence the outcome variables of achievement and interest in subject matter. They developed a causal model of PBL and evaluated the influence of various variables on each other using a complex path analysis method. This was an important attempt to frame the operational theoretical constructs in PBL. In line with these constructs, various studies had been carried out to investigate how these variables affected each other in the PBL environment. For instance, Gijselaers & Schmidt (1990) demonstrated that the quality of the problem (an input variable) presented to the group influenced the functioning of the group (a process variable). Using a similar causal model, Van den Hurk et al. (2001) showed that the quality of the learning issues identified and the depth of reporting had a positive impact on the students' achievement. Schmidt & Moust (2000) discovered that group functioning affected the learning outcomes and intrinsic motivation of the students in PBL. What is clear from the above literature is that PBL environment is a complex and multi-factorial environment in which there are strong and complex interplay between various variables. As a result, a research direction to better understand how these variables interacted with each other and influenced the outcomes of the PBL process was set. The following sections outline such research trend.

2.4 Factors influencing the process of learning in PBL

2.4.1 Activation of student's prior knowledge

One important premise of PBL process is that small group interaction over the problem presented at the beginning of a PBL cycle necessitates the activation of students' prior knowledge. The activation of prior knowledge focuses the learning effort and fosters the development of new knowledge to be mastered. A blood-cell-problem study conducted by Schmidt et al. (1984) showed that students who had gone through the problem analysis phase can recall almost twice as much information about osmosis (which is the main underlying principle involved in the blood-cell-problem) compared to those who had not discussed the problem in a free-recall test. This demonstrated that problem analysis in a small group indeed has a strong activating effect on prior knowledge. A later study by Schmidt et al (1989) where the same problem was presented to a group of novices, it was discovered that when the novices' prior knowledge was activated through the analysis of a problem, they developed better understanding of the knowledge relevant to solving the problem, even if their prior knowledge may be limited or even incorrect. This research has clearly shown that the activation of the learners' prior knowledge facilitated the subsequent processing, understanding and retention of new information in the PBL process. This occurred as the nature and quality of students' prior knowledge determined what was recalled in group interactions, what hypothesis were generated and what learning issues were identified subsequently (Schmidt et al., 1995).

2.4.2 The quality of the problem

As pointed out by Schmidt and Moust (2000), there was surprisingly little research on the influence of problem on student achievement in PBL. In a study of about 240 PBL groups across four curriculum years, it was shown that the quality of the problems in the block book

used by the students greatly and directly influenced the amount of time spent for independent study, the functioning of the groups and the achievement of the students (Gijselaers and Schmidt, 1990). Clearly, these results supported the hypothesis that the quality of the problem used has great effect on the process and outcome variables in PBL. These findings suggested that the quality of the problem used enhanced the productivity of the group. Consequently, it resulted in the students spending more time in independent study which in turn raised the achievement of the students.

Meanwhile, a number of other studies attempted to provide a clearer description on the characteristics of a good PBL problem. Schmidt and Moust (2000) suggested that problems should be adapted to the knowledge level of the students and they must be transparent in that the students are aware of what is expected of them. Hmelo-Silver (2009) pointed out that the characteristics of a good PBL problem must be complex, ill-structured and open ended in order to promote flexible thinking in the learners. Apart from that, a good problem must also be realistic and resonate with the learners' life experiences and provide feedback regarding the effectiveness of the learners' knowledge, reasoning and learning strategies. The study also stressed that though the ill-structured nature of PBL problem promotes high levels of collaborative interaction among the PBL participants, they may need good facilitation for that to happen.

As PBL approaches were being implemented in other disciplines outside the medical fields, other problem types were investigated and Walker and Leary (2009) concluded that problem types did have influential effects in PBL. Two problem types in particular, namely design problems and strategic performance problems, had the greatest achievement effects on the

PBL cases studied. Though the research literature in this area was thin, the results in these studies had clearly demonstrated that the quality of the PBL problems had direct effects on the process and outcome of the PBL approach. This, as rightly highlighted by Schmidt and Moust (1995), implied that serious attention must be given to the careful design of the PBL problems. Additionally, they argued that experience with PBL has shown that it was easier to improve on the quality of the problem than to ensure consistently good tutor performance.

2.4.3 Tutor's role and facilitation in PBL

There has been considerable research on tutor's behavior, performance and roles. PBL advocates would generally agree that the tutors play a critical role in students' learning and the outcomes of learning. Many studies have clearly shown that tutor's facilitation is an important variable in determining how students learn and the outcome of their learning.

One of the early research to specifically explore the role of tutors in PBL was conducted by Gijselaers and Schmidt (1990). They postulated a causal model of PBL in which seven key variables were identified to have their differential influence on the PBL process. These seven key variables included (1) prior knowledge of the students, (2) Quality of block book (i.e. the PBL problems), (3) tutor functioning, (4) student independent study time, (5) group functioning, (6) Student achievement and (7) student's interest in the subject. Questionnaires developed under each of these key variables were given to about 240 PBL groups across the first 4 curriculum years. One of the key findings in their research was that tutor functioning had a direct differential effect on the group functioning and this in turn impacted the students' interest in the subject matter. It was also found that tutor functioning had an indirect causal influence on student achievement. These results reflected the critical role of the tutors in the PBL process. Schmidt et al. (1995) developed a rating scale based on the above causal model

of PBL and the rating scale was administered to 1800 students of the Health Sciences at the University of Limburg, Netherland. Statistical analysis of the rating scale showed that tutor performance, as predicted using the causal model of PBL, was a significant variable in the PBL process. Using a cognitive analysis, Frederiksen (1999) reported that the tutors played a significant role in facilitating an organized and coherent approach to the process of inquiry and reasoning among the members in the PBL group. Hmelo-Silver (2004) suggested that the tutor's role is critical to the success of the PBL process as tutors directly support several of the goals of PBL. She argued that PBL tutors serve by modeling good learning strategies and quality thinking skills and at the same time help the students to collaborate effectively in the group towards the construction of flexible knowledge. A study by Van Berkel and Dolmans (2006) to investigate the effects of tutors' competencies on several key variables in PBL revealed that tutors' competencies in stimulating active learning impacted positively the effective use of the PBL problem. Apart from that, the group functioning was also shown to be positively influenced by the tutors' contributions in fostering collaboration among the members in the groups by giving regular, constructive feedback to the groups. As highlighted by Hmelo-Silver and Barrows (2006), tutors play a pivotal role in the PBL process through modeling, coaching and monitoring the group functioning, selecting and implementing appropriate strategies to advance the PBL discourse.

Dolmans et al. (2002), in their review of research trends on the tutor in PBL observed that there were three major trends in the literature and there were (1) studies on the differential influence of content expert and non-content expert tutors on student achievement, (2) studies on process variables and (3) studies on the relationship between the tutor characteristics and differential contextual circumstances. Each of these trends is discussed below:

2.4.3.1 The study of differential influence of content expert and non-content expert tutors on student achievement.

Schmidt (1977) compared the achievement level of 150 PBL students from Maastricht University who were facilitated by 20 tutors randomly assigned to the PBL groups, about half of which was non expert tutors and the rest were content expert. The non-expert tutors were staff from non-medical faculties such as the social science and basic science. The study showed no difference in the achievement level of the students for their end-of-course tests. On the other hand, De Volder and Schmidt (1982) in their study of 125 PBL groups in the first four years of medical school from the same university found that the groups which were facilitated by expert tutors performed somewhat better than the students guided by non-expert tutors. The study also showed that tutors who were considered experts asked more stimulating questions and provided more explanations. A study by Swanson et al (1990) on the impacts of the tutors' professional backgrounds on student performance indicated that there was no effect of tutors' expertise on the student performance. Further studies by Schmidt et al. (1993) and Schmidt (1994) in the same university indicated that students who were guided by expert tutors performed better than students who were guided by non-expert tutors. Similar studies by other researchers elsewhere on expert and non-expert tutors also pointed to inconclusive results (Schmidt & Moust, 2000)

At the same time, there were studies done on comparing staff and student tutors on students' achievement. Almost all of these studies were conducted at Maastricht University where advanced undergraduate students were hired as tutors for PBL students from different schools such as the health sciences, law and economics programs. Essentially, the results were inconclusive as well (Schmidt & Moust, 2000). For instance, in a study by De Volder et al.

(1985) where 17 students facilitated groups were compared with 28 groups tutored by the academic staff in three consecutive courses in health sciences, the results showed significant differences favoring staff tutors in one course but no differences in the other two. Similarly, a study by Moust et al. (1989) indicated mixed results. Swanson et al. (1990), in their investigation of the achievement of PBL groups facilitated by staff and students revealed that there was no difference in the students' achievement. Schmidt et al. (1993) studied the exam performance of 334 PBL groups guided by staff tutors and 400 groups guided by student tutors in the health sciences program. The results indicated that the students guided by the staff tutors performed slightly better. However, the difference was statistically small. In a study by Moust and Schmidt (1994) to evaluate the effects of staff and students tutors on student achievement from the faculty of Law where the students' level of academic achievement was tested by essay questions, no differences in the students' level of academic achievement was recorded. Regehr et al (1995) conducted a study of the effect of tutors' content expertise on student learning, group process and participant satisfaction, reported that there was no significant difference between groups led by the expert and non-expert tutors. In short, these studies have drawn inconclusive or mixed findings in terms of the students' achievement.

Some attempts were made to explain the seemingly contradictory findings. Schmidt et al. (1993) outlined three major reasons. Firstly, it may be related to the poor definition of what constituted subject-matter expertise. In some studies a very stringent definition of subject-matter expertise was used. For instance, in the study conducted at the University of Michigan, only those who had an active research interest in the specific topic studied by the students were considered content experts. It was doubtful if such a definition was necessary to

understand the effective role of the tutors in PBL. On the other hand, some researchers used rather broad qualifications to differentiate between content and non-content experts. Consequently, the analysis may lack the sensitivity to detect possible differences in the tutors. Such an explanation was also noted by Davies et al. (1994) in their study of the effects of content-expert tutors and non-content expert tutors on student achievement and the results showed no significant difference between those groups led by the expert tutors. They highlighted the fact that their classification of content and non-content experts may have led to the inconclusive findings as all the tutors can be classified as expert tutors by virtue of their training since they were all faculty members from the departments of family practice, internal medicine, microbiology and immunology, pathology, and pediatrics.

Secondly, Schmidt et al. (1993) argued that the inconclusive results may due to the magnitudes of the samples studied. According to the researchers, most of the studies focused on one single unit or even part of a unit rather than an entire year. In such situations, even if the subject-matter expertise did make a difference, such contributions would be limited and may not be noticeable. Finally, the researchers reasoned that in cases that did not report differences, it may be that the expert tutors did not behave any differently from the non-experts because in many PBL courses, tutors were discouraged from using their expert knowledge to intervene the learning process. To support their claims, Sherbrooke study in Canada was quoted as an example. In the study, students rated the facilitative behaviors of their tutors and it was found that out of the seven critical behaviors of the tutors, only one of which was found to be significantly different. This suggests that the expert tutors behaved very much the same way as the non-expert tutors in some situations. A study by Schmidt (1994) found that other variables in the PBL environment such as the students' prior

knowledge and the levels of structure in the course did have an impact on student achievement. He argued that such findings could potentially explain why in some studies on the effects of expert tutors did not yield positive results. This is because in some well-structured PBL courses, students relied less on the tutors for their learning and under such circumstances, the influence of the expert tutors would be minimal. Two important studies conducted by Davis et al. (1992 & 1994) seem to point to the same direction. In an earlier study, Davis et al. (1992) discovered that students who were led by expert tutors achieved better results than students who had non-expert tutors. In a follow-up research, Davis et al. (1994) investigated the efficacy of a well-designed and highly focused PBL case in removing the influence of content expert, found out that there was no significant difference in the performance between the 13 groups led by the content expert tutors and the other 14 groups led by non-expert tutors. The result supports Schmidt's (1994) explanation for the lack of positive results in some studies on the effects of expert tutors on student achievement as students in highly structured PBL courses tended to rely minimally on the influence of the expertise of the tutors. Davis et al.'s research also showed that there was no difference in student satisfaction between the groups led by expert and non-expert tutors. Students were highly satisfied with the learning experience in both groups.

In summary, the research outcomes of expert and non-expert tutors on student achievement indicated non-conclusive or mixed results. As a result, there was a shift among the researchers from outcome-oriented research to pay more attention on the impact of expert and non-expert tutors on the process variables in PBL and the findings of which are described in the paragraph below.

2.4.3.2 The study of differential influence of content expert and non-content expert tutors on process variables in PBL.

These studies focused on the effect of content expert and non-content expert tutors on the PBL collaborative process and its outcome. A study was conducted in 1988 at Harvard Medical School during which an interdisciplinary course using a PBL curriculum was facilitated by expert and non-expert tutors (Silver & Wilkerson, 1991). Data analysis revealed significant differences in the nature of the tutors' comments, the use of tutorial time, the patterns of tutorial interaction, and the tutors' roles when the groups were facilitated by expert and non-expert tutors. In groups which were facilitated by expert tutors, student-student interactions occurred less often and tutor-student discussion dominated the process. It was also observed that expert tutors tended to take on a more directive role in guiding the discussions in that they spoke more often and for longer durations. Apart from that they were also quick to provide more direct answers and suggested more items for discussion. Drawing from this analysis, the researchers highlighted a potential pitfall of having expert tutors who may not be aware of the effects of their own intervention and authority in shaping the learners in the PBL process. For instance, a shift from a more student-student interaction to tutor-student interaction may create a less optimal learning environment for the development and acquisition of self-directed learning skills for the students. Hence, the educational benefits of PBL may be lost. A study by Davis et al. (1992) to compare the percentage of student-initiated and tutor-initiated activities found that there were no significant differences between the groups led by expert tutors and those led by non-expert tutors. On the other hand, Eagle et al. (1992) claimed that, across 35 simulated patient case encounters of which 24 of the groups led by non-expert tutors and 11 of the groups by expert tutors, the groups led by the expert tutors generated twice as many learning issues per case compared to the groups

facilitated by the non-expert tutors. Besides that, the issues identified by the expert tutors were three times more compatible with the curriculum objectives. The research also found that groups which were led by expert tutors spent approximately twice as much time per case in addressing their learning deficiencies.

Davis et al. (1994) found that in a more focused and structured PBL case, a significantly larger percentage of the interaction (25.8% of the total group time) was given to tutor-initiated activity in groups which were led by expert tutors in comparison to student-initiated activity in the non-expert tutors groups (11.4% of the total group time). These findings were rather unexpected because it was reasoned that the non-expert tutors would have used more teacher-directed behavior to direct the discussion using the additional information provided in the more focused case. The outcomes of this study also showed a significant increase of the amount of teacher-directed discussion (25.8%) as compared to their earlier study (Davis et al., 1992) where only 15.5% of the group time was devoted to teacher-directed discussion.

Dolmans et al. (2002) concluded that though the studies on process variables did not provide conclusive results, it can be seen that in general, the content expert tutors tended to be more directive and they used their subject-matter expertise to drive the facilitation process while the non-expert tutors tended to use their process- facilitation expertise more in guiding the groups. More importantly, these inconclusive results also point to the complexity of PBL learning environment where multiple variables tend to influence each other to affect the learning outcome and the functioning of the group. Also, it can be clearly seen that the behavior of the tutors is not a stable characteristic but is influenced by the differential PBL contextual circumstances such as the level of structure of the PBL process and the focus of

the case. The effects of differential contextual circumstances on the tutors' behavior are the focus of the following section.

2.4.3.3. The study of the influence of differential contextual circumstances on tutor characteristics.

Barrows (1985) is one of the earlier researchers to claim that faculty members who are good tutors can successfully facilitate in any course. As pointed out by Gijselaers (1997), implicit to such a claim was the assumption that tutor behavior is a stable characteristic under any contextual circumstances. In other words, it was assumed that PBL tutors will demonstrate identical tutor behavior despite the fact that these tutors may be facilitating student learning in diverse contexts such as group compositions, group sizes, level of structure in the PBL curriculum, students' prior knowledge, and so on. Gijselaers (1997) argued that several studies on teacher behavior in different classroom environments had shown that teachers tended to respond differently under different situations. Hence, he reasoned that PBL tutors are likely to respond and behave differently in different situations and that their tutor behavior is not a stable characteristic but will vary depending on the demands of the contextual circumstances. As such, there was a need to conduct some in-depth studies on the effects of contextual circumstances on tutor behavior. In a major study conducted at the University of Maastricht in the Netherlands, Gijselaers (1997) investigated the stability and generalizability of the tutor behavior of 427 faculty members of the medical school across 25 PBL courses over a period of eight consecutive years where evaluation data were collected from 2,299 PBL groups. In this study, stability is seen as the extent of correlation of a tutor's behavior as measured in one course compared to the same measure in a different course and generalizability refers to the extent that measures of tutor behavior are stable across courses. The result showed that the stability and generalizability of tutor behavior was low across the

different PBL groups. This provides strong evidence that tutor's behavior is an unstable characteristic and is influenced by the contextual circumstances. However, the research did not investigate what those contextual circumstances were. Another aspect of the study was to address the issue if tutor behavior was affected by departmental affiliation. It was discovered that tutor behavior was weakly to moderately related to departmental affiliation. Again, the study did not explore specifically what were the factors responsible for the differences in tutor behavior.

A review conducted by Neville (1999) concluded that the degree of tutor content knowledge that was necessary for effective student learning varied in different PBL environment. Drawing from a study by Schmidt (1994), he concluded that when the level of structure of a PBL course was low and the students lacked the appropriate prior knowledge of the subject being addressed, the leadership of the tutors played a critical role in the student learning process. On the other hand, as the students matured and became more familiar with the PBL process, the tutors would delegate more and students took more leadership in shaping the learning process. In other words, novice students in PBL need more guidance and direction from the tutors but as they acquire the skills of an expert learner, they can flourish in a less structured learning environment. According to Savin-Baden (2003), her many years of involvement in training and coaching PBL tutors have caused her to conclude that tutor's behavior is not a constant characteristic but is affected by the learners and the their learning contexts. Drawing from the concept of ecologies of practice (Stronach et al., 2002), Savin-Baden (2003) concluded that it would be more productive to study the tutor's role in the ecologies of practice.

Other research that is closely related to the influence of contextual circumstance on tutors includes the study on the effects of contextual circumstances on tutor performance or evaluation. Dolmans et al. (1999) conducted a study on the influence of the productivity of the PBL groups on tutor performance. 136 tutors with each of them ran two groups per unit were rated in their performance by the students and the ratings were analyzed for their discrepancies across the two groups. It was discovered that 39% of the tutors were found to have discrepancies in their tutor performance across the two groups. Additionally, it was observed that when a discrepancy tutor (tutor who was rated differently by the students) was given a low and high tutor performance across the two groups, the low performance rating corresponded with low group productivity score in the same group and the high performance rating corresponded with high group productivity score in the same group. This clearly is an indication that the tutorial group's productivity has differential effects on the tutor's performance. These findings indicate that groups with low productivity require much more input and scaffolding from the tutors and groups that are highly productivity tend to rely less on the competency of the tutors. Thus, tutor performance as evaluated by the students will vary with the productivity of the PBL groups.

To summarize, research on the influence of contextual circumstances on tutor characteristics indicated that there were several key differential contextual circumstances and these included (1) the focus of the problems, (2) structure of PBL courses, (3) students' level of prior knowledge and, (4) the productivity of the tutorial groups and (5) students' familiarity with the PBL process.

2.5 The skills and strategies of effective PBL tutors

One area of research on PBL tutors revolved around the skills or profile of effective tutors and the strategies they used to affect learning in the PBL groups. If the key role of PBL tutors was to scaffold the learning process then it was argued that there must be identifiable tutor skills that could effectively scaffold the student's learning process. This area of research attempted to identify such tutor skills and strategies.

A study by Wilkerson (1994) of first year student ratings of PBL tutors at Harvard Medical School in 1987-1988 indicated that tutors were seen as most helpful when they promoted critical appraisal of information, questioning and probing the reasoning process, and provided balance between basic science and clinical discussions. Dolmans et al. (1994) in developing a rating scale for tutor evaluation concluded that three factors were critical to effective tutoring and there were (1) guiding students through the learning process, (2) content knowledge input and (3) commitment to the group learning.

A major study undertaken by Schmidt and Moust (1995) provided further insight into tutor effectiveness. The key purpose of the study was to test the theoretical model for an effective tutor which was proposed by Moust (1993) in his earlier research. A key concept in Moust's theory was that cognitive congruence is a necessary condition for effective tutoring. A tutor who exhibits such behavior is able to express oneself in language and concept that connect with the students and frame his contributions at a level that meets the students' understanding. In order to achieve that, a tutor must display social congruence and possess subject-matter expertise. Social congruence is a tutor's willingness to act informally with students and display an attitude of personal caring and interest in their lives and learning. Without social

congruence, it would be difficult for the tutor to put oneself in the shoes of the students and be able to anticipate and understand the challenges that the students are going through while engaged with the PBL problems. On the other hand, subject-matter knowledge would allow the tutor to ask appropriate questions that are relevant to the subject being discussed. Therefore, according to Moust (1993), both subject-matter expertise and social congruence are necessary conditions for cognitive congruence to happen. In Schmidt and Moust's (1995) research, data from 524 tutorial groups in the University of Limburg's health sciences curriculum was collected and analyzed using a structural-equations modeling approach. The results showed that the theoretical model of the effective tutor fitted the data extremely well. This indicated that effective tutoring necessitated three distinct qualities and they were (1) the possession of a suitable subject-matter knowledge, (2) a willingness to become involved with students in an authentic way and (3) the skill to frame one's contributions in language that makes sense to the students. The study had demonstrated that these three skills were interrelated and they positively impacted the PBL's group functioning, students' independent study time and student achievement. Another key contribution of this research was the merging of two different views regarding effective tutoring. One of such views emphasizes the importance of the tutor's ability to empathize and relate informally with the students and in the process creating a conducive learning environment where students feel free to share and exchange ideas. The other view puts the emphasis on the tutor's subject-matter expertise as a critical factor in determining the students' learning as discussed in the earlier section. The results presented in the research, however, have clearly suggested that both skills are indeed needed.

De Grave et al. (1999), however, argued that though the concept of cognitive congruence did provide some helpful insights on effective tutoring, it did not provide enough specific information about the kind of tutor intervention that makes the tutoring process impactful. Hence, there was a need to develop a more specific profile that could be used to determine the variations in tutor effectiveness. An instrument based on the theory and research on PBL and co-operative learning called Tutor Intervention Profile (TIP) was developed and it contained four key dimensions of tutor behavior and they included (1) stimulating elaboration, (2) directing the learning process, (3) integration of knowledge, and (4) stimulating interaction and individual accountability. The first two dimensions dealt with tutor interventions in the PBL group before the students engage in independent study and the last two dimensions were interventions used during the reporting phase when students re-group after the independent study. The instrument contained 33 statements of tutor behavior under the four stated dimensions. In the study, the instrument was rated by the students for 67 tutors across three courses and, as expected, the results showed that the tutors who were perceived to be most effective received high scores for each of the dimensions of tutor interventions. Another study to investigate the facilitator's skills was conducted by Koschmann et al. (1999). In the study they analyzed a segment of the interaction in a PBL meeting and they concluded that several moves were initiated by the facilitator to scaffold the participants' elucidation of the theory that they used to explain the patient's medical problem. One of the facilitator's moves that was significant was reformulating or re-voicing what students said in a way that moved the interaction forward. Frederiksen (1999) reasoned that the facilitator's actions ensured that the group's elaboration of the theory was organized and coherent.

Enlisting the help of an expert facilitator, Hmelo-Silver and Barrows (2006) designed a study which aimed at understanding the goals and strategies of the expert in facilitating the PBL process. The participants in this study were five third-year medical students who have had two years of PBL experience in a medical curriculum. They were facilitated by a master facilitator (the second author of this study) for a total of five hours over two sessions of 2.5 hours each. The sessions were videotaped and transcribed and the data were analyzed using a combination of interaction analysis and stimulated recall technique. The results revealed that the strategies of the expert facilitator were consistent with his overall goals for student learning. The key strategies employed were: (1) pushing for explanation; (2) re-voicing, in which the facilitator restated what the students said; (3) summarizing; and (4) generating hypotheses. The facilitator also took advantage of the PBL routine and gave more focus to the learning process. For instance, the facilitator asked the students to re-evaluate their hypotheses written on the whiteboard and encouraged them to match their hypotheses with the patient data that they were given. There are a couple of important contributions from this research. As reasoned by the researchers, being able to articulate a set of key strategies that foster student learning in PBL is an important step towards helping new PBL facilitators learn the art of facilitation. The study also reveals that a tutor's strategies are heavily influenced by the beliefs and learning goals of the tutor. This is clearly demonstrated by the expert tutor's overall strategy and made explicit by the tutor's comments through stimulated recall session. Driven by his beliefs about the importance of student reasoning and the learners assuming their responsibility for learning, the expert tutor tailored his strategies carefully and intentionally to steer the learning process in that direction. In other words, a tutor's behavior and leadership throughout the PBL process is not merely a response to the contextual circumstances but is also strongly driven by the tutor's beliefs about learning. Obviously, this

has important implication for the training and development of faculty members to be effective PBL tutors.

A study that built on the same set of data was done by the same researchers (Hmelo-Silver and Barrows, 2008). In the study, they analyzed and categorized the questions used by both the tutor as well as the students to create opportunities for the process of collaborative knowledge building. Using the question taxonomy developed by Graesser and Person (1994), they found that the tutor asked a total of 343 questions and out of that, 11% belonged to the short-answer questions where they were directed to focus the student attention, 13% long-answer questions to push for clarification and elaboration, and the rest (75%) were meta questions meant to evaluate hypotheses, check understanding, and monitor group functioning. In short, their findings showed that the facilitator supported the process of knowledge building largely through asking open-ended metacognitive questions as he guided the students to progressively advance their collective understanding of the problem they were dealing with. The study also indicated that the facilitator never made any evaluative comments other than to occasionally guiding the students to realize that the ideas they were working on might need to be a learning issue for further research. However, Zhang et al. (2010) argued that the questioning framework used in Hmelo-Silver and Barrows' study would not be as appropriate for a collaborative PBL context as the framework was developed from a one-to-one tutoring setting originated from the research conducted by Graesser and Person (1994). Hence, there was a need to develop a new questioning framework that is sensitive to the PBL context. Another interesting feature about the research undertaken by Zhang et al. (2010) was that the PBL setting was outside of the medical education. Data were collected from the PBL facilitation process of two groups of in-service teachers who were

engaged in a professional development program to improve their content and pedagogical knowledge. The study showed that, to stimulate productive interactions and to advance discussion in the groups, tutors asked the following types of questions: (1) questions to solicit ideas to start, continue or redirect a discussion; (2) questions to reframe ideas to formulate hypotheses and learning issues; (3) questions to clarify ideas; (4) questions to push for elaboration; and (5) questions to check for interpretation. This study also provided an interesting comparison to that conducted by Hmelo-Silver and Barrows (2008) in which the PBL students were experienced PBL learners, whereas the students in Zhang et al's (2010) research were new to PBL. In the study by Hmelo-Silver and Barrows, 5% of the tutor's questions were used to help the students formulate the learning issues for self-directed learning. On the other hand, in Zhang et al.'s (2010) study, 21% of the tutors' questions were reframing questions aimed at assisting the students to generate their learning issues. The findings from these two studies agreed with the study of the influence of differential contextual circumstances on tutor characteristics (see section 2.4.3.3). These findings implied that when the PBL learners are new and unfamiliar with the PBL discourse, more scaffolding from the tutor is needed. However, as the students gain more experience and skills in the PBL process, they assume the role of expert learners and with less prompting from the tutor. The results from Zhang et al. (2010) also showed that many of the questions asked by the tutors were contingent on the students' comments and ideas (67% of the total questions asked). They drew the conclusion that effective tutors ought to be flexible in their strategies for tutoring and must be able to respond to the learning situations on the fly. Another key finding from this study was that different types of facilitation questions have different functions and they suggested a sequence of questions that the facilitator can use to advance and deepen the thinking of PBL participants. For instance, facilitators can access the participants' initial

thinking by asking questions to solicit their ideas, followed by clarifying questions that push for clear articulation of ideas and eventually deepen their thinking by getting the participants to explain or elaborate their opinions.

In a recent study conducted by Pourshafie and Murray-Harvey (2013), a thematic analysis of 63 pre service teachers' reflective written responses on the subject of effective facilitation drew the conclusions that there were three pre-requisites for effective facilitation and these included (1) the facilitators' attitude conveying belief in the capacity of learners; (2) the facilitators assuming a humble posture of learning and (3) the facilitators' abilities to create environments which were conducive to participation and mutual support through scaffolding and group work. The paper also suggested that to the extent that a PBL facilitator is able to integrate these three qualities, the PBL will be a rich learning experience for both the facilitator and participants.

To sum, the major contributions from these studies included the articulation of specific skills, particularly the skills to ask different types of questions as well as the strategies of the effective tutor to stimulate productive interactions. The instruments developed, for instance the TIP and the rating scale for tutors, are potentially helpful for the training and development of faculty members who are involved in tutoring the PBL process. The findings from the research also showed that PBL environment is extremely complex in that different PBL contextual circumstances would require tutors to draw from a wide repertoire of strategies and skills to respond strategically to optimize the student learning and the accomplishment of PBL goals.

Hmelo-Silver (2009) pointed out that as PBL advances into different educational contexts other than the medical and health sciences, one important issue of tutor involvement will be one of scale. She suggested that the medical school environment where each PBL group has a dedicated tutor might not be possible in many other educational contexts. In her research, she reported the successful use of a wondering facilitation model where the facilitator moved from group to group, adjusting the time spent for each group according to the needs of the group. More research in this area is needed in this area.

2.6 Collaboration in PBL groups

Collaborative groups are a key feature in PBL (Hmelo-Silver, 2009). Though group functioning in PBL groups has shown to be a critical variable in the causal model of PBL and that helping the group members to be good collaborators is one of the key PBL goals, there has been little direct research in this area (Hmelo-Silver, 2009). Instead, the research has mainly focused on the factors which affected the collaboration or the effects of collaboration among the PBL group members. De Grave et al. (1984) conducted an experiment in which the problem of osmosis was analyzed individually and in a small group. It was discovered that the small group discussion had a larger impact on the activation of prior knowledge than individual analysis. However, the study did not investigate how small group collaboration resulted in better activation of student prior knowledge. Prinz et al. (1998) developed an interesting technique for assessing tutors and students' activities in tutorial groups. A portable stereophonic audiotape recorder was used to record the PBL sessions. The tutor's activities were recorded in one channel and the students' activities were recorded in the other channel. A computer program was used to generate automated analysis of the activities, given the relative amount of speech on each channel. The technique was found to be useful in

providing quick feedback to tutors. However, it did not provide helpful information to assess the quality of the interactions in the tutorial groups. Lohman and Finkelstein (2000) investigated the effect of group size on the quality of the group collaboration. 12 PBL groups were given the same case and the students and tutors were randomly assigned to the groups. four groups consisted of three students each, six students each, and nine students each met once a week for two hours over a period of weeks. Data collected shown that the degree of self-directedness was higher for small and medium size groups and quality of discussion was rated higher among members from the small and medium size groups than the big size groups. The researchers argued that when the group size was big, members in the groups had less opportunity to contribute their ideas and to participate fully.

A questionnaire based on the theories of collaborative learning was developed and validated by Visschers-Pleijers et al. (2005a) and three dimensions were identified and showed a good fit with the data. These factors were exploratory questioning (open questions, critical questions, verification questions, alternative arguments), cumulative reasoning (arguments in general, arguments reason, continuous arguments), and handling conflicts (conflicts about knowledge, negations, counter-arguments). Data also revealed that, from the students' perception, exploratory questioning was the best predictor regarding the productivity of the PBL groups. However, it was found that counter-arguments and contradiction in the subject did not play a crucial role in accounting for the variance in the productivity of the groups. This was rather disappointing as the researchers had expected that these two factors would contribute toward a rich context for advancing the group interaction. They argued that it was likely that the students perceived contractions as confusing and felt insecure to handle them. In a separate study (Visschers-Pleijers et al., 2005b) where the same set of questionnaire was

used and students were asked to rate the occurrence and desirability of the items in the questionnaire, it was found that negations and alternative arguments occurred least often in the group interactions and the desirability score on conflicts about knowledge was lower the score for the occurrence. These results affirmed the argument that students generally do not respond constructively to conflicts or contradictions as they feel insecure in confronting those conflicts.

2.7 Cognitive process and collaborative knowledge building in PBL

Conceptual change in students is considered an indication of knowledge construction. In a study to capture the conceptual change in students in the PBL process, De Grave et al. (1996) discovered that whenever a student experienced a cognitive conflict between her initial theory and the data that was given, it created a rich context for interaction and building of alternative theories. In the same study, it was also reported that the quality of the alternative theory proposed (especially its scope, simplicity and fruitfulness) played a crucial part in fostering meaningful interactions that promoted conceptual change in students. In a study conducted by Visschers-Pleijers et al. (2004), they analyzed the group interactions in a PBL setting using a coding system developed by Van Boxtel (2000) and the results showed the presence of elaborations and co-constructions, which were the key indicators of individual and collaborative knowledge construction respectively in the collaborative setting. De Grave et al. (2005), using the stimulated recall procedure, analyzed the thinking processes of individuals in the PBL group, concluded that the PBL process induced cognitive conflict which led to students' conceptual change.

Though these preliminary studies have shed some light on the nature of the cognitive processes and knowledge building in the PBL environments, they, as rightly pointed out by Hmelo-Silver and Barrows (2008) only focused on a tiny segment of the PBL meeting and did not integrate the different levels of analysis needed to fully understand the process of collaborative knowledge building. For instance, the study performed by Visschers-Pleijers et al. (2004) were confined to the three brief slices of the reporting phase of the PBL cycle and the process of elaboration and co-constructions were studied independently and there was no integration of these analysis to provide a more complete understanding of how these processes work together to contribute towards collaborative knowledge building. Consequently, as Hmelo-Silver and Barrows proceeded to argue, it was difficult to derive pedagogical implications from such analysis. They proposed that in order to examine the process of knowledge building, a larger time scale comprising a full problem is needed. This kind of big grain analysis would provide a larger context for which the process of knowledge building can be better understood. In order to perform a big grain analysis of a PBL process, Hmelo-Silver and Barrows (2008) examined episodes of knowledge building discourse in a PBL group which consisted of five second-year students who were familiar with the PBL process and led by an expert tutor (the second author: Barrows). Through the use of multiple methodologies, they showed that the PBL discourse resulted in the creation of a conceptual artifact which represented the participants' causal explanation for the problem under discussion. It was found that the tutor as well as the students shared responsibility for the process of knowledge building. As discussed in Section 2.4.3, the tutor helped support progressive discourse by asking many open-ended questions, and offered few ideas. This was done through the use of various questioning tactics that helped the PBL participants to realize the limits of their understanding and helped them to problematize their ideas. It is interesting

to note the tutor never made evaluative statements other than occasionally guided the students to identify the key learning issues for further research. On the other hand, the students actively monitored their own thinking and progress. They spent a great deal of time and effort in constructing a rich problem representation. They built on each other's ideas and progressively developed a shared understanding of the problems at hand. The researchers concluded that knowledge building in PBL discourse was characterized by (1) building a deep understanding of a problem, (2) asking questions which promote deep thinking and (3) continual efforts to refine and improve ideas shared by the group.

2.8 Conclusion

The review of the literature points to some important findings in PBL research and helps shape the research direction for the future. It is clear that PBL is a complex, multi-factorial learning environment and there are strong, complex interplays between these factors. In other words, these factors contextually influence each other and affect the process and outcome of PBL. Though the study of these factors and their characteristics do provide us with helpful insights regarding the process of PBL, there is greater awareness that PBL research ought to be framed around established learning theories or constructs. Key researchers such as Dolmans et al. (2005) and Hmelo-Silver (2009) have called for future research to be grounded on major theoretical constructs. Additionally, Hmelo-Silver and Barrows (2008) also highlighted that there is a need to investigate the cognitive and social processes in PBL tutorials as there have been very few detailed studies in these areas.

Research in the last decade has indicated that PBL as a learning strategy is strongly underpinned by constructivist theory. Hence, it has become increasingly clear that future

research in PBL ought to be more theory driven. Indeed, this is crucial for developing a deeper understanding of how the construction of knowledge works in a PBL setting. Such understanding will help bridge the gap between theory and practice in PBL so that the future design, improvement and development of the PBL strategy and environment can be underpinned by informed theoretical understanding.

CHAPTER 3: RESEARCH METHODOLOGY

The philosophical orientation of this research is grounded in the interpretive paradigm (Merriam, 2009). The interpretive paradigm suggests that reality is socially constructed and hence there is no single interpretation of reality but rather "there are multiple realities, or interpretations, of a single event" (Merriam, 2009, p. 8). The word constructivism is often used interchangeably with interpretivism. The constructivist nature of interpretive research is well described by Creswell (2007):

> In this [interpretivist] worldview, individuals seek understanding of the world in which they live and work. They develop subjective meanings of their experience…These meanings are varied and multiple, leading the researchers to look for complexity of views…Often these subjective meanings are negotiated socially and historically. In other words, they are not simply imprinted on individuals but are formed through interaction with others (hence social constructivism) and through historical and cultural norms that operates in individuals' lives.

In short, as Merriam (2009) highlighted, interpretive researchers are interested in "understanding the meaning people have constructed, that is, how people make sense of their world and the experiences they have in the world" (p. 13). Table 3.1 summarizes the epistemological perspective of interpretive research:

As discussed in Chapter 1, the purpose of this study was to develop a deeper understanding of the phases of social interactions which lead to the social construction of knowledge in a PBL setting. A number of researchers had argued that the PBL process is

Table 3.1 Epistemological perspective of interpretive research (Merriam, 2009)

	Purpose	Types	Reality
Interpretive Research	Describe, understand, interpret	Phenomenology, ethnography, hermeneutic, grounded theory, naturalistic/qualitative	Multiple realities, context-bound

consistent with constructivism (Hendry et al., 1999; Schmidt et al., 2000; Savery and Duffy, 2001, Dolman et al., 2005; Pelech, 2008), suggesting that a successful PBL process should foster the construction of new meaning or new way of interpreting the experiences of the PBL participants. However, the evidence to validate such a claim is thin and indeed there have been few studies which provide a detailed understanding of the social and cognitive processes of PBL (Hmelo-Silver, 2008). Hence, this research undertook to examine the social processes of the PBL participants and sought to understand in what ways or under what circumstances did the social construction of knowledge occur. As the focus of this study was to learn about how a process has occurred (social construction of knowledge) and in what ways the participants went about constructing a reality of the problem they were dealing with, interpretive research was selected as the methodology for this research.

3.1 Design and implementation

3.1.1 Interpretivist lense

The design and implementation of an interpretive research is grounded in the ontological, epistemological and methodological tenets of interpretive paradigm. As discussed above, the interpretive paradigm assumes multiple realities and these realities are context-bound. According to Merriam (2009), there are four characteristics which are key to

understanding the nature of interpretive research and these include (1) the focus of interpretive research is on process, understanding, and meaning; (2) the researcher is the primary instrument of data collection and analysis; (3) the product is richly descriptive and (4) the process is inductive.

This research demonstrated all the four characteristics mentioned above in that the focus of this study was to examine the process of social construction of knowledge among the participants in the PBL setting and sought to understand in what ways or under what circumstances did the process of social construction of knowledge occur (the first characteristic). In this study, the researcher served as the primary instrument for all data collection and analysis (the second characteristic). The product of this study was richly descriptive as it described in details the research context, the participants involved and the data collected from various sources such as the video and audio recording of the participants' PBL sessions, the participants' individual journal reflections as well as the electronic book which chronicled the participants' on-going experience throughout the course (the third characteristic). Finally, the process of this study was inductive in that the implementation of this research was not to verify the constructivist theory of learning which underpins the PBL process; rather the theory was used to frame and examine the process of social construction of knowledge. Additionally, the codes for the categories and sub-categories were introduced as the data emerged. The framing of this study and the emergent approach to the coding process are discussed in details in the section below.

3.1.2 Role of theory

Qualitative research is inductive in nature; that is, researchers often gather data to build concepts, hypotheses or theories rather than to test theories deductively as in positivist research. Merriam (2009) emphasized that "often qualitative researchers undertake a qualitative study because there is a lack of theory or an existing theory fails to adequately

explain a phenomenon" (p. 15). However, that does not imply that "the qualitative researcher has a blank mind bereft of any thoughts about the phenomenon under study" (p. 16) and she went on to stress that "all investigations are informed by some discipline-specific theoretical framework that enable us to focus our inquiry and interpret the data" (p.16).

This study drew on the theory of social constructivism. It was argued that the PBL environment is essentially a constructivist learning environment in that the participants' learning is situated in the context of a real life, complex problem whereby they have to wrestle through multiple perspectives that lead to the social negotiation or collaborative co-construction of new meaning and shared understanding of the problem they are dealing with. Hence, the PBL process is underpinned by social constructivism. It is important to note that the design and implementation of this study was not to deductively test the theory as it might be in an experiment; rather the use of the theory was to provide a useful framework to detect and examine the process of social construction of knowledge as it occurred in the PBL setting.

With this in mind, Stahl's (2000) phase model of collaborative knowledge building processes (Appendix 1) was used as an initial framework to guide the selection of a suitable research site where it was most likely to contain exchanges representing the social construction of knowledge. Besides that, Stahl's model of collaborative knowledge building was also used to frame the initial analysis process. As the data emerged, it was discovered that there were some limitations in Stahl's model as the phases identified in the model were too broad and lack specificity in detailing the moves that advanced the interaction from one phase to another. As a result, Gunawardena et al.'s (1997) Interaction Analysis Model (IAM) (Appendix 2) was used to frame the initial coding. The key factor

which influenced the choice of IAM as a guide for the initial analysis was that the model was developed using the social constructivist framework to examine the social construction of knowledge in a computer-mediated debate. In other words, the IAM seemed to have a good match with the constructivist learning environment in the PBL discourse. As data emerged, new categories of phases of interaction and operations describing the participants' cognitive activities within a phase had to be introduced in order to accommodate the new patterns and themes that emerged. In the event if the data was inconsistent with IAM, a different framing would have been used (as had happened to Stahl's). Through an iterative process, the IAM was modified and this modified version of IAM (mIAM) represented the different phases of interaction that had occurred in the process of social construction of knowledge in the PBL discourse. The process is outlined in Figure 3.1:

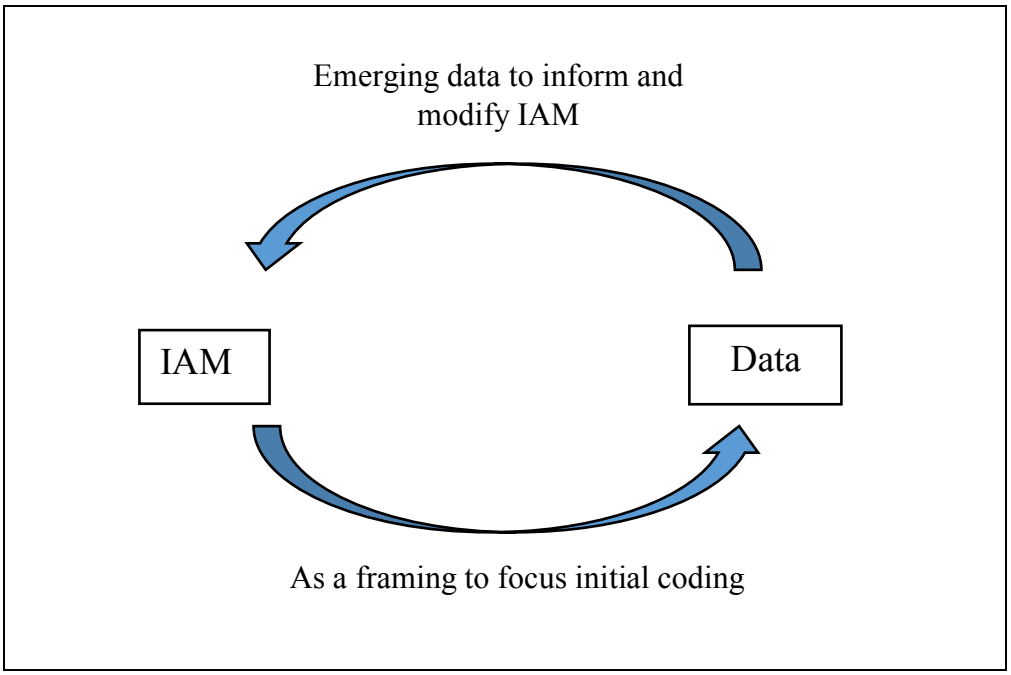

Figure 3.1: The iterative process to inform and modify IAM

In this regard, the framework was not used to guide a deductive design but to frame the initial analysis of the discourse. Additionally, several conclusions in the form of major themes and tentative hypotheses regarding the complexity of the problem, the role of

facilitation and the collaborative efforts of the PBL participants were derived from the empirical data that emerged, and not prior to the study. This is consistent with Merriam's (2009) conclusion that:

> "Typically, findings inductively derived from the data in a qualitative study are in the form of themes, categories, typologies, concepts, tentative hypotheses, and even theory about a particular aspect of practice" (p. 16).

3.2 Sampling

Merriam (2009) pointed out that there are two basic types of sampling and there are probability (of which simple random sampling is the most familiar example) and nonprobability sampling, the most common form of which is called purposive (Chein, 1981) or purposeful (Patton, 2002). The goal of probability sampling is to allow for statistical generalization and since statistical generalization is not the goal of interpretive research, the most appropriate sampling strategy for interpretive research is nonprobability sampling.

According to Merriam (2009), purposeful sampling is also necessary as the researcher "wants to discover, understand and gain insight and hence must select a sample from which the most can be learned" (p. 77). Similarly, Patton (2002) argues that

> The logic and power of purposeful sampling lies in selecting information-rich cases for study in depth. *Information-rich* cases are those from which one can learn a great deal about issues of central importance to the purpose of the Inquiry, thus the term *purposeful* sampling (p. 230, emphasis in original).

A number of scholars (Creswell, 2007; Miles and Huberman, 1994; Patton, 2002) have identified several types of purposeful sampling and the common ones are (1) typical sampling; (2) unique sampling; (3) maximum variation sampling; (4) convenience sampling; (5) snowball or chain sampling; (6) theoretical sampling; (7) criterion sampling and (8) combination or mixed sampling.

3.2.1 Site selection and participants

In this study, the process of social construction of knowledge was investigated in the context of a PBL environment. This necessitated a purposive sampling with the primary criteria being the participants were engaged in the PBL process. Literature review, as highlighted in Chapter 2, provided the guidelines for identifying a PBL site that would be suitable for this research. Barrows (1996) suggested that a core PBL model has the following general characteristics: (1) learning is student-centred, (2) learning is facilitated in a small group, (3) the tutor functions as a guide, (4) real life problems are the starting point for learning before any preparation or study has occurred, (5) the skills and knowledge that are required to solve the problems are acquired in context and (6) new information is gathered through self-directed learning. Dolman et al. (2005) drew a similar observation and proposed that there are essential features in a PBL process and they are (1) realistic problem being used as a stimulus for learning, (2) tutors function as facilitators to scaffold students' learning and (3) collaborative environment as stimulus for interactions.

The above PBL criteria as well as Stahl's (2000) were used as an initial guide to identify an information-rich PBL site where the process of social construction of knowledge was likely to happen. This has led to the selection of the instructional technology course offered in a master's program in the School of Education in a public university in Malaysia. The instructional technology course was offered as a core subject to students

who were pursuing the masters in instructional technology program, or as an elective for several other masters programs in the School of Education. The primary reasons for the selection of this site for the study were that (1) the course was conducted in an essentially PBL environment based on the criteria set by Barrows (1996) and Dolman et al. (2005), (2) the course was designed to help students develop a complex, multi-faceted and situated form of knowledge known as TPACK (Mishra & Koehler, 2006). Hence, the learning process was constructivist in nature. (3) The overall milieu and activities of the course was based on Nonaka and his colleagues' SECI model of knowledge creation (Takeuchi & Nonaka, 2004; Nonaka & Nishiguchi, 2001) and that knowledge sharing and construction can be effectively cultivated through the process of socialization, externalization, combination and internalization (Tee & Karney, 2009). In short, such a site would have a high possibility for the process of social construction of knowledge to occur, and open to be studied.

As the program was in the midst of being phased out, the said course had only three students. J, R and F, were enrolled in this 14-week course. J was a high school English teacher, R was a full-time student whose previous job experience included the design of science educational courseware, and F was the principal of an elementary school which was well equipped with ICT facilities. Both J and F were experienced teachers with each having at least 10 years of teaching experience. The PBL group was formed comprise these three students with the course instructor serving as the dedicated PBL facilitator. This course had been offered in the past three years with the instructor serving as the PBL facilitator.

The 14-week course was divided into two major sections and the students had to work on two PBL cases (known as Case One and Case Two among the students) over these 14

weeks, where seven weeks were allocated for each of the PBL cases. For each of the seven week section, the first three-week segment was designed to give students time to define and conceptualize the problems they had decided to work on as a PBL group. At this PBL stage, the participants worked through a number of tentative hypotheses (i.e. possible root causes of the problem) and in the process they were being made aware of the knowledge gaps that exist in order for them to address the problem. These gaps included a list of learning issues the participants had collaboratively formulated for further research as well as evidence or data that had to be collected to validate their arguments or reasoning. The second two-week segment was for the group to consider different solutions, propose and select a solution. The third one-week segment was for the group to implement the selected solution in a pilot or full-blown situation. The fourth and final one-week segment was for the participants to more formally present and discuss the process and outcome of the entire learning cycle. Throughout each of the seven-week durations, the participants worked iteratively through collaborations and self-directed activities. This research dealt with Case Two of the course in which the participants worked on a real life problem that the teachers in F's school were experiencing in regards to the integration of technology into the teachers' teaching and learning in the school.

TPACK is an integrated knowledge and it consists of mutually reinforcing relationships among its three elements of technology, pedagogy and content knowledge (Koehler & Mishra, 2005). Briefly, content knowledge (C) refers to the subject matter that is to be learned. Technologies (T) include the standard technologies such as chalk and blackboard and extend to more current technologies such as the Internet and related digital devices and modalities which make information accessible. Pedagogy (P) is the process and methods of teaching and learning, including the strategies for evaluating student learning. The interactions among the three elements are vital in determining the optimal strategy to

promote students learning and understanding. In the context of this course, TPACK was developed by having the PBL participants to work through a real life problem of practice which had the following characteristics: (1) The problem had to be directly related to teaching and learning (as oppose to say, policy or management issues), (2) the problem had to be complex, that is, the problem did not have a single, simplistic answer, and (3) the problem preferably had to be common or similar to what was being faced by at least two other participants in the group.

The course was conducted using an improvised PBL approach. The improvisations were attempts to scaffold the learning process of the students who were new to the PBL process. Most of these students were more accustomed to the traditional method of lecture-based learning in their previous educational experience. Additionally, these improvisations were made in order to deal with the large class of students where the instructor did not have the facility of having a dedicated facilitator to a small group of students as is typically practiced in medical schools where PBL are conducted (Hmelo-Silver, 2009).

The key aspect of improvisation was the use of guided instruction. This included the use of (1) mini lectures which were given on a just-in-time basis (Hmelo-Silver, 2009), (2) selected readings and (3) recommended approaches to the process of problem solving, for instance, Bransford and Steins' (2002) model of problem solving process whereby participants were encouraged to identify gaps in their knowledge in order to bridge the gaps between what they knew and what they needed to know. Though there were some improvisations, the approach remained essentially PBL because it was based on a real life, complex problem, solved through a combination of facilitated sessions, collaborative interactions and self-directed activities. As discussed in the beginning of Section 3.2.1,

the approach had all the general characteristics of a core PBL model highlighted by Barrows (1996) and Dolman et al. (2005).

3.2.2 Informed consent

Consent was sought from all the three students who enrolled in the course and each was given a consent statement describing the intent of the research, their rights and obligations as a student participant (Appendix 3). All the three students gave full consent to being participants in the research.

3.3 Instrumentation

As pointed out by Merriam (2009), one of the characteristics of the nature of interpretive research is that the researcher is the primary instrument for data collection and analysis. Humans are ideally suited for such a research design as they are responsive and adaptive and such qualities are congruent with the goal of interpretive research which focuses on gaining a deeper insight on the participants' construction and understanding of the world around them. Additionally, humans are able to process data holistically, immediately, sensatorily, and curiously (Lincoln & Guba, 1985). These unique human characteristics are immensely useful in exploring and examining data that emerges from the participants dealing with complex, real life problem. Apart from that, Merriam (Merriam, 2009) also stressed that human instrument can "expand his or her understanding through nonverbal and verbal communication, process information immediately, clarify and summarize material, check with respondents for accuracy of interpretation" (p. 15) as among some of the advantages in using human instrument in this regard.

3.4 Data collection and recording

There were three sources of data in this research and they included (1) observation, (2) documentations and records and (3) the students' deliverable. Each of these sources of data is described below:

3.4.1 Observation

Merriam (2009), citing Gold's (1958) classic typology, presented four different categories of observers. These four categories are (1) complete participants where the observer is a member of the group being studied. However, the observer's role is concealed so as not to disrupt the natural activity of the group; (2) participant as observer where the observer's activities are known to the group and subordinate to his or her role as a participant; (3) observer as participant where the observer's participation in the group is secondary to the role of information gathering; and (4) complete observer in which the observer is either totally hidden from the group (e.g. behind a one-way mirror) or in a completely public setting (e.g. in an airport). Creswell (2008), on the other hand, proposed the following three popular roles that observers might consider assuming. First, taking on the role of participant observers. In this role, the researchers take part in the setting where they are observing and taking notes while participating fully in the activities. Second, being nonparticipant observers who visit sites as observers without getting involved in the activities of the participants. In this role, the observer is an "outsider" who sits on the periphery to observe and record the phenomenon under study (e.g. the back of the classroom) and third, a changing observational role in which the observers adapt to their roles as the situations required. For instance, a researcher may enter a site as a nonparticipant observer where his or her initial role is simply to 'look around' to get acquainted with the physical setting of the site in the early phase of the research and then to switch to the role of participant observer as the researcher slowly gets involved with the activities of the participants.

In this study, the researcher took on the role of a nonparticipant observer as described by Creswell (2008). As the focus of the research was to investigate the process of social construction of knowledge as it occurred in the PBL interactions, the key part of the researcher's observation was the content of the participants' interactions during the PBL sessions. The on-site observations of the entire PBL cycle were captured using a video recorder. In a couple of the sessions where there were more un-facilitated group discussions, a tape recorder was also used to help capture the group conversations with greater clarity. The recorded conversations became the key source of raw data from which the study's coding and analysis were conducted. The researcher also took written notes on activities which had not been able to capture on the video or audio devices (for instance, when participants were referring to some online instruments on the computer screen during parts of their discussions) so that the whole range of activities that were happening in the interactions were fully recorded. The researcher sat behind the participants to make and record his observations. The physical set up of the site is shown in Figure 3.2 below:

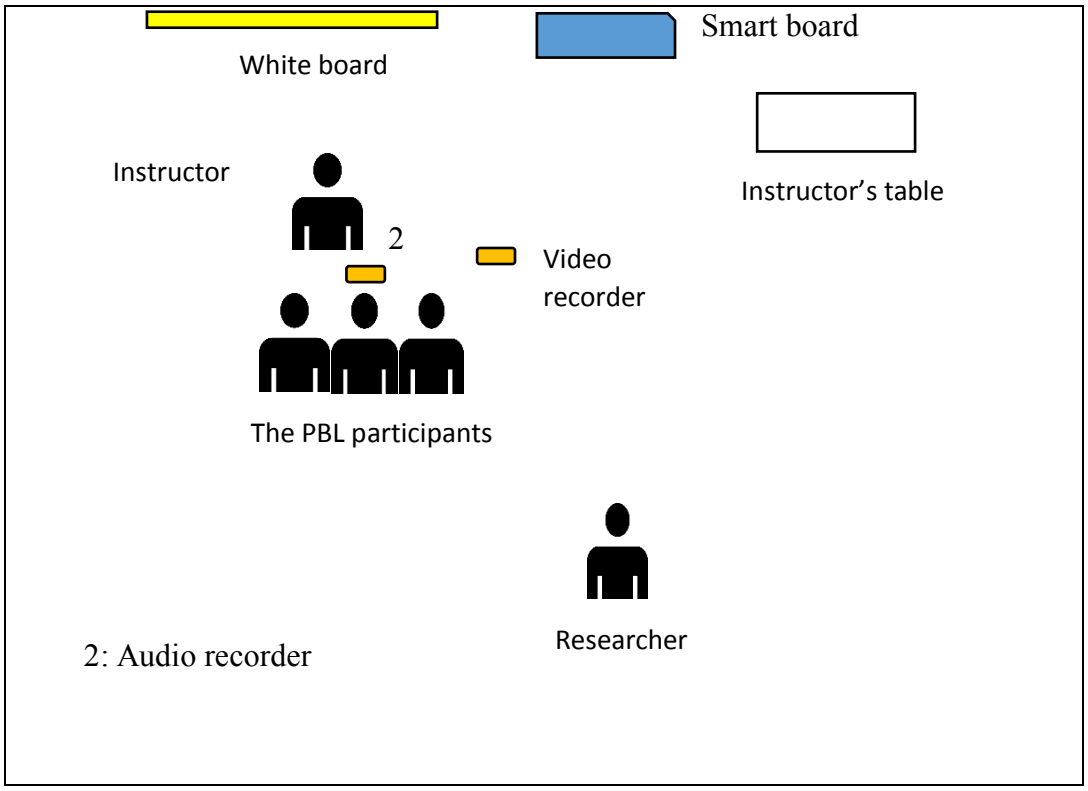

Figure 3.2: The physical set up of the site

3.4.2 Documents and records

Documents and records are "paper trails" that the researchers use to increase knowledge and understanding of the research environment (Patton, 1990). This study did not make a distinction between "documents" and "records". For this research purposes, documents and recorded included the personal journal reflections of the participants, the Gwave (now defunct) online discussion threads and the electronic book (eBook) that was collaboratively written by the participants. An integral part of the design of the instructional technology course was that the students were required to respond to weekly reflection questions posted by the course instructor as a form of journal entry. The reflection questions were designed to help the PBL participants to reflect on their own learning process as they engaged in the development the technological, pedagogical and content knowledge. The reflection questions were posted on Google site weekly by the instructor and the participants were required to respond individually to the questions on the Google site (a sample of the reflection questions posted by the instructor is shown in Appendix 4). The Gwave online discussion threads were found to contain mostly logistical discussions (e.g. the participants arranging for a suitable time and venue to meet, discussing the schedules of the teachers in F's school and some unrelated social conversations). As a result, the conversation threads were not included in the triangulation of the data sources. The eBook was a project that the participants were required to collaboratively work on using a wiki web site. The eBook chronicled the participants' on-going experience throughout the course (a sample of the eBook is shown in Appendix 5).

3.4.3 Unobtrusive measures

Unobtrusive measures relate to data that are not elicited directly from the research subjects or data that accumulated without intent (Lincoln & Guba, 1985). Unobtrusive measures are generally stable, simple and direct, often with unambiguous face validity.

In this research, the unobtrusive measures were the digital footprints that were "stamped" with precise dates and times (e.g. the participants' personal journal reflections). The recording devices such as the video and audio recorders also contained the precise time stamp.

3.4.4 Recording modes

Tools for recording data included (a) a brief Word document log with notes about each PBL session and the researcher's field notes and reflections on the meetings; (2) Video recorder which captured the video footage of the entire PBL sessions; (3) audio recorder which recorded the conversations in two of the PBL sessions; (4) documents and records archived and managed in electronic folders (including the course documents, the participants' individual journal reflections, the instructor's questions for reflection, the content of the eBook) and (5) transcripts of the PBL sessions 6-9 (a sample of the transcripts is shown in Appendix 6).

Fidelity (Lincoln & Guba, 1985), which refers to the researcher's ability to capture and reproduce the data as they were presented in the field, was achieved through the use of video and audio recorders and the data was digitally stored and managed in electronic folders.

3.5 Data analysis

Data analysis is a complex process of making meaning (Merriam, 2009). The process allows us to make sense of the data collected through "consolidating, reducing and interpreting what people have said and what the researcher has seen and read" (Merriam, 2009, p. 175-176). Through the process of data analysis, researchers derive meanings or understandings or insights which constitute the research findings. In other words, the practical goal of data analysis is to find answers to the researchers' research questions.

3.5.1 Unit of data

As Merriam (2009) proposed, data analysis begins with the identification of segments in the data set which are sensitive to the research questions. Each segment is a unit of data which is relevant or meaningful in providing answers to the research questions asked. Hence, a unit of data can be as small as a word or as large as several pages of field notes, depending on its relevance to a particular aspect of the research. Citing Lincoln and Guba (1985), Merriam (2009) pointed out that there are two criteria which describe a unit of data. First, a unit if data should be heuristic in that it reveals information which is relevant to the inquiry and stimulate the reader to think beyond the particular bit of information. Second, the unit is also the smallest piece of information about something that can stand by itself, that is, it can be understood and interpreted by readers with broad understanding of the research topics but not necessarily of this particular research context.

In this study, the transcripts of the PBL participants were parsed into conversational episodes for more detailed analysis. A conversational episode was a segment of the PBL discourse and they represented the key exchanges between the participants which contributed to a deeper understanding of the process of social construction of knowledge. In other words, these exchanges contained information and data that were relevant to the inquiry. As a general rule, the length and content of each episode represented the participants' engagement with a particular topic or subject that were meaningful in answering the research questions. For instance, the following conversational episode (Episode 7) was parsed from Session 6 of the participants' interaction and it contained exchanges that represented the sharing of information among the participants (that is, Phase I of the process of social construction of knowledge, the details of which are discussed in the next section).

From the conversational episode, a unit of analysis was generally taken as the conversational turn and a new turn occurred when the speaker changed. For instance, in Episode 7, a conversational turn occurred when the speaker changed from R to F, or from J to F. Each of these conversational turns was analysed and coded accordingly (coded here as PhI/D for each of the conversational turns as the participants were largely engaged in asking and answering clarifying questions, a cognitive operation that was consistent with PhI/D in mIAM. More detailed discussion on categorizing and coding in next section)

Episode 7		mIAM Code	Time
R:	What are the training [courses] did the teachers get regarding technology?	PhI/D	6D, 18:14
F:	Now is 100% in house training. That means I have to schedule the training for them. For some teachers I have refresher course, re-training them on how to use technology.	PhI/D	
J:	This in-house training, what do you train them on?	PhI/D	
F:	Train them on T. This year 2011, none is being done for TPCK because of lack of funds and planning.	PhI/D	
J:	So when you said training them on T, that means like put all the teachers in one room and then…	PhI/D	
F:	Not just put them in one room; get them to attend refresher course on how to use the Smartboard and how to use the laptops. We did have an Intel Teach Program.	PhI/D	
R:	What is the Intel Teach Program?	PhI/D	
F:	Intel Teach Program is the TPCK…(trying to find the right way to describe the Program)	PhI/D	
I:	What is the curriculum in the Program?	PhI/D	
F:	Using technology to teach. Their main focus is project based learning.	PhI/D	
J&R:	Do you have examples?	PhI/D	
R:	Example?		
F:	I'll bring bring the module.		
I:	But you can briefly explain it. If you look at the framework, the P they use in the curriculum is actually the project based learning. The T is the use of computers	PhI/D	

(Continued on next page)

	that helps the Intel agenda. They basically use computers to support project based learning. They have run in few hundred schools in Malaysia.		
F:	Most… most of the newer ones have certificates…	PhI/D	
I:	So, how many have Intel Teaching certs?	PhI/D	
F:	Now, probably 40%.	PhI/D	
I:	40%?		
F:	Ya.	PhI/D	6D, 21:41

In some exchanges, a single conversational turn may contain more than one cognitive operations. In such a situation, the conversation turn was parsed into additional units of data and coded accordingly. The episode below (Episode 4) provides an example of such an incidence:

Line	Episode 4		mIAM Code	Time
1	J:	The two is the experienced or the young ones?	PhI/D	6D, 02:46
2	F:	The two is the ones with 23 years of experience.	PhI/D	
3	I:	Now, do you have a sense of the TPC	PhI/A	
4		[Technological, Pedagogical, Content knowledge]?		
5	J:	How many of them…		
6	I:	Have advance TPC?	PhI/A	
7	F:	No, no. OK, change! Two out of nine is the TPC.	PhIII/A, PhIII/B	
8	I:	OK, but they are the ones that use technology?	PhI/D	
9	F:	Yes!		
10	I:	The others also use technology?	PhI/D	
11	F:	We need to say that for T because we train everyone		
12		with technology. T should be nine out of nine.	PhII/D	
13	I:	Oh…		
14	F:	Because they know; they have technological	PhII/D	
15		knowledge. But TPC only two.	PhIII/B	6D, 03:36

In line 7, F's statement consisted of two separate cognitive operations. The first was a statement of her own inconsistency in her reasoning (coded as PhIII/A) and the second was in pointing out the specific area of inconsistency (coded as PhIII/B).

3.5.2 Categorizing

3.5.2.1 Coding

The process of categorizing begins when a researcher starts to make notes, comments and observations to the data that strike the researcher as relevant for answering the research questions (Merriam, 2009). These notations given to the data are the codes and they can be taken from the words used by the participants, the researcher's own words or a concept borrowed from the literature. A category is created when codes with similar conceptual characteristics are grouped together. In this study, the main rounds of coding were conducted in consultation with the course instructor to ensure consistency of interpretation as the data emerged.

3.5.2.2 Naming the categories

There are three approaches in naming the categories (Merriam, 2009). The first and the most common approach is when the researcher comes up with terms, concepts that he or she sees in the data. The second approach is to organize the data into scheme suggested by the participants and the third approach is to borrow classification schemes from sources outside the study at hand. Merriam stressed that in borrowing a categorizing scheme "requires that the categories be compatible with the purpose and theoretical framework of the study" (2009, p. 185). As Glaser and Strauss (1967) emphasized,

> Merely selecting data for a category that has been established by another theory tends to hinder the generation of new categories, because the major effort is not generation, but data selection. Also, emergent categories usually prove to be the most relevant and the best fitted to the data. Working with borrowed categories is more difficult since they are harder to find, fewer in number, and not as rich; since in the long run they may not relevant, and are not exactly designed for the purpose, they must be re-specified (p. 37).

Merriam (2009) highlighted several criteria that should characterize the categories that are constructed during the process of data analysis. Categories should be (1) *responsive* to the purpose of the research, that is, they provide answers to the research questions, (2) *exhaustive*; there are enough categories to include all relevant data, (3) *mutually exclusive* where a relevant unit of data can be placed in only one category, (4) *sensitive* to the data; it captures as closely as possible the exact meaning of the phenomenon, and (5) *conceptually congruent* to provide the same level of abstraction for all the categories (p. 185-186, emphasis original). In this study, some categories of analysis were adopted from Gunawardena et al.'s (1997) IAM (Appendix 5) and other categories were developed as the data emerged. As can be seen from the discussion below, these categories were congruent to the criteria stated by Merriam.

As discussed briefly in Section 3.1.2, Stahl's (2000) model of collaborative knowledge building processes was used as an initial guide to focus the inquiry and frame the coding of the emerging data at the early stage of data analysis. The model provided a framework to focus on units of data that can be relevant or meaningful to the analysis of the PBL discourse. This approach was consistent to Merriam's (2009) argument that a researcher is often uncertain of what is ultimately relevant or meaningful to the research at the beginning of a study. As such, a theoretical framework can be useful to "focus our inquiry and interpret the data" (p. 16). However, as the data emerged, it was found that there were some limitations in the model as the phases identified in Stahl's model were too broad and lacked the specific details that were necessary for the investigation of the process of social construction of knowledge. In other words, the emerging data indicated that a new framework was necessary as Stahl's model could not accommodate the new categories and sub-categories of cognitive activities that were externalized as public statements by

the participants in the PBL discourse. In response to the limitations, Gunawardena et al.'s (1997) IAM was used to frame and categorize the analysis of the data. There were a number of key factors which influenced the choice of IAM as an initial frame for analysing the PBL discourse. First, the IAM model was developed based on the social constructivist framework to examine the social construction of knowledge in a computer-mediated debate. This was in line with Merriam's (2009) assertion that a borrowed framework must contain categories which are compatible with the purpose and theoretical framework of the study. Second, IAM contains specific, identifiable phases and their corresponding cognitive operations to investigate the process of social construction of knowledge. For instance, in the phase coded as 'negotiation of meaning/co-construction of knowledge' in IAM (Phase III), there are five different specific, identifiable cognitive operations such as (1) 'negotiation or clarification of the meaning of terms'; (2) 'negotiation of the relative weight to be assigned to types of argument'; (3) identification of areas of agreement or overlap among conflicting concepts' and so on, and thirdly, as affirmed by a number of other researchers, IAM offers a more holistic view of the flow of interaction and knowledge construction (Lily Lu & Jeng, 2006; Jeong, 2003; Marra, Moore, & Klimczak, 2004). However, as Glaser and Strauss (1967) cautioned, selecting data only to fit into the established categories tend to hinder the generation of new categories. It is important to point out that in this study the use of IAM to focus the initial inquiry did not deter the researcher from creating new categories as the framing of the analysis was responsive to the emerging data. A new category or sub-category was created when emerging data in the PBL discourse showed recurring themes and these themes were salient to answering the research questions. On top of that, the inclusion of these new category and sub-categories was the result of discussion and consultation with the course instructor to ensure that the interpretations of the categories were consistent with the emerging data. For instance, Phase II and its sub-categories (Phase II/A to Phase

II/E) were recurring themes in the PBL discourse and they represented a category of social process in which the PBL participants shared and explored multiple perspectives or hypothesis in their efforts to conceptualize a shared understanding of the problem they were dealing with. As a result, a modified version of IAM (mIAM) emerged as the analysis of data reached its saturation stage. Figure 3.3 shows the modified IAM.

As indicated in the figure, six phases (Phase I to Phase VI) of interaction pattern were identified in the PBL discourse. This illustrates how the categorization of the data had been responsive to the emerging patterns or themes of PBL discourse and served to answer the research questions of the study (criteria 1). As noted above, the evolvement and development of mIAM was informed by the emerging data and through several iterative processes, all the new category and sub-categories were added until a saturation of the data was reached. This emergent approach to categorizing the data through a series of iterative processes ensured that all data that was considered important or relevant to the process of social construction of knowledge can be placed in a category or sub-categories (criteria 2). This can be clearly seen in Chapter 4 where all the episodic analysis of the participants' interactions fell within the phases and sub-phases of mIAM. Great care was taken to ensure that the new category and sub-categories created were sensitive to the data as possible (criteria 4). For instance, the description of Phase II/C ("Asking and answering questions to prompt members to respond to a set of data or to validate a supposition or hypothesis") was more exact or sensitive in capturing what was in the data in comparison to a category such as "Question or opinion to prompt the members" which did not reveal as much. It should also be pointing out that the naming of Phase II was conceptually congruent to all other phases in IAM (criteria 5). In IAM, the abstraction that characterises the phases was the process of social negotiation that occurred among

PHASE I: Sharing/Comparing of information

A. Sharing or asking and answering questions to share an observation or opinion from one or more members [PhI/A]
B. A statement of agreement from one or more members [PhI/B]
C. Corroborating examples provided by one or more members [PhI/C]
D. Asking and answering questions to clarify the details of statements or examples [PhI/D]

PHASE II: The exploration of an opinion or hypothesis

A. Selecting and providing data or information that relates to an opinion or hypothesis that is being explored [PhII/A]
B. Describing or asking and answering questions to describe an opinion or hypothesis [PhII/B]
C. Asking question or making statement to prompt members to respond to a set of data or to validate an opinion or hypothesis [PhII/C]
D. Building and providing a statement of justification to validate an opinion or hypothesis [PhII/D]
E. Identification of specific evidence or data to be collected to validate an opinion or hypothesis [PhII/E]

PHASE III: The discovery & exploration of dissonance or inconsistency among ideas, concepts or statements

A. Expressions of doubts or puzzlement or disagreement by one or more members [PhIII/A]
B. Identifying and stating areas of disagreement or inconsistency [PhIII/B]
C. Asking& answering questions to clarify the source and extent of disagreement or inconsistency [PhIII/C]
D. Restating the member's position, and possibly advancing arguments or considerations in its support by references to the member's experience, or formal data collected [PhIII/D]

PHASE IV: Negotiation of meaning/co-construction of knowledge

A. Asking and answering questions, or sharing an idea to negotiate for a new and deeper understanding underlying an issue [PhIV/A]
B. Proposal and negotiation of new statements embodying compromise, co-construction [PhIV/B]

PHASE V: Testing and modification of proposed synthesis or co-construction

A. Testing of new statement against personal experience [PhV/A]
B. Testing against formal data collected [PhV/B]

PHASE VI: Agreement statement(s)/Applications of newly constructed meaning

A. Summarization of agreement (s) [PhVI/A]
B. The proposal and design of cultural artifacts [PhVI/B]
C. Metacognitive statements by the participants illustrating their understanding that their knowledge or ways of thinking (cognitive schema) have changed as a result of the social interaction [PhVI/C]

Figure 3.3 The modified Interaction Analysis Model (mIAM)

the participants (Gunawardena et al., 1997). Hence, the naming of Phase II ("The exploration of an opinion or hypothesis") characterized the social negotiation that the participants went through as they explored multiple perspectives in the PBL discourse. Additionally, inserting the category as Phase II in the model gave an indication of the level of mental function of the phase in relation to the rest of the phases (In the same article, Gunawardena et al. (1997) argued that the phases in IAM represent a flow from lower mental functions to higher mental functions as group members engaged in the process of social construction of knowledge).

In this study, criteria 3 posed the most difficult challenge as the exclusivity of the phases may not appear to be straight forward or direct. In some situations, a particular unit of data may seem to fit into more than one category of the mIAM. For instance, consider the following statement uttered by one of the PBL participants (participant F):

> "Like the Jordan graduate, he knows. He did all the e-report and everything. *[His technological knowledge] is definitely OK*, *but* to slot where, to know where the T goes with P&C, that, he has a problem with that." [8D, 16:49]

Such an utterance, if taken in isolation, can be "a statement of observation or opinion" (a Phase I/A statement) or "a statement of justification to validate an opinion" (a Phase II/D statement). However, when the statement was analyzed in its context of conversation, it can be seen that F was sharing her personal experience to validate an opinion because just prior to the above utterance, F was arguing that the problem with the teachers in her school was that they have high technological skills but they do not have the skills to integrate their technological knowledge with the pedagogical content knowledge (refer to Episode 30) and she validated her opinion with her personal experience with the Jordan graduate in her school. In other words. Hence, her utterance above was coded as PhII/D rather than

PhI/A. This following statement exemplifies another instance where an utterance must be considered in its proper conversational context in order to appreciate the mutual exclusiveness of the categories in mIAM. In Episode 36, R stated that:

> "Because from the SQSS data,[1] we know that T is high. From SKPM,[2] we know that the P&C are linked. So we know that there is a gap here and we want to target this gap." (Episode 36, Line 17-20)

Similar to the preceding example, if the statement was analyzed in isolation, it can either be a Phase II/D statement (the participant was "building and providing a clear statement of justification to support an opinion or hypothesis") or a Phase V/C statement (the participant was testing a new proposed statement against formal data collected"). Again, the coding was decided upon by the context in which the statement was made. In this episode, it was clear that R was alluding to the instruments SQSS and SKPM to test and modify the new definition of the problem that the participants were negotiating. In short, R was testing the viability of the new definition of the problem by alluding to the data from SQSS and SKPM. By referring to the larger context in which R's statement was made, it was clear that R's statement should be coded as PhV/B. A Phase II/D code would have meant that the statement was made in a Phase II type interaction which involved the early exploration of an opinion shared. Since the interaction in which R's statement was uttered had gone into the phase of co-construction and negotiation (a Phase IV type interaction), it has progressed beyond a Phase II type interaction. Clearly, when the categories and sub-categories were analyzed in their proper conversational context, the mutually exclusiveness of the categories became apparent. Table 3.2 shows the categories

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[1] SQSS refers Smart School Qualification Standard, a ranking system that is used to monitors schools' use of ICT, the competency of its end-users and the uptake of applications provided by the Ministry of Education of Malaysia and their IT infrastructure.

[2] SKPM stands for Standard Kualiti Pendidikan Malaysia, an instrument provided by the Ministry of Education of Malaysia for evaluating the quality of teachers' T&L in schools.

and sub-categories for mIAM and their respective examples of interaction analysis.

Table 3.2 Coding of categories and sub-categories for mIAM and the respective examples of interaction analysis

Category	Sub-Category		Example
	mIAM Code	Description	
PHASE I	PhI/A	Sharing or asking and answering questions to share an observation or opinion from one or more members	"Teachers in my school, despite the wealth of technology they have, they shun away using technology…" (6C, 35:38)
	PhI/B	A statement of agreement from one or more members	"Ya, they have the technological knowledge." (Episode 9)
	PhI/C	Corroborating examples provided by one or more members	"From my experience in designing the CDs for primary levels, especially for the sciences, there seemed to be many topics to be covered, like photosynthesis, seed growth, more than 40 topics." (Episode 19)
	PhI/D	Asking and answering questions to clarify the details of statements or examples	"This in-house training, what do you train them on?" (Episode 7)
PHASE II	PhII/A	Selecting and providing data or information that relates to an opinion or hypothesis that is being explored	"Yes! 3 labs [are] all working. 1 lab is [equipped with] Window 7. Another lab is an open source lab." (Episode 6)
	PhII/B	Describing or asking and answering questions to describe an opinion or hypothesis	"I think there is a reason why teachers are reluctant to incorporate technology. This is my personal experience: sometimes it takes such a long time to find materials." (8C, 07:42)
	PhII/C	Asking question or making statement to prompt members to respond to a set of data or to validate an opinion or hypothesis	"… so, we are asking F if she could have information like what could possibly be the reasons for them to put it aside. Is it because of time or issues like that…" (Episode 21)
	PhII/D	Building and providing a statement of justification to validate an opinion or hypothesis	"I'm saying that their T is almost 100%. Why is that? Because the administration of the school is totally digital." (Episode 9)

Table 3.2, continued

Category	Sub-Category		Example
	mIAM Code	Description	
PHASE II	PhII/E	Identification of specific data to be collected to validate an opinion or hypothesis	"We are reading the article and like the examples of teachers with TPCK. Get 1 or 2 situations and get the teachers to write [their] reflections." (Episode 11)
PHASE III	PhIII/A	Expression of a doubt or puzzlement by one or more members	"Not skilled? (with doubtful tone giggling)" (Episode 30)
	PhIII/B	Identifying and stating area of disagreement or inconsistency	"No, they don't have the skills to integrate; they do have the technological skills! Technology high but to integrate low." (Episode 30)
	PhIII/C	Asking and answering questions to clarify the source and extent of disagreement or inconsistency	"If the data is so positive about using technology for learning, why don't you use it more?" (Episode 23)
	PhIII/D	Restating the member's position, and possibly advancing argument or consideration in its support by references to the member's experience, or formal data collected	"Not skilled? F, it's 5, 5, 5! (referring to the teachers' high scores on SQSS for their technological knowledge)
PHASE IV	PhIV/A	Asking and answering questions, or sharing an idea to negotiate for a new and deeper understanding underlying an issue	"No, they do not have the skills to integrate; they do have the technological skills. Technology high but to integrate low." (Episode 30) [Note: The participant was negotiating for a new understanding of the problem that the teachers in her school were facing: that the lack of integration of technology in their teaching was not due to a lack of technological skills to do so]
	PhIV/B	Proposal and negotiation of new statements embodying compromise, co-construction	"After considering all the possible reasons that crop up, we felt that we would like to look at TPCK as the main issue and we felt that based on the data from SSQS [sic] and SKPM, we felt that the issue here is they are not able to integrate the knowledge that they have to the content." (Episode 36)

Table 3.2, continued

Category	Sub-Category		Example
	mIAM Code	Description	
PHASE V	PhV/A	Testing of new statement against personal experience	"… if you used technology, that is based on my experience, there will be some changes because the students will be very excited and interested and of course the question will be: but does that ensure that the objectives are achieved? Based on my experience, it does. I might have listed 3 objectives and I might not be able to achieve all 3 but at least 1 will be achieved which would be much difficult if that was a normal way of [teaching with no technology]." (Episode 40)
	PhV/B	Testing against formal data collected	"Because from the SQSS data, we know that T (referring to the teachers' technological knowledge) is high. From SKPM, we know that the P (pedagogical knowledge) and C (content knowledge) are linked. So we know that there is a gap (referring to the teachers' T being separate or not integrated with their P and C) here, and we want to target this gap." (Episode 36)
PHASE VI	PhVI/A	Summarization of agreement(s)	(Refer to CHAPTER 4, Table 4.3 and the ensuing discussion on page 131)
	PhVI/B	The proposal and design of cultural artifact	(Refer to CHAPTER 4, Figure 4.2 on page 137 which contains a conceptual artifact showing R's new way of thinking about the related root causes)
	PhVI/C	Metacognitive statements by the participants illustrating their understanding that their knowledge or ways of thinking (cognitive schema) have changed as a result of the social interaction	"Case 2 challenges me to really look at the problem with a [sic] different eyes and from many angles. I have to break away from opinions that I had already formed after dealing with this problem for quite a while now. Breaking away is not easy but it is something I have to do so that the problem will be clearly defined." (F's Journal Reflection, entry date: November 18, 2011)

This coding process was regularly cross checked with the instructor of the course as the data emerged to ensure consistency in interpretations. This happened when the large grain analysis of the discourse was taking place and emerging episodes were being identified and coded. In analyzing the interactions in the episodes, the researcher did the initial coding and the instructor would cross check the coding with mIAM. When there were discrepancies, the researcher would first attempt to provide clarification, explanations or justifications for how the statements were being coded. In most situations, these discrepancies were contextual in nature (as discussed above) and a detailed discussion on the contexts from which the coding were decided would ensued until agreements were reached. In few other instances, the discussion resulted in the refinement of the naming of the sub-categories so as to be more exact in capturing the meaning of the participants' statements.

The above discussion also affirmed the assertion made by Hmelo-Silver and Barrows (2008) that in order to develop a deeper and detailed understanding of the social processes of knowledge building that could provide meaningful pedagogical implications, an interaction analysis which cuts across a larger time scale and learning context (also referred to as large grain analysis and discussed in greater details in CHAPTER 2) is required. Unlike the analysis which focused only on a tiny segment of the PBL meeting, a large grain analysis, as can be seen from the preceding discussion, allowed for the integration of the different levels of analysis to provide a fuller understanding of the process of social construction of knowledge.

3.5.3 Case study construction

As Merriam (2009) highlighted, the rationale for using a case study design as opposed to other research design depends on the researcher's research questions. She pointed out that case study is heuristic in that the study illuminates the reader's understanding of the

phenomenon under study. Yin (2008, p. 13) suggested that case study design has a distinct advantage in dealing with questions of "how" and "why". This study aimed to investigate and describe the process of social construction of knowledge as it occurred in a PBL setting and seek to develop a deeper understanding of how the process worked. As such, the case study method was the preferred method for this research.

Since the research method was a qualitative case study, it involved "an in-depth description and analysis of a bounded system" (Merriam, 2009, p. 40). The bounded system comprised three PBL participants and the in-depth analysis focused on the entire problem definition phase of the PBL cycle as the participants engaged in the social construction of TPACK. The case study format was intended to provide the readers with a rich description of the participants' interpretation and construction of their experience as they engaged with the problem they have identified to work on collaboratively. Additionally, this research also featured other key characteristics of a qualitative case study which included the researcher as the primary instrument of data collection and analysis as well as the use of an inductive investigative strategy (Merriam, 2009). The inductive investigative strategy was discussed in great details in section 3.1.2 (refer to page 53-55).

3.6 Validity and reliability

All research seeks to produce valid and reliable results. Traditionally, particularly in quantitative research, the concept of validity and reliability have been practiced to enhance the trustworthiness of research findings. Several scholars have argued for the need to re-theorize the concept of validity and reliability in qualitative research in order to arrive at perspectives which are congruent to the philosophical paradigm of qualitative research (Merriam, 2009). Lincoln and Guba (1985), for instance, use the terminologies

such as credibility, transferability, dependability and confirmability as substitutes for internal validity, external validity, reliability and objectivity. Furthermore, with the wide variety of qualitative research methods, different criteria have been applied to assess the validity and reliability of a research method (Creswell, 2007). While these debates and theorizing on validity and reliability in qualitative research are necessary and expected to go on, the concerns for validity and reliability need to be addressed in practical ways. According to Merriam (2009), several strategies can be used to enhance the internal validity, reliability, and external validity of qualitative research (of what Lincoln and Guba (1985) would refer to as credibility, consistency/dependability, and transferability). The sections below address the issues related to the internal validity, reliability and external reliability of this study:

3.6.1 Internal validity or credibility

Merriam (2009) referred to internal validity as dealing with the match between reality and research findings. One of the underlying assumption in qualitative research is that "reality is holistic, multi-dimensional, and ever changing" (p. 213). In short, reality is not a single, fixed, objective phenomenon; but rather it is constructed and it represents the diverse interpretations of the participants in a particular context. Hence, what is being investigated is attempting to describe individual's interpretation of reality. Since the primary instrument for data collection and analysis in qualitative research is the human being, Merriam (2009) argued that the researcher as the primary instrument would have a "closer" access to the participants' interpretations of reality than any other data collection instruments. She asserted that "when rigor is viewed in this manner, internal validity is a definite strength of qualitative research" (p, 214). Also, as reality is constructed rather than being captured in an objective manner, the strategies to enhance internal validity would be to increase the "correspondence between research and the real world" (Wolcott, 2005, p.160). Accordingly, Merriam (2009) suggested that following

strategies for increasing the internal validity of qualitative research: (1) triangulation of multiple data sources, (2) members checks where the researcher obtains feedback on his or her emerging findings from some of the interviewees, (3) adequate engagement in data collection in order to "get as close as possible to participants' understanding of a phenomenon" (p. 219) until the data is saturated, (4) the researcher's position highlighting the researcher's personal biases, dispositions, and assumptions regarding the study to be under taken, (5) peer review whereby the researcher's raw data is reviewed and the findings assessed for plausibility based on the data.

In this study, the strategies used to enhance its internal validity included the triangulation of multiple data sources collected from the PBL discourse transcripts, the participants' personal journal reflections and the participants' deliverable in the form of an eBook. Member checks were conducted through emails by providing each PBL participants with a copy of the draft case study report and was asked to review it for credibility and accuracy (Appendix 7). Besides that there was adequate engagement with the participants as the researcher was at the site at the start of the course (though data collection only began at week six when the participants started to work on Case Two) and remained engaged throughout the entire period of the course which lasted for 14 weeks. The early engagement during which the participants were working on Case One was to familiarize with the interaction style of the participants and at the same time to allow the participants to be accustomed to the presence of the researcher at the site. The engagement with the participants also included the written notes of the researcher's personal observation regarding the participants' activities that may not be fully captured by the video and audio recording (discussed in greater details in Section 3.4.1). The researcher's basic assumptions were built on the social constructivist framework. This was largely due to the review of literature where a number of articles had highlighted that the PBL process

as an instructional approach is consistent with the constructivist paradigm (Hendry et al., 1999; Schmidt et al., 2000; Savery and Duffy, 2001, Dolman et al., 2005; Pelech, 2008). With the assumption that the learning environment in the PBL setting was essential constructivist in nature, this study opted for Stahl's (2000) model of knowledge building and subsequently Gunawardena et al.'s (1997) IAM as initial frameworks to frame the initial coding of the data.

3.6.2 Reliability or consistency

As discussed above, one of the assumptions of interpretive paradigm is that reality is not static but ever changing. Since reliability "refers to the extent to which research findings can be repeated" (Merriam, 2009, p. 220) and is built on the assumption that there is a single, fixed reality, it is problematic in the social sciences as human behavior is not static but constantly changing. As such, it is to be expected that the replication of a qualitative research will not produce the same results. This, however, as Merriam pointed out "does not discredit the results of the original or subsequent studies. Several interpretations of the same data can be made, and all stand until directly contradicted by new evidence" (p. 222). Hence, a more pertinent question for a qualitative research is one of consistency between the research findings and the data collected. Lincoln and Guba (1985) were the first to conceptualize reliability in qualitative research as "dependability" or "consistency" and argued that researchers should focus on presenting results that make sense in that they are consistent with the data collected and not on whether if the results are replicable.

Merriam (2009) suggested that there are several strategies that can be used to enhance reliability or consistency and these are triangulation, peer examination, researcher's position, and the audit trail. The first three of the strategies have been discussed in the preceding section. For instance, triangulation of the various data sources in this study, for

example, the transcripts of the PBL discourse, the PBL participants' journal entries, the eBook, provides consistency in interpretation as well as "data that are most congruent with reality as understood by the participants" (p. 222). The audit trail which described in detail how the data were collected and recorded was presented in Section 3.4, and Section 3.5 provided the detailed audit trail for how the data were analyzed and categorized.

3.6.3 External validity or transferability

According to Merriam (2009), external validity deals with "the extent to which the finding of one study can be applied to other situations" (p. 223). In other words, the results of a study that are externally valid are assumed to be generalizable, that is, the results can be applied to other situations which share equivalency between the sample and population from which it was drawn. Again, there is a need to conceptualize generalizability in ways that are congruent to the paradigm in interpretive research. Lincoln and Guba (1985) suggested the idea of transferability and argued that "the burden of proof lies less with the original investigator than with the person seeking to make an application elsewhere. The original inquirer cannot know the sites to which transferability might be sought, but the appliers can and do" and proposed that the original investigator ought to furnish "sufficient descriptive data" to make transferability possible (p. 298). Hence, in qualitative research, generalizability of a study "involves leaving the extent to which a study's findings apply to other situations up to the people in those situations" (Merriam, 2009, p. 226).

The strategies use to enable transferability include the use of rich, thick description of the study which refers to a detailed description of the research context. Another strategy is to select sample of study which has maximum variation. In this study, a rich, thick description of the context was presented in Section 3.2.1 where a detailed description of

site selection, and the participants were presented. In this study, the sample was criterion based as the process of social construction of knowledge among the participants was investigated in the PBL setting. Additionally, there were only three students enrolled in the course and consequently they became the only PBL group in the course. As such, there was no opportunity for the selection of a sample with maximum variation as suggested by Merriam (2009).

CHAPTER 4: FINDINGS

This chapter aims to answer the following research questions:

Research question 1: How does social construction of TPACK occur in a PBL setting?

Research question 2(a): What elements in the essential features of the PBL setting support the social construction of knowledge?

Research question 2(b): What elements in the essential features of the PBL setting hinder the social construction of knowledge?

4.1 The social construction of knowledge in a PBL setting

In answering research question 1, a large grain analysis (Hmelo-Silver and Barrows, 2008) which spanned the entire problem definition stage of the PBL cycle was analyzed. The discourse was parsed into episodes which provided relevant and meaningful information for answering the research question. A modified AIM (Figure 3.3) emerged in the analysis of the interactions of the three PBL participants. As the conversation unfolded, mIAM provided the framework by which the cognitive operations of the participants that were made visible were analyzed and coded in identifiable phases. The advancement of these phases during the discourse indicated the extent to which the social construction of knowledge had occurred.

The following scenario describes the transformative process that the PBL participants went through in co-constructing a new and shared understanding of the problem that the group was dealing with. The PBL participants J, R and F were engaging in the early stages of the PBL cycle to define the problem that related to the use of technology among the teachers' in the school in which F was the principal.

As the participants went deeper to unpack their interpretations of the problem, the discourse took them through a journey of frustrations, conceptual changes and discoveries. It exposed and challenged the superficiality of their initial understanding of the problem and, through the process of co-construction and negotiation, transformed it into a shared understanding that embodied the complexity of constructing technological, pedagogical content knowledge (TPACK).

4.1.1 The participants' initial interpretation of the problem (A discourse which stayed mainly at Phase I and Phase II of mIAM)

4.1.1.1 Clarifying the magnitude of the problem

Three students J, R and F were enrolled in the instructional technology course in their pursuit of a master's program in a public university. J was a high school English teacher, R was a full time student whose previous job experience included the design of science educational courseware, and F was the Principal of a primary school which was well equipped with Information and Communication Technology (ICT) facilities.

In the following extended scenario, the three participants J, R and F were at the problem definition phase of the PBL cycle where they set out to clearly define the real life problem that the teachers in F's school were facing regarding the use of technology in their teaching and learning. F began to describe her impression of the problem as:

> "Teachers in my school, despite the wealth of technology they have,
> they shun away from using technology…" [6C, 35:58][3] (PhI/A)

[3] [6C, 35:58] indicates the time stamp in the video. It refers to the video taken at session 6, segment C, at time 35-minute 58-second. In the above utterance and all the utterances in the subsequent conversational episodes, transcripts have been edited for readability and length. All omissions in the transcript are indicated by an ellipsis (…).

J responded by asking "What are the reasons they give for not utilizing what they have?" [6C, 36:58] Here, the instructor (denoted as 'I') intervened and suggested that it might be premature to start exploring the reason why. Rather, the participants needed to first understand the magnitude of the problem:

	Episode 1	mIAM Code	Time
I:	OK, before we ask those kind of questions maybe one of the question we need to ask is…we want to understand the magnitude of the root problem. Like how many teachers you would say do not have TPCK?	PhI/A	6C, 37:06
	I mean these are just based on your observations, we don't have the evidence yet. You have how many teachers?		6C, 37:27

The instructor intervened and modelled the kind of clarification question that the participants could ask to explore the magnitude of the problem. F's clarified that the school had 70 teachers and went on to describe her observation of the problem using the English teachers as an example:

(Video 6C ends at 37:26 and the next video segment is 6D, 00:00)

	Episode 2	mIAM Code	Time
F:	For example, English. Out of [the] nine [teachers], only two use technology. That mostly for the "G"* approach.	PhII/A	6D, 00:10
I:	That is interesting. Fish is using the word "use" technology. She is even hesitant to use the word "two of them have TPCK" because you don't know that…	PhI/A	
F:	I should say that, because all the English teachers are all… optionists*; their teaching option is English, which is also a luxury actually. All nine are English teachers, one with 23 years of teaching	PhII/D	6D, 01:03

(Continued on next page)

	experience. The youngest should have three years of teaching experience. I can say most have…out of the nine, seven have good content [knowledge]. They know English quite well. Two do not speak English as well as an English teacher should.		
I:	So you're saying seven out of nine have good…	PhI/D	
F:	…[good] with C, because they are optionists, all are	PhI/D	
	optionists,[4] their content should be nine out of nine.	PhII/D	6D, 02:35

In the above statement, F provided her justification of the observation that all the English teachers had good content knowledge as they were trained to teach the subject. Her conclusion was that nine out of the nine teachers have good content knowledge (though she had earlier commented that the ratio of English teachers with good content knowledge was seven out of nine). The instructor pressed for further clarification from F:

	Episode 3	mIAM Code	Time
I:	O, it's nine out of nine?	PhI/D	6D, 02:36
F:	Ya, nine out of nine, and the P[edagogical knowledge]…	PhI/B	
I:	So you're saying P[edagogical knowledge] is seven out of nine. T[echnological knowledge] would be two out of nine. [5]	PhII/C	6D, 02:45

This led to more clarification regarding the magnitude of the problem:

[4] F uses the term 'optionists' to refer to teachers who were teaching the subject for which they were trained. It carries the same meaning as specialist teachers.

[5] In this chapter, P refers to pedagogical knowledge, T refers to technological knowledge and C refers to content knowledge as conceptualized in the context of Mishra and Koehler's (2005) technological, pedagogical and content knowledge (TPACK).

Line	Episode 4		mIAM Code	Time
1	J:	The two is the experienced or the young ones?	PhI/D	6D, 02:46
2	F:	The two is the ones with 23 years of experience.	PhI/D	
3	I:	Now, do you have a sense of the TPC	PhI/A	
4		[Technological, Pedagogical, Content knowledge]?		
5	J:	How many of them…		
6	I:	Have advance TPC?	PhI/A	
7	F:	No, no. OK, change! Two out of nine is the TPC.	PhIII/A, PhIII/B	
8	I:	OK, but they are the ones that use technology?	PhI/D	
9	F:	Yes!		
10	I:	The others also use technology?	PhI/D	
11	F:	We need to say that for T because we train everyone		
12		with technology. T should be nine out of nine.	PhII/D	
13	I:	Oh…		
14	F:	Because they know; they have technological	PhII/D	
15		knowledge. But TPC only two.	PhIII/B	6D, 03:36

The clarification process helped F to recognize the inconsistency in her own thinking when she exclaimed "No. No. OK, change! Two out of nine is the TPC!" (Line **7**) In other words, she started to realize that the teachers' technological knowledge should be nine out of nine (Line **12**) as they were all trained in the use of technology and that out of the nine teachers, only two uses technology with high level of TPACK (Line **15**). In short, she was able to see the distinction between technological, pedagogical and content knowledge and technological knowledge.

The episodes above exemplified a conversational flow which started with Phase I type interaction (mainly the sharing and clarification of information) and progressed through Phase II (exploration of ideas through justification) and Phase III (discovery of inconsistency in ideas). Throughout these exchanges, the instructor played a critical role in leading the

conversation by modelling to the participants the use of clarification and justification questions to explore the magnitude of the problem.

As can be seen from the following exchanges, the instructor continued with the same approach of clarification and justification to explore a variety of ideas associated with the teachers' TPACK. For instance, the group was led to examine the teachers' technological knowledge (Line **5-9**), content knowledge (Line **10**), and technological, pedagogical and content knowledge (Line **27**) based on F's experience as the principal of the school; with the instructor continually pressing for clear justification (Line **8, 11-13, 15, 19-23**). Apart from that, the instructor constantly reminded the participants concerning the need to verify the data provided by F (Line **1, 34, 37**).

Line	Episode 5		mIAM Code	Time
1	I:	We have to remind ourselves this is based on F's		6D, 03:37
2		observation. OK? This is just English. Now,		
3		let's say, generally? Roughly? You won't have		
4		the precise data. Can we do the same thing?	PhI/A	
5	F:	Out of the 70, arr, 19 being new teachers which	PhII/A	
6		I did not have the time and money to give them		
7		training, structured training. 70 minus19?		
8	I:	51. 51 out of 70 have good pedagogy?	PhII/C	
9	F:	T!	PhI/A	
10	I:	T. P? P would be roughly 80%. Content?	PhI/A	
11	F:	English teachers are all optionists. Science, all are	PhII/A	
12		optionists. I have problem with Bahasa Malaysia		
13		(*Malay Language*)* teachers.		
14	I:	Really?	PhI/D	
15	F:	Yes. Out of the 15, 6 are not optionists…	PhI/D	
16	I:	But now they are being forced to [teach other		
17		subjects]		
18	F:	But,…		

(Continued on next page)

19	I:	So, what you're saying, this (Content) is also	PhII/C	
20		about 85% range?		
21	F:	Ya. All the Agama teachers, all 19 of them are	PhII/D	
22		optionists. All English teachers are optionists.		
23		All science are also there.		
24	I:	Which basically means they were trained to teach	PhI/D	
25		those subjects?		
26	F:	Yes.	PhI/D	
27	I:	How about teachers with TPC?	PhI/A	
28	F:	TPC…(thinking)		
29	I:	This is going to be a very rough gauge.	PhI/A	
30	F:	Ya. Arr…Should have brought the result for		
31		pencerapan (*classroom observation*)[6]…(thinking		
32		and calculating). 25%? 25% is a very, very	PhI/A	
33		rough estimate.		
34	I:	OK. So what do we do (directing the question	PhII/C	
35		to the group) with this information?		
36	R:	How do we confirm that?	PhII/C	
37	I:	OK. Can we verify this data?	PhII/C	6D, 07:38

As the discourse progressed, the instructor, with the help of the KND table (KND table is a PBL tool that is commonly used in the early stage of a PBL cycle to help participants identify what they already know (K), what else they need to know (N) and what they have to do (D) to bridge the knowledge gap), guided the participants to identify the data that they needed to know in this early stage of the PBL cycle in order to ascertain that there is a real problem:

[6] In this Chapter, translated words or sentences in the conversational episodes are expressed in italic format.

Episode 6		mIAM Code	Time
I:	Just to pause for a second. What we're discussing here, we can easily say this is what we know and this is what we need to know, OK? (referring to the KND table on the board) But this is just one aspect. What else do we need to know? We can talk about this data. What else do we know about the problem? Actually, it's good for the group members to ask you (referring to F). What do you all want to know about her teachers? One of the things is to verify that there is a real problem.	PhI/A	6D, 10:27
F:	The technology in my school. I have 1141 PCs.	PhII/A	
I:	You have more PCs than students.	PhI/A	
F:	Yes! Three labs all working. One lab is Window XP, one lab.is Window 7. Another lab is an open source lab.	PhI/B; PhII/A	
I:	And then every classroom has computers?	PhII/A	
F:	No. We used to have in every classroom. But when the money stopped coming in, the year 2000 technology became obsolete. We did not replace those in the classroom. We replaced those in the lab. On top of that, early last year, we got 522 Classmate PCs for Year Three, Four and Five, which I'm so sad because they are not fully utilized. Internet connectivity is whole campus, 24 hours.	PhII/A	
I:	Broadband?	PhII/A	
F:	Broadband. Also, they are not being used. So I was telling them I've got one big stone in my heart. I'm not doing my job well.	PhII/A	
I:	How do you know it's not being used?	PhII/D	
F:	Through *classroom observation*. Also, every room has a a log book and feedback from the students. I walked around and noticed it's not being used. On top of that, I've got three Interactive Whiteboards. The one I use is the most used one. I put one in Year Two, to be shared with Year One and Two. One in Year Three, for Year Three and Four and one in Year Five for Year Five and Six. The one in Year Five, the dust layer is about half inch thick (laugh).	PhII/D	6D, 13:36

This probing led the group to see another aspect of the problem and that was, the school was well equipped with ICT infrastructure. For instance, the school was equipped with 1141 PCs (more PCs than the entire student population of the school), three computer labs, Broadband connectivity for the whole campus and three Interactive Whiteboard. However, these ICT facilities were not well utilized by the teachers as F pointed out jokingly that "The one (Interactive Whiteboard) in Year Five, the dust layer is about half inch thick!" (last line of the episode).

This prompted R to ask F "Did you ask your teachers why are they not using the technology?" [6D, 13:37; PhII/B]. This led to a long discussion (almost 27 minutes) as the participants, with the help of the instructor, explored each possible reason with great details. Here is one snap-shot of their probing:

Episode 7		mIAM Code	Time
R:	What are the training [courses] did the teachers get regarding technology?	PhI/D	6D, 18:14
F:	Now is 100% in house training. That means I have to schedule the training for them. For some teachers I have refresher course, re-training them on how to use technology.	PhI/D	
J:	This in-house training, what do you train them on?	PhI/D	
F:	Train them on T. This year 2011, none is being done for TPCK because of lack of funds and planning.	PhI/D	
J:	So when you said training them on T, that means like put all the teachers in one room and then…	PhI/D	
F:	Not just put them in one room; get them to attend refresher course on how to use the Smartboard and how to use the laptops. We did have an Intel Teach Program.	PhI/D	
R:	What is the Intel Teach Program?	PhI/D	
F:	Intel Teach Program is the TPCK…(trying to find the right way to describe the Program)	PhI/D	

(Continued on next page)

I:	What is the curriculum in the Program?	PhI/D	
F:	Using technology to teach. Their main focus is project based learning.	PhI/D	
J&R:	Do you have examples?	PhI/D	
R:	*Example*?		
F:	I'll bring bring the module.		
I:	But you can briefly explain it. If you look at the framework, the P they use in the curriculum is actually the project based learning. The T is the use of computers that helps the Intel agenda. They basically use computers to support project based learning. They have run in few hundred schools in Malaysia.	PhI/D	
F:	Most… most of the newer ones have certificates…	PhI/D	
I:	So, how many have Intel Teaching certs?	PhI/D	
F:	Now, probably 40%.	PhI/D	
I:	40%?		
F:	Ya.	PhI/D	6D, 21:41

As can be seen from the above exchanges, the participants asked for clarification in order to understand the nature of the training that the teachers had gone through. They made an effort to minimize biases and making assumptions through such questions like "So when you said training them on T, that means like put all the teachers in one room and then…?" (from J) and "Do you have examples?" *(*from J and R).

In this entire facilitated interaction, the focus of the discussion was mainly to clarify the magnitude and nature of the problem. Additionally, the justification provided by F was based on her personal experience; there was no dispute at this point. The conversation stayed essentially within Phase I and II of mIAM (except for Episode 4 where there was a brief exchange in which F corrected herself of her own inconsistent statements). (6D ends at time 37:07)

Moments later when the group was un-facilitated, they continued to explore the possible reasons why the teachers were not using technological knowledge in their classroom teaching. What ensued, as you will notice, was a series of exchanges that explored the issues rather superficially. In a short burst of a 1-minute conversation, six different reasons were given:

Line	Episode 8		mIAM Code	Time
1	F:	…*I'm really frustrated*, because the English class	PhII/A	6E, 07:33
2		I even subscribed for them, you know Enchanted		
3		Learning? I subscribed for them, also not put into		
4		good use.		
5	J:	I think the whole problem now is they don't know..	Uncodable[7]	
6	F:	(Interrupt) No, that's why in my *previous* reflection,		
7		it's the TPCK (pointing to the whiteboard)!	PhII/B	
8	J:	Maybe they don't know. I think now the issue is…	Uncodable	
9	R:	(Interrupt) *But training should be…*	Uncodable	
10	J:	(Interrupt) *There is training.*	PhII/A	
11	R:	*Perhaps the training did not target…*	Uncodable	
12	J:	*There is no implementation*… Maybe I give you	PhII/A	
13		everything, *right*? I train you this…		
14	F:	(Interrupt) Sometimes I question myself, do I give	Uncodable	
15		too much…?		
16	J:	(Interrupt) No, I think, what, what, the issue here is	PhI/A	
17		you give them what they need but there is no room		
18		for them to sit, think and…		
19	F:	(Interrupt) Probably.	PhI/B	6E, 08:39

The six reasons that they tossed around were: the teachers don't know (Line **5**), problem with TPCK (Line **7**), training (Line **9-11**), implementation (Line **12**), the school providing too much training to the teachers (Line **14**) and there was no room for the teachers to sit and think (Line **15**). But as can be seen from the above exchanges, no one challenged the

[7] "Uncodable" refers to statements which carry unclear or ambiguous meaning.

assumptions or the potential biases of these observations and no justifications were given. On top of that, the members did not make effort to listen to each other. It can be clearly seen that the participants interrupted and cut into each other's conversation frequently (see Lines 6**, 9, 10, 14, 16** and **19**). Consequently, the members' ideas and arguments were not given the space to develop further or more fully. In many of these exchanges the statements can't be coded using the mIAM as their meanings were unclear.

Though there were instances when disagreements were beginning to surface (refer to lines **5-7**, **14-18**), these disagreements were not taken up for further exploration before they were interrupted by another new idea. As a result, the conversation did not develop into a grounded discourse which began to happen only in the next segment.

4.1.1.2 Grounded discourse which revolved around the clarification and justification of data

A brief moment later, the conversation took a turn and the interruptions stopped when F started to describe to the group her interpretation of the problem that her teachers were facing. F explained that the teachers in her school were skilled in technology but they rarely used it:

Episode 9		mIAM Code	Time
J:	I think now the issue is they have the…	Uncodable	6E, 09:22
F:	(Interrupt) They have the T.	PhI/A	
J:	Ya, they have the T.	PhI/B	
F:	They have the T, they have the P, they have the C. It's the…	PhI/A	
J:	To merge, to bring them together.	PhIV/A	
F:	*This is how it looks like*, (proceed to draw 2 circles of P&C which overlap some and a separate T circle as indicated in Figure 4.1). *There is P*. *There is C*, *They are able to do this*, pedagogy	PhIV/A	

(Continued on next page)

	and content, *they can do that*…	
J:	*I think the problem is they do not know how to bring in T,*	PhIV/A
F:	*There is T, but T is not incorporated into this* (referring to	PhIV/A
		P&C)
J:	Yes (nodding in agreement). But we need to verify this.	PhI/B
	Is this true? Is this the problem now, we need to verify.	PhII/C
F:	*I'm saying that their T is almost 100%. Why is that? Because the administration of the school is totally digital.*	PhII/D
J:	*So there is no reason for saying they do not have T, right? They have the T.*	PhI/B
F:	Test papers must be digital. *I don't allow for photocopying and pasting. They have to scan and upload*. We have a virtual file system. The file is put in the server so that everybody can access …	PhII/D
		6E, 10:49

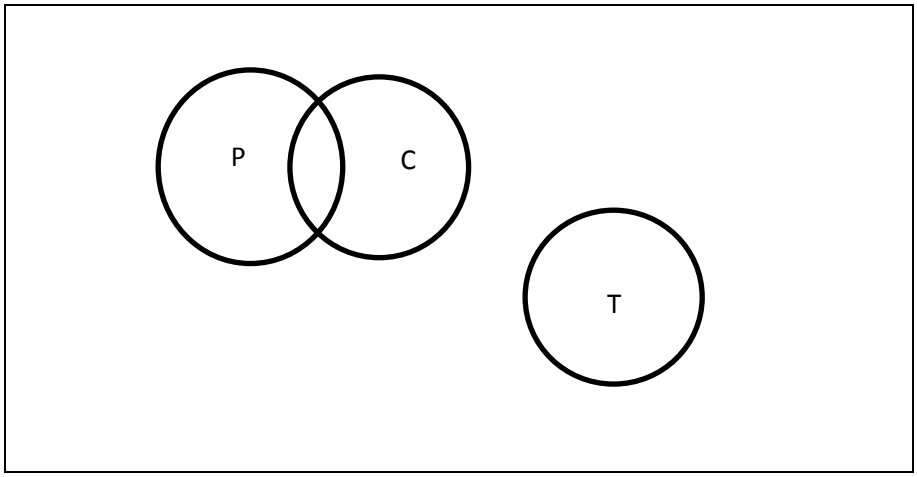

Figure 4.1 F's interpretation of the teachers' state of TPCK in her school. [6E, 09:43]

In the above exchanges, F provided evidence to support her interpretation of the problem. Additionally, the visual representation of the problem that she provided (Figure 4.1) seemed to help in that the participants started to anchor their exploration of ideas using the TPACK framework. As a result, the interaction became more grounded and, as can be clearly observed from the above conversation, the interruptions stopped and the participants were now more attentive to each other's opinions. This led to a clearer understanding of the

problem scenario and both J and R agreed that the next step was to verify F's hypotheses that the teachers' technological knowledge was separate from their pedagogical content as they simultaneously responded to F by saying "We need to verify that" (Line **4**):

Line	Episode 10		mIAM Code	Time
1	F:	Technology in the administrative part OK, email	PhII/D	6E, 11:12
2		and so on. This is what is missing. (pointing to	PhIV/A	
3		the diagram she drew).		
4	J&R:	We need to verify that.	PhII/C	6E, 11:24

The suggestion by J and R was immediately taken up for further exploration as they brainstormed some possible methods for data collection. The validity of each of the methods was also explored. Towards the end of the session, they proposed to look into developing some survey tools to verify their interpretation of the problem as depicted in Figure 4.1. The session ended at time 27:11.

When the meeting resumed in the following week, the group presented their ideas on data collection. The main focus of their discussion was on the tools and methods that the group would like to use for data collection. Here is a snap shot of such a discussion:

Episode 11		mIAM Code	Time
I:	So how are you going to verify the state of TPCK?	PhII/C	7E, 18:34
F:	We are reading the article and like the examples of teachers with TPCK. Get one or two situations and get the teachers to write reflections.	PhII/E	
I:	In response to that?	PhI/D	
F:	Ya, in response to that. And their own reflections on	PhI/D	

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	their own…		
I:	Their own practice.	PhI/D	
F:	Probably also include their beliefs. I want to know what they think about putting technology into…	PhII/E	
I:	Into what?	PhI/D	
R:	P&C	PhI/D	
F:	Ya, P&C.	PhI/B	7E, 19:30

The interaction moved between Phase II/C and Phase II/E of mIAM as they decided on the specific data which they needed to collect to validate their hypotheses that the teachers' technological knowledge was separate from their pedagogical content knowledge. (NOTE: The group has slightly less than an hour of discussion time as the first part of the session was used for the presentation of Case One)

When the group returned for their next session (Session 8), they were ready to present their findings regarding the state of the teachers' TPACK. (Note: Before the participants met for session 8, they had a discussion, which the researcher had no privy to, and decided against the idea of getting the teachers to write their reflections on some examples of teachers with high level of TPACK, an idea which was discussed in Episode 11. Instead, they preferred to use some of the standard instruments on which the teachers had been assessed). J started by saying that, based on her observation of the data collected from SQSS, the teachers rated themselves highly in their technological knowledge and F concurred with that observation:

Episode 12		mIAM Code	Time
J:	She (refer to F) brought the questionnaire (refer to SQSS) and I was looking through it and I found that the majority of the teachers, they feel that they have the knowledge, they are confident with their knowledge because they rated themselves as four and five when it comes to technology. They rated themselves very highly. But when you look at the implementation part, using it in the classroom, arr, some said they used it once a week, some said once a month. So…	PhII/D	8B, 09:00 8B, 09:52
	(few minutes later)		
J:	And these teachers…what is very fascinating is they have it, knowledge wise. They know they have it. They are very confident because they rated themselves very highly: five, most of them or all criteria are five. So knowledge wise, they are very strong.	PhII/D	8B, 12:29
F:	I think my teachers are all 100% IT literate. They know how to…their Microsoft Word are intermediate or advanced level, one or two with basic. The rest are all good.	PhI/C	8B, 13:07

As can be seen from the above conversation, the validation of the teachers' high T was straight forward and without any disputes as the participants were able to provide justification through two sources of data and these included formal data collected (SQSS) as well as through F's knowledge of the teachers. The conversation stays within Phase II of mIAM.

4.1.1.3 The validation of the teachers' technological knowledge being separate from their pedagogical content knowledge

Though the teachers' technological skills were high, they rarely used them in their teaching and learning as highlighted by J in the above exchanges:

> They are confident with their knowledge because they rated themselves as four and five when it comes to technology. They rated

> themselves very highly. But when you look at the implementation part, using it in the classroom, arr, some said they used it once a week, some said once a month. (Episode 12; 8B, 09:08)

Despite being highly skilled in technology, the teachers were using technology in their teaching either once a week or once a month. The group did a more detailed analysis later and reported in their eBook:

> The SQSS indicated that teachers have good technology knowledge. This is shown in the series of question on how they rate themselves in using some listed tools. However, teacher only integrated technology in classroom, in average at least once a month. This is pretty low in frequency given that the teachers recognized themselves as well-versed in technology. [eBook, Case 2. Chapter title: Development of a Smart School Teachers' TPCK, Section I (1)]

The instructor helped them to put this data into perspective through the following exchanges:

Episode 13		mIAM Code	Time
I:	On average, how many periods does a teacher have in a week?	PhI/D	8B, 11:21
F:	Arr…30 periods a week.	PhI/D	
I:	So many? 30 periods?	PhI/D	
J:	In my own school is like that. They teach more than one subject. They don't like…	PhI/C	
F:	They have core subjects which they major in.	PhI/D	
I:	Just to put things in perspective. Let's just say 30 periods a		

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	week. That is 120 periods a month. Once a month, that is one period in 120 periods a month using technology.	PhII/A	
F:	Which is pathetic.	PhI/A	8B, 11:58

Clearly, the usage of technology by the teachers was indeed low (one in 120 periods a month). That was a clear indication that the teachers' technological knowledge was separate from their pedagogical content knowledge as highlighted by the following exchanges between F and the instructor:

Episode 14		mIAM Code	Time
F:	T is like…where do I come in?	PhI/A	8B, 14:09
I:	Ya, ya. Once every 120 periods.	PhI/B; PhII/D	
F:	T gets out of the big circle.	Uncodable	
I:	Ya, once every 120 periods. It's fair to say that T is fairly…		
F:	Separate!	PhII/D	
I:	…from the P&C, because it's not even part of their P&C. So now we have the data to verify that T is quite separate from the P&C.	PhII/D	8B, 14:35

The process of validation in this instance was also straight forward as they had robust data to support their arguments that the teachers' technological knowledge was separate from their pedagogical content knowledge. The discourse moved between Phase I and II of mIAM.

4.1.1.4 The process of validation of the teachers' pedagogical content knowledge

As the conversation progressed, the instructor reminded the group regarding the need to verify their conclusion that the teachers' pedagogical and content knowledge were integrated. The instructor pushed for a good justification from the group by asking "The question that

we have to get back to is: how do you assess? Can you just use SKPM?" [8B, 25:24] (PhII/C) (The group had earlier mentioned that the data from the instrument SKPM can be used to verify the teachers' pedagogical and content knowledge). The following two threads of conversation (separated by an interval of about 5 minutes) highlighted the justifications given by F and J:

Episode 15		mIAM Code	Time
I:	The question that we have to get back to is: How do you assess [that P&C are combined]? Can you just use SKPM?	PhII/C	8B, 23:30
J:	It's very detailed. It's …	PhI/A	
R:	What are some of the things that they measure? How do they…what are some of the things that they observe?	PhI/D	
J:	*Student participation* is one of the criteria. And then they give, arr…if *there is no student participation*, the teacher gets only one point.	PhI/D	
R:	*Student participation? Does that mean* students…	PhI/D	
F:	It's online.	Uncodable	
J:	… (can't decipher) they want to observe a teacher…	PhI/D	
F:	*Classroom management, management of lessons.*	PhI/D	
R:	*Does it deal with pedagogy?*	PhI/D	
J:	*It does*.	PhI/D	
F:	*It does*. It's quite extensive.	PhI/D	8B, 24:31

Episode 16		mIAM Code	Time
R:	*But, J, have you seen the instrument?*	PhI/D	8B, 31:37
J:	I do observe…	PhI/D	
R:	O, you do observe.	PhI/D	
J:	Teachers who are under me, I do observe using that.	PhI/D	
R:	So do you think *the questionnaire is OK, if we want to find out if the teachers' P&C are combined? Like if*	PhII/C	

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	a teacher only reads from the text book? Can we find that out from the questionnaire?		
J:	*Yes! We can tell* how well the teacher knows the content because that instrument is very…	PhII/C	
R:	Detailed?	PhI/D	
J:	Ya, detailed. So we know whether the teacher is achieving the objectives…	PhI/B PhI/D	
R:	*Is it possible to tell?*	PhI/D	
J:	*Definitely.*	PhI/D	
R:	*Now we can answer this* (pointing to scenarios A on the board)	PhI/A	
J:	*But can't tell about their technological knowledge. Can definitely tell about their P&C, it's very clear.*	PhII/D	8B, 32:20

As can be seen from the above conversation, Both F and J argued that since the instrument SKPM was detailed and it evaluated many areas that related to a teacher's pedagogical and content knowledge and these included students' evaluation, class room management, the teacher's content knowledge and students' learning objectives, it can be used to assess if the teachers' pedagogical and content knowledge were combined by looking at their scores (the maximum score being 6). As the conversation progressed, both F and R provided more detailed examples of how the instrument SKPM can revealed the state of the teachers' pedagogical and content knowledge.

The above episodes exemplified the process of clarification, justification and verification of information as the participants sought to construct their initial interpretation of the problem. The instructor modelled good questioning strategies to help the participants to clarify the magnitude of the problem. F provided good justification by alluding to her experience with the teachers as well as the ICT facilities in her school. The data from SQSS and SKPM were aptly applied to validate their interpretation that the teachers' technological knowledge was

not integrated with their pedagogical content knowledge (Figure 4.1). There was no dispute at this stage as the process of clarification and justification was straight forward and the participants produced clear arguments and data to support their interpretation of the problem at hand. The interactions remained largely at Phase I and Phase II of mIAM.

4.1.1.5 Cognitive puzzlement and a muddled interaction

Up to this point, the group was quite convinced that the teachers' problem was that their technological knowledge was separate from their pedagogical and content knowledge. This was because the data from SKPM showed that the teachers' pedagogical and content knowledge was integrated and the data from SQSS revealed that the teachers, though they had high technological knowledge, they rarely applied the knowledge to their teaching and learning in the classrooms. This prompted J to share her own experience as an attempt to identify the root cause of the problem they were dealing with:

> "I think there is a reason why teachers are reluctant to incorporate technology. This is my personal experience: sometimes it takes such a long time to find materials." [8C, 07:36] (PhII/B)

Both R and F responded to J's statement as shown in the following exchanges:

Line	Episode 17		mIAM Code	Time
1	F:	True. In my school, it's not just about finding	PhI/C	8C, 07:50
2		the materials, it's too much preparation…		
3	J:	Preparation includes finding materials. (Describing		
4		a personal experience)…But to find the pictures	PhI/C	
5		that really tell me the context of what I want to		
6		explain, it took me three days to just prepare for one…		
7		just to make sure the students understand the poem.		
8		That's only to understand the poem and what about		
9		the exercise. So I think… this is the issue of		

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10		motivation as well. I feel that I don't have that	PhII/B	
11		much time…		
12	R:	Therefore not motivated!	PhII/B	
13	J:	I feel like I spent so much time for something so	PhI/C	
14		small, when there are so many things to cover.		
15		Why don't I just…		
16	F:	Use easier technology.		
17	J:	It's not just technology but anything that gets…	PhI/C	
18	R:	Things done.		
19	F:	Get the message across…		
20	R:	…It's like choosing a teaching strategy: instead of	PhI/C	
21		having group works, some teachers prefer to lecture		
22		as this allows for more content to be covered…		
23	F:	(Nodding in agreement) It's like teaching	PhI/C	
24		mathematics, especially at the lower primary level.		
25		You have to start with the concept. For example, in		
26		order to teach the concept of 'division', teachers		
27		should be using concrete objects like marbles and get		
28		the students to distribute the marbles into, say, three		
29		groups with equal number of marbles in each		
30		group. Then they learn the concept of 'division'…		
31		But some teachers bypass the process because the		
32		method takes time		
33	R:	They just use example like 15 divide by three	PhI/C	
34		equals to five, then recite it!		
35	F:	Five multiply by three are [sic] 15. But the concept	PhI/C	
36		is not clearly communicated. In my case, it was		
37		much later that I truly understand the concept of		
38		division.		8C, 10:54

Both R and F supported J's statement by providing corroborating examples (Line **1-11, 13-19, 20- 38**). And the conversation stays mainly at Phase I/C

At this point, J began to question her own observation and expressed her doubt about the issue of time constraint and attempted to explore if there could be deeper issues that the

teachers were wrestling with and they used the idea of time constraint as an easy out. This advanced the conversation, for the first time, to Phase IV/A of mIAM:

Episode 18		mIAM Code	Time
J:	But is it true that the teachers don't have enough time?	PhII/C	8C, 10:55
R:	Or we think that they don't have enough time?	PhII/C	
J:	Is it true that the teachers do not have enough time or they just want an easy way out?	PhIV/A	
F:	Hmm…that's the question.	PhI/A	8C, 11:14

However, both J and R did not respond to this new line of discussion. Instead, they re-stated their arguments for time constraint by giving more corroborative examples, leaving a potentially deep issue unexplored. This brought the conversation back to Phase I/C:

Episode 19		mIAM Code	Time
J:	For example, in the upper form, I always feel I don't have enough time because there's much to cover. For example, within a subject, like my subject English… language is in fact not so bad because I'm repeating the same skills in different versions but at the end of the day, it's about writing skills, grammar…but in primary schools (directed the question to F), do the teachers have to cover many topics within a year?	PhI/C	8C, 11:20
R:	From my experience in designing the CDs for primary levels, especially for the sciences, there seemed to be many topics to be covered, like photosynthesis, seed growth…more than 40 topics. Is there sufficient time to cover in a year?	PhI/C	
J:	Then they have a lot to cover in a year.		
F:	(Nodded in agreement)	PhI/B	
R:	Because of that they have to rush to finish the syllabus.	PhI/C	
J:	They also have time constraints.	PhI/B	8C, 12:25

As the discussion did not progress beyond the issue of time constraint, the group started to consider other alternative hypotheses. As indicated in the following exchanges, the discussion remained shallow as they skimmed from one possibility to another without giving good justifications and these possibilities include issues like lack of motivation (Line **1-3**) and lack of support (Line **7-11**). Furthermore, they did not have the data to support or reject these possibilities. J's argument that the teachers did not have the support was speculative as she said "Maybe, maybe..." (Line **7, 9-10**). Similarly, the group did not have the data to show that time constraint (Line **16-17**) or the teachers' lack of motivation was an issue (Line **18-20**). Before long, the participants began to feel frustrated and unsure as they responded to each other's comments with frowns (Line **3**) and giggles (Line **20**). The conversation vacillated between Phase II/A and Phase II/C of mIAM . Here are some snap-shots of the interaction:

Line	Episode 20		mIAM Code	Time
1	J:	…*Because the motivation has to be strong.*	PhII/B	8C, 13:44
2		*Regardless of what we say*, so basically the issue		
3		of motivation? time constraint? (Frowns). Maybe		
4		it's because of time constraint?		
5	R:	We can't really tell. Yes, time constraint can also	PhII/B	
6		be a problem.		
7	J:	Or maybe they feel that they are working alone.	PhII/B	
8	R:	And have no support…	PhII/B	
9	J:	They don't have a team, no support. Maybe,	PhII/B	
10		maybe…*The school wants me to use, but I can't*		
11		*do it alone. Besides, I don't have time…*		
12	R:	*From SQSS and SKPM combined, there is*	PhII/D	
13		*evidence that the problem is the same as A. Now*		
14		*the question is 'why'. It could be due to time*	PhII/C	
15		*constraint, lack of motivation*…(can't decipher)		
16	F:	*If the issue is time, what data to support that?*	PhII/C	
17	R:	Ya.	PhI/B	

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18	F:	*Lack of motivation, what data to support that?*	PhII/C	
19	R:	*What's the evidence?* We don't have the evidence	PhII/C	
20		yet (giggling). *We have definitely verified that*	PhI/A	
21		*this is the problem* (referring to Scenario A).		
22	F:	To verify this (referring Scenario A), I can bring		
23		their scores.	PhII/E	
24	R:	But to do interviews (to find out the other	PhI/A	
25		possibilities), we are talking to the same group of		
26		teachers.		
27	J:	Where are we going to get…or…	PhIII/A	
28	R:	The verification?		8C, 15:53

The following interactions demonstrated their struggle in dealing with the myriad of possible root causes they had raised:

Line	Episode 21		mIAM Code	Time
1	J:	As we were discussing, few other issues came up.		8C, 21:52
2		We were wondering, we were questioning is it	PhIII/A	
3		because they don't want or is it because of some		
4		other issues like time constraint, or is it purely like		
5		they feel that they are alone trying to come up with		
6		modules or plan things, and they are alone. So we		
7		were asking F if she could have information like	PhII/C	
8		what could possibly be the reasons for them to put		
9		it aside. Is it because of time or issues like that. F		
10		said she had asked the teachers to do some		
11		reflections…		8C, 22:38

(Note: For the next few minutes, the group sought clarification from F regarding the teachers' reflections. F clarified that the reflection exercise was given at the end of the academic year to provide the teachers an opportunity to reflect on some areas of their teaching and learning in the school such as the curriculum, classroom experience and extra-curricular activities. The reflection exercise was not designed to discover the teachers' state of TPACK)

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12	I:	R and J, what's your response to this data set?	PhII/C	8C, 26:35
13	R:	We still cannot say what's the problem yet. That's	PhIII/A	
14		why, just now J said we need to know the		
15		reasons behind. We don't know the whys. There		
16		are still things we need to find out.		
17	J:	Things like they have the knowledge but they	PhIII/A	
18		don't want to integrate it. So there must be		
19		something that causes this. We are thinking along		
20		those lines like time constraint…but the feedbacks	PhIII/A	
21		are only from two teachers. And both seem to say		
22		that they have limited time. So time seems to be		
23		one of the contributing factors…		8C, 27:47

Both J and R were not able to get to the bottom of the problem as they wrestled with a range of possibilities. As R put it, "We don't know the whys. There are still things we need to find out" (Line **15-16**). Similarly, J noted that though some teachers had expressed that they struggled with limited time (Line **22**), the data was too thin to conclude that time constraint was the root issue since "the feedbacks are only from two teachers" (Line **20-21**). The cognitive puzzlement that the participants experienced at this stage caused the interaction to muddle at Phase III/A of mIAM.

4.1.2 Negotiating for a deeper understanding of the root problem (A discourse which advanced into Phase III and Phase IV type interaction)

4.1.2.1 Probing deeper through role play

What occurred in the subsequent exchanges highlighted the instructor's intervention that advanced the interaction into deeper phases. In responding to their puzzlement, the instructor modelled the process of probing deeper by role-playing the scenario when he said:

> "OK, let's play out the scenario…J is the teacher in school. J, do you use technology every day?" (8C, 30:29; PhI/A)

And the subsequent exchanges took place:

Episode 22		mIAM Code	Time
J:	No. not every day.	PhI/A	8C, 30:36
I:	How many times a month?	PhI/D	
J:	A lot of contributing factors…whether I'm able to book the room, that's one issue. If I'm able to use it, approximately, it'll be once a week…because I have my literature lessons and I try to bring in technology because they know the teacher will talk less and they will enjoy the lesson…also more visuals.	PhI/D	
I:	Do you feel your students have learned better?	PhI/A	
J:	I did ask them…almost 60% say that they enjoy the lesson because I'm the only teacher who brings them to the lab and use technology. They feel that they learn better.	PhI/A	8C, 31:47

J's response indicated that though her experience with the use of the technology in her teaching and learning had been positive, she did not use technology very frequently, and it was only once a week. The instructor was quick to pick up this inconsistency in her statements and the inconsistency was articulated and explored further when he pressed:

Episode 23		mIAM Code	Time
I:	If the data is so positive about using technology for learning, why don't you use it more?	PhIII/C	8C, 31:51
J:	Time constraint!	PhIII/C	8C, 32:03

By identifying the area of inconsistency and seeking to clarify the cause of this inconsistency, the instructor pushed the discourse to Phase III/C. J was quick to respond by stating that 'time constraint' was her reason for not using technology more often in her teaching and learning. The instructor enquired further by asking "How? What limits your time?" [8C, 32:06; PhIII/C]

J supported her position by sharing her personal experience of dealing with technology in her lesson preparation:

Episode 24		mIAM Code	Time
J:	In order to prepare, the main thing is what we want to put up should be able to achieve the objectives of the lessons and sometimes it's not easy, you need to scroll down for quite some few pages before you find something suitable. Or sometimes you might have to pick a few, put it together or redo the whole thing so that it fits into what you want to achieve.	PhIII/C	8C, 32:10
I:	You are referring to internet resources?	PhI/D	
J:	Internet as well as my own resources. Sometimes I will type the dialogues and I have to find pictures so that I can have a face that is speaking…that takes a lot of time.	PhI/D PhIII/D	8C, 32:59

When J reiterated the issue of time constraint with her personal experience, the instructor led her to consider some other potentially deeper challenges that teachers may face when they used technology in their teaching and learning. He led with the question:

> "Does your pedagogy change when you use technology?" (8C, 33:03; PhIV/A)

This advanced the discourse to Phase IV/A as the instructor attempted to negotiate for a new and deeper way of looking at the issue of time constraint. This line of negotiation continued:

Episode 25		mIAM Code	Time
J:	Yes, I think I'm more student oriented because I talked less. 'What do you think? Tell me'. There is more interaction between me and them. And also, they speak more.	PhIV/A	8C, 33:05
I:	Does that…What I almost hear is the risk that you may	PhIV/A	

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	plan a 45 min class but your objective may not be met.		
J:	There were a few times that had happened.	PhIV/A	
I:	Is the risk higher when you use technology?	PhIV/A	
J:	Initially, when I started, I was everywhere. As I began to use; adapt and adopt; now it's getting better. I make sure that the objectives are achieved. I think with experience and time and practice, it will get better.	PhIV/A	8C, 34:08

The instructor used the opportunity to highlight the value of looking beyond the surface in order to get to the root cause:

Episode 26		mIAM Code	Time
I:	The last 2 minutes, I was leading her a little bit by the way I was asking the questions. About 5 minutes ago, in the middle of the discussion, she specifically talked about time. But subsequently after that, what happened? Was it about time?	PhIV/A	8C, 34:09
F:	No…		
I:	I just want to point out to you that just because somebody says he doesn't have time, it doesn't mean that is the root problem… why did they not do it (using technology to teach)? Because using technology requires them to change. It requires them to change their pedagogy and changing pedagogy takes time because things become unpredictable… All of a sudden you have to deal with things that you've never have to deal with in the past, that's the part that takes time. It's just not, maybe it is just not as simple as…	PhIV/A PhIV/B	
F:	No time to do it.		
I:	All of a sudden, it takes you out of your regular way of functioning. To most human being, that's uncomfortable. So I'm just raising this as an issue because…you need to be prepared to probe deeper.	PhIV/B	8D, 00:18

(NOTE: Video 8C ends at 37:05)

To arrive at a clearer interpretation of the problem they were dealing with, the instructor pushed the group to re-think the significance of the possible root causes they had been discussing when he stressed:

> So, if you go deeper into this, you can begin to get a picture what kind of data you'll get. So I'll ask you again, the same question earlier, is this information critical? Will it change the shape of your problem? Will it change the nature of your problem? [8D, 07:22; PhIV/A]

In response to the instructor's question, the group started to re-collect their thoughts and many exchanges were made to help each other to consolidate their arguments. They eventually arrived at the conclusion that there could only be two possibilities to explain why the teachers' technological knowledge was separate from their pedagogical content knowledge and they were: either the teachers 'do not want to' or they 'do not know how'. This critical scenario is described in the next segment.

4.1.2.2 Shifting the nature of the problem

R alluded to the data from SQSS and asked:

Episode 27		mIAM Code	Time
R:	*If we refer to SQSS, it only shows that T is high, it does not tell us if the teachers know how to integrate their T into their P and C, is that right? We don't know that, or like what J pointed out, they know but refuse to use it?*	PhIV/A	8D, 10:23 8D, 10:34

R's statement about SQSS indicated that she was beginning to recognize the limitation of the instrument and pointed out that the data only showed that the teachers' technological

knowledge was not linked to their pedagogical content knowledge, it did not provide the reasons why. In other words, the complexity of the problem cannot be explained using the data from SQSS. As the conversation progressed, the complexity of the problem began to overwhelm them. This was evident in the following exchanges as they vacillated between "they know" and "they don't know", doubting and laughing at their own reasoning:

Episode 28		mIAM Code	Time
J:	*Like the previous discussion, we can't tell if the teachers know how to integrate…most teachers only use one percent. That means…*	PhIII/A	8D, 12:59
F:	*They know…*	PhIII/A	
J&R:	(Laugh)	PhIII/A	
R:	*They know?* (Giggle)	PhIII/A	
J:	*They don't know*? (All three laugh at their own comments)	PhIII/A	8D, 13:20

Clearly, there were some degree of cognitive puzzlement expressed by the participants as they wrestled with multiple sources of data (for instance, the data from SQSS as well as the low percentage usage of technology in the classroom among the teachers) and realized that these data did not provide the reasons why there was no integration of the teachers' technological knowledge with their pedagogical content knowledge. At this juncture, their conversation remained stuck at Phase III/A of mIAM.

Eventually, J proposed a way out and suggested that they should just settle for 'they don't know' as the root cause since the group did not have the data to validate the other possible root causes:

Episode 29		mIAM Code	Time
J:	*That is the question now, do we conclude that they don't know or ....If we said that they don't have time, then that data is critical. We just take it that they don't know that's why they are not doing it and we can stick to the…*	PhIII/A PhII/E PhII/B	8D, 15:29
	(Long pause)		8D, 15:51

Obviously, this line of discussion was dictated by whether they had the data, there was no good justification given when she argued ''we just take it that they don't know that's why they are not doing it…''. A short while later, J reiterated: "Just take it that they don't know. Because they don't know, that's why they don't integrate…" [8D, 16:12; PhII/D]. The interaction reverted to Phase II of mIAM.

At this point, F expressed her disagreement and argued that the main issue was that the teachers did not have the skills to integrate their technological knowledge into their pedagogical content knowledge (Line **1**). In response to that, both R and J expressed their doubts over F's statement (Line **3-4**). In Line 4, J re-stated her position that the teachers were skilled in technology as they obtained very high scores for their technological knowledge in SQSS.

Line	Episode 30		mIAM Code	Time
1	J:	*Not that they don't know; they are not skilled!*	PhIII/B	8D, 16:20
2		(Original: Bukan tak tahu; tak mahir!)		
3	R:	*Not skilled?* (with doubtful tone and giggling)	PhIII/C	
4	J:	*Not skilled, F? It's five, five, five!* (referring to the	PhIII/D	
5		teachers' scores for their technological knowledge		

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6		on SQSS)		
7	F:	*No, they do not have the skills to integrate; they*	PhIII/B	
8		*do have the technological skills!* (Original: No,		
9		tak mahir integrate; bukan tak mahir technology!)		
10		Technology high but to integrate low.	PhIV/A	8D, 16:33

Here, F clarified that the phrase "not skilled" (original "tak mahir") was referring to the teachers' skills to integrate their technologic knowledge with their pedagogical content knowledge; rather than their technological skills (Line **7-8, 10**). F reiterated that the teachers' technological skills were high but they lacked the skills to integrate their technological knowledge into their teaching and learning (Line **10**). These exchanges exemplified a discourse situation whereby the participant's cognitive operations moved the process of social construction of knowledge from Phase III to a more advance phase PhIV/A (i.e. negotiating for a new and deeper understanding underlying an issue) as F pushed for a new line of discussion and a deeper way of looking at the problem ("Technology high but to integrate low"). For the first time, a potential root problem emerged in the participants' discourse. This shifted the nature of the problem from "do not want" (original "*tak nak*") to "do not have the skills" (original "*tak mahir*").

The instructor affirmed this critical moment as he said:

> "Now, that's an interesting perspective. It does take a different skill to integrate. That's a very good observation!" [8D, 16:45; PhIV/A]

F supported her argument by providing some examples taken from her personal experience:

Episode 31		mIAM Code	Time
F:	Like the Jordan graduate, he knows. He did all the *e-report* and everything. *[His technological knowledge*] is definitely OK, *but* to slot where, to know where the T goes with P&C, that, he has a problem with that.	PhII/D	8D, 16:49
I:	Based on you looking through that (referring to SQSS), how many percentage will fall into this category?	PhII/A	
J:	Quite a number, I would say.	PhII/A	
I:	Like half?	PhII/A	
J:	Ya, it was almost half.	PhII/A	
I:	Half of 80, is it?	PhI/D	
F:	Half of 69.	PhI/D	
I:	So we are talking about 30. Is that surprising to you?	PhI/D	
F:	No. I have observed seven of my English teachers, Out of the seven, three uses tech[nology], two uses it well, incorporating games and using the laptops. She did OK but she is not doing it all the time.	PhII/D	
I:	So 3 out 7. So it's quite consistent with the overall data…	PhII/D	8D, 18:10

However, this critical moment where F initiated a new line of thinking was not taken up for further exploration. As the following exchanges indicate, the participants merely skirted around the issue. As the instructor tried to fade his scaffold (Line **1-2**), the participants struggled to move the conversation forward as they were unsure how to validate the various possible root causes (Line **5-6, 10-12**). They vacillated between 'do not know how' and 'do not want' and the conversation stayed within Phase II of mIAM:

Line	Episode 32		mIAM Code	Time
1	I:	So what do we do now? I'm trying very hard to	No code	8D, 18:16
2		fade here!		
3	F:	Probably see why…	Uncodable	
4	R:	Don't know how or don't want. If don't want is it	PhII/B	
5		because no benefit or no time? *Can we ask them*	PhII/E	
6		*if they know [how to integrate]*?		
7	F:	Probably, when they said they used it once a	PhII/A	
8		month, it's like the Ustaz, he is using CDs to		
9		demonstrate…		
10	R:	If *they do not want to*, there are two possible	PhII/B	
11		reasons: no benefit or no time. *One other reason is*		
12		*that they do not know how, but is that valid?*	PhII/C	8D, 19:43

F continued to press for negotiating a deeper way of understanding the issue when she stated that the teachers would need to change their pedagogies when they used technology in their teaching (Line **1-2**):

Line	Episode 33		mIAM Code	Time
1	F:	Actually, it's a fact that their pedagogies have to	PhIV/A	8D, 20:15
2		change. *That is for sure.* Because [it is] very		
3		comfortable just to use…		
4	R:	What we are used to…	PhI/B	
5	F:	Whiteboard and the marker, and some are the	PhV/A	
6		lecture kind of teachers, or worksheet kind of		
7		teachers, give worksheets and then teach and give		
8		worksheets. Comfortable with that. Their pedagogies		
9		produce results so to change to another new…		
10		another pedagogy using technology, that…Because		
11		they don't have any logistic problem. Internet	PhV/A	
12		problem. Internet could be slow sometimes but		
13		it's there, 24 hours. Electricity no problem, never		
14		have a black-out.		8D, 21:16

In short, F was arguing that using technology would require the teachers to move out from pedagogies which they were comfortable with ("White board and the marker", Line **5**), and such a change can be uncomfortable for the teachers. Again, the members in the group did not respond to this effort to negotiate further; instead, they proceeded to define the problem.

4.1.3 Dealing with cognitive dissonances (A discourse which vacillated between Phase II and Phase V of mIAM)

As you will notice from the following exchanges, each time as the participants attempted to co-construct a shared understanding of the root problem, they were often encumbered by the re-emergence of the other possible root causes. Consequently, the process of co-construction was 'hijacked' and the formulation of the problem was not complete. Table 4.1 below shows the four episodes where the attempted processes of co-construction were interrupted and ended prematurely:

Table 4.1 Four occurrences where the process of co-construction were interrupted and ended prematurely

Line	Occurrences	Time	mIAM Codes
	Occurrence 1		
1	*R: We define the problem as…*	8D, 21:27	PhIV/A
2	*F:* Don't know how to integrate…		
3	*R: So, there is no need to ask further questions.*		PhII/B
4	*J:* Just sum it up as although they are good at ICT		
5	knowledge but they are not confident? Or they are		
6	not…they don't know or is it they are not confident?		PhIII/A
7	*F*: They are not…		
8	*R&J: Don't, don't [ask more questions]. There will be*		
9	*more…There is no need to ask.*	8D, 22:02	

Table 4.1, continued

		Occurrence 2		
10 *11* *12* *13* *14* *15* *16*	*J:* *R:*	Although they have good ICT knowledge, they are not able to integrate… *That becomes the root cause. If we explore, 'no confidence' can be a possible root cause too. There are many [possible root causes]. How to resolve that? If they have no confidence, then we need to provide training.*	8D, 22:36 8D, 22:42	PhIV/A PhIII/A
		Occurrence 3		
17 *18* *19* *20* *21* *22* *23* *24* *25*	*F:* *R:* *F:* *R:* *F&J:* *J:*	*It's not a confidence issue. They are certainly confident. But they do not know how.* *So, what should be the root cause?* *[They] do not know how to change their pedagogies.* *[They] do not know how to change their pedagogies; that means they do not know how to integrate.* *Ya.* *If we explore further, there will be a long list of possible reasons.*	8D, 23:30 8D, 24:00	PhII/A PhIV/A PhIII/A
		Occurrence 4		
26 *27* *28* *29* *30* *31* *32* *33* *34*	*R:* *J:* *R:* *J:* 	*That's what we need to explore but we have decided on the root cause and we do not want to consider the other [root causes]. We want to look at their problem as not being able to…* *Because this is what is really related, if we start taking time…* *Or motivation…* *This is going to be a very long list to settle, as you said. I don't think…*	8D, 26:08 8D, 26:26	PhI/A PhIII/A

Table 4.2 on the next pages provides a summary of such occurrences:

Table 4.2 A summary of occurrences where the process of co-construction were 'hijacked'

Occurrence	The attempt to co-construct the problem statement	The emergence of multiple root causes which 'hijacked' the process of co-construction
1	Line 1-2	Line 5-9
2	Line 10-12	Line 12-16
3	Line 19-23	Line 24-25
4	Line 26-29	Line 30-34

For example, in Occurrence 1, as the participating were attempting to co-construct the definition of the problem (Line 1-2, 4), the issue of possible root causes re-occurred when J asked "they don't know or is it they are not confident?" (Line 5-9) and as a result the conversation was sidetracked and the formulation of the root problem ended prematurely. These episodes demonstrated that the issue of root causes still remained unresolved at this point. After the above series of back-and-forth discussions, F continued to make a case for "don't know how", convincing the rest to come to a shared understanding:

Episode 34		mIAM Code	Time
F:	*So, clearly, they don't have the skills…that is, they don't know how*.	PhIV/B	8D, 26:28
R:	*Yes, don't know how to integrate their T with their P and C…*	PhIV/B	
F:	Don't know how to integrate T with P and C. How do we know that? Because…	PhIV/B	
R:	Because [of the] results [from] SQSS and SKPM.	PhV/C	

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	SKPM shows that their P and C are combined…		
F:	P and C OK.	PhV/C	
R:	But T is high. However, T is not linked, right?	PhIV/B	
J:	Yes. OK, is it clear now, right?	PhI/B	
R:	OK.		8D, 26:55

In the above exchanges, all the 3 participants were negotiating for a new problem statement that would embody the idea that the teachers were not able to integrate their technological knowledge with their pedagogical content knowledge. This pushed the conversation to PhIV/B. F asked for evidence to test the proposed new statement and R alluded to the data from SQSS and SKPM. Though at this point the discourse was advancing into the early part of PhV/C (as R's reply to F's question "How do we know that?" was an attempt to test the newly synthesized problem statement by drawing data from SQSS and SKPM), no one questioned if the data was appropriate for justification.

In an earlier discussion (Episode 27; 8D, 10:27), R had pointed out that the data from SQSS and SKPM only showed that the teachers' technological knowledge was high; it did not provide the evidence that the teachers were not able to integrate their technological knowledge with their pedagogical content knowledge. However, this critical observation about the limitation of the data from SQSS and SKPM was not picked up here and as a result the testing process did not go deeper.

When the instructor returned to the group, the probing resumed and the following exchanges took place:

Episode 35		mIAM Code	Time
R:	We have decided that the other possible reasons (for the lack of integration of technology in teachers' P&C) are not critical.	PhI/A	8D, 29:30
I:	Why?	PhII/C	
J:	Because we feel that if we are going to list out the reasons, it's going to be quite a number…and time constraint is one of our issues.	PhII/D	
R:	We foresee that if we explore further, the issue will no longer be TPCK anymore. The issue may become one of motivation…	PhII/D	
F:	Or plain laziness, or…	PhII/D	
R:	We don't want to think about that.	PhII/D	8D, 30:13

R commented that the group had decided that "the other possible reasons are not critical". When pressed by the instructor to provide their reasoning, their justifications were superficial. J pointed out that "we feel that if we are going to list out the reasons, it's going to be quite a number…and time constraint is one of our issues" and R put it as "We don't want to think about that". In short, their conceptualization of the possible root causes was still based on convenience and lacking in substantive reasoning.

As they elaborated further, the incoherence of their thinking was also reflected in their articulation of the problem they were dealing with:

Line	Episode 36		mIAM Code	Time
1	J:	After considering all the possible reasons that	PhIV/B	8D, 30:43
2		might crop up, we felt that we would like to look		
3		at TPCK as the main issue and we felt that based		
4		on the data from SSQS [sic] and SKPM, we felt that		
5		the issue here is they are not able to integrate the		

(Continued on next page)

6		knowledge that they have to the content.		
7	F:	The technology…		
8	J:	The technology knowledge that they have, to the		
9		content.		
10	I:	Say the last part again, the last sentence.	PhI/D	
11	F:	They are not able to integrate the T knowledge	PhIV/B	
12		they have to the content. (laugh)		
13	R:	P and C…		
14	J:	And therefore, of course that also leads to the	PhIV/B	
15		pedagogy…Am I making any sense?	PhIII/A	
16		(all the three participants laugh)		
17	R:	Because from the SQSS data, we know that T is	PhV/B	
18		high. From SKPM, we know that the P and C are		
19		linked. So we know that there is a gap here and		
20		we want to target this gap.		
21	J:	Just want to bring the T into P and C… (laugh)	PhIV/B	
22	I:	You all don't sound too convinced!	PhI/A	8D, 32:02

J attempted to propose their new, and co-constructed understanding of the problem (Line **1-6**). This advanced the conversation to PhIV/B. However, as can be seen from her comment, the articulation of the problem was incomplete and inaccurate when she said "we felt that the issue here is they are not able to integrate the knowledge that they have to the content" (Line **5-6**). In her statement, J missed out specifying the technological knowledge and, on top of that, only "content" is mentioned; rather than pedagogical and content knowledge. (Note: The group had earlier proposed that the root problem was that "the teachers are not able to integrate their technological knowledge into their pedagogical and content knowledge." [Episode 34; 8D, 25:21]). Realizing that J's statement was incoherent, F jumped in to correct (Line **7**). As a result of that, J detected her own mistake and she immediately corrected herself by saying:

> "The technological knowledge that they have, to the content." (Line **8-9**)

The instructor, sensing their hesitation, pushed for more clarity by getting the participants to re-state the problem (Line **10**). J responded by saying:

> "They are not able to integrate the T knowledge they have to the content.
>
> (Line **11-12**)

At this instance, J was laughing at her own comment. R decided to help out by clarifying that the integrating of technological knowledge was with pedagogical content knowledge; rather than just to content knowledge (Line 13). In response to R's comment, J tried to re-state the problem and her question "Am I making any sense?" (Line 15) drew laughter from all the participants. That was followed by another attempt by R and J to articulate the problem (Line 17-21) and both of them ended up laughing at their own comments (Line 21). Clearly, both R and J were not convinced by their own reasoning. This was picked up by the instructor, as he said "You all don't sound too convinced!" (Line 22). The instructor's comment causes them to make another attempt to justify their reasoning:

Line	Episode 37		mIAM Code	Time
1	R:	Reason such as there is no benefit in using	PhI/A	8D, 32:15
2		technology, we do not want to target that.		
3	J:	How to explain that? If the issue is like they are	PhIII/A	
4		not confident, then we can somehow help them.		
5		But if the issue is something like lack of		
6		motivation, we were wondering…Because our		
7		focus is still TPCK then suddenly motivation		
8		issue comes in, we feel that to settle this…		
9	F:	It is not necessary to go into the motivation issue.	PhI/A	8D, 32:58

R argued that they 'do not want to target that' (Line **1-2**) and F reasoned 'it is not necessary to go into the motivation issue' (Line **9**). However, both of them did not provide a clear and coherent justification for not considering all these other possibilities. J's thought is still fuzzy as she struggled with the explanation as she asked "How to explain that?" (Line **3**) and followed by a series of incoherent ideas (Line **4-6**). As the discussion vacillated between PhII and PhV, the participants' basic understandings of the problem were beginning to be challenged. How will they try to resolve this?

4.1.4 Moving towards a coherent conceptualization of the problem (A discourse which progressed from Phase IV through Phase VI of mIAM)

Here, the instructor helped them to probe deeper:

Line	Episode 38		mIAM Code	Time
1	I:	But if even with the question of motivation,	PhIV/A	8D, 32:59
2		why are they not motivated? It can come back		
3		to the same reason: they are not motivated because		
4		they don't see the benefit. Or they are not		
5		motivated because they are lazy? Not really, right?		
6		Your teachers (referring to F) are fairly	PhV/A	
7		hardworking, right?		
8	F:	Maybe just one…	PhV/A	
9	I:	How many percent would you say are	PhI/D	
10		hardworking teachers?		
11	F:	More than 70-80 percent.	PhI/D	
12	I:	So most of them are hardworking, so motivation	PhIV/A	
13		is not a huge issue…		
14	F:	But motivation for using technology is an issue…	PhIV/A	
15	I:	Right. So the question is: why?	PhIV/A	
16	R:	They probably don't know how.	PhIV/A	8D, 33:58

The above exchanges exemplified deep probing as the instructor constantly negotiated for a new and deeper way of looking at how the root causes interacted with each other. This brought the discourse back to PhIV/A. As the probing continued, the instructor helped them to see that, potentially, many possible reasons for not using T could be traced back to one or two root causes. For instance, in the discourse, members began to see that the issues of lack of motivation or the teachers did not see the benefits (Line **1-4**) of using technology may possibly be due to the root problem that the teachers were not able to integrate their technological knowledge with their pedagogical content knowledge into (Line **16**).

This line of probing initiated by the instructor was caught on by J. Using a similar probing process, she argued that if the root cause was addressed, that is, if the teachers were able to integrate their technological knowledge with their pedagogical content knowledge, then the learning process will be more effective and the "objectives will be achieved in a much easier way". In short, if the teachers saw such benefits, they will realize that all the other possible reasons, including lacking in time, can be put aside:

Episode 39		mIAM Code	Time
J:	If they know how to integrate it well then they will be able to see that the time issue would not be such a major issue because they would be able to see that although… it might take some time initially. But if they are able to see that by integrating this, in the long run, my students will benefit; the objectives will be achieved in a much easier way. I think all the other possible reasons can be put aside.	PhIV/B	8D, 35:16 8D, 35:52

J's statement represented a significant shift in her conceptualization of the root problem. About 90 minutes ago, she had argued that time constraint was the main reason why the teachers in F's school were not using technology in their T&L. Her articulation of the problem then was simplistic and superficial. (Reproduce below for reference):

> J: I think there is a reason why teachers are reluctant to incorporate technology. This is my personal experience: sometimes it takes such a long time to find materials. [8C, 07:36; PhII/B]

As can be seen from her new statement, her cognitive schema had gone through a transformative process. Here, she recognized that time constraint was no longer a major issue as teachers who had high level of TPACK were more effective in achieving the learning objectives. Clearly, her way of thinking about TPACK was growing in sophistication; she was able to coherently argue why by having the ability to integrate their technological knowledge with their pedagogical content knowledge, the teachers could potentially address multiple issues that were related to root causes. Her new statement embodied the deep thinking and the participants' co-construction process. This advanced the discourse to PhIV/B.

The instructor affirmed J's argument and re-voiced her statement:

> "OK, you're making some progress here…So, one of the arguments is if they know how to integrate, time shouldn't be as big an issue because they know, in the long term, it evens out." [8D, 35:54; PhIV/B]

The instructor continued with his probing by asking:

> "What about the second one (referring to the reason 'no additional benefits'), for example, for the sake of argument." [8D, 36:30; PhIV/A]

The following discourse ensued:

Episode 40		mIAM Code	Time
R:	No additional benefit*; this has the same argument as time factor.* If they already have the skills to do it, they can see the extra benefits the students will get.	PhV/B	8D, 36:31
J:	Let's say if you use it…this is a trial and error basis. Usually for weaker classes, if you used technology, this is based on my experience; there will be some changes because the students will be very excited and interested and of course the question will be: but does that ensure that the objectives are achieved? Based on my experience, it does. I might have listed three objectives and I might not be able to achieve all three but at least one will be achieved, which would be much difficult if that was a normal way of …	PhV/A	
R:	With no technology.	PhIV/A	
J:	Yes, with no technology.	PhI/B	
I:	Let me make sure I'm hearing you right. If they have skills to integrate T with their P&C, then they will…	PhIV/B	
R:	See the additional benefits.	PhIV/B	
I:	See the benefits of their implementations. Is that your argument?	PhIV/B	
R&J:	(Nodding in agreement)		8E, 00:43

With the prompting of the instructor, both R and J were co-constructing their collective understanding of the root problem. Again, the instructor's line of probing was emulated here and both R and J were able to argue why the integration of technological knowledge would bring additional benefit to the teachers' teaching and learning as such integration would allow

the teachers to achieve certain objectives that would otherwise be difficult without the use of technology. These responses from R and J indicated that their collective understanding of the root problem was clearer and more coherent than before.

The instructor ended this segment of the discourse by highlighting to the group the importance of probing deeper and getting to the bottom of the root issue:

> We've done some mental gymnastics here in the last 30 minutes. I'm glad you see that If we spent the time and figured out five or six reasons, really, if you have the skills, then you'll address multiple reasons…So that's what we've been talking about. The skills to integrate can address a lot of the issues that your teachers feel; whether it be an attitude issue or time issue or don't-see-the-benefits issue. [8E, 05:27]

As the discourse progressed further, the group realized that they needed a different set of data to verify the teachers' ability to integrate their technological knowledge into their pedagogical and content knowledge. They proceeded to a detailed un-facilitated discussion on how the data can be collected and the discussion ended 15 minutes later.

As pointed out by the instructor, the participants' conceptual understanding of the problem had gone through a transformative process as the discourse took them deeper into the advance phases of the mIAM. The changes in their conceptualization of the problem can be triangulated using the participants' journal reflections. As the reader will soon discover through these personal reflections, their co-constructed conceptions of the root problem are coherent, consistent and have a degree of sophistication that they didn't use to have.

The reflection question posted by the instructor that the participants were responding to was crafted as follows:

> Case 2: Is the problem clearly defined? (follow up questions that may be helpful: Is the problem consistent with with Scenario A (PC separate from T) or B (T,P & C are separate), or another scenario altogether? Can data confirm that it is indeed the crux of the problem? (Posted Nov 10, 2011, 1:19 AM, for students' reflection after session 8)

The following table highlights the summarization and conceptualization of the root problem by each of the participants F, J and R as written in their journals:

Table 4.3: The three participants' journal entries on the summarization and conceptualization of the root problem.

Characteris-ticcs of the problem	Line	F's Journal Reflection (Entry Date: November 18, 2011)	J's Journal Reflection (Entry Date: November 10, 2011)	R's Journal Reflection (Entry Date: November 15, 2011)
1. Teachers' technologi-cal knowledge is high	1.1 1.2 1.3 1.4 1.5 1.6 1.7 1.8 1.9	The SSQS questionnaire shows that the teachers say that they have good IT knowledge and can use it to teach.	It is also interesting that the SQSS questionnaire indicates that majority of the teachers feel that they have enough knowledge when it comes to IT	The SQSS indicated that teachers have good technology knowledge. This is shown in the series of question on how do they rate themselves in using some listed tools.

Table 4.3, continued

Characteris-tics of the problem	Line	F's Journal Reflection (Entry Date: November 18, 2011)	J's Journal Reflection (Entry Date: November 10, 2011)	R's Journal Reflection (Entry Date: November 15, 2011)
2. Teachers' technologi-cal knowledge is separate from their pedagogical and content knowledge (Scenario A, refer to Figure 4.2)	2.1 2.2 2.3 2.4 2.5 2.6 2.7 2.8 2.9 2.10 2.11 2.12 2.13 2.14 2.15 2.16 2.17 2.18 2.19 2.20 2.21 2.22 2.23 2.24 2.25 2.26 2.27 2.28 2.29 2.30 2.31 2.32 2.33 2.34 2.35 2.36 2.36	The SSQS also confirmed the fact that the teachers are not using IT technology as much and as often as they should have given that the school is equipped with 100s of computers and connected to the internet. The problem is consistent with Scenario A where the P & C are separated from T. The element 9 (T & L) in the Standard Kualiti Pendndidikan Malaysia [SKPM] indicates that the teachers P and C are good and interlinked while the SSQS indicates high level of T knowledge. The symptom indicated by the SSQS : The teachers use technology in their T & L less than 10 periods a month despite having high T knowledge	PC [Pedagogy and Content Knowledge] is separated from T [Technology]. The teachers have been given many types of trainings that would enable them to be confident in incorporating technology into their lessons. However, they do not seem to apply it into their daily teaching and learning task.	However, teacher only integrated technology in classroom, in average at least once a month. This is pretty low in frequency given that the teachers recognized themselves as well-versed in technology. We agreed that the problem is consistent with Scenario A where teachers have adequate level of T, P and C plus the P and C is integrated or linked. These are derived from the results of SQSS and SKPM. However, teacher doesn't seem to integrate the T into their P&C. This is proven by the SQSS data in which teachers recorded low frequency in integrating technology into Teaching and Learning (T&L).

The above reflections indicated that the participants' conceptualization of the problem had become clearer and more consistent. All the three participants argued that SQSS validated

the claim that the teachers' technological knowledge was high (Line 1.1 to 1.6 for F, Line 1.1 to 1.8 for J and Line 1.1 to 1.9 for R).

All the three participants also concluded that the problem was consistent with scenario A (Refer to Figure 4.1 for Scenario A) which indicated that the teachers' technological knowledge was separate from their pedagogical content knowledge (Line 2.14 to 2.18 for F, Line 2.1 to 2.5 for J, Line 2.13 to 2.20 for R). Furthermore, all three of them provided clear justification for concluding that the teachers' technological knowledge was separate from their pedagogical content knowledge. F and R reasoned that the data from SQSS showed that teachers' technological knowledge was high and yet their usage of technology integrated with pedagogy and content was low (Line 2.1 to 2.12 for F, Line 2.1 to 2.11 as well as 2.20 to 2.34 for R). Since SKPM indicated that their pedagogical and content knowledge were integrated, hence combining the data from SKPM and SQSS would indicate that they were not integrating their high knowledge of technology into their pedagogical content knowledge. J, on the other hand, argued that the teachers, despite having received many types of training in the use of technology (therefore technological knowledge should be high) did not use technology in their teaching and learning (Line 2.5 to 2.17).

Additionally, they also acknowledged the limitation of SQSS and SKPM. F reflected in her journal:

> "The group however feels that the data from both SKPM and SSQS may not be enough because they do not really show the teachers knowledge in the integration of T with their P & C" [F's Journal Reflection, entry date: November 18, 2011]

Similarly, R wrote that:

> As for now the data from SQSS and SKPM can only confirm the symptoms (Teacher has high/good T but teacher didn't integrate T in P&C didn't integrate T in P&C) but we have yet to get the data from teachers reflection that can show more if they really don't have sufficient skill to integrate T into their P&C.' [R's Journal Reflection, entry date: November 15, 2011]

This collective understanding of the limitation of SQSS and SKPM revealed that their conceptual understanding had changed through the process of co-construction in their discourse. At one point in their earlier discussion (Episode 34), the group had incorrectly concluded that the data from SQSS and SKPM can validate the root problem that the teachers were not skilled in integrating their technological knowledge into their pedagogical and content knowledge (Reproduced here for clarity of discussion):

Line	Episode 41[8]		mIAM Code	Time
1	F:	So, clearly, they don't have the skills…that is,	PhIV/B	8D, 26:28
2		they don't know how.		
3	R:	Yes, don't know how to integrate their T with	PhIV/B	
4		their P and C…		
5	F:	Don't know how to integrate T with P and C.	PhIV/B	
6		How do we know that? Because…		
7	R:	Because [of the] results [from] SQSS and SKPM.	PhV/C	
8		*SKPM shows that their P and C are combined…*		
9	F:	P and C OK.	PhV/C	

(Continued on next page)

10	R:	But T is high. However, T is not linked, right?	PhIV/B	
11	J:	Yes. OK, is it clear now, right?	PhI/B	
12	R:	OK.		8D, 26:55

In the above exchanges, as they were wrapping up their concluding thoughts about the root problem, F asked if they had the data to validate their hypothesis that the teachers did not know how to integrate their technological knowledge with their pedagogical and content knowledge (Line **5-6**) and R responded that the data from SQSS and SKPM can be used to validate such hypothesis (Line **7-8**). No one challenged R's reason and they concurred with her (Line **9-12**).

The participants' journal reflections also indicated that they had come to realize that the data SQSS and SKPM were inadequate and new data had to be collected in order to verify the teachers' ability to integrate their technological knowledge with their pedagogical and content knowledge. F concluded that:

> Therefore we came up with a set of questions that the teachers answer to indicate their knowledge and ability to carry out the integration of T with P and C. The questionnaires have been collected and will be scrutinized in the coming class. [F's Journal Reflection, entry date: November 18, 2011]

J mentioned that:

> "The team is now waiting for the written response from the teachers as to their personal opinion about incorporating technology into their lessons" [J's Journal Reflection, entry date: November 10, 2011]

[8] Episode 34 is being assigned as Episode 41 to maintain the flow from the previous episode (Episode 40) for ease of reference in the following discussion.

And R wrote that:

> "But we have yet to get the data from teachers' reflection that can show more if they really don't have sufficient skill to integrate T into their P and C" [R's Journal Reflection, entry date: November 15, 2011]

This was not the only explicit conceptual change that had occurred as the result of the social interaction. As the reader may recall, the participants were earlier struggled with the complexity of the problem they were dealing with, and in a number of instances, their attempts to co-construct the root problem were prematurely ended by their inability to deal with all the possible root causes (Refer to Table 4.1 and Table 4.2)

As can be seen from the participants' journal reflections, their conceptions of these root causes had changed and as a result they were able to clearly articulate how the possible root causes related to the root problem they had identified. R elaborated that:

> To identify if this is the root problem, we discussed on the whys of this situation (scenario A). We discussed some of possibilities of why teacher didn't integrate / not able to integrate T into P&C:
>
> - Teacher do not have the skills to integrate T into P&C
> - Time constraint
> - Logistic issues
> - No support / motivation issue / not confident
> - Teacher's beliefs – anti-technology

Upon more discussion, we think that issues about time, logistic, motivation and others is actually under the umbrella of teacher do not have or have insufficient skill to integrate T

into P and C. This may be clearer illustrated in the table below (Reproduced here from R's Journal Reflection, entry date: November 15, 2011):

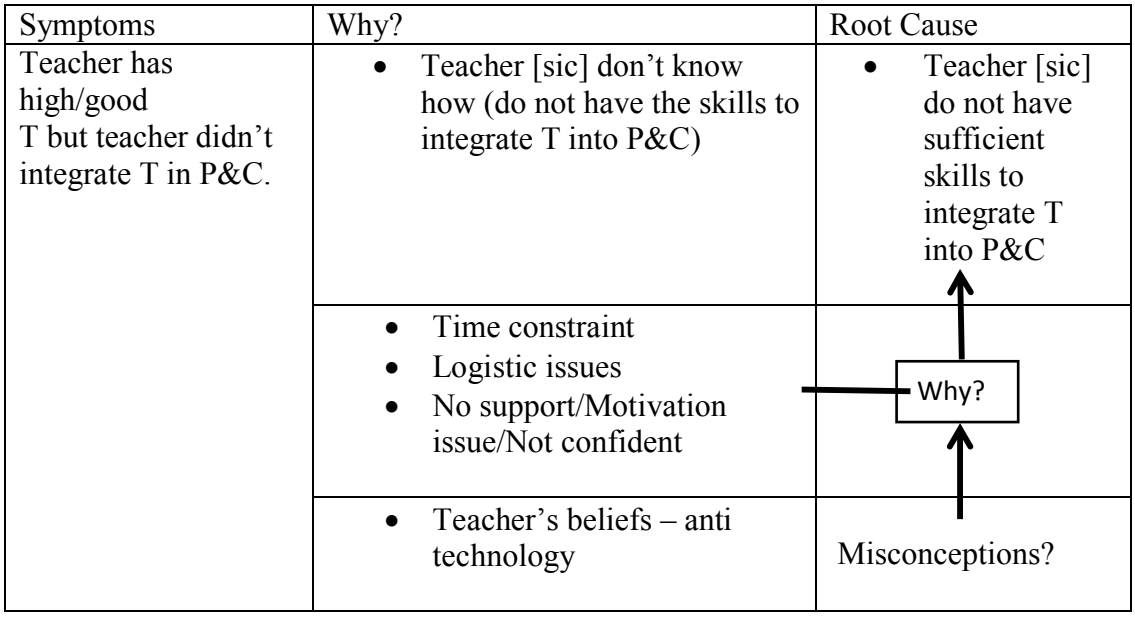


Figure 4.2 Conceptual artifact showing R's new way of thinking about the root causes

From the above reflections, it was evident that R's thinking has gone through a transformative process. She wrote in her reflection that the social interaction in the group has brought about a new way of thinking for her regarding the possible root causes. This new way of thinking was coherently stated as:

> "We think that issues about time, logistic, motivation and others is actually under the umbrella of teachers do not have or have insufficient skill to integrate T into P and C" [R's Journal Reflection, entry date: November 15, 2011]

The transformation in her thinking was clearly captured in the conceptual artifact that she developed and shown in Figure 4.2. J, similarly, was able to argue that:

> "The excuses such as there is no time and lazy are just a way for them to divert themselves from giving the actual reason for their refusal to incorporate technology into their lessons" [J's Journal Reflection, entry date: November 10, 2011]

As can be observed from the above reflections, the participants R and J were able to transform a list of seemingly random, unrelated possible root causes into a cohesive understanding of how the skill to integrate technological knowledge with pedagogical and content knowledge would address multiple issues related to possible root causes.

The participants' clear conceptualization of the problem was equally evident in their summary of the root problem. J put it as:

> "The case in our hands deals with teachers who do not have the skills to integrate technology into their lessons. This is the root cause" [J's Journal Reflection, entry date: November 10, 2011]

F argued that:

> "From the data we have and some discussion we did, the root cause of Case 2 can be: The teachers do not know how to integrate their technology in their T[eaching] & L[earning]" [F's Journal Reflection, entry date: November 18, 2011]

And R concluded that:

> "The root problem is that: Teachers do not have (sufficient) skills to integrate T into P and C" [R's Journal Reflection, entry date: November 15, 2011]

R and J identified the root problem as the teachers did not the skills to integrate their technological knowledge with their pedagogical and content knowledge while F stated that the teachers did not know how to integrate their technology in their teaching and learning. It can be noted that their definitions were clear and consistent.

They were two key features in the participants' journal reflections as they articulated the problem scenario. Firstly, as outlined in the above discussion, their summarization of their co-constructed understanding of the problem was coherent and embedded with clear justification of statements. For instance, they clearly explained why the teachers' technological knowledge was high, why the teachers' technological knowledge was separate from their pedagogical and content knowledge. Secondly, the conceptualization of the problem was sophisticated in that the problem representation was rich and they were able to convincingly argue about the limitation of SQSS and SKPM, their new way of thinking about the possible root causes in relation to the teachers' ability or skill to integrate their technological knowledge with their pedagogical and content knowledge (as reflected in R's conceptual artifact), the new set of data they needed to collect and finally their clear definition of the problem they were dealing with. These two key features indicated the cognitive operations that have advanced the participants' discourse into PhVI/A (summarization of their co-constructed understanding of the problem), and PhVI/B (R's design of the cultural artifact).

4.1.5 Summary

The above discussion focused on the analysis of the discourse as the three participants engaged in the problem definition stage of a PBL cycle. Using the mIAM, the analysis was carried out to examine the process of social construction of TPACK as it occurred in the PBL discourse.

The analysis of the participants' interactions captured the six phases from Phase I to Phase VI of mIAM. This exemplified an interaction where the social construction of knowledge occurred over the problem definition stage of the PBL process.

The early stage of the discussion revolved mainly with constructing a rich representation of the real life problem that the participants were dealing with. As the focus of the interaction was on the clarification and justification of ideas and information provided by F based on her knowledge and experience as the principal of the school, there was no dispute and the social interaction remained within Phase I and Phase II of mIAM. Additionally, the validation of the problem scenario (refer to Figure 4.1) was straight forward as the participants drew upon substantive evidence collected from formal data SQSS and SKPM. The social interaction remained within Phase I and Phase II of mIAM. This segment of the discourse enriched their understanding on the magnitude and nature of the problem they were dealing with. There were also some instances when the group discussion was un-facilitated, the participants were seen to deal with issues rather superficially and in some situations, the dissonances in their thinking were not explored further. As a result, the conversation did not develop beyond Phase II of social construction of knowledge.

A critical moment which advanced the social interaction beyond Phase II of mIAM occurred when the participants began to explore some hypotheses regarding the root problem. In a typical PBL fashion, a number of root causes were identified as they hypothesized about the reasons for the separation of the teachers' technological knowledge from their pedagogical and content knowledge. As they delved deeper into the issue of time constraint as a possible root problem, one of the participants, J, began to negotiate for a new way of looking beyond the issue of time constraint and started to probe deeper. Though that was a significant move in advancing the interaction, it was not fully explored as participants quickly returned sharing corroborating examples to support the issue of time constraint. This took the conversation back to Phase I of mIAM. At this point, the instructor intervened and through role-playing with one of the participant, he helped the participants realize the inconsistencies in their thinking and probed deeper as he guided the group to negotiate for a new way of looking at the issue of time constraint. This led the participants to see beyond the surface to get to the bottom of the problem. The social construction of knowledge advanced to Phase III and Phase IV of mIAM.

As the group probed deeper into the root problem, F argued that the reason the teachers did not integrate their technological knowledge into their pedagogical and content knowledge was because they did not have the skills to do so. This completely shifted the nature of the problem as the participants had argued earlier that the root cause could possibly be due to reasons such as time constraint, lack of motivation, or they didn't see the benefits of using technology and so on. Again, this critical moment was not picked up by the other participants for deeper exploration and the social exchanges reverted back to Phase II as they vacillated between 'they do not know' and 'they do not want'.

At this juncture, the participants were a little overwhelmed by the complexity of the problem as they struggled to articulate clearly the root problem. From the standpoint of knowledge construction, it can be said that participants' cognitive schema was still not well organized as there was some degree of dissonance in their thinking about the root causes which still have not been fully resolved. Again, the instructor intervened and scaffolded the progress of the interaction by helping them to explore the possible root causes further, constantly negotiating for a new way of looking at how the root causes interacted with each other. This brought the discourse back to Phase IV of mIAM. This line of probing initiated by the instructor was caught on by the participants and using a similar approach, they began to co-construct a more cohesive understanding of the root problem and how it related to other possible root causes. The conversation progressed through Phase IV of mIAM. From a list of random, seemingly unrelated hypotheses of root causes, the participants began to develop a more coherent understanding of the problem.

The process of co-construction and negotiation eventually led to a clearer articulation of the problem scenario they are dealing with. This can be observed from their journal reflections. Their summarization and conceptualization of the problem was coherent, rich and had a degree of sophistication that reflected the deep probing and challenge that the participants had gone through. This was succinctly put by F when she reflected on her journal regarding the group's discussion:

> Case 2 challenges me to really look at the problem with a[sic] different eyes and from many angles. I have to break away from the opinions that I had already formed after dealing with this problem for quite a while now. Breaking away is not easy but it is something I

have to do so that the problem will be clearly defined. [F's Journal Reflection, entry date: November 18, 2011][PhVI/C]

4.2 Elements which supported or hindered the process of social construction of knowledge

Dolman et al. (2005) argued that though there are many variations of PBL, there are three essential features that characterize the practice of PBL and there are (1) realistic problems being used as a stimulus for learning, (2) tutors function as facilitators to scaffold students' learning and (3) collaborative environment as stimulus for interactions.

In this research, these three essential features of the PBL setting were examined in relation to the social construction of knowledge using the mIAM framework. For each of these essential features, conversational episodes which affected the movement of the PBL discourse based on the mIAM were analyzed. Factors which moved the discourse into more advance phases of mIAM were considered the elements in the PBL setting that support social construction of knowledge. On the other hand, factors which prevented the discourse from moving into more advance phases of mIAM were considered the elements which hinder social construction of knowledge.

The purpose of this analysis was to answer the following research questions:

Research question 2(a): What elements in the essential features of the PBL setting support the social construction of knowledge?

Research question 2(b): What elements in the essential features of the PBL setting hinder the social construction of knowledge?

4.2.1 The impact of real life problem in PBL on social construction of knowledge

Specifically, this section aimed to address the following research questions in the context of the real-life problem that the participants were dealing with:

Research question 2(a)(i): What elements of real-life problem in the PBL setting support the social construction of knowledge?

Research question 2(b)(i): What elements of real-life problem in the PBL setting hinder the social construction of knowledge?

The root problem that the group was addressing revolved around the actual problem situation faced by the teachers' in F's school. F's initial description of the problem was:

> "Teachers in my school, despite the wealth of technology they have,
> they shun away from using technology…" [6C, 35:58; PhI/A]

From the outset, the participants were presented with a real-life problem that was highly ill-structured in nature. The ill-structured nature of the problem was immediately evident as there was no clear parameters or set boundaries given concerning the problem. Additionally, the participants were not furnished with any information and data that would be needed to solve the problem other than F's statement that the school was well equipped with technology. As the reader will soon discover, this realistic and ill-structured nature of the problem heightened its complexity as the participants had to sort through divergent perspectives, multiple representations of the problem and to determine what information and data were necessary to construct and synthesize a collective understanding of the problem.

4.2.1.1 The impact of realistic and ill-structured nature of the problem on social construction of knowledge

In the early stage of the PBL cycle, the participants were aware of the ill-structured nature of the problem and they were forced to seek for more information, relying initially on F's experience of the teachers and the school. As the problem they were dealing with was real, the participants had the opportunity to challenge and seek validation on the information given by F. As a result, the discussion became data driven and this created a rich context for the process of clarification and justification as they sought to co-construct a shared understanding of the problem. For instance, when F started to describe the magnitude of the problem in Episode 4, R responded by asking:

"How do we confirm that?" [6D, 07:33; PhII/C]

And the instructor reiterated her question to the group:

"OK, can we verify this data?" [6D, 07:35, PhII/C]

This compelled the participants to seek verification to the statements they heard. This exemplified the data driven nature of the discussion and such situations occurred rather consistently throughout the discourse. The following exchanges demonstrated another data driven nature of the discussion (Reproduced here from a segment of Episode 7 for clarity of discussion):

Line	Episode 42		mIAM Code	Time
1	J:	So when you said training them on T, that means	PhI/D	6D, 19:00
2		like put all the teachers in one room and then…		
3	F:	Not just put them in one room; get them to attend	PhI/D	
4		refresher course on how to use the Smartboard and		
5		how to use the laptops. We did have an Intel Teach		
6		Program.		
7	R:	What is the Intel Teach Program?	PhI/D	

(Continued on next page)

8	F:	Intel Teach Program is the TPCK…(trying to find	PhI/D	
9		the right way to describe the Program)		
10	I:	What is the curriculum in the Program?	PhI/D	
11	F:	Using technology to teach. Their main focus is	PhI/D	
12		project based learning.		
13	J&R:	Do you have examples?	PhI/D	
14	R:	Contoh?	PhI/D	
15	F:	I'll bring the module (noted down on her		
16		notebook).	PhI/D	6D, 20:03

In the above exchanges, F was describing the different types of training that the teachers had gone through for developing their technological knowledge and one of which was the Intel Teach Program (Line **5-6**). This prompted the participants to seek for more specific data in order to understanding the nature of the training that the teachers had attended (Line **7, 10, 13-14**) and F responded that she will show them the module of the training (Line **15**).

The opportunity to be data driven in the problem definition stage of the PBL cycle presented a set of challenges that were unique to working on a real-life problem. Unlike a hypothetical problem scenario, the participants working on a real-life problem had to contend with growing and unspecified amount of information and data that they had to sort through in order to decide which information, data or ideas were necessary and relevant to the conceptual space of the problem. In other words, the PBL participants had to contend with much 'ambient noises' around them and be able to evaluate what were the important information or data they needed to focus on. For instance, when the participants were discussing about the teachers' usage of technology in their teaching and learning, they discovered that the data from SQSS showed that the incident rate was only about one percent (that is the teachers' usage of technology in the classroom was limited to only one period per month. In a month, there was about 100 periods). Though the participants were clear about

the real data that they had, they were not as clear regarding the implication of this piece of data. As a result, the instructor pressed them for deep reasoning by asking:

> "Basically, one percent incident rate. OK, so we have this part here. Now does this data add character to the problem? So, again, is this data critical?" [8D, 12:37; PhII/C]

The instructor's question highlighted the critical feature of a real-life problem. When the participants involved in iterative process of verification and justification using data from real-life situation, they were forced to evaluate and decide if some of the data were critical and relevant in shaping their interpretation of the problem. From the standpoint of knowledge construction, the process of verification and justification were critical in challenging the participants' knowledge schema. As they constructed their arguments for justification, they had to constantly structure and restructure their conceptual schema in order to generate viable and coherent arguments and hence fostered the social construction of knowledge.

As the discourse progressed over the next three sessions, the participants sorted through the data and information through the iterative process of clarification, verification and justification. As a result, the conception of the problem began to emerge with greater clarity and richness. Table 4.4 on the following page shows the key data that shaped the conception of the problem:

Table 4.4 Key data that shaped the participants' conception of the problem

Excerpt	Key Data	Researcher's Memo	Time	Original Episode
1	F: The technology in my school. I have 1141 PCs. I: You have more PCs than students. F: Yes! Three labs all working. One lab is Window XP, one lab is Window 7. Another lab is an open source lab. I: And then every classroom has computers? F: No. We used to have in every classroom. But when the money stopped coming in, the year 2000 technology became obsolete. We did not replace those in the classroom. We replaced those in the lab. On top of that, early last year, we got 522 Classmate PCs for Year 3, 4 and 5, which I'm so sad because they are not fully utilized. Internet connectivity is whole campus, 24 hours. I: Broadband? F: Broadband. Also, they are not being used. So I was telling them I've got one big stone in my heart. I'm not doing my job well. I: How do you know it's not being used? F: Through *classroom observation.* Also, ever room has a log book and feedback from the students. I walked around and noticed it's not being used. On top of that, I've got three Interactive Whiteboards. The one I use is the most used one. I put one in Year 2, to be shared with Year 1 and 2. One in Year 3, for Year 3 and 4 and one in Year 5 for Year 5 and 6. The one in Year 5, the dust layer is about half inch thick (laugh).	The school was well equipped with ICT facilities: (1) 1141PCs, more PCs than the entire student population of the school, (2) three computer labs where the PCs were installed with the latest operating systems, (3)522 Classmate PCs, (4) Internet connectivity is broadband, whole campus and 24 hours (5)three Interactive Whiteboard. However, these good ICT facilities were not fully utilized by the teachers. (Several evidence provided by F and these included: (1) classroom observation, (2) the log book and student feedback and (3) her personal observation regarding the use of the ICT equipment).	6D, 10:56 6D, 13:36	6

Table 4.4, continued

Excerpt	Key Data	Researcher's Memo	Time	Original Episode
2	F: …We did have an Intel Teach Program. R: What is the Intel Teach Program? F: Intel Teach Program is the TPCK…(trying to find the right way to describe the Program) I: What is the curriculum in the Program? F: Using technology to teach. Their main focus is project based learning. J&R: Do you have examples? R: *Example?* F: I'll bring the module.	The majority of the teachers were well trained with technological knowledge.	6D, 19:45 6D, 20:24	7
3	F: *There is T, but T is not incorporated into this* (referring to P and C) J: Yes (nodding in agreement). But we need to verify this. Is this true? Is this the problem now, we need to verify.	F represented the problem as the teachers' technological knowledge was not integrated with their pedagogical content knowledge.	6E, 10:01 6E, 10:10	9
4	J: She (referring to F) brought the questionnaire and I was looking through it (referring to SQSS) and I found that the majority of the teachers, they feel that they have the knowledge, they are confident with their knowledge because they rated themselves as 4 & 5 when it comes to technology. They rated themselves very highly. But when you look at the implementation part, using it in the classroom, arr, some said they used it once a week, some said once a month. So…	Data from SQSS showed that the teachers' technological knowledge was high. However, the data also showed that they rarely applied this knowledge in their teaching and learning.	8B, 09:09 8B, 09:52	12

Table 4.4, continued

Excerpt	Key Data	Researcher's Memo	Time	Original Episode
5	I: The question that we have to get back to is: How do you assess (that P&C are combined)? Can you just use SKPM? J: It's very detailed. It's … R: What are some of the things that they measure? How do they…what are some of the things that they observe? J: *Student participation* is one of the criteria. And then they give, arr…if *there is no student participation*, the teacher gets only one point. R: Student participation, *does that mean* students… F: It's online (i.e. students giving their feedback online) J: … (can't decipher) they want to observe a teacher… F: *Classroom management, management of lessons.* R*: Does it deal with pedagogy?* J: *It does*. F: *There is*. It's quite extensive.	Data from SKPM validated that the teachers' pedagogical and content were integrated. The participants provided justification on why the data from SKPM was adequate in verifying their pedagogical content knowledge.	8B, 23:30 8B, 24:31	15
6	R: From SQSS and SKPM combined, there is evidence that the teachers are not integrating technology into their pedagogy and content. Now the question is 'why'	Integrating the data from SQSS and SKPM, the participants argued that the teachers' technological knowledge was not integrated with their pedagogical content knowledge.	8C, 14:35 8C, 14:51	20 (Line 12)
7	R: *If we refer to SQSS, it only shows that T is high, it does not tell us if the teachers know how to integrate their T into their P and C, is that right? We don't know that, or like what J pointed out, they know but refuse to use it?*	The group began to see the limitation of SQSS as R pointed out that SQSS did not provide the reason why the teachers' technological knowledge was not integrated with their pedagogical content knowledge.	8D, 10:23 8D, 10:34	27

The above excerpts demonstrated the participants' interaction with the real data which had resulted in a growing and increasingly richer representation of the problem which would have not been possible with hypothetical problem scenarios where the perimeters and data were static and 'finite'. The above excerpts showed that, as the participants went through some iterative processes of clarification, verification and justification using real data, they began to co-construct a shared understanding of the underlying problem. For instances, in the last three excerpts (Excerpt 6-8), the data showed the growing sophistication and understanding of the problem as the participants processed the data deeper. Excerpt 6 indicated the integration of data from SQSS and SKPM which allowed them to conclude that the teachers' technological knowledge was not integrated with their pedagogical content knowledge. However, as they probed deeper and explored the possible root causes, they realized that one likely cause for the lack of integration of the teachers' technological knowledge was that the teachers did not have the skills to do so (refer to Episode 30, 31 for the detailed discussion). However, as R pointed out in Excerpt 7, the data from SQSS did not provide the information if the teachers had the skills to integrating their technological knowledge with their pedagogical content knowledge. This compelled them to further discuss how the group may gather a new set of data to ascertain the level of the teachers' technological, pedagogical content knowledge. This eventually led them to design a set of reflection questions that would allow them to assess if the teachers have the skills to integrate their technological knowledge with their pedagogical content knowledge.

4.2.1.2 The impact of the complexity of the problem on social construction of knowledge

As the reader will notice from the following discussion, the real problem that the participants were dealing was also complex in nature. At one point in their discussion, they were

convinced that the teachers' technological knowledge was high (Episode 12). However, the teachers were not integrating their technological knowledge with their pedagogical content knowledge (Episode 13 and 14). This prompted the participants to ask why that was happening. As a result the following discussion ensued (Episode 20, reproduced here for clarity of discussion):

Line	Episode 43		mIAM Code	Time
1	J:	…*Because the motivation has to be strong.*	PhII/B	8C, 13:38
2		*Regardless of what we say*, so basically the issue		
3		of motivation? time constraint? (Frowns). Maybe		
4		it's because of time constraint?		
5	R:	We can't really tell. Yes, time constraint can also	PhII/B	
6		be a problem.		
7	J:	Or maybe they feel that they are working alone.	PhII/B	
8	R:	And have no support…	PhII/B	
9	J:	They don't have a team, no support. Maybe,	PhII/B	
10		maybe…*The school wants me to use, but I can't*		
11		*do it alone. Besides, I don't have time…*		
12	R:	*From SQSS and SKPM combined, there is*	PhII/D	
13		*evidence that the problem is the same as A. Now*		
14		*the question is 'why'. It could be due to time*	PhII/C	
15		*constraint, lack of motivation*…(can't decipher)		
16	F:	*If the issue is time, what data to support that?*	PhII/C	
17	R:	Ya.	PhI/B	
18	F:	*Lack of motivation, what data to support that?*	PhII/C	
19	R:	*What's the evidence?* We don't have the evidence	PhII/C	
20		yet (giggling). *We have definitely verified that*	PhI/A	
21		*this is the problem* (referring to Scenario A).		
22	F:	To verify this (referring Scenario A), I can bring		
23		their scores.	PhII/E	
24	R:	But to do interviews (to find out the other	PhI/A	
25		possibilities), we are talking to the same group of		
26		teachers.		
27	J:	Where are we going to get…or…	PhIII/A	
28	R:	The verification?		8C, 15:53

As can be seen, the participants started to consider many possible root causes and these included the lack of motivation, time constraint (Line **1-4**) and lack of support (Line **7-11**). At this point, the discussion was fairly speculative in nature as the participants uttered words like "maybe" (Line **3,7**), "maybe, maybe" (Line **9-10**) and "it could be due to" (Line **14**). What happened in the next segment of the conversation was critical as it prevented the participants from slipping into further speculation in their discourse.

F started by questioning if they had any evidence to support the hypothesis that time constraint was a root cause (Line **16**) and this was followed by a similar question on the lack of motivation as a root cause (Line **18**). This helped R to realize that they needed more data to validate the list of hypotheses that they had (Line **19-20**). Clearly, these exchanges were driven by the authentic situation they were dealing with and this resulted in: (1) The participants started to re-evaluate what they knew and this was reflected in R taking a step back and re-assessed the data from SQSS and SKPM (Line **12-13**, **20-21**) and (2) It prevented the participants from making unsubstantiated assumptions and conclusion too prematurely. This was evident as both F and R reminded the group that their hypotheses were yet to be verified as they still had not provided any real evidence (Line **16-18**, **22-23**).

A little while later when the instructor returned and asked for their response to the data that they had gathered the following exchanges occurred (segment of Episode 21, reproduced here for clarity of discussion):

Line	Episode 44		mIAM Code	Time
1	I:	R and J, what's your response to this data set?	PhII/C	8C, 26:35
2	R:	We still cannot say what's the problem yet. That's	PhIII/A	
3		why, just now J said we need to know the		
4		reasons behind. We don't know the whys. There		
5		are still things we need to find out.		
6	J:	Things like they have the knowledge but they	PhIII/A	
7		don't want to integrate it. So there must be		
8		something that causes this. We are thinking along		
9		those lines like time constraint…but the feedbacks	PhIII/A	
10		are only from two teachers. And both seem to say		
11		that they have limited time. So time seems to be		
12		one of the contributing factors…		8C, 27:45

R and J indicated that their understanding of the problem was still fuzzy and there were more things they needed to find out (Line **2-4** for R and Line **6-8** from J). In other words, the participants recognized that there were still discrepancies in their interpretation of the problem and it was premature to agree on the root cause. These discrepancies created a cognitive puzzlement or tension that was critical to the construction of knowledge as it pushed the participants to probe deeper and try to find resolution to the puzzlement. The comments by J and R demonstrated the opportunity and the impetus for deeper reasoning supported by the authentic and ill-structured problem they were dealing with.

At this point, it was clear that not only the problem was ill-structured, it was complex as well. As illustrated in the above excerpts, the complexity of the problem was seen in the multiple potential root causes that emerged as the discourse progressed. As a result multiple sources of data were required to verify that the participants were attacking the right problem.

This complexity, as the reader will soon discover, had the potential to stimulate deep thinking and reasoning that led to more advance phases of mIAM. On the other hand, when the complexity of the problem was not productively handled, the discourse mired at the lower phases of mIAM and it hindered the social construction of knowledge.

The following exchanges demonstrated a situation where the complexity of the problem became overwhelming and it began to hinder the discourse from progressing further. As they explored the possible root causes, R began to realize the limitation of SQSS when she said:

> If we refer to SQSS, it only shows that T is high. It does not tell us if the teachers know how to integrate their T into their P and C, is that right? We don't know that, or like what J pointed out, they know but refuse to use it? [Episode 27, 8D, 10:23; PhIV/A)

R pointed that the data from SQSS only showed the separation of the teachers' technological knowledge from their pedagogical content knowledge; it did not address the reasons why. In short, R was pointing out that the complexity of the root problem they were dealing with cannot be explained using the data from SQSS. At this point of their discussion, they were confronted with many possibilities and they did not have the data to ascertain which the root cause was. As the discussion progressed, their confusion over the possible root causes became evident (Episode 28, reproduced here for clarity of discussion):

Line	Episode 45		mIAM Code	Time
1	J:	*Like the previous discussion, we can't tell if the*	PhIII/A	8D, 12:59
2		*teachers know how to integrate…most teachers*		
3		*only use one percent. That means…*		
4	F:	*They know…*	PhIII/A	

(Continued on next page)

5	J&R:	(Laugh)	PhIII/A	
6	R:	*They know?* (Giggle)	PhIII/A	
7	J:	*They don't know?*	PhIII/A	
8		(All the three participants laughing at their own		
9		contradictory comments)		
10	F:	Like what you said, they know how to do.	PhIV/A	
11		(meaning the teachers know how to incorporate		
12		technology into their teaching). Whether that is a		
13		low TPCK, that's what we need to probe.		8D, 13:32

Here, in the context of their discussion, F argued that "the teachers know" (Line **4**) how to join their technological knowledge into their pedagogical and content knowledge. Both J and R responded with great puzzlement as they laughed at F's comment (Line **4-5**) and J expressed her doubt on F's comment by asking "they don't know?"(Line **7**). Obviously, there was cognitive dissonance among them and there were discrepancies in their collective interpretation of the problem.

F responded by saying that the teachers knew how to use technology in their lessons. However, as she went on to clarify; the use of technology was not an indication of their level of technological, pedagogical content knowledge (Line **10-13**) implying that someone who used technology in their teaching may still have low level of technological, pedagogical content knowledge. F's reply demonstrated another layer of complexity of the problem and that was the complex nature of the technological, pedagogical content knowledge. For instance, the word "to join" (Line **1**) was likely to have been interpreted and understood differently in relation to technological, pedagogical content knowledge among the participants and this created the cognitive dissonance and caused further confusion among them.

As the conversation mired at Phase II of mIAM, J proposed a way out and suggested that the group should just accept that the teachers did not know how to integrate their technological knowledge and that was why they rarely used it:

> That is the question now, do we conclude that they don't know or [PhIII/A] ….If we said that they don't have time, then that data is critical [PhII/E]. We just take it that they don't know that's why they are not doing it and we can stick to the…[PhII/B][Episode 29]

As can be observed, J's statement was not substantiated with evidence. A long pause ensued as the rest of the participants were seen to be unsure on how to respond to J's proposal. These exchanges showed that as the participants struggled with multiple root causes, the nuanced understanding of technological, pedagogical content knowledge and the resultant cognitive dissonances and confusion, they were overwhelmed by the complexity of the problem they were dealing with and resorted to a superficial response to this heavy cognitive load.

A similar incident happened a while later as the group attempted to co-construct their definition of the root problem (Refer to Table 4.1). In four separate short exchanges, the participants were repeatedly brought back to Phase II type discussion just as they were starting to advance into Phase IV of mIAM. In these incidences, the complexity of the root causes remained unresolved and their conceptual schema of the problem representation was in a state of dissonance. As a result, the attempts to co-construct the definition of the problem ended prematurely.

However, in instances where the complexity of the problem was handled productively, it created the opportunities for deep learning as participants negotiated for new ways of interpreting the problem at hand. The following exchanges demonstrated how the complexity of the problem, when it was resolved, led to conceptual change. As noted earlier, when the participants were overwhelmed by the number of seemingly unrelated root causes, they resorted to the easy way out by ignoring some of these root causes without providing clear justification. For instance (Refer to Episode 37), R argued that:

> "Reason such as there is no benefit in using technology, we do not want to target that" (8D, 32:15; PhII/B)

And F reasoned that:

> "It is not necessary to get into the motivation issue" (8D, 32:51; PhII/B)

In both instances, R and F did not provide any clear justification for not considering all these other root causes. At this point, the instructor intervened and guided the participants to explore new and deeper ways of looking at the root causes and this advanced the conversation to Phase IV/A of mIAM (Episode 38, reproduced here for clarity of discussion):

Line	Episode 46		mIAM Code	Time
1	I:	But if even with the question of motivation,	PhIV/A	8D, 32:59
2		why are they not motivated? It can come back		
3		to the same reason: they are not motivated because		
4		they don't see the benefit. Or they are not		
5		motivated because they are lazy? Not really, right?		
6		Your teachers (referring to F) are fairly	PhV/A	
7		hardworking, right?		
8	F:	Maybe just one…		
9	I:	How many percent would you say are	PhI/D	
10		hardworking teachers?		

(Continued on next page)

11	F:	More than 70-80 percent.	PhI/D	
12	I:	So most of them are hardworking, so motivation	PhIV/A	
13		is not a huge issue…		
14	F:	But motivation for using technology is an issue…	PhIV/A	
15	I:	Right. So the question is: why?	PhIV/A	
16	R:	They probably don't know how.	PhIV/A	8D, 33:58

The instructor began by helping the participants to realize there could be potential connection between these possible root causes (Line **1-5**). The participants caught on with this line of deep probing and they began to restructure their understanding of these root causes. When the instructor commented that most of the teachers were hardworking and hence motivation was not a huge issue with them (Line **12-13**), F jumped in and reasoned that motivation was not an issue but motivation for using technology was an issue (Line **13**). The instructor concurred and probed deeper by asking why (Line **15**) and R pointed out the teachers probably did not know how (Line **16**). This line of deep probing to see the connection between multiple root causes led to some major conceptual changes in the participants' conception of the problem. J, for instance, demonstrated a significant conceptual change in her interpretation of the problem when she argued:

> If they know how to integrate it well then they will be able to see that the time issue would not be such a major issue because they would be able to see that although…No, it might take some time initially. But if they are able to see that by integrating this, in the long run, my students will benefit; the objectives will be achieved in a much easier way. I think all the other possible reasons can be put aside. (8D, 35:16; PhIV/B)

Note that just 90 minutes before this, J had argued very simplistically that time constraint was the main reason why the teachers in F's school were not integrating their technological knowledge into their pedagogical content knowledge. However, as can be seen above in her new co-constructed statement of the problem, she was able to coherently reason why time constraint was not a major issue when the teachers were able to integrate their technological knowledge with their pedagogical and content knowledge. In other words, she started to realize that the teachers' ability to integrate their technological knowledge with pedagogical and content knowledge could address multiple issues that were related to the root cause. Her way of thinking about technological, pedagogical content knowledge was growing in sophistication. This was a clear indication that her conceptual schema has gone through a transformative process as she brought resolution to the cognitive tension that she experienced earlier.

Similarly, R demonstrated a growing sophistication in her thinking about technological, pedagogical and content knowledge when she and J were able to argue that the integration of the teachers' technological knowledge with their pedagogical content knowledge would help the teachers to be more effective as the integration of technological knowledge would allow teachers to achieve certain objectives that would otherwise be difficult without the integration of technology (Refer to Episode 40).

4.2.1.3 Summary

The PBL setting had presented the participants with a real life problem which was ill-structured and complex in nature. As can be seen from the above discussion, the real and ill-structured nature of the problem supported the social construction of knowledge by making the discourse data-driven and not speculative. Through several iterative processes of

clarification, verification and justification using real data, the participants explored and had to identify data and information that were relevant and critical to the conceptual space of the problem. As a result they co-constructed a growing and richer representation of the problem they were dealing with.

As the discourse progressed, the complexity of the problem began to emerge as the participants delved deeper into the multiple data sources and working through a list of seemingly unrelated possible root causes. This led to a series of cognitive puzzlements, dissonances as well as multiple representations of the problem. The discourse indicated that the complexity of the PBL problem could lead to two possibilities. When the participants were dealing with complex situations and the discussions were well facilitated and supported by effective collaboration among the participants (this relates to the other two essential features of the PBL process that will be discussed later), the complexity of the problem serves as an stimulus and impetus for deep thinking and reasoning and this supported the social construction of knowledge by advancing the discourse into deeper phases of mIAM (Phase III to Phase V). However, when the complexity of the problem was not productively handled, the participants became overwhelmed with cognitive overload and the discourse muddled at the early phases of the mIAM and did not progress beyond that. Under such circumstances, the complexity of the problem hindered the social construction of knowledge. The impact of the complexity of the problem is illustrated in Figure 4.3:

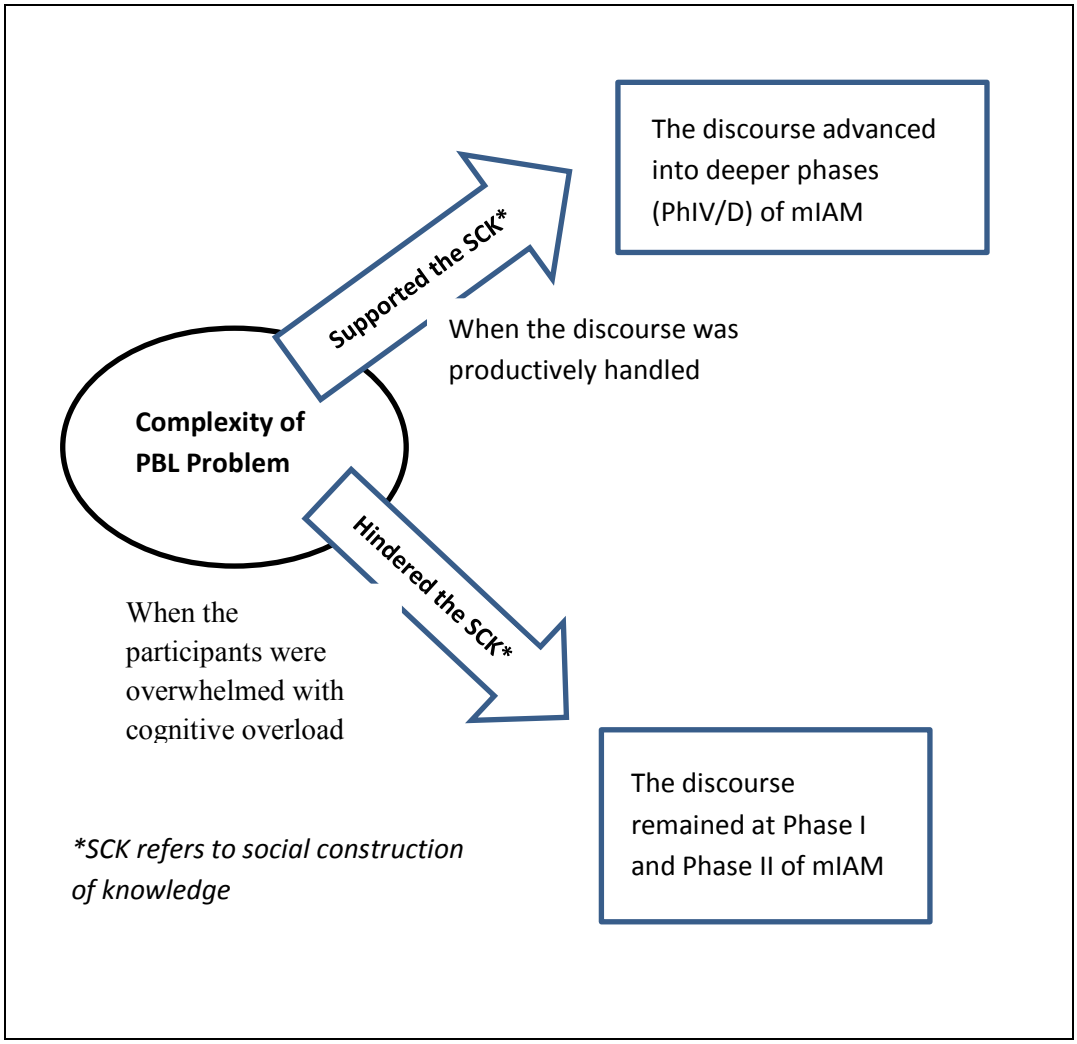


Figure 4.3 The impact of the complexity of the PBL problem on the social construction of knowledge

4.2.2 The impact of facilitation on social construction of knowledge

In this section, we aimed to answer the following questions:

Research question 2(a)(ii) What elements of facilitation in the PBL setting support the social construction of knowledge?

Research question 2(b)(ii) What element of facilitation in the PBL setting hinder the social construction of knowledge?

4.2.2.1 Pushing for verification and justification

In the earlier discussion (session 7), the participants, based on the information provided by F, had hypothesized that the problem they were dealing with was that the teachers' technological knowledge was separate from their pedagogical content knowledge (see Figure 4.1). In the following excerpt, the instructor helped them to facilitate the co-construction of a shared representation of the problem.

The discourse started with the instructor's probing question:

> "How to confirm F's assessment of the teachers? ... Do we have information to verify it? Do we?" (8B, 08:48; PhII/C)

Here, the instructor was pushing for verification. J responded by saying that data from SQSS verified that the teachers had high technological knowledge. However, the data also showed that the teachers' usage of technology in the classroom was very low, specifically, it was used only about once a month (for the detailed discussion, refer to Episode 12). The instructor pressed for deeper reasoning by getting the participants to consider the implication of that piece of data as he inquired:

> "So what kind of conclusion can we draw from such data?" (8B, 10:01; PhII/C)

As a result, the following exchanges occurred:

Line	Episode 47		mIAM Code	Time
1	J:	At the moment it's too early, I think.	PhII/C	8B, 10:06
2	I:	But assuming that a lot of teachers are like that,	PhII/C	

(Continued on next page)

3		what kind of conclusion can we draw? People		
4		who are saying 'yes, I have TPCK' but when		
5		the question comes 'How often do you use		
6		technology? 'Once a month'.		
7	J:	I guess it reflects our Question 2,[9] whereby they	PhII/C	
8		feel that 'I have it for myself, thank you, but I		
9		think I can go without it for my classes'. And		
10		they feel that whatever they're doing in class		
11		is enough to get the students to…		
12	F:	To pass.		8B, 10:48

In the above exchanges, the instructor was constantly probing for verification and justification (Line **2-6**). This compelled the participants to do two things. First, the probing created opportunity for the participants to make their opinions public or transparent so that these opinions can be taken up for further evaluation or explication. In Line **7-12**, J expressed her opinion that the data implied that the teachers did not see the benefit of using technology in their classroom. However, the line of reasoning might be a little premature as the data only showed that the teachers rarely used their technological knowledge. The data did not provide explanation as to why the usage of technology was low. Second, the probing forced the participants to think deeper as they attempted to justify their argument or reasoning with the data that they had collected. For instance, it can be seen from the above conversation that J's argument did not match with the data from SQSS and hence her reasoning or explanation at that point was not viable and coherent. This process of probing for verification and justification was critical to the social construction of knowledge as it exposed inconsistency among ideas. Potentially, this cognitive tension could stimulate the participants to re-examine and re-structure their cognitive schema and help them to co-construct a more viable and

[9] Question 2 (Line 7) refers to a question that the instructor asked in their earlier discussion and that was 'Could the students have learned just as effectively without technology? Why? Why not?'

accurate representation of the problem.

In response to J's premature reasoning, the instructor modeled good thinking and reasoning by guiding the participants to see the direct implication of the data (refer to Episodes 13 and 14 for the detailed discussion), rather than to draw conclusion that went beyond the scope of the data. This led the participants to stay on track in their discussion and focused on what the data was saying instead of being drawn into some other speculative, potentially less productive reasoning.

This was clearly seen in the way both J (Line **1-5**) and F (Line **6-9**) responded to the instructor's line of reasoning in the below exchanges:

Line	Episode 48		mIAM Code	Time
1	J:	And these teachers…what is very fascinating is	PhII/D	8B, 12:28
2		they have it, knowledge wise. They know they		
3		have it. They are very confident because they		
4		rated themselves very highly: five [out of five],		
5		most of them or all criteria are five. So knowledge		
6		wise, they are very strong.		
7	F:	I think my teachers are all 100% IT literate. They	PhI/C	
8		know how to…their Microsoft Word are		
9		intermediate or advanced level, one or two with		
10		basic. The rest are all good.		
11	I:	So here, we have the majority of teachers with	PhII/C	
12		high T…		
13	F:	But they are not linked. The P, C and T are not	PhI/A	
14		linked. Just one here, one here, one here		
15		(gesturing 3 separate circles).		
16	I:	Why do you say that? Why is it not linked?	PhII/C	
17	F:	Probably P&C linked but T…They don't see	PhIV/A	

(Continued on next page)

18		how T comes into their pedagogy and content.		
19		Or probably they don't need it because we		
20		have...		
21	I:	… this is a good example. But this is where	PhII/C	
22		the data comes in. If, we, after looking at the		
23		survey we verify that what J is saying is true,		
24		that's exactly what you're talking about: teachers		
25		who have potentially P&C but T is kind of		
26		outside.		8B, 14:08

The instructor re-stated what the data from SQSS was actually showing them (Line 11-12). This led the participants to consider the implication of the data from SQSS and F argued that the teachers' technological knowledge, pedagogical knowledge and content knowledge were all separate (Line 13-15). Again, the instructor pressed her for justification (Line 16). As a result, F reframed her argument to stay consistent with her earlier comment that the teachers' pedagogical and content knowledge were linked but their technological knowledge was not integrated with their pedagogical content knowledge (Line 17-18). The instructor affirmed her line of reasoning and helped the participants to re-focus on the implication of the data from SQSS (Line 21-26). In contrast, as the reader will see in the later section when the discussion was not facilitated, the participants sidetracked and the conversation spiraled into unproductive interaction.

As the discourse progressed, the instructor brought up the issue of the teachers' pedagogical content knowledge and challenged the participants' earlier conclusion that the teachers' pedagogical and content knowledge are integrated:

> "…So now we have the data to verify that T is quite separate from the P&C. We don't know…we don't have the data to say whether P&C is well combined…" (8B, 14:31; PhII/C)

This probing statement compelled the participants to reassess the teachers' pedagogical and content knowledge and based on the feedback provided by F, they were some examples that could cast doubts on the teachers' content and pedagogical knowledge. For instance, some English teachers had problem with their spelling and some of them had only gone through one-year diploma training. Apart from that, a number of students who were in the religious classes were struggling with the basic skills of the subject and F attributed this to the teachers' poor teaching (that is, a pedagogical issue).

At this juncture, the instructor highlighted the inconsistency in their thinking:

> "So now, your earlier observation on the P&C are overlapped, at least with the two groups that you talked about, maybe they are not overlapped?" (8B, 21:47; PhIII/A)

F defended her thinking by saying:

> "Or maybe the overlap is so little" (8B, 22:00; PhIII/C)

However, the instructor pressed further:

> "…Now the question is: For the context of the project, how do you verify this data? How do you know somebody's P&C is separate or overlap?" (8B, 22:20; PhII/C)

F commented that the instrument SKPM was adequate to assess the teachers' pedagogical content knowledge:

> "…I have an instrument and that's a national level instrument: Standard Kualiti Pendidikan Malaysia, SKPM. There's one part for

teachers' teaching. It's quite intricate. It's quite detailed…" (8B, 22:44; PhII/C)

At this point, the instructor decided to help the participants to collate their thinking and highlighted the importance of probing deeper in order to get to the right root issue. Up to this point, the participants were quite certain that the problem they were dealing with was consistent with Scenario A (Figure 4.1) and that was the teachers' technological knowledge was not integrated with their pedagogical content knowledge. The instructor's probing had guided the participants to re-think and examine if their conclusion that the teachers' pedagogical and content knowledge were integrated was premature and was not supported by formal data.

These series of exchanges highlighted the elements in the facilitation process that supported the social construction of knowledge. The instructor's push for verification and justification in the early part of the discourse advanced the conversation into the Phase II of mIAM. Then he guided the conversation to progress through the various operations within Phase II as he pressed them to provide clear and coherent explanation and justification. In the process of defending their arguments, the participants began to reveal some inconsistencies in their own thinking. The instructor was quick to identify and expose these inconsistencies and consequently, the participants were forced to re-examine the basis of their arguments. This advanced the conversation to Phase III of the mIAM. These exchanges ended with the participants agreed to look into the teachers' scores in SKPM and compared it with SQSS to validate that the problem was consistent with Scenario A.

4.2.2.2 Identifying inconsistencies and cognitive dissonances

A few minutes later, the participants began to get into a more complex discussion on the many seemingly unrelated possible root causes. This conversational episode clearly demonstrated how soft scaffold through the use of role-playing by the instructor helped advance the interaction into deeper phases of mIAM. In this episode, J started by commenting that time constraint was a reason why the teachers were not integrating their technological knowledge with their pedagogical content knowledge. This was followed by the participants exchanging corroborating examples to support J's statement. As a result, the conversation remained at Phase I/C of mIAM (refer to Episode 17 for the detailed discussion). Interestingly, J started to question her own reasoning and explored if there could be deeper issues and the teachers just wanted an easy way out. This pushed the conversation to Phase IV/A of mIAM as she attempted to negotiate for a new way of looking at the issue of time constraint. However, both F and R did not respond to that probing and they continued to provide more corroborating examples to support the idea of time constraint and the discussion reverted to Phase I/C of mIAM.

When the instructor rejoined the discussion, the issue of time constraint re-surfaced and he led the participants to probe deeper through role-playing (refer to Episodes 22-26 for the detailed discussion). Similar to the earlier incident, the instructor's intervention included his diagnosis and articulation of J's inconsistent ideas (Episode 23). But unlike the earlier incident, the complexity of the issue here created the opportunity for the instructor to probe deeper. Here, the instructor negotiated for a new way of looking at the issue. When J re-stated her position that time constraint was an issue, the instructor guided the participants to consider some potentially deeper challenges that the teachers may face as they attempted to integrate their technological knowledge with their pedagogical content knowledge. These

deeper challenges were reflected in the following exchanges (reproduced here from Episode 25 for clarity of discussion, except Line 1-2 which represented the question asked by the instructor before the exchanges):

Line	Episode 49		mIAM Code	Time
1	I:	Does your pedagogy change when you use	PhIV/A	8C, 33:03
2		technology?		
3	J:	Yes, I think I'm more student oriented because I	PhIV/A	
4		talked less. 'What do you think? Tell me'. There		
5		is more interaction between me and them. And		
6		also, they speak more.		
7	I:	Does that…What I almost hear is the risk that		
8		you may plan a 45 min class but your objective	PhIV/A	
9		may not be met.		
10	J:	There were a few times that had happened.	PhI/B	
11	I:	Is the risk higher when you use technology?	PhIV/A	
12	J:	Initially, when I started, I was everywhere. As I	PhIV/A	
13		began to use; adapt and adopt; now it's getting		
14		better. I make sure that the objectives are		
15		achieved. I think with experience and time and		
16		practice, it will get better.		8C, 34:08

As can be seen from the above exchanges, the deeper challenges were that the teachers might need to change their pedagogy (Line 1-2) and put up with the risk (Line 7-9) that their objectives may not be achieved when they tried to integrate their technological knowledge with their pedagogical content knowledge. Here, the instructor was negotiating for a deeper understanding of the issue and this advanced the conversation to Phase IV/A of mIAM. The instructor concluded his probing by pointing out to the participants that they must look beyond the surface problems and be prepared to probe deeper to get to the bottom of things.

Though the instructor, through his role-playing, did explicitly commented that time constraint was a simplistic way of looking at the problem at hand (refer to Episode 26), clearly both J and R did not internalize the instructor's line of argument as moments later the participants still repeatedly commented that time constraint could be a possible root problem. For example, J, in her attempt to narrow down the list of possible root causes commented that:

> That is the question now, do we conclude that they don't know or ….If we said that they don't have time, then that data is critical [PhII/E]. We just take it that they don't know that's why they are not doing it and we can stick to the…[PhII/B][Episode 29]

And a little while later, R asked:

> "Don't know how or don't want. If don't want is it because no benefit or no time? [PhII/B] *Can we ask them if they know [how to integrate]?*" [PhII/E; Episode 32]

And R repeated the same argument:

> "If *they do not want to*, there are two possible reasons: no benefit or no time." [PhII/B; Episode 32]

F, on the other hand, did try to negotiate for a new line of discussion similar to that modeled by the instructor when she argued:

> "Actually, it's a fact that their pedagogies have to change…" (PhIV/A; Episode 33)

However, both J and R did not take up this line of discussion and the group proceeded to work on the definition of the problem.

In this episode of role-playing, the intervention provided by the instructor was direct as he asked leading questions and ended the role-play with a short, 5-minute mini-lecture about the issue of time constraint. Though the instructor's line of discussion advanced the interaction to Phase IV/A of mIAM, the social process was superficial in that the participants did not have the space to engage in a deeper manner of social negotiation on the issue as they were essentially told 'what to think'. This episode illustrated that when the instructor's intervention was too direct and lacked the social participation of the group members, the conversation did not mature and there was little conceptual change in the thinking pattern of the participants. Hence, the participants reverted to Phase II type of discussion and this prevented the interaction from progressing beyond Phase IV/A.

4.2.2.3 Creating appropriate social space for social negotiation

In contrast, the following interaction showed a different facilitation process that was more effective in fostering conceptual change in the participants. In this interaction, the participants started by saying that they had decided not to consider some possible root causes as that would take too much of their time and one such possible root cause was the issue of teachers' level of motivation in using technology in the classroom (Line **1-2**). (Episode 38, reproduced here for clarity of discussion):

Line	Episode 50		mIAM Code	Time
1	I:	But if even with the question of motivation,	PhIV/A	8D, 32:54
2		why are they not motivated? It can come back		
3		to the same reason: they are not motivated because		
4		they don't see the benefit. Or they are not		

(Continued on next page)

5		motivated because they are lazy? Not really, right?		
6		Your teachers (referring to F) are fairly	PhV/A	
7		hardworking, right?		8D, 33:23

As can be seen from the instructor's response, his intervention was quite similar to that happened in the role-play episode as he interjected with direct and leading questions to help the participants see the relationship between these root causes (Line **3-5**). However, as the interaction progressed, there was a significant divergent in the facilitation process from the role-play episode:

Line	Episode 51		mIAM Code	Time
1	F:	Maybe just one…	PhV/A	8D, 33:30
2	I:	How many percent would you say are	PhI/D	
3		hardworking teachers?		
4	F:	More than 70-80 percent.	PhI/D	
5	I:	So most of them are hardworking, so motivation	PhIV/A	
6		is not a huge issue…		
7	F:	But motivation for using technology is an issue…	PhIV/A	
8	I:	Right. So the question is: why?	PhIV/A	
9	R:	They probably don't know how.	PhIV/A	
10	F:	They will argue: If I don't use, I can still teach…	PhIII/B	
11	I:	'If I don't use, my students still pass' or 'they	PhIII/D	
12		still get their A's and B's'. OK, I guess you'd		
13		expect me to ask the question. But how do you		
14		know they don't use it because they don't have	PhII/C	
15		the skills to integrate? That's the main argument		
16		right now, right?		8D, 34:27

Unlike the role-play that happened between the instructor and J, here the instructor created a greater social space by his probing questions. This was significant as the participants were forced to think deeper when they contributed their ideas to co-construct their interpretation of the problem at hand. When the instructor concluded that the teachers' motivation was not

a huge issue as they were hardworking (Line 5-6), F jumped in and commented that the motivation for using technology was an issue (Line 7). Here, F was probing deeper into the issue of motivation and clearly, she was able to articulate and negotiate for a new meaning of motivation. When the instructor pressed for justification (Line 8), R was quick to argue that the teachers probably did not know how (Line 9). F challenged that argument by stating that the teachers can still teach as effectively even if they did not use technology (Line 10). The instructor re-voiced her statement and further challenged the participants' earlier conclusion that the teachers did not have the skills to integrate their technological knowledge with their pedagogical content knowledge. At this point, the instructor was subtly influencing the movement of the conversation by challenging their ideas and pushing for deeper reasoning from the participants with more open-ended and meaningful questions (Line 8, 12-16). This facilitation process helped the conversation to stay within Phase III and Phase IV of mIAM and provided a rich context for the negotiation process.

In response to the instructor's probing (Line 12-16), the participants gave the following arguments:

Line	Episode 52		mIAM Code	Time
1	J:	They only used it once a week…	PhII/C	8D, 34:33
2	I:	Though they have fairly high T…	PhII/C	
3	J:	So we are basing it on that ground. But…of		
4		course it can also be some other reasons.	PhII/C	
5	F:	… Because if they have the skills to integrate,	PhII/D	
6		they can do it in groups, if they know how to do		
7		it…		
8	J:	If they know how to integrate it well then they	PhIV/A	
9		will be able to see that the time issue would not be		

(Continued on next page)

10		such a major issue because I think they would be		
11		able to see that although…No, it might take some		
12		time initially. But if they are able to see that by		
13		integrating this, in the long run, my students will		
14		benefit; the objectives will be achieved in a much		
15		easier way. I think all the other possible reasons		
16		can be put aside.		
17	I:	OK, you're making some progress here. So, one	PhIV/B	
18		of arguments is if they know how to integrate,		
19		time shouldn't be as big an issue because they		
20		know in the long term, it evens out.		8D, 36:02

As soon as J started to put forth her reasoning, she realized that her own reasoning was not well substantiated as the data only showed that the teachers were using technology once a week; it did not show that the teachers did not have the skills to integrate their technological knowledge with their pedagogical content knowledge. As J pointed out, there can also be many other possible reasons (Line 3-4). In short, as J attempted to defend their conclusion about the problem, she detected her own inconsistency in her thinking and this caused her to abandon that line of reasoning. In response to that, F argued that if the teachers had the skills to integrate they can do it in groups, perhaps implying that working collaboratively in groups may lighten the teachers load and help solve the issue of time constraint (Line 5-7). Though her line of argument was not clear, it prompted J to build on F's last sentence "if they know how to do it…" (Line 6-7) as she argued that time constraint would not be a major issue if the teachers know how to integrate their technological knowledge with their pedagogical content knowledge (Line 8-16).

As discussed in Section 4.1.4, J's statement in Episode 39 represented a major shift in her conceptualization of the problem as for the first time her articulation of the problem had shifted away from her earlier simplistic view that time constraint was the root cause that

prevented the teachers from integrating their technological knowledge with their pedagogical content knowledge. Her statement represented a proposal and negotiation of a new understanding of the problem they were dealing with and this advanced the interaction to Phase IV/B of mIAM.

At this juncture, the instructor affirmed the participants' line of reasoning and summarized the main argument put forward by J that if the teachers were skilled in integrating their technological knowledge, time shouldn't be as big an issue for the teachers (Line 17-20)

Again, contrasting this to the role-play episode where the instructor provided direct instruction on the issue of time constraint through his mini-lecture, here the instructor merely summarized what had been said by the participants and created more opportunity for the process of negotiation to develop. This can be seen in the following exchanges (taken from Episode 40):

Line	Episode 53		mIAM Code	Time
1	I:	What about the second one, for example, for the	PhIV/A	8D, 36:30
2		sake of argument.		
3	R:	No additional benefit. *This is the same as the issue*	PhIV/B	
4		*with time*, if they already have the skills to do it,		
5		they can see the extra benefits the students will get.		
6	J:	Let's say if you use…technology, this is based	PhV/A	
7		on my experience; they will be some changes		
8		because the students will be very excited and		
9		interested and of course the question will be:		
		(End of Video Session 8D)		
10		but does that ensure that the objectives are	at 37:05)	
11		achieved? Based on my experience, it does. I		

(Continued on next page)

12		might have listed three objectives and I might not		
13		be able to achieve all three but at least one will be		
14		achieved, which would be much difficult if that was		
15		a normal way of …		
16	R:	With no technology.	PhIV/B	
17	J:	Ya, with no technology.		8E, 00:20

In Line 1-2, the instructor created the opportunity for deep reasoning to occur by getting the participants to argue how other possible root causes could potentially be addressed. Both R and J's co-constructed arguments represented a sophistication that came from a high level of technological, pedagogical content knowledge as they reasoned that the integration of technological knowledge would allow the teachers to achieve their learning objectives that would otherwise be not possible without the integration of technology (Line 11-17).

Line	Episode 54		mIAM Code	Time
1	I:	Let me make sure I'm hearing you right. If they	PhIV/B	8E, 00:22
2		have the skills to integrate T with their P&C, then		
3		they will…		
4	R:	See the additional benefits.		
5	I:	See the benefits of their implementations. Is that		
6		your argument?		
7	R&J:	(Nodding heads in agreement)		8E, 00:43

Again, the instructor re-voiced (Line 1-2) and summarized (Line 5-6) the participants' new, co-constructed understanding of the problem. By now, it can be observed that the instructor was subtly but consistently leading the participants to reason with the TPACK framework that if the teachers had the skills to integrate their technological knowledge with their pedagogical content knowledge, they would be able to address multiple issues related to the root problem.

In the ensuing 5 minutes of interaction, the instructor, using the same framework of reasoning, created numerous opportunities for the participants to test and develop their own ideas and worked towards a collective understanding of the root problem that was becoming increasingly clear and coherent. Towards the end of this transformative discourse, the instructor made clear to the participants the framework of reasoning that he was using in the discourse:

> "We've done some mental gymnastics here in the last 30 minutes. I'm glad you see that if we spent the time and figured out five or six reasons, really, if you have the skills, then you'll address multiple reasons." (8E, 05:27; Ph IV/B)

These exchanges exemplified a critical moment in the social construction of knowledge when the participants delved deeper into the complexity of the problem they were dealing with. The instructor's intervention played a significant part in fostering a rich environment for deep and meaningful social negotiations to occur. As the reader may recall, in section 4.2.1.2 it was shown that when the participants were confronted with the complexity of the problem of multiple root causes, they were overwhelmed by the cognitive dissonances created by these issues (refer to Episode 27, 28 for the detailed discussion) and eventually they resorted to a superficial response to their cognitive overload (refer to Episode 29 for the detailed discussion). As can be seen from the above exchanges, the instructor adopted a facilitation process that was distinctly different from the role-play technique. Here, he used meaningful and open-ended questions to create a larger social space for the participants to engage and co-construct a shared understanding of the root problem. Apart from that, the instructor's use

of the guiding framework (rather than a direct instruction which he used in the role-play) to ground the interaction was a critical element which supported the participants in deeper process of negotiations. The combination of deep and meaningful probing with open-ended questions and the use of his guiding framework created the appropriate social space for the social construction of knowledge to advance further into deeper phases of mIAM. This approach to facilitation was critical as it allowed the interactions to develop and mature and allowed the participants to successfully negotiate and co-construct a shared understanding of how multiple root causes can be addressed. (The use of frameworks to support the social construction of knowledge will also be discussed in the section 4.2.3 on collaborative interactions.)

Table 4.5 provides an analysis of the contrasting elements that supported and hindered the social construction of knowledge using the episode of the role-play and the above discourse where the instructor modeled good strategies and deep reasoning:

Table 4.5 Contrasting elements in the facilitation process which supported or hindered the social construction of knowledge

Elements of Facilitation which Supported the Social Construction of Knowledge (Refer to the above last five excerpts)	**Elements of Facilitation which Hindered the Social Construction of Knowledge from advancing beyond Phase IV of mIAM (Refer to Section 4.2.2.2)**
1. The facilitator created a greater social space for the participants to formulate and express their ideas. This was mainly done through asking meaningful and open-ended questions that required the participants to think deeply to get to the root of the issue. As a result, the participants challenged each other's ideas and detected their own inconsistencies in their thinking. This provided a rich context for the process of social negotiation that allowed the participants to re-examine and re-structure their conceptual schema.	1. The instructor asked mainly direct, leading questions that were rhetorical in nature. The participants were essentially told 'what to think'. There was little social space for new ideas and multiple perspectives to emerge and the conversation became less productive as there were fewer opportunities for ideas to be evaluated or challenged. As a result, the process of social negotiation was compromised and the conversation did not mature.
2. The framework was used to guide the participants to hook their thinking at critical points. This happened when the participants began to connect and link ideas together regarding the possible root causes and the instructor re-voiced and summarized the participants' co-constructed arguments and new understanding and kept the interaction in a relevant conceptual space that allowed ideas to develop and mature.	2. The framework was used in a structured manner to guide the discussion. This was done through a mini-lecture that summarized the instructor's main ideas in the early part of the role-play and ended the discourse. The participants did not have the opportunities to wrestle with their ideas and thinking. As a result, the process of social negotiation was compromised and the conversation did not mature.

These two different facilitation processes brought contrasting outcomes as well. As discussed earlier, the role-play that the participants went through did not result in significant changes in their understanding of the issue with time constraint as moments later they continued to argue that time constraint could be a possible root cause for the teachers for not integrating their technological knowledge with their pedagogical content knowledge. However, in the

last episode when the facilitation process was guided by the elements which supported the social construction of knowledge, there was a significant shift in the conceptual schema of their understanding regarding the issue with time constraint. This shift was clearly evident in their journal reflections. Reflecting on their understanding of the problem they were dealing after session 8, J wrote:

> The case in our hands deals with teachers who do not have the skills to integrate technology into their lessons. This is the root cause" The excuses such as there is ***no time*** [emphasis mine] and lazy are just a way for them to divert themselves from giving the actual reason for their refusal to incorporate technology into their lessons. (Journal Entry November 10, 2011. The same day after Session 8)

R, meanwhile, reflected that:

> Upon more discussion, we think that issues about ***time*** [emphasis mine], logistic, motivation and others is actually under the umbrella of teacher do not have or have insufficient skill to integrate T into P and C. (Journal Entry November 15, 2011, five days after Session 8)

And she supported her argument with a table which clearly argued that time constraint was an issue that can be addressed if the teachers have the skills to integrate their technological knowledge with their pedagogical content knowledge (refer to Figure 4.3). In their reflections, they clearly understood that time constraint was a simplistic way of looking at the root problem and they were able to coherently argue that the issue with time constraint can be addressed if the teachers have the skills to integrate their technological knowledge with their pedagogical content knowledge. Their summarization of the root problem and

design of the reflection artifact indicated a stable and significant change in their conceptual schema, through a process of facilitated interactions that advanced the social construction of knowledge.

4.2.2.4 Summary

The elements of facilitation which supported the social construction of knowledge were (1) the instructor pushed for verification and justification. This created the opportunity for the participants to make their ideas public for further evaluation and explication. Additionally, the push for justification also compelled the participants to develop substantive and coherent arguments and this moved the interactions into Phase II of mIAM. (2) The instructor, through deep probing, identified the inconsistencies and cognitive dissonances in the participants' arguments. As the discourse progressed into more advance phases of mIAM, the participants were dealing with greater complexity of the problem. Here, the instructor demonstrated deep probing as he guided the participants to diagnose inconsistencies in their arguments and helped them to work through their cognitive dissonances in order to get to the root of the problem. As discussed above, this moved the interaction to Phase III of mIAM. At these phases, (3) the instructor created appropriate social space through the use of meaningful, open ended questions. Besides that, he grounded the discussion on a framework that allowed the participants to negotiate and co-construct a shared interpretation of the root problem and tested the new understanding of the root problem with new set of data. As a result, the interaction moved into Phase IV and Phase V of mIAM.

The analysis of the above interactions also showed that a critical point occurred when the participants advanced into Phase III and Phase IV types of interactions. In these phases, the participants had to wrestle with a myriad of issues that related to the root causes. As can be

seen from the incident of the role-play by the instructor, there were a couple of elements in the facilitation that hindered the social construction of knowledge. First, when the instructor led by using direct and leading probing questions, there was little social space for new ideas and multiple perspectives to emerge and the conversation became less productive. Second, when the use of guiding framework became too structured, the conversation did not mature and the social construction of knowledge was hindered.

4.2.3 The impact of collaborative interactions on social construction of knowledge

Specifically, this section aimed to address the following questions:

Research question 2(a)(iii) What elements of collaborative interactions in the PBL setting support the social construction of knowledge?

Research question 2(b)(iii) What elements of collaborative interactions in the PBL setting hinder the social construction of knowledge?

In this PBL approach, the instructor assumed a wandering facilitation model (Hmelo-Silver, 2000) which required the participants to work collaboratively on their own without facilitation in some segments of the PBL sessions.

4.2.3.1 Reinforcing collaborative interactions in the early Phases of mIAM

The discussion started with the participants attempting to understand the nature and characteristics of the problem they were being confronted with. In the early stage of the discussion, the instructor led by modeling good questioning technique to begin to construct a shared interpretation of the problem at hand (refer to Episodes 1-6). In these episodes, the instructor played the key role in probing for more information based on F's experience with the teachers and the school and the discussion revolved around F's responses to the

instructor's questions. As the conversation progressed, the participants began to emulate the probing technique of the instructor and there was a clear shift in their collaborative efforts as they took on the role to probe and explore further.

At the start of Episode 7, R explored with the equation:

> "Did you ask your teachers why are they not using the technology?"
>
> [6D, 13:37; PhII/B)

This led to a productive discussion on the nature of the problem as the participants built on each other's line of thinking with good clarification questions. Below is an example of the participants' collaborative efforts in constructing a shared interpretation of the problem (A segment of Episode 7 is reproduced here for clarity of discussion):

Line	Episode 55		mIAM Code	Time
1	R:	What are the training [courses] did the teachers get	PhI/D	6D, 18:14
2		regarding technology?		
3	F:	Now is 100% in house training. That means I have	PhI/D	
4		to schedule the training for them. For some teachers		
5		I have refresher course, re-training them on how to		
6		use technology.		
7	J:	This in-house training, what do you train them on?	PhI/D	
8	F:	Train them on T. This year 2011, none is being	PhI/D	
9		done for TPCK because of lack of funds and		
10		planning.		
11	J:	So when you said training them on T, that means	PhI/D	
12		like put all the teachers in one room and then…		
13	F:	Not just put them in one room; get them to attend	PhI/D	
14		refresher course on how to use the Smartboard		
15		and how to use the laptops. We did have an Intel		
16		Teach Program.		
17	R:	What is the Intel Teach Program?	PhI/D	

(Continued on next page)

18	F:	Intel Teach Program is the TPCK…(trying to find	PhI/D	
19		the right way to describe the Program)		
20	I:	What is the curriculum in the Program?	PhI/D	
21	F:	Using technology to teach. Their main focus is	PhI/D	
22		project-based learning.		
23	J&R:	Do you have examples?	PhI/D	
24	R:	*Example*?		
25	F:	I'll bring bring the module.		
26	I:	But you can briefly explain it. If you look at the	PhI/D	
27		framework, the P they use in the curriculum is		
28		actually the project based learning. The T is the		
29		use of computers that helps the Intel agenda. They		
30		basically use computers to support project based		
31		learning. They have run in few hundred schools in		
32		Malaysia.		
33	F:	Most… most of the newer ones have certificates…	PhII/A	
34	I:	So, how many have Intel Teaching certs?	PhI/D	
35	F:	Now, probably 40%.	PhI/D	
36	I:	40%?		
37	F:	Ya.	PhI/D	6D, 21:45

In the above exchanges, both R and J built on each other's thinking as they sought clarifications from F (Line **1-2, 17, 23-24** for R, and Line **7, 11-12, 23** for J). This probing was critical as it minimized biases and avoided making assumptions regarding the nature of the problem.

As the participants began to emulate this kind of probing, the instructor's intervention faded gradually and the participants assumed greater initiative to carry the discussion forward. For instance, in an eight-minute long discussion in which the above excerpt was part of the conversation, the instructor only intervened twice (Line **20** and **26**). The instructor was quick to affirm their line of probing when he commented on the progress of the discourse:

"…You all are asking some good questions" (6D, 23:16; PhI/A)

However, when the instructor left the group a while later, the un-facilitated conversation took a sharp turn and, as discussed in Episode 8, it became superficial where a number of issues were tossed around without much probing by the participants (refer to Episode 8). In addition to that, they interrupted and cut into each other's comments. Consequently, the discourse did not progress further. (These contrasting situations showed the importance of facilitation to support the collaborative efforts of the participants and suggested that there was a strong interplay between the key features of the PBL. The interplay of the three key features of PBL on social construction of knowledge will be discussed in greater details in Section 4.2.4.)

Another key development in this un-facilitated part of the conversation happened when F began to describe to the group her interpretation of the problem using the TPACK framework. This discussion was captured in Episode 9. As soon as F drew the three circles to represent the state of the teachers' technological, pedagogical and content knowledge (refer to Figure 4.1), the discussion became grounded and focused and the interruptions that occurred so frequently in the earlier discussion stopped almost immediately. This advanced the discourse through Phase II of mIAM. As highlighted in the earlier section (Section 4.1.1.2), this incident showed how a shared framework provided the support that the participants needed to ground their thinking and argument and helped them to identify the specific evidence that needed to be collected in order to validate their hypothesis.

The above analysis suggested that the participants were able to deal productively with Phase I and Phase II type of interaction. They built on each other's ideas and thinking and asked good clarification questions to co-construct their understanding of the problem. The use of a clear framework (in this case the TPCK framework) also grounded the participants' interaction and pushed the social construction of knowledge into Phase II/E of mIAM.

4.2.3.2 Elements in collaborative interactions which hindered the social construction of knowledge

As the discourse progressed, their collaborative interactions ran into difficulties when they dealt with more advanced phases of social construction of knowledge. In Episode 20, the participants were evidently overwhelmed by the complexity of the problem as they struggled to make sense of the multiple possible root causes. At this point, the instructor intervened with his role-play (refer to Section 4.1.2.1). As discussed in the above section, though the intervention advanced the conversation it did not result in significant change in their understanding of the root problem. Soon, they became doubtful of their assessment of the teachers' state of technological, pedagogical and content knowledge as they vacillated between the arguments "the teachers know" and "the teachers do not know" how to integrate their technological knowledge with their pedagogical content knowledge (Episode 28). As their confusion deepened, J proposed an easy way out and urged the members to just settle for the teachers 'do not know' as the root cause (Episode 29). This was followed by a long pause as the participants did not know how to respond to J's unsubstantiated proposal.

Eventually (Episode 30), F countered that the root issue here was that the teachers 'do not have the skills' ("*tak mahir*") to integrate their technological knowledge and not because they 'do not have the technological skills' ("No, *tak mahir* integrate, *bukan tak mahir* technology"). She posited that the teachers' technological knowledge was high but their ability to integrate was low ("Technology high but to integrate low!"). Clearly, this was a critical moment for social construction of knowledge as she negotiated for a new way of looking at the root problem (Phase IV/A).

The instructor highlighted and underscored the significance of F's argument by saying:

> "Now, that's an interesting perspective. It does take a different skill to integrate. That's a very good observation!" (8D, 16:35; PhIV/A)

Despite the instructor's positive comment, the participants did not respond to this new line of discussion as they reverted to previous comments on the teachers did not see the benefit of using technology or that they were limited by time constraint. As a result, the discourse fell back to Phase II of mIAM, leaving a critical idea to go un-developed.

As the conversation progressed, the participants' discussions were continually bogged down by their inability to resolve the confusion caused by the multiple root causes. Table 4.1 highlighted four occurrences where such confusion occurred. These series of exchanges showed how the participants resorted to speculative arguments without providing substantive evidence and opted for an easy way out when they were overwhelmed with cognitive overload.

In the above exchanges, it can be concluded there were two elements in the collaborative process which hindered the advancement of the conversation and they were (1) the inability of the participants to work through the cognitive overload as the complexity of the problem overwhelmed them and (2) the inability of the participants to detect the critical perspective that was shared. Though F's argument shifted the nature of the problem from 'do not want' to 'do not have the skills' (original '*tak nak*' and '*tak mahir*' respectively), the participants were quite oblivious to this critical shift in argument. Consequently, they failed to probe deeper and missed the opportunity to co-construct a new understanding or representation of the problem.

4.2.3.3 Summary

The above excerpts showed that the participants' collaborative interactions supported the social construction of knowledge when they emulated the instructor's good probing technique. This was particularly evident in the early part of the problem definition stage where the participants built on the examples of exploration and clarification demonstrated by the instructor as they co-constructed their interpretation of the problem.

The use of a clear and appropriate framework (in this case the TPACK framework) played an important part in grounding the participants' discussion and helped anchor their collaboration with a shared language. The TPACK framework was particularly useful in shaping the participants' interactions as it brought focus and served as a basic framework to understand and interpret the complex problem they were dealing with.

However, as the problem developed greater complexity, it can be seen that the participants' collaborative efforts were hindered by their inability to work through the cognitive overload. Apart from that, their inability to recognize key ideas or perspectives that were being shared also hindered the progressed of the discourse.

In the above discourse, there were instances which clearly showed the interplay of the key features of a PBL setting which affected the social construction of knowledge. The interplay between these key PBL features underscored the significance of the multi-factorial nature of the PBL setting and highlighted how these features interacted and mutually influenced the development of the discourse. The following section explored the interplay between these key PBL features.

4.2.4 The interplay of the three essential features of PBL in advancing the social construction of knowledge

In answering research question 2, each key essential features of the PBL was treated separately in order to highlight the impact of each of these features in supporting or hindering the social construction of knowledge. However, as discussed above, these features did not function in isolation. The strong interplay between these features suggested that these essential features must work in tandem in order to advance the social construction of knowledge.

Episodes 50-54 in section 4.2.2.3 provide a fitting illustration on how the interplay between these essential features foster the advancement of the social construction of knowledge. The complexity of the real life problem that the participants were dealing with became apparent when they started to address the multiple root causes of the problem (refer to the discussion in the first paragraph of section 4.2.3.2 Elements in collaboration which hindered the social construction of knowledge). This complexity, together with the instructor's facilitation and the participants' collaborative interactions interacted productively and transformed their collective understanding of the root problem.

The complexity of the real-life problem, when appropriately handled, provided a rich context where deep probing and reasoning were conducted. This was critical to advancing the conversation into the deeper phases of mIAM. In contrast to the early stages of the PBL cycle where the interactions were still simple and straight forward (refer to Episodes 1-6) and the conversation stayed essentially within Phase I and II of mIAM as the ideas and opinions shared in this early exploration were without much contention, the complexity of the problem that emerged in later discussions compelled the instructor and the participants to explore

various cognitive dissonances and delved deeper into the process of social negotiation and helped advanced the conversation into deeper phases of mIAM.

As can be seen from Episodes 50-54, the instructor's facilitation and the participants' collaborative interactions were critical in exploiting the complexity of the problem in productive ways. In Episode 50 and 51, the instructor led the participants in exploring the possible root causes. He commented that, based on F's experience with the teachers in her school, the teachers' motivation was not a huge issue as most of the teachers in F's school were generally hardworking (Episode 51, Line 1-6). At this point, F counter argued that motivation for using technology was an issue (Episode 51, Line 7). This prompted the instructor to ask why (Episode 51, Line 8).

As the conversation progressed in the subsequent episodes, the interplay of the three essential features of PBL began to intertwine and the process of co-construction went deeper. The contributions of the facilitation process were that the instructor created appropriate social spaces by (1) asking open-ended and meaningful questions that required the participants to think deeper to get to the root of the problem (Episode 51, Line 8, 12-16), (2) re-voicing the participants' ideas as a way of summarizing their thoughts and allowed for social negotiation to develop (Episode 52, Line 17-20; Episode 54, Line 1-3, 5-6), (3) using the TPACK framework to keep the discussion in relevant conceptual space and negotiated for new and deeper ways of addressing the issue of root causes (refer to Table 4.5; Episode 53, Line 1-2).The participants, on the other hand, contributed to the process of co-construction by (1) identifying and articulating logical incoherence (Episode 52, Line 1-4), (2) challenging each other's ideas (Episode 51, Line 9-10) and (3) building on each other's ideas and co-constructed a shared understanding of the problem they were dealing with (Episode 52, Line

5-16; Episode 53, Line 6-17). The interplay of these three essential features of PBL to foster the social construction of knowledge is summarized in Table 4.6 below:

Table 4.6 Summary of the interplay between the 3 essential features of PBL to foster the social construction of knowledge

The three essential features of PBL	**The contribution of each of these essential features to the process of social construction of knowledge**
1) The real-life complex problem	It provided the information rich context where cognitive dissonances and deep process of social negotiation were conducted.
2) The instructor's facilitation	The instructor a) asked open-ended and meaningful questions compelled the participants to think deeper to get to the root of the problem. b) re-voiced the participants' ideas as a way of summarizing their thoughts and allowed for deeper social negotiation to occur. c) used the TPACK framework to keep the discussion in relevant conceptual space and negotiated for new and deeper ways of addressing the root causes.
3) The participants' collaborative interaction	The participants a) identified and articulated the logical incoherencies in their own and the members' thinking b) challenged each other's ideas. c) built on each other's thinking and co-constructed a shared understanding of the problem they were dealing with.

Contrasting this to situations where the facilitation was less effective, for instance, the role-play in Section 4.1.2.1, it did not result in significant change in the participants' understanding of the root cause and the interpretation of the problem remained simplistic. Similarly, when the participants failed to respond to critical comments or questions (refer to

Episodes 17-19, 30-31) and the interactions did not progress into more advance phases of mIAM.

The effective interplay of these three essential features of PBL resulted in a significant shift in the conceptual schema of all the three participants regarding the root problem. As discussed in the last paragraph of Section 4.1.5, the conceptual changes can be observed from their journal reflections and their conceptualization of the problem was coherent, rich and had a degree of sophistication that reflected the deep probing and challenge that the participants had gone through.

CHAPTER 5: SUMMARY AND CONCLUSIONS

This research was prompted by the desire to develop a deeper understanding of how the social construction of knowledge occurs in a PBL setting. A number of studies have advocated that PBL as an instructional approach is consistent with social constructivist learning theory (Pelech, 2008; Savery & Duffy, 2001; Hendry et al., 1999), implying that a productive PBL process should result in the social construction of knowledge among the participants. However, the evidence to support such a claim was thin and indeed there were few studies which focused on the social processes of PBL (Hmelo-Silver & Barrows, 2008).

In order to develop a deeper and detailed understanding of the processes which advanced the social construction of knowledge, this study analysed a large time scale of interaction which spanned the entire problem definition stage of the PBL cycle. This approach was in line with the assertion that deeper and more meaningful pedagogical implications on knowledge building required analysis which cut across a larger time scale and learning context (also referred to as large grain analysis); rather than merely focussing on thin slices of PBL meetings which often characterised many of the previous studies on the cognitive or social processes of the PBL practices (Hmelo-Silver & Barrows, 2008). The analysis of the PBL participants' discourse captured the advancement of the interactions from Phase I to Phase VI of mIAM indicating that the social construction of knowledge was extensive as they worked through the problem definition stage of the PBL cycle.

5.1 Key features that surrounded the social construction of knowledge

There were some notable features that surrounded the process of social construction of knowledge in this PBL setting. The early stage of the discourse revolved around the construction of a rich representation of the real life problem that the participants were dealing with. At this level of discussion, the complexity of the real life problem had not emerged and the participants were largely focusing on exploring and clarifying the information related to the problem. They were able to quickly emulate the instructor's probing technique and began to co-construct a shared representation of the problem. As the interactions were fairly simple and straight forward, there were no disputes at this stage and the interactions remained at Phase I and Phase II of mIAM. This segment of the discourse enriched the participants' understanding of the magnitude and nature of the problem they were dealing with.

However, as the discourse progressed the complexity of the problem began to surface and the participants had to wrestle with a myriad of complex issues which included the multiple root causes and different interpretation of the problem. Though there was an attempt by one of the participants to negotiate for a new way of understanding the root problem, the rest of the members did not respond to this significant move and quickly returned to sharing corroborating examples and the interaction reverted to Phase I of mIAM. The instructor intervened and through role-playing and mini lecture, he moved the interaction to Phase III and Phase IV of mIAM. Though the instructor's intervention advanced the conversation, detailed analysis of subsequent exchanges revealed that there were no significant changes to the participants' understanding of the root problem. In other words, the intervention technique, though succeeded in moving the interaction forward, was not effective in affecting real conceptual change at this stage.

As the participants delved deeper into the issues related to the possible root causes and multiple representations of the root problem, they were overwhelmed by the heavy cognitive load they were facing and became confused. As a result, they resorted to taking an easy way out by dismissing many of the possible root causes without providing a clear and good justification. Notably, this occurred in several episodes of the interactions where the interactions were either not facilitated or when they were facilitated minimally. Consequently, the interactions remained trapped in Phase II of mIAM. At this critical juncture, the instructor intervened and created an appropriate social space which allowed for robust social negotiation to emerge and develop further. This approach to facilitation proved effective and led to significant changes to the participants' conceptual understanding of the root problem. The transformative process which the participants had gone through was evident in their journal reflections as their summarization and conceptualization of the problem were logical, coherent, and had a degree of richness and sophistication that embodied the deep probing and reasoning of the discourse. As discussed in greater detail in CHAPTER 4, this appropriate facilitative approach moved the interaction through Phase IV to Phase VI of mIAM and promoted a deeper process of social construction of knowledge.

5.2 The specific ways in which the three essential features of PBL affected the social construction of knowledge

Though there has been a number of studies which revealed the multi-factorial nature of the PBL environment (more discussion on the multi-factorial nature of PBL later), they provided little insight into how or in what ways each of these factors affected the PBL process. For instance, Gijselaers and Schmidt (1990), showed that there was a positive

causal relationship between the quality of the PBL problem, the instructor's facilitation and the group functioning in the PBL process. Still, the study did not pinpoint how these factors interacted with each other and contributed positively to the PBL process. Similarly, Hmelo-Silver (2009) suggested that the characteristics of a good PBL problem must be complex, ill-structured and open ended in order to promote flexible thinking in the learners. However, it did not explain how the realistic and complex nature of the problem add to the productive PBL process. This study provided valuable insights into the specific ways in which the three essential features of PBL supported or hindered the social construction of knowledge. These three essential features were the (1) real-life and complex nature of the problem, (2) instructor's facilitation and (3) collaborative interactions of the PBL participants.

5.2.1 The role of the real life, complex problem

As we have seen from addressing second research question, the real and complex nature of the PBL problem provided an information-rich context for deep probing and reasoning. As opposed to hypothetical problem scenarios, the real-life nature of the problem made the discourse data-driven and less speculative. Through several iterative process of clarification, verification and justification, the participants were compelled to explore and identify specific data and evidence that were relevant and critical to the conceptual space of the problem. In doing so, the participants have to constantly re-structure their cognitive schemas to accommodate and integrate the new and relevant data and evidence. The complexity of the problem also served as a stimulus and impetus for deep thinking and reasoning as the participants wrestled with multiple perspectives, cognitive dissonances and negotiated for new ways of understanding the root problem. Hence, when the complexity of the problem was productively handled, it pushed the participants to probe deeper and promoted the social construction of knowledge.

However, in situations where the complexity of the problem imposed a heavy cognitive load on the participants, they became overwhelmed and the process of social construction of knowledge was hindered.

5.2.2 The role of facilitation

The instructor's facilitation was critical in scaffolding the process of social construction of knowledge. Specifically, the facilitator's interventions include (1) the push for verification and justification to generate logically coherent arguments (Phase I and Phase II of mIAM), (2) the diagnosis and identification of inconsistent ideas and cognitive dissonances (Phase III of mIAM), (3) the creation of appropriate social space to encourage social negotiation and co-construction of a collective understanding of the problem (Phase IV of mIAM) that led to the testing of the newly co-construction interpretation of the problem (Phase V of mIAM) and the participants' summarization and conceptualization of the root problem (Phase VI of mIAM in the form of personal reflections. As can be seen, the facilitation helped move the discourse through Phase I to Phase VI of mIAM and foster the social construction of knowledge that we recognize as deep learning. In addition to that, this research had demonstrated how important it is for facilitators to appropriate suitable facilitation strategies at different phases of the process of social construction of knowledge. It was observed that when the participants were dealing with greater complexity of the problem, the facilitation strategy must provide adequate scaffold (so that the participants did not overwhelm by the heavy cognitive load) and at the same time, creating appropriate social space to allow for new ideas to be evaluated, challenged and negotiated. This sets a rich context for meaningful and deeper social negotiation to occur. In contrast, the incident of the role-play and mini lecture (refer to Section 4.2.2.2) had demonstrated that when less effective facilitation technique was used, it limited the opportunity for robust social negotiation to take its course and the process of social construction of knowledge was compromised.

5.2.3 The role of the participants' collaborative interactions

The participants too, played a crucial role in advancing the process of social construction of knowledge. Analysis of the collaborative interactions showed that during the initial part of the problem definition stage, the participants' emulation of the instructor's good exploratory and clarification technique supported their efforts to co-construct a rich representation of the problem. Additionally, it was observed that the use of the TPACK framework helped ground the participants' interactions and anchored their discussion with a common language and focus.

However, there were situations when the participants failed to recognize and respond to critical moments or questions that were raised during the discourse (even at the prompting of the instructor), leaving an important idea or concept go un-developed. Obviously, this impeded the process of social construction of knowledge.

5.2.4 The complex interplay between the three essential features of PBL

It is important to re-state that these three essential features of PBL did not function in isolation but interacted in complex ways to affect the social construction of knowledge. In other words, the three essential features of PBL must work in tandem in order that the process of social construction of knowledge is extensive and transformative. When these features interacted effectively and productively with each other, the discourse advanced into deeper phases of mIAM and the process of social construction of knowledge was extensive. However, as we have observed in CHAPTER 4, in situations where the instructor's facilitation were less effective or that the participants failed to respond to critical moments, the discourse ended prematurely and the interactions did not progress beyond the early phases of mIAM.

Additionally, this study has shown that in instances where the PBL participants were dealing with the complex problem, the instructor's intervention can lead to two very contrasting outcomes. When the complex problem was productively facilitated, it advanced through the deeper phases of mIAM and resulted in extensive social construction of knowledge. However, when the complex problem was not adequately facilitated, the participants became overwhelmed by the heavy cognitive load and the process of social construction of knowledge was hindered.

The above occurrences highlight the important connection between the subject of cognitive load and the role of facilitation, a subject which was keenly debated between Kirschner et al. (2006) and Hmelo-Silver et al. (2007). Kirschner et al. (2006) had argued that half-century of empirical research have provided overwhelming and unambiguous evidence that minimally guided instructions such as the PBL process and other types of discovery learning are unlikely to result in effective learning. They posited that the complexity of the problem that the participants have to deal with imposes heavy cognitive load that is detrimental to learning, especially among novice learners who have not acquired the basic knowledge of the subject that is required to address the problem. Hmelo-Silver et al. (2007), in response, contended that PBL approaches are highly scaffolded and the scaffolded PBL environments provide the learners the opportunity to engage in complex tasks in ways that reduce the cognitive load and make the tasks more accessible and manageable. Hence, as they pointed out, the PBL approach is a powerful and effective model of learning.

This research, interestingly, validated the contrasting viewpoints put forward by Kirschner and Hmelo-Silver. A number of exchanges in the discourse had shown that the

information-rich and complex PBL environment did impose a heavy cognitive load on the participants and in circumstances where the interactions were minimally guided or facilitated (due to less effective facilitation or as the instructor gradually faded from scaffolding), the participants were seen muddled in their interactions and the process of social construction of knowledge was hindered (refer to Table 4.1). Clearly, this observation validated Kirschner's position that minimally guided instruction hampers effective learning. On the other hand, this study also supported Hmelo-Silver's argument that scaffolded PBL environments provide the opportunity for the participants to deal with complex tasks. This was exemplified by the deep probing and reasoning that occurred when the interaction was well facilitated by the instructor and led to significant conceptual shifts in the participants' interpretation of the root problem.

The above observations underscore the critical role of facilitation in fostering the social construction of knowledge. Indeed, without effective and appropriate facilitation, the process of social construction of knowledge was limited and it did not progress beyond the initial phases of mIAM. This finding is consistent with other research evidence that facilitation in PBL is an important factor in determining how students learn (Hmelo-Silver, 2004; Schmidt & Moust, 2000; Schmidt et. al., 1995). Additionally, the fine-grain analysis of the discourse allowed us to go a step further in that we are now able to clearly identify and articulate the specific facilitation interventions that advanced the interactions of the participants into deeper phases of mIAM to foster the process of social construction of knowledge.

5.3 The major contributions of this study

This study demonstrated that the mIAM can be a useful theoretical framework for examining the levels and extent of social construction of knowledge in the PBL discourse. Clearly, the mIAM framework with its specific and identifiable phases of cognitive activities was useful in illuminating the movement of the discourse in advancing the social construction of knowledge. Hence, one major contribution of this study lies in the development and application of mIAM for PBL discourse. In particular, the model of analysis afforded by mIAM could serve as a guide for PBL facilitators to frame their interventions or probing questions in ways that could move the PBL discourse into deeper phases of social construction of knowledge. For instance, if the participants were in a Phase II type discussion where multiple hypothesis are shared (a very typical situation in the problem definition stage of the PBL cycle), the facilitator can prompt the participants to clearly descript the alternative perspective or opinion for further evaluation or exploration. This intervention moves the interaction to Phase II/B of mIAM. As the opinion is clearly articulated, the instructor can seize this opportunity to push the participants to justify the alternative perspective. The interaction progresses into Phase II/C of mIAM. At this junction, the instructor can guide the participants to evaluate the quality of the validation process. In situations where the justification is weak or speculative and not well supported by data, the instructor may refer to Phase II/D as a guide and facilitate the identification of specific data or evidence to be collected to provide good and clear justification to their perspective. Hence, the interaction advances into deeper levels of the cognitive activities in the social construction of knowledge. This approach to using the mIAM as a framework for intervention to advance the discussion can be applied at every phase of the participants' interaction and the instructor's familiarity with the framework can afford an effective and efficient way to advance the social construction of knowledge in PBL processes.

Apart from that, the framework can lead to a deeper understanding of how or under what circumstances the social construction of knowledge occurs. As such, the mIAM framework can inform the training and development of PBL facilitators in order to equip them with the awareness, understanding and the practical intervention skills to scaffold the discourse movements from lower to higher phases of mIAM. On top of that, the framework can provide strategic evaluative feedback to PBL instructors by helping them to identify which of their facilitation strategies and skills that had supported or hindered the process of social construction of knowledge. The PBL participants too, can also benefit from knowing the framework so that they are able to quickly grasp the thinking behind the instructor's facilitation strategies and goals and to emulate such strategies and goals in moving the interaction forward.

This study also affirmed the claim that the PBL environment is a multi-factorial environment and that these factors interact with each other to affect the outcomes of the PBL process (Gijselaers and Schmidt, 1990; Schmidt and Gijselaers, 1990). Hence, this study supports the assertion that comparative studies which treated PBL as a uniform or pure intervention to evaluate its effectiveness in comparison to conventional, lecture-based curricula was pointless in that they could not provide valid conclusions to the effectiveness or the lack of it in such interventions (Norman & Schmidt, 2000). Due to the multi-factorial nature of PBL environment, there existed a myriad of factors that could potential influence the outcome of the PBL process and made it impossible to attribute success or failure based solely on the PBL interventions. As Faidley et al (2000) rightly pointed out, PBL is "a sophisticated design that requires attention to learner and to teacher, to content and to context"

The complex interplay of these factors has several implications for the design and implementation of the PBL process in different educational contexts. In contexts where the real life problems are ill-structured, complex and open-ended (for instance, in social sciences), the participants must be given sufficient time and space to wrestle with the less definable amount of new information and data in order to co-construct a rich representation of the problem. To short-cut this process would undermine the quality of probing, testing and reasoning that are necessary for a robust process of social construction of knowledge. Apart from that, the PBL facilitators must constantly be aware of the degrees of complexity of the problem that the participants are dealing with at different stages of the PBL process so that appropriate facilitative approaches can be implemented to reduce the cognitive load of the participants to promote effective learning. As discussed earlier, at different phases of the social construction of knowledge, different facilitation skills and strategies are needed to move the discourse forward.

5.4 Summary

As stated at the beginning of this chapter, this research aimed to better understand how or in what ways does the process of social construction of knowledge occur. The analysis of the participants' interactions demonstrated that the PBL discourse exemplified all the six phases of mIAM, indicating that the participants had gone through a substantive constructivist learning experience as they worked through the entire problem definition stage of the PBL cycle. Indeed this study affirmed the claim that the practice of PBL is underpinned by constructivist learning theory (Pelech, 2008; Savery & Duffy, 2001; Hendry et al., 1999) and identified the social processes which helped advance the social construction of knowledge. The detailed examination of the phases of social construction of the participants' TPACK had contributed to a deeper understanding of the elements in the essential features of PBL which supported and hindered the process of social

construction of knowledge. This study represented an important and one of the few attempts to examine the social process outside medical education and contributed to the field by revealing a model of facilitation and interaction that promote the social construction of knowledge.

5.5 Limitations of the Study

The purpose of this research was to investigate the process of social construction of knowledge as it occurred in the PBL setting. Thus, a number of strategies were applied to enhance the validity and credibility of the study and these included the method of triangulation, adequate engagement in data collection, reflecting on and stating the researcher's position, audit trail and the use of rich, thick description of the setting and the findings. However, as with most studies, this study had several limitations. These include (1) the analysis of the interactions was confined to ideas or cognitive activities that were made public. Obviously, the thinking processes of the participants occurred at the social as well as the individual levels and the thinking processes at these two levels affected and developed from each other (Gunawardena et al., 1997). However, the cognitive activities at the individual level were not made public and hence there would be instances where the interactions were affected by the internal processing of ideas and such processing were not made public for analysis. The triangulation of data (for example, the data collected from their personal reflections) was an attempt to probe into their individual thinking. However, what was reported in the reflections may not fully capture the extent of their thinking process. Hence, the manifestation of learning may not be complete and the study only captured what was reported or demonstrated publicly, (2) it was likely that there were communications that took place among the participants that were not privy to the researcher. There were a few meetings and discussions that the participants made reference to during their interactions at the PBL sessions. Though

Gwave was set up for the purpose of capturing such data and information that had occurred outside of the classroom interactions, the participants did not take on to this mode of communication and the interactions on Gwave were largely social and logistics in nature. A fuller or broader range of data or information from the participants from different contexts of interactions other than the PBL sessions would have yielded a wider perspective or a deeper insight on the investigation of the process of social construction of knowledge, and (3) the limited response from the participants during the member checking phase. To solicit feedback from the participants, email communications were sent out to each participant to invite them to review the case report for credibility and accuracy, however, only one participant responded. Although the lone response from the participant was affirmative in nature, more feedback would have supported the credibility of the study.

5.6 Future Research

Future research should include the use of stimulated recall (De Grave et. al., 1996) to stimulate the participants to verbalize their thinking processes in critical interactional episodes which advance the process of social construction of knowledge. As discussed in the first limitation of this study, there were thinking processes that occurred at the individual level and these cognitive processes were not externalized. Stimulated recall would help to identify the cognitive and metacognitive processes of the PBL participants as they engage in the process of social construction of knowledge. This exploration of the individual thinking processes would allow for a deeper understanding of how the interactions move or progress into more advance phases of mIAM as they respond to each other's ideas in different phases of the conversation.

The mIAM was developed and applied in a PBL process that was situated in an education context. The model has proven to be adequate and responsive in examining the social construction of TPACK among the three PBL participants in this education context. Future research needs to be conducted to investigate if this modified interaction model can be applied in other PBL settings (for instance, in other disciplines of study such as engineering or business) or other adaptations are needed to make the model equally useful in other PBL settings.

This study has helped to identify a set of facilitation moves and strategies that are particularly relevant and effective in facilitating a PBL learning context that is ill-structured and open-ended. Additionally, one of the challenges for the instructor in facilitation is knowing when and how to gradually fade one's scaffolding so that the participants may take on the role of deep probing and reasoning independently. Further studies are required to understand if these facilitation skills and strategies can be developed into cultural tools that can provide novice facilitators with a clear framework to facilitate the social construction of knowledge in different PBL settings.

One of the important observations that emerged from the study was that at certain points in the PBL discourse, the participants failed to recognize and respond to critical moments or questions (even with the subtle prompting from the facilitator) and leaving critical ideas to go un-developed. Future research should examine what support or scaffold is needed to assist the students to recognize and respond to such critical moments. There were some early indications that the use of clear framework (in this study, the use of TPACK framework) could help participants ground their discussion and provide a conceptual

hook to focus their interactions. However, more studies are needed to understand how this works.

REFERENCES

Aalst J. V. (2009). Distinguishing knowledge sharing, knowledge construction and knowledge creation discourses. *International Journal of Computer-Supported Collaborative Learning*, *4*(3), 259-287.

Albanese, M. A. & Mitchell, S. (1993). Problem-based learning: A review of literature on its outcomes and implementation issues. *Academic Medicine*, *68*, 52-81.

Azer, S. A. (2001). Problem-based learning: Challenges, barriers and outcome issues, *Saudi Medical Journal*, *22*(5), 389-397.

Barrows, H. S. (2000). *Problem-based learning applied to medical education*. Springfield, IL: Southern Illinois University Press.

Barrows, H. S. (1996). Problem-based learning in medicine and beyond. In L. Wilkerson & W. H. Gijselaers (eds.). *Bringing problem-based learning to higher education: Theory and practice. New directions for teaching and learning, 68*, 3-13. San Francisco: Jossey-Bass Inc. Publishers.

Barrows, H. S. (1987). *The Tutorial Process*. Springfield, IL: Southern Illinois University.

Barrows, H. S. (1986). A taxonomy of problem-based learning methods. *Medical Education*, *20*, 481-486.

Barrows, H. S. (1985). *How to design a problem-based curriculum for the preclinical years.* New York: Springer.

Barrows, H. S. and Tamblyn, R. (1980). *Problem-based learning: An approach to medical education*. New York: Springer.

Berkson, L. (1993). Problem-based learning: Have the expectations been met? *Academic Medicine, 68*(10), 79-88.

Birgegard G., & Lindquist, U. (1998). Change in student attitudes to medical school after the introduction of problem-based learning in spite of ratings. *Medical Education*, *32*, 46-49.

Blumenfeld, P. C., Marx, R. W., Soloway, E., & Krajcik, J. S. (1996). Learning with peers: From small group cooperation to collaborative communities. *Educational Researchers*, *25*(8), 37-40.

Boud, D., & Feletti, G. I. (1997). *The challenge of problem-based learning* (2nd ed.). London, UK: Kogan Page.

Boud, D., & Feletti, G. (Eds.) (1991). *The challenge of problem-based learning*. New York: St. Martin's Press.

Bransford, J. D., & Stein, B. S. (2002). *Ideal problem solver* (2nd ed.). New York: W.H. Freeman and Company.

Bridges, E. & Hallinger P. (1992). *Problem-based learning for administrators*. ERIC Clearinghouse on Educational Management, University of Oregon.

Bridges, E. M., & Hallinger, P. (1995). *Implementing problem-based learning in leadership development*. Eugene, OR: ERIC Clearinghouse on Educational Management, University of Oregon.

Chein, I. (1981). Appendix: An introduction to sampling. In L. H. Kidder (Ed.), *Selltiz, Wrightsman & Cook's research methods in social relations.* (4th Ed.) (p. 418-441). Austin, TX: Holt, Rinehart and Winston.

Colliver, J. A. (2000). Effectiveness of problem-based learning curricula: Research and theory. *Academic Medicine*, *75*, 259-266.

Cooley, W. W. & Lohnes, P. R. (1976). *Evaluation research in education*. New York: Irvington.

Creswell, J. W. (2007). *Qualitative inquiry & research design* (2nd Ed.). Thousand Oaks, CA: Sage.

Creswell, J. W. (2008). *Educational Research: Planning, conducting, and evaluating quantitative and qualitative research*, (3rd Ed.). Pearson International Edition, Pearson Education, Inc., Upper Saddle River, New Jersey 07458.

Davis, W. K., Nairn, R., Paine, M. E., Anderson, R. M., & Oh. M. S. (1992). Effects of expert and non-expert facilitators on the small-group process and on student performance. *Academic Medicine, 67*(7), 470-474.

Davis, W. K., Oh, M. S., Anderson, R. M., Gruppen, L., & Nairn, R. (1994). Influence of a highly focused case on the effect of small-group facilitators' content expertise on students' learning and satisfaction. *Academic Medicine, 69*(8), 663-669.

De Grave, W. S., Dolmans, D. H. J. M., & van der Vleuten, C. P. M. (1999). Profiles of effective tutors in problem-based learning: scaffolding student learning. *Medical Education, 33*, 901-906.

De Grave, W. S., Boshuizen, H. P. A., & Schmidt, H. G. (1996). Problem-based learning: cognitive and metacognitive processes during problem analysis, *Instructional Science*, *24*, 321-341.

De Volder, M. L., De Grave, W. S., & Gilselaers, W. H. (1985). Peer teaching: academic achievement of teacher-led versus student-led discussion groups. *Higher Education, 14*, 643-650.

De Volder, M. L., & Schmidt, H. G. (1982). *Tutor: inhoudsdeskundige of procesbegeleider (Tutor: resource person or facilitator?).* In H.G. Schmidt (Red.), Probleemgestuurd onderwijs. Harlingen: Stichting voor Onderzoek van het Onderwijs.

Dewey, J. (1938). *Experience and education*. New York: Kappa Delta Pi.

Distlehorst L. H., & Robbs, R. S. (1998). A comparison of problem-based learning and standard curriculum students: Three years retrospective data. *Teaching and Learning Medicine*, *10*, 131-137.

Dolmans, D. H. J. M. (2003). The effectiveness of PBL: the debate continues. Some soncerns about BEME movement, *Medical Education*, 37, 1129-30.

Dolmans, D. H. J. M., De Grave, W., Wolfhagen, I.H.A.P., & van der Vleuten C. P. M. (2005). Problem-based learning: Future challenges for educational practice and research, *Medical Education 39*, 732-741.

Dolmans, D. H. J. M., Gijselaers, W. H., Moust, J. H. C., DeGrave, W. S., Wolfhagen, I. H. A. P., & Van Der Vleuten, C. P. M. (2002). Trends in research on the tutor in problem-based learning: Conclusions and implications for educational practice and research. *Medical Teacher*, *24*(2), 173-180.

Dolmans, D. H. J. M., Wolfhagen, I. H. A. P., Hoogenboom, R. J. I., & Van der Vleuten, C. P. M. (1999). Is tutor performance dependent on the tutorial group's productivity? Toward further resolving of inconsistencies in tutor performance. *Teaching and Learning in Medicine*, *11*(4), 186-191.

Dolmans, D. H. J. M., Wolfhagen, I. H. A. P., Schmidt, H. G., & Van der Vleuten, C. P. M. (1994). A rating scale for tutor evaluation in a problem-based learning curriculum: validity and reliability. *Medical Education*, 28(6): 550-558.

Duffy, T. M. (1994). Corporate and Community Education: Achieving success in the information society. *Unpublished paper.* Bloomington, IN: Indiana University.

Eagle, C. J., Harasym, P. H., & Mandin, H. (1992). Effects of tutors with case expertise on problem-based learninf issues. *Academic Medicine, 67*(7), 465-469.

Frederiksen, C. H. (1999). Learning to reason through discourse in a problem-based learning group. *Discourse Processes, 27*, 135-160.

Geerligs, T. (1995). Students' thoughts during problem-based small group discussions. *Instructional Science*, *22*, 269-278.

Gijbels, D., van de Watering, G., Dochy, F., & van den Bossche, P. (2006). New learning environments and constructivism: The students' perspective, *Instructional Science, 34*, 213-226.

Gijselaers, W. H. (1997). Effects of contextual factors on tutor behavior. *Teaching and Learning in Medicine*, *9*(2), 116-124.

Gijselaers, W. H., & Schmidt, H. G. (1990). The development and evaluation of a causal model of problem-based learning. In Z. Noorman, H. G. Schmidt & E. Ezzat (eds), *Innovation In Medical Education: An Evaluation of Its Presence Status*, 95-113. New York, NY: Springer Publishing Company.

Glaser, B. G., & Strauss, A. (1967). *The discovery of grounded theory*. Chicago: Aldine.

Gold, R. (1958). Roles in sociological field observations. *Social Forces, 36*, 217-223.

Graesser, A. C., & Person, N. K. (1994). Questions asking during tutoring. *American Educational Research Journal, 31*(1), 104-137.

Grol, R., Mokkin, H., Helsper-Lucas, A., Tielen, V., & Bulte, J. (1989). Effects of the vocational training of general practice consultation skills and medical performance. *Medical Education, 23*(6), 512-521.

Gunawardena, C. N., 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.

Hamilton, J. D. (1976). The McMaster curriculum: A critique. *British Medical Journal, 1,* 1191-1196.

Hassebrock, F., & Prietula, M. J. (1992). A protocol-based coding scheme for the analysis of medical reasoning. *International Journal of Man-machine Studies*, *37*, 613-652.

Hendry, G. D., Frommer, M., & Walker, R. A. (1999). Constructivism and problem-based learning, *Journal of Further and Higher Education*, *23*(3), 359-371.

Hmelo-Silver, C. E. (2009). *What do we know about problem-based learning? Current status and future prospects*. Symposium proceedings, 2nd International PBL Symposium, 10-12 June 2009, Republic Polytechnic, Singapore.

Hmelo-Silver, C. E. (2004). Problem-based learning: what and how do students learn? *Educational Psychology Review*, *16*(3), 235-266.

Hmelo-Silver, C. E. (2000). Knowledge Recycling: Crisscrossing the landscape of educational psychology in a problem-based learning course for preservice teachers. *Journal on Excellence in College Teaching*, *11*, 41-56.

Hmelo-Silver, C. E., & Barrows, H.S. (2008). Facilitating collaborative knowledge building. *Cognition & Instruction*, *26*, 48-94.

Hmelo-Silver, C. E., & Barrows, H. S. (2006). Goals and stretegies of a problem-based learning facilitator. *The Interdisciplinary Journal of Problem-based Learning*, *1*(1), 21-39.

Hmelo-Silver, C. E., & Ferrai, M. (1997). The problem-based learning tutorial: Cultivating higher order thinking skills. *Journal for the Education of the Gifted, 20*(4), 401-422.

Hmelo-Silver, C., Shikano, T., Bras. B., Mulholland, J., Realff, M., & Vanegas, J. (1995). *A problem-based course in sustainable technology*. In D. Budny, R. Herrick, G. Bjedov, & J.B. Perry (Eds), Frontiers in Education 1995. Washington D.C.: American Society for Engineering Education.

Hmelo-Silver, C. E., Duncan, R. G., & Chinn, C. A. (2007). Scaffolding and achievement in problem-based and inquiry learning: A response to Kirschner, Sweller, and Clark (2006). *Educational Psychologist, 42*(2), 99-107.

Jeong, A, C. (2003). The sequential analysis of group interaction and critical thinking in online threaded discussions. *American Journal of Distance Education*, *17*(1), 25-43.

Jonassen, D. H. (1991). Evaluating constructivistic learning. *Education Technology, 28*(11), 13-16.

Kanuka, H., & Anderson, T. (1998). Online social interchange, discord, and knowledge construction. *Journal of Distance Education, 13*(1), 1-19.

Kapur, M., & Kinzer, C. K. (2007). Examining the effect of problem type in a synchronous computer-supported collaborative learning (CSCL) environment. *Educational Technology Research and Development*, *55*, 439-459.

Kek, M. Y. C. A., & Huijser, Henk. (2011). The power of problem-based learning in developing critical thinking skills: Preparing students for tomorrow's digital futures in today's classroom. *Higher Education Research & Development, 30*(3), 329-341.

Kirschner, P. A., Sweller, J., & Clark, R. E. (2006). Why minimal guidance during instruction does not work: An analysis of the failure of constructivist, discovery, problem-based, experiential, and inquiry-based teaching. *Educational Psychologist, 41*(2), 75-86.

Koehler, M. J., & Mishra, P. (2005). Teachers learning technology by design. *Journal of Computing in Teacher Education*, *21*(3), 94-102.

Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for teacher knowledge. *Teachers College Record, 108*(6), 1017-1054.

Koehler, M. J., Mishra, P., & Yahya, K. (2007). Tracing the development of teacher knowledge in a design seminar: Integrating content, pedagogy and technology. *Computers & Education, 49*, 740-762.

Koschmann, T. (1999).Toward a dialogic theory of learning: Bakhtin's contribution to understanding learning in settings of collaboration, In: Proceedings of *Computer-Supported Collaborative Learning (CSCL '99)*, Palo Alto, CA.

Koschmann, T., Glenn, P., & Conlee, M. (1999). Theory presentation and assessment in a problem-based learning group. *Discourse Processes, 27*, 119-133.

Lewis, K. E., & Tamblyn, R. M. (1987). The problem-based learning approach in baccalaureate nursing education: how effective is it? *Nurs. Pap.*, *19*(2), 17-26.

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

Lohman, M. C., & Finkelstein, M. (2000). Designing groups in PBL to promote problem-solving skills and self-directedness. *Instructional Science, 28*, 291-307.

Lu, L. F., & Jeng, I. (2006). Knowledge construction in in-service teacher online discourse: impacts of instructor roles and facilitative strategies. *Journal of Research on Technology in Education, 39*(2), 183-202.

Mamede, S., Schmidt, H. G., & Norman, G. R. (2006). Innovations in problem-based learning: what can we learn from recent studies? *Advances in Health Sciences Education*, *11*, 403-422.

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

Mergendoller, J. R., Maxwell, N. L., & Bellisimo, Y. (2006). The effectiveness of problem-based instruction: A comparative study of instructional method and student characteristics. *Interdisciplinary Journal of Problem-based Learning*, 49-69.

Merriam, S. B. (2009). *Qualitative research: A guide to design and implementation* (2nd Ed.). Jossey-Bass.

Miles, M. B., & Huberman, A. M. (1994). *Qualitative data analysis: An expanded sourcebook*. (2nd Ed.). Thousand Oaks, CA: Sage.

Milter, R. G., & Stinson, J. E. (1993). *Educating Leaders for the New Competitive Environment*. In Gijselaers, G., Tempelaar, S., Keizer, S. (Eds.), Educational innovation in economics and business administration: The case of problem-based learning. London: Kluwer Academic Publishers.

Moore, G. T., Block, S. D., Style, C. B., & Mitchell, R. (1994). The influence of the New Pathway curriculum on Harvard medical students. *Academic Medicine, 69*(12), 983-989.

Moore, J. L., & Marra, R. M. (2005). A comparative analysis of online discussion participation protocols. *Journal of Research on Technology in Education, 38*(2), 191-212.

Moust, J. H. C. (1993). *On the role of tutors in problem-based learning: contrasting student-guided with staff-guided tutorials*. PhD dissertation, Maastricht, The Netherland: University Press.

Moust, J. C., & Schmidt, H. G. (1994). Effects of staff and student tutors on student achievement. *Higher Education, 28,* 471-482.

Moust, J. H. C., De Volder, M. L., & Nuy, H. J. P. (1989). Peer teaching and higher level cognitive learning outcomes in problem-based learning. *Higher Education, 18,* 737-742.

Newman, M. (2003). *A pilot systematic review and meta-analysis on the effectiveness of problem-based learning*. Newcastle: Learning and Teaching Subject Network for Medicine, Dentistry and Veterinary Medicine.

Newstetter, W. C. (2006). Fostering integrative problem solving in biomedical engineering: The PBL approach. *Annals of Biomedical Engineering*, *34*, 217-225.

Nonaka, I., & Nishiguchi, T. (2001). *Knowledge emergence: Social, technical, and evolutionary dimensions of knowledge creation*. Oxford: Oxford University Press.

Norman, G. R., & Schmidt, H. G. (1992). The psychological basis of problem-based learning: a review of the evidence. *Academic Medicine*, *67*(9), 557-565.

Norman, G. R., & Schmidt, H. G. (2000). Effectiveness of problem-based learning curricula: theory, practice and paper darts, *Medical Education*, *34*, 721-728.

Patton, M. Q. (1990). *Qualitative evaluation methods* (2nd Ed.). Thousand Oaks, CA: Sage.

Patton, M. Q. (2002). *Qualitative research and evaluation methods* (3rd Ed.). Thousand Oaks, CA: Sage.

Pelech, J. (2008). *Delivering constructivism through Project Based Learning (PBL).* Institute for Learning Centered Education, 1-14.

Piaget, J. (1977). *The development of thought: Equilibrium of cognitive structures*. New York: Viking Press.

Pourshafie, T., & Murray-Harvey, R. (2013). Facilitating problem-based learning in teacher education: Getting the challenge right. *Journal of education for Teaching, 39*(2), 169-180.

Prinz, J. F., Yip, H. Y., & Tipoe, G. L. (1998). Techniques for rapid quantitative assessment of activity levels in small-group tutorials. *Medical Education, 32*(4), 422-425.

Regehr, G., Martin, J., Hutchison, C., Murnaghan, J., Cusimano, M., & Reznick, R. (1995). *Teaching and Learning in Medicine: An International Journal, 7*(4), 225-232.

Rotgans, J. I., & Schmidt, H. G. (2011). Cognitive engagement in the problem-based learning classroom. *Advances in Health Sciences Education, 16*(4), 465-479.

Savery, J. R., & Duffy, T. M. (2001). *Problem-based learning: an instructional model and its constructivist framework*, CRLT Technical Report No. 16-01, Indiana University, 1-17.

Savery, J. R., & Duffy, T. M. (1995). Problem-based learning: an instructional model and its constructivist framework. *Educational Technology, 35*(5), 31-37.

Savin-Baden, M. (2003). *Facilitating problem-based learning*. The Society for Research into Higher Education. Open University Press, 90.

Savin-Baden, M. (2000). *Problem-based learning in higher education: Untold stories.* Buckingham: SRHE/Open University Press.

Schmidt, H. G. (1995). Problem-based learning: An introduction, *Instructional Science*, *22,* 247-250.

Schmidt, H. G. (1994). Resolving inconsistencies in tutor expertise research: Lack of structure causes students to seek tutor guidance. *Academic Medicine*, *69*, 656-662.

Schmidt, H. G. (1993). Foundations of problem-based learning: Some explanatory notes. *Medical Education, 27*, 422-432.

Schmidt, H. G. (1983). Problem-based learning: rationale and description, *Medical Education*, *17*, 11-16.

Schmidt, H. G. (1977). *Niet medici als tutor; maakt het een verschil*? (Non-physicians as a tutor: does it make a difference?) Internal report, Faculty of Medicine, Maastricht University, Maastricht, the Netherlands.

Schmidt, H. G., & Moust, J. H. C. (1995). What makes a tutor effective? A structural-equations modeling approach to learning in problem-based curricular. *Academic Medicine*, *70*(8), 708-714.

Schmidt, H. G., & Moust, J. H. C. (2000). In D.H. Evensen and C.E. Hmelo (eds). *Problem-based learning: A research perspective on learning interactions*. Mahwah, NJ: Lawrence Erlbaum, 19-52.

Schmidt, H. G., & Gijselaers, W. H. (1990). *Causal modeling of problem-based learning*. Paper presented at the Annual Meeting of the American Educational Research Association, Boston, M.A.

Schmidt, H. G., Dolmans, D., Gijselaers, W. H., & Des Marchais, J. E. (1995). Theory-guided design of a rating scale for course evaluation in problem-based curricula. *Teaching & Learning in Medicine, 7*, 82-91.

Schmidt, H. G., De Volder M. L., Grave, W. S. de, Moust, J. H. C., & Patel, V. L. (1989). Explanatory models in processing of science text: the role of prior knowledge activation through small group discussion. *Journal of Educational Psychology*, *81*(4), 610-619.

Schmidt, H. G., Ahrend, A. van der, Kokx, I., & Boon, L. (1993). *Peer versus staff tutoring in problem-based learning*. Paper presented at the Annual Meeting of the American Educational Research Association, Atlanta, GA.

Schmidt, H. G., Van der Arend, A., Moust, J. H. C., Kokx, I., & Boon, L. (1993). Influence of tutors' subject matter expertise on student effort and achievement in problem-based learning. *Academic Medicine, 68*(10), 784-789.

Silver, M., & Wilkerson, L. (1991). Effects of tutors with subject expertise on the problem-based tutorial process. *Academic Medicine, 66*(5), 298-300.

Smits, P., Verbeek, J., & De Buisonje, C. (2002a). Problem-based learning in continuing medical education: A review of controlled evaluation studies. *British Medical Journal, 324,* 153-156.

Stahl, G. (2000). *A Model of Collaborative Knowledge-Building*. In B. Fishman & S. O'Connor-Divelbiss (Eds.), Fourth International Conference of the Learning Sciences, 70-77. Mahwah, NJ: Erlbaum

Stronach, I., Corbin, B., McNamara, O., Stark, S., & Warne, T. (2002). Towards an uncertain politics of professionalism: teacher and nurse identities in Flux. *Journal of Educational Policy*, *17*(1), 109-138.

Swanson, D. B., Stalehoef-Halling, B. F., & Vleuten, C. P. M. van der. (1990). *Effects of tutor characteristics on test performance of students in a problem-based curriculum*. Bender, W., Hiemstra, R. J., Scherpbier, A. J. J. A. and Zwierstra (Eds.). Teaching and assessing clinical competence. Groningen, the Netherlands: BoekWerk Publications.

Takeuchi, H., & Nonaka, I. (2004). *Hitotsubashi on knowledge management*. Singapore: John Wiley & Sons (Asia).

Tan, O.S. (2003). *Problem-Based Learning Innovation: Using problems to power learning in the 21st century*. Thompson Learning.

Tan, O.S., Little, P., Hee, S.Y., & Conway, J. (Eds) (2000). *Problem-based learning: Educational innovation across disciplines*. Singapore: Temasek Centre for Problem-based Learning.

Tee, M. Y., & Karney, D. (2009). A framework and mental model to foster deep learning in the classroom. In Akbar Hussain & Noraini Idris (Eds). *Dimensions of Education*. New Delhi: Gyan Publishing.

Van Berkel, H. J. M., & Dolmans, D. H. J. M. (2006). The influence of tutoring competencies on problems, group functioning and student achievement in problem-based learning. *Medical Education, 40,* 730-736.

Van Boxtel, C. (2000). *Collaborative concept learning: Collaborative learning tasks, student interaction, and the learning of Physics concepts*. Enschede, PrintPartners Ipskamp.

Van den Hurk,, M. M., Dolmans, D. H. J. M., Wolfhagen, H. A. P., & van der Vleuten, C. P. M. (2001). Testing a causal model for learning in a problem-based curriculum. *Advances in Health Sciences Education*, *6*, 141-149.

Van der Vleuten, C. P. M., Verwijnen, G. M. & Wijnen, W. H. F. W. (1996). Fifteen years of experience with progress testing in a problem-based learning curriculum. *Medical Teacher, 8(2)*, 103-109.

Visschers-Pleijers, A. J. S. F., Dolmans, D. H. J. M., Wolfhagen, I. H. A. P., & van der Vleuten, C. P. M. (2005a). Development and validation of a questionnaire to identify learning-oriented group interactions in PBL. *Medical Teacher 27*(4), 375- 381.

Visschers-Pleijers, A. J. S. F., Dolmans, D. H. J. M., Wolfhagen, I. H. A. P., & van der Vleuten, C. P. M. (2005b). Student perspectives on learning-oriented interactions in the tutorial group. *Advances in Health Sciences Education, 10*, 23-35.

Visschers-Pleijers, A. J. S. F., Dolmans, D. H. J. M., Wolfhagen, I. H. A. P., & van der Vleuten, C. P. M. (2004). Exploration of a method to analyze group interactions in problem-based learning. *Medical Teacher*, *26*(5), 471-478.

Vygotsky, L. (1978). *Mind in society: The development of higher psychological processes.* Cambridge, MA: Harvard University Press.

Vygotsky, L. S. (1962). *Thought and language*. Cambridge, MA: MIT Press.

Walker, A. E., & Leary, H. (2009). A problem-based learning meta analysis: differences across problem types, implementation types, disciplines, and assessment levels. *Interdisciplinary Journal of Problem-based Learning, 3*, 12-43.

Wilkerson, L. (1994). Identification of skills for the problem-based tutor: students and perspectives. *Instructional Science, 22*(4), 303-315.

Wolcott, H. (2005). *The art of fieldwork* (2nd Ed.). Walnut Creek, CA: AltaMira Press.

Wolcott, H. F. (1992). *Posturing in qualitative inquiry*. In M. D. LeCompte, W. L. Millroy, & J. Preissle (Eds.), The handbook of qualitative research in education, 3-52. New York: Academic Press.

Yin, R. K. (2008). *Case study research: Design and methods* (4th ed.). Thousand Oaks, CA: Sage.

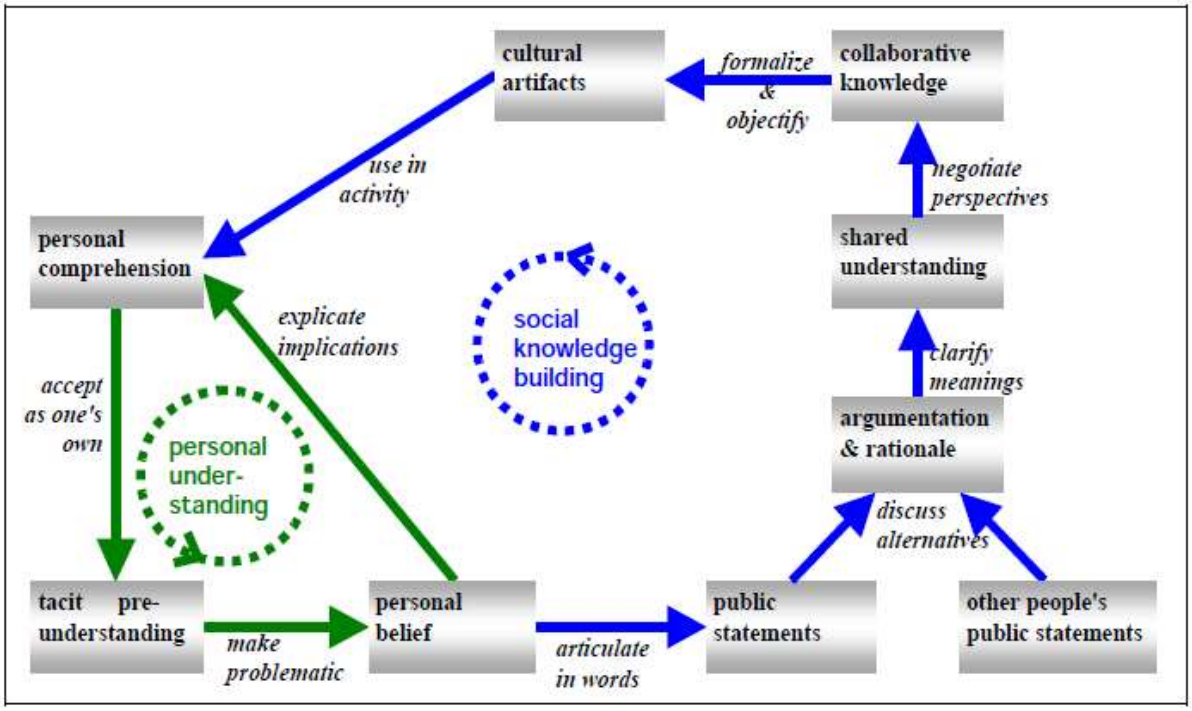
Yinger, R. J. (1986). Examining thought in action: a theoretical and methodological critique of research on interactive teaching, *Teaching and Teacher Education*, *2,* 263-282.

Zhang, M., Lundeberg, M., Koehler, M., & Eberhardt, J. (2008). *Conditions for collaborative knowledge construction of in-service science teachers in problem-based professional development*. Paper presented at the National Association for Research in Science Teaching.

Zhang, M., McConnell, T. J., Koehler, M. J., & Eberhardt, J. (2010). Using questioning to facilitate discussion of science teaching problems in teacher professional development. *Interdisciplinary Journal of Problem-based Learning, 4*(1), 57-82.

APPENDICES

APPENDIX 1: Stahl's (2000) model of collaborative knowledge building processes



APPENDIX 2: Gunawardena et al.'s (1997) Interaction Analysis Model for examining social construction of knowledge in computer conferencing

PHASE I: SHARING/COMPARING OF INFORMATION. Stage one operations include:

A. A statement of observation or opinion [PhI/A]
B. A statement of agreement from one or more other participants [PhI/B]
C. Corroborating examples provided by one or more participants [PhI/C]
D. Asking and answering questions to clarify details of statements [PhI/D]
E. Definition, description, or identification of a problem [PhI/E]

PHASE II: THE DISCOVERY AND EXPLORATION OF DISSONANCE OR INCONSISTENCY AMONG IDEAS, CONCEPTS OR STATEMENTS. (This is the operation at the group level of what Festinger [20] calls cognitive dissonance, defined as an inconsistency between a new observation and the learner's existing framework of knowledge and thinking skills.) Operations which occur at this stage include:

A. Identifying and stating areas of disagreement [PhII/A]
B. Asking and answering questions to clarify the source and extent of disagreement [PhII/B]
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 [PhII/C]

PHASE III: NEGOTIATION OF MEANING/CO-CONSTRUCTION OF KNOWLEDGE

A. Negotiation or clarification of the meaning of terms [PhIII/A]
B. Negotiation of the relative weight to be assigned to types of argument [PhIII/B]
C. Identification of areas of agreement or overlap among conflicting concepts [PhIII/C]
D. Proposal and negotiation of new statements embodying compromise, co-construction [PhIII/D]
E. Proposal of integrating or accommodating metaphors or analogies [PhIII/E]

PHASE IV: TESTING AND MODIFICATION OF PROPOSED SYNTHESIS OR CO-CONSTRUCTION

A. Testing the proposed synthesis against "received fact" as shared by the participants and/or their culture [PhIV/A]
B. Testing against existing cognitive schema [PhIV/B]
C. Testing against personal experience [PhIV/C]
D. Testing against formal data collected [PhIV/D]
E. Testing against contradictory testimony in the literature [PhIV/E]

PHASE V: AGREEMENT STATEMENT(S)/APPLICATIONS OF NEWLY-CONSTRUCTED MEANING

A. Summarization of agreement(s) [PhV/A]
B. Applications of new knowledge [PhV/B]
C. Metacognitive statements by the participants illustrating their understanding that their knowledge or ways of thinking (cognitive schema) have changed as a result of the conference interaction [PhV/C]

APPENDIX 3: The Participants' Consent Statement

INFORMED CONSENT STATEMENT

Hello, thank you for taking the time to read this document intended to support the practice of protection for human subjects participating in research. The following information is provided for you to decide whether you wish to participate in the present study. You may refuse to sign this form and not participate in this study. You should be aware that even if you agree to participate, you are free to withdraw at any time. If you do withdraw from this study, it will not affect your relationship with this unit, or the services it may provide to you.

The purpose of this study is to better understand the processes and conditions that help cultivate knowledge and skills that are important for teachers.

The study will be carried out from July 2011 through April 2012. If the need arises, a follow-up discussion may be scheduled at a later time convenient to you. Each consenting participant may be asked to contribute from 1 to 5 hours of time over the entire duration of the study, as explained below.

By giving your written consent to participate in the study, you are consenting to (a) be interviewed for a maximum of 5 hours over the entire duration of the study (this can take place at different intervals), (b) be observed during participation in the course, and, or (c) allow course assignments and projects to be analyzed. Although names of participating individuals and organizations will be collected, they will not be used in any written reports of the findings of the study. Through use of a data coding system and pseudonyms, diligent effort will be made to preserve the anonymity of participants and agencies. However, absolute anonymity cannot be guaranteed because it is possible that readers of the case study report might recognize participants and/or agencies by virtue of their independent knowledge of the research site and/or participants. A copy of this consent statement is being provided for you to keep.

Each participant can subsequently withdraw his or her consent at any time. Should such a decision to withdraw be made, please notify Dr Tee Meng Yew at mytee22@yahoo.com. Your participation is solicited, but is strictly voluntary. If you have concerns about the study or your participation in it, please don't hesitate to ask questions. We appreciate your cooperation very much.

Sincerely,

Tee Meng Yew
Principal investigator & faculty supervisor
Faculty of Education
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Consent to Participate and Be Quoted

I have read this Consent and Authorization form. I have had the opportunity to ask, and I have received answers to, any questions I had regarding the study and the use and disclosure of information about me for the study.

Having read and understood the attached Informed Consent Statement and the material below, I hereby grant written permission to participate in the research and to be quoted.*

_____ _____

Signature of participant Date

With my signature I acknowledge that I am over the age of eighteen and have received a copy of the consent form to keep.

*Consent to be Quoted means that the participant agrees that the information s/he provides during an interview(s) or observation(s) may be quoted, in writing, with the understanding that her/his name will not be attributed to what she/he said. In addition, the participant consents to having her/his role (e.g., student, professor) stated in connection with the quotation.

APPENDIX 4: A sample of the reflection questions that the PBL participants needed to respond to weekly.

Home

Recent Announcements

Questions for Journal 12 **Final journal entry.**1) Mishra and Koehler (2006) argue that thoughtful pedagogical uses of technology require the complex interplay of three knowledge bases i.e.pedagogical, technological and content knowledge. Do you think YOU have developed this ability to "interplay" these three knowledge bases to improve the teaching and learning process? Please provide examples and justifications for your response.2) Throughout this class, you have engaged in numerous activies inside and outside of class. What are 2 or 3 activities that was most effective in helping you develop a better understanding of the role of technology in teaching and learning? Please provide examples whenever possible.3) Open: Please share any other reflections you have.
Posted Dec 29, 2011, 9:30 PM by Meng Yew Tee

Question for Journal 11 Designing a compelling/robust technology-based teaching and learning activity requires an advanced interplay of T, P, and C knowledge. In the previous reflection, you agreed that this cannot "be taught by lectures and demonstrations." Then how can these knowledge and skill be developed? (can this be done without blind trial and error? can this be done in a way that raises the likelihood of a positive learning experience of that aforementioned "interplay"?)
Posted Dec 9, 2011, 3:37 PM by Meng Yew Tee

Question for Journal 10 In this article by Koehler & Mishra (which some of you may have read), they suggest that designing a technology-based teaching and learning activity cannot "be taught by lectures and demonstrations." (p.98). Do you agree with them? Why or why not?
Posted Dec 2, 2011, 6:39 PM by Meng Yew Tee

Questions for Journal 9 What does research-based literature say about "how to develop TPACK"?- What are 2-3 ideas from research-based literature that can help with your project?- What makes these ideas particularly compelling?
Posted Nov 25, 2011, 5:22 PM by Meng Yew Tee

Question for Journal 8 19.11.11. Are you progressing merely based on anecdotal experience or are you also beginning to use other kinds of knowledge resources? (Look back also to your Journal 5 entry)
Posted Nov 18, 2011, 4:35 PM by Meng Yew Tee

Showing posts **1 - 5** of **14**. View more »

APPENDIX 5: A sample of the eBook (some texts are blocked out for anonymity)

Case 2

Chapter title: Development of a Smart School Teachers's TPCK.

o **Authored by:** [redacted]

o **Introduction:**

Background:

SK [redacted] is situated in [redacted] Centre. It is a single session school with 1080 pupils, 67 teachers and 11 non-teaching staff. The school started its first session on 27th January 2000 as the 1st primary school in [redacted] The pupils are children of the federal government staffs who stay in [redacted]

Teachers' background:

Number of teachers = 69 (13 male & 56 female)

Age groups: 51 years old & above	= 4
41 - 50 years old	= 10
31 - 40 years old	= 32
21 - 30 years old	= 23

36 graduates and 33 non-graduates

School's technological infra is very good as it is a smart school and a cluster school of excellence.

Teachers have high level of IT skill and competent in using the technology.

Despite all this, teachers do not integrate technology in their T & L to the maximum.

I - Identification of problem

what we did: we analyze 2 surveys SKPM , SQSS & Borang soal selidik P & P to identify the problem

what happen:
we identify that teachers P&C are combined and at an acceptable level but T is somewhat not linked to the P&C

However the T of the teachers are fairly high in which teachers know
SSQS questionaire shows that teachers have high level of competency in ICT but it did not really indicate their ability to integrate ICT into their teaching and learning process. Most of the questions only asked about teachers knowledge in using computers and the peripherals and not many questions are about integration of ICT.

SKPM - standard kualiti Pendidikan Malaysia in the Elemen 9 (Teaching and Learning) indicate the teachers' pedagogy skills and the monitoring is done by school admin and head of subject panel. The process of monitoring is done and marks/percentage given must be within a certain value set for the school.

Recognizing this fact, we came up with a simple questionnaire to gauge the teachers' ability to integrate ICT in their T & L. The answers they gave, however, did not fully explain their capabilities to integrate ICT into their T & L.

1. The SQSS indicated that teachers have good technology knowledge. This is shown in the series of question on how do they rate themselves in using some listed tools. However, teacher only integrated technology in classroom, in average at least once a month. This is pretty low in frequency given that the teachers recognized themselves as well-versed in technology.

Rumusan daripada maklumbalas borang SSQS

1. Bilangan guru yang mengisi borang mengikut subjek

Bil	Subjek	Bilangan guru yang mengisi borang
1	Bahasa Malaysia	14
2	English	5
3	Science	5
4	Matematik	5
5	Pendidikan Agama Islam	11
Jumlah		40

2. Rumusan

Bil	Kriteria	Bilangan guru mengikut subjek				
		BM	Eng	Science	Math	PAI
	Penggunaan ICT dalam P&P					
	bilangan waktu guru mengintegrasikan bahan p & p berasaskan teknologi dalam proses P&P bagi tempoh sebulan.	40	100	30	30	120
	Penggunaan sistem/portal pengurusan isi kandungan pembelajaran	Tidak	Ya	Tidak	Tidak	tidak
	Kekerapan menggunakan kandungan berkaitan pendidikan dari rancangan TV / Web TV untuk P&P (waktu sebulan)	3	4	2	2	2
	Kekerapan guru menggunakan peralatan atau bahan teknologi pendidikan lain selain dari komputer dan TV P (waktu sebulan)	10	20	15	10	20
	Jangkamasa guru mencari maklumat/bahan dari Internet untuk P&P (dalam dan luar waktu persekolahan) P (minit sebulan)	60 – 120	181 – 240	121 - 180	60 - 120	121 - 180
	kekerapan guru menggunakan bahan berasaskan ICT untuk membina bahan pengajaran:	1 kali dlm 2 minggu	1 kali seminggu	1 kali seminggu	1 kali dlm 2 minggu	1 kali seminggu

APPENDIX 6: A sample of the original transcripts of a PBL session

TRANSCFRIPTS OF SESSION 6 (Video Segments 6C TO 6E)

PBL Participants: F, J and R

Instructor: I

The start of Case 2 discussion (Time 34:35 – Till end of Video Session 6C)

Note: Utterances with incomplete sentences in the transcripts are indicated by an ellipsis (…)

J: What's the focus?

F: Focus is using technology or using technology in the teaching.

I: So you already have, if you think about it, the IDEAL (*writing on the whiteboard). You already start verbalizing the identification of problem because the question is: How do we help teachers develop TPCK? Think deliberately. What is the next step? You kind of have the thesis statement but use this (*pointing to IDEAL) as a guide. Look, we need to provide the problem with greater definition. Definition has to do…what is the characteristics of the problem? So can you describe the problem for us?

F [35:58]: Arr…teachers in my school, despite the wealth of technology they have, they shun away from using technology. They know what they can do. Some teachers are really prolific in using it. Got one bahasa Arab teacher, use a lot of technology. He gets Arab students to converse, not to say converse, to interact using ThinkQuest..but she too has…At first she is really into it but the passion has died down.

I: OK. Questions from the other group members.

J: What are the reasons they give for not utilizing what they have?

F: As usual la, time, class control.

I [37:06]: OK, before we ask those kind of questions maybe one of the question we need to ask is…we want to understand the magnitude of the root problem. Like how many teachers you would say do not have TPCK? I mean these are just based on your observations, we don't the evidence yet. You have how many teachers?

(END of Video Session 6C at Time 37:26)

Video Session 6D (Starts at Time 00:00)

I: 70 teachers. Arr…for example, English. Of 9 only 2 uses technology. That mostly for the G approach.

I: That is interesting. Fish is using the word 'use' technology. She is even hesitant to use the word two of them have TPCK because you don't know that. Because…and that is a very important distinction. Just because a person uses technology does not mean they have highly advanced TPCK, right? They are those who use technology who completely don't do a good job teaching..

F: I should say that, because all the English teachers are all English language teachers, optionists; their teaching option is English, which is also a luxury actually. All 9 are English teachers, one with 23 years of teaching experience. The youngest should have 3 years of teaching experience. I can say most have…out of the 9, 7 have good content. They know English quite well. Two do not speak English as well as an English teacher should.

I: So you're saying 7 out of 9 have good…

F: I'm thinking in that frame already (*pointing to the whiteboard) with all the experience. With C, because they are optionists, all are optionists, their content should be 9/9.

I: O, it's 9 out of 9?

F: Ya, 9/9 and the P…

I: So you're saying P is 7/9. T would be 2/9

J [02:46]: The 2 is the experienced or the young ones?

F: The 2 is the ones with 23 years of experience.

I: Now, do you have a sense of the TPC?

J: How many of them…

I: Have advance TPC?

F: No, no. OK, change! 2/9 is the TPC.

I: OK, they are the ones that use technology.

F: Yes!

I [03:17]: The others also use technology?

F: We need to say that for T because we train everyone with technology. T should be 9/9.

I: O.

F: Because they know; they have technological knowledge. But TPC only 2. [03:36]

I: We have to remind ourselves this is based on F's observation. OK? This is just English. Now, let's say, generally? Roughly? You won't have the precise data. Can we do the same thing?

F: Out of the 70, arr…19 being new teachers which I did not have the time and money to give them training, structured training. 70-19?

I: 51. 51 out of 70 have good pedagogy?

F: T!

I: T. P? P would be roughly 80%. Content?

F: English teachers are all optionists. Science, all are optionists. I have problem with Bahasa Malaysia teachers.

I: Really?

F: Yes. Out of the 15, 6 are not optionists. They are all the KPLI teachers and they are trained to teach KH.

I: But now they are being forced to…

F: But, but, in public schools, they have only 2 KH teachers. Now, I have about six.

I: So, what you're saying this (Content) is also about 85% range?

F: Ya. All the Agama teachers, all 19 of them are optionists. All English teachers are optionists. All science are also there.

I: Which basically means they were trained to teach those subjects?

F: Yes.

I: Teachers with TPC?

F: TPC…(*thinking)

I: This is going to be a very rough gauge. [06:21]

F: Ya. Arr…Should have brought the result for pencerapan…(*thinking and calculating). 25%? 25% is a very, very rough estimate.

I: OK. So what do we do (*directing the question to the group) with this information?

R: How do we confirm that?

I: OK. Can we verify this data? [07:38]

F: I can bring my Buku Pencerapan.

I: What was the word? O, pencerapan! How to verify this data?

F: I have my Buku Pencerapan where I give scores…

R: But scores are based on?

J: You went into the class and you observed the T&L.

F: Using the Likert scale of 1-5, 5 being the best.

I: Is the number of items there consistent with TPCK? [08:23]

J: Not very. We can look at it for the Content.

F: Mostly P and C. Very few on T, only 2-3 questions on T. I do the pencerapan, my senior assistant do the pencerapan. I also get another (teacher?) to do the pencerapan.

I: Do the teachers get three different scores, or just one?

J&F: Just one.

F: To report everything we have what we called Sistem Kualiti Pendidikan Malaysia (SKPM). SKPM is what I use to do self-monitoring for my school using the teachers' scores, and one of the big percentage is on how teachers teach, how good the teachers in my school. So, from there I have the pencerapan thing.

J: But of course the whole thing is overall picture of the teacher's lesson. If we want to specify the T per se…

F: P and C…

J: Is obvious.

F: Is obvious because all the questions are there.

I: But no questions on TPC?

J: The questions are only about the use visual aids. [09:58]

I [10:27]: Just to pause for a second. What we're discussing here, we can easily say this is what we know and this is what we need to know, OK? (referring to the diagram* on the board) But this is just one aspect. What else do we need to know? We can talk about this data. What else do we know about the problem? Actually, it's good for the group members to ask you (referring to F). What do you all want to know about her teachers? One of the things is to verify that there is a real problem.

F: The technology in my school. I have 1141 PCs.

I: You have more PCs than students.

F: Yes! Three labs all working. One lab is Window XP, one lab is Window 7. Another lab is an open source lab.

I: And then ever classroom has computers?

F: No. We used to have in every classroom. But when the money stopped coming in, the year 2000 technology became obsolete. We did not replace those in the classroom. We replaced those in the lab. On top of that, early last year, we got 522 Classmate PCs for Year 3, 4 and 5, which I'm so sad because they are not fully utilized. Internet connectivity is whole campus, 24 hours.

I: Broadband?

F: Broadband. Also, they are not being used. So I was telling them I've got one big stone in my heart. I'm not doing my job well.

I: How do you know it's not being used?

F: Through pencerapan. Also, ever room has a log book and feedback from the students. I walked around and noticed it's not being used. On top of that, I've got three Interactive Whiteboards. The one I use is the most used one. I put one in Year 2, to be shared with Year 1 and 2. One in Year 3, for Year 3 and 4 and one in Year 5 for Year 5 and 6. The one in Year 5, the dust layer is about half inch thick (laugh). [13:36]

R: [13:37] Did you ask the teachers why are they not using the technology? What are the..

J: Causes.

F: The most generic reason is time. Time and the hassle of moving the students to the…shouldn't be a hassle because I put the whiteboards…the make up of my school is 5 class and at the center there's a (can't decipher) center. It's just a very short walking distance.

J: And they can't even manage that?

F: Ya. You would feel that they are permalas. It's not actually malas, but, arr…now that we are…as I read this (pointing to the green booklet), you know what kept me thinking? Probably they are more like in the Giving mode. So Giving mode not much of a…they can manage that without a lot of technology. And then the thing to produce is good results, as many straight As students as possible, which can be achieved by rote learning. Get students to memorize things and regurgitate. Not much…

J: Since you have 3 labs, have you tried assigning…

F: Ya, I did. Lab 1 is for 1 and 2. Now the labs are being used by Year 1, 2 and 3 because they have ICT classes in the lab.

J: Is there…because sometimes inmy school, they have …they make it…

R: Compulsory. Wajib.

J: Ya, wajib. In my school, they make it compulsory. But once you put this lab is for Standard 1 and 2, but still there is no like, OK, this, this day for Standard 1?

F: It's all in the time-table. [6D, 15:56]

R: But you have like at least you have to spend one period with technology, do you have that?

F: [16:07] I put it in a way that for Year 1, 2 and 3, they have like 12 periods a week for Bahasa Malaysia whereby two periods have to be in the lab. For English (can decipher) they have to do it in the lab but then since Year 3, 4 and 5 they have the (can decipher) some teachers, with the (can decipher) they use it in the classroom but there are quite a number of technical problems especially with the Broadband. We have APIS (?) donated by Arubah (?) but after they donated it, they disappeared. So…

R: No maintianence?

F: Ya, ino maintenance, no technical help. For that 1141 PC's and laptops, I have only one tecgnician, who is also a OKU (orong kurang upaya) because he walks with a limp. But I do have one IT coordinator but this coordinator also has to teach, like 14 periods a week, as opposed to 30 periods most teachers have. [18:13]

R: [18:14] What are the training did the teachers get regarding technology?

F: Now is 100% in house training. That means I have to schedule the training for them. For some teachers I have refresher course, re-training them on how to use technology.

J: This in house training, what do you train them on?

F: Train them on T. This year 2011, none is being done for TPCK because of lack of funds and planning.

J: So when you said training them on T, that means like put all the teachers in one room and then…

F: Not just put them in one room; get them to attend refresher course on how to use the Smartboard and how to use the laptops. We did have a Intel Teach Program. (more description on the Intel Program) [6D, 19:37]

R: What is the Intel Teach Program?

F: Intel Teach Program is the TPCK…(trying to find the right way to describe the Program)

I: What is the curriculum in the Program?

F: Using technology to teach. Their main focus is project based learning.

J&R: Do you have examples?

R: Contoh?

F: I'll bring bring the module.

I: But you can briefly explain it. If you look at the framework, the P they use in the curriculum is actually the project based learning. The T is the use of computers, that helps the Intel agenda. They basically use computers to support project based learning. They have run in few hundred schools in Malaysia.

F: Most of the IBGM…(cant decipher), most of the newer ones have certificates…

I: So, how many have Intel Teaching certs?

F: Now, probably 40%.

I: 40%?

F: Ya. [21:41]

I: That is interesting. The Intel Program, technically, should have T and P, in theory la…

J: In my school, we need all this and don't have it, and here the teachers have everything…So sad!

I: [22:20] OK, just to recap. Recap is a good collaborative technique. We have talked about…(summarize for the group).

F: The 40% I have got to check.

I: OK, but it's rough la. You can verify it later. So you have some reasons. What other case do you need to know? Do you fully understand the reasons why they are not doing this (refering to using T)? [23:16] You all are asking some good questions.

J: Do teachers have modules that they can just use to carry it out, based on technology?

F: Not many. I'm focussing on English because that subject pull my UPSR percentage down last year. [24:04]

(Then the group discussed the percentage passes in the school. English is the only subject that has slipped from 92% to 86%. Trying to understand the reason for the decline in percentage passing for English) [27:33]

I: [27:34] OK, other questions to define the problem? So we know a little bit about the condition, the what. We know a little bit about why, why the condition is such. We know how they develop their…a little bit of their background…

F: I got a presentation about my school that will give you an idea what kind of technology I have and

J: one more thing, kak, are these teachers first excited and later decline or are they the moment they get it they already tak minat?

F: Excited first … (*contninue to show the group her presentation) And I have only put up 6 kiosks with touch screens computers and students have been using that. [29:00]

J: Ada vandalism cases tak?

F: No. This is the enrolment (*continue to elaborate on her presentation)

(Evidently the students in the schools are tech savvy. They have won several ICT related competitions and hence low ICT literacy among students shouldn't be the reason for teachers not using technology in the classroom)

J: So I think the students are able, they are capable. I think it's not the problem of the students now.

F: That's why I said it's the teachers…

I: So a word of caution here. Try not to jump to conclusion here. We don't know what the quality of the students is. Fish may know more because she is the principal there but the rest of us don't…Need to look at the evidence as scientifically as possible…

F: *continue to show the facilities in her school using the presentation.

(A short conversation about the Terengganu Project and why the Project fails)

(Video 6D ends at 37:07)

Beginning of Video Session 6E (Time 00:00)

I: To recap. We have a bunch of what we know. There are something that we need to know. We want to verify some of this information. What other need-to-know information do we need? Are we covering the major variables or concerns to help us understand the nature of the problem? Are we missing any major elements in trying to define the problem?
[01:02]

J: Now that we have to be as neutral as possible, there is a need for us to know whether the students would prefer to use technology in their lessons.

F: O yes!

J: We need to know from the students.

I: What do we need to know from the students?

J: How excited they are if they have a lesson that incorporates technology?

F: We do need a scientific evidence or …probably survey. Because I can easily give my observation. In Putrajaya whenever there is a competition with regards to ICT, my school is the Champion. State champion all the time.

J: Is it the same group of students?

F: Not the same group of students. Different group of students. And then they use ICT in other things. Producing songs, producing…A group of students is producing a corporate video for the school. I trained the Cyber brigade to make movies using Moviemaker.

I: The main differentiation, what J is asking is, this are involving select groups of students. It doesn't involve the thousand of students you have?

F: When we have this ThinkQuest program, some teachers are using TQ. In fact, yesterday I did a rough estimation with the show of hands. I asked the assembly how many of them have Facebook (FB) account. More than ¾. Year 1 students, almost half has FB.

I: They know they are breaking the law, right? They are under-aged.

ALL: *laugh

J: The issue is now FB for entertaining and also FB for…

I: FB for learning.

J: Ya, FB for learning?

F: I'm channeling them towards FB for more (can't decipher) use. My counseling unit has FB and generally…as I was saying in class how they open up better online…

I: OK, let's pause a second. There's 30 min. I'm going to fade completely. [4:10]
I'm going to let you all swim for 15 min and I just want to hear what your outcomes are at the end of 15 min; what do you plan to do seven days before the next class.

(Group on their own – un-facilitated discussion)

F: This is the percentage passes. UPSR English 86, slide down from 92!

R: Sekarang, students memang suka (technology) tapi klas ini nak periksa English kan? Kalau cikgu guna technology, sudah lambat students nak tahu content untuk boleh jawab exam? Atau, Ok, students suka technology tapi persembahan cikgu lambat?

F: Tak, … (can't decipher)

J: Ada students yang rasa, kalau cikgu guna technology, dia tak belajar apa-apa.

R: Ya, yang itu.

F: Tak ada, in primary school tak…probably the respect is still there…one thing is the respect is still there and they are eagerly waiting. I observed 2 classes, year 3, these are the 2 classes yang akan cari cikgu(?). Cikgu ini guna macam-macam potfolio, buku cerita, guna bahan Internet…

R: How about Year 6?

F: Year 6 is totally rote learning and totally zoomed for the exam.

R: Itu yang saya sebut. Macam kalau students itu exam year, dia macam guna technology nanti tak sempat nak…

F: (interrupt) Exam year yes but for the exam class Year 6, I have all this Zoom A(?) where they answer the questions online. Dia masuk dalam itu program macam Score A itu kan? Score A is expensive lah, Zoom A itu pendidikan punya module(?). They go and do that.

R: Itu independent lah..

F: Independent and we do have sessions where they have to get into the lab and teachers give them the answers…answers for the set of questions; set taken from the Zoom A program.

J: Kak tadi kata, klas bagus kan? 2 klas itu? Itu klas bagus kan? Is it a good class?

F: Ya.

J: So, does that mean cikgu yang klas Ok prefer lah guna technology, kan? Sebab senang, cepat…

F: (interrupt) No!

J: Klas lemah dia tak guna.

F: Lemah ni yang klas kat cikgu itu.

J: Cikgu tu?

F: Cikgu ni! In fact, (can't decipher)

J: Lagi cepat?

F [07:16]: Lagi capat. And what makes…I'm not too sure what makes me angry but…[07:33] buat kak geram, because the English class I even subscribe for them, you know Enchanted Learning? I subscribed for them, also not put into good use.

J: I think the whole problem now is they don't know…

F: (Interrupt) No, that's why in my reflection yang itu, it's the TPCK (*pointing to whiteboard)!

J: Maybe they don't know. I think now the issue is…

R: (Interrupt) Tapi training sepatutnya…

J: (Interrupt) Training ada.

R: mungkin training itu tak target…

J: Implementation part tu tak nampak. Maybe I give you everything, kan? I train you this is…

F: (Interrupt) Sometimes I question myself, do I give too much?

J: No, I think, what, what, the issue here is you give them what they need but there is no room for them to sit, think and…

F: (Interrupt) Probably. [08:39] Again, Macam Terengganu itu, itu my problem, my mistake or my folly(?) or whatever, is giving them on that. But I do take care of the maintenance and everything. Cuma yang (can't decipher) tu I got problem with funding (can't decipher) yang guna Blackboard tu ..

J: Probably but this may be jumping into conclusion. I think now the issue is they have the…[09:22]

F: (Interrupt) They have the T.

J: They have the T…

F: They have the T, they have the P, they have the C. It's the…apa ni…

J: To merge, to bring them together.

F: Macam ni, macam ni (*proceed to draw 2 circles of P&C which overlap some and a separate T circle). P ada, C ada, yang ini dia boleh buat, pedagogy dan content, dia boleh buat… [10:00]

J: Saya rasa yang nak bawa masuk T itu problem…

F: T ada, kalau nak cangkukkan T kat sini (referring to P&C) tak ada.

J: But we need to verify this. Is this true? Is this the problem now, we need to verify.

F: Nak kata T tu almost 100% out sebab apa tahu? Pengurusan sekolah semua digital.

J: So tak ada alasan kata tak tahu, kan? Tak ada T tu, memang ada lah.

F: Test papers must be digital. I tak bagi dia orang fotostat, paste. Tak ada. Scan then kena upload. We have a virtual file system. The file is put in the server so that everybody can access lah [10:49] (Proceeded to elaborate on other online admin facilities). Technology in the administrative part OK. Email semua ada. Tapi ni, ni (*pointing to the diagram she drew) yang tak ada. [11:24]

J&R: We need to verify that.

F: Probably survey. Interview?

J: Just tanya saja lah!

F: Interview susah because I'm in the group, unless you're independent from me. They will not…

J: They will not reveal, kalau guru besar asking questions.

F: Unless you're another group and I'm not involved in the group.

J: We come as independent researchers.

F: (Provided a long corroborating example of how teachers will not be truthful if she is involved) [13:08]

F: Survey should be better.

R: Kena buat soalan lah.

F: Survey better because survey has no names. [13:39]

(followed by deciding when to have the survey)

J: We need the teachers to open up, to tell the reasons why. [16:30]

R: Kita perlu tahu sebernanya kenapa. mungkin pasal masa tu surface kan?

J: Ya, surface. Masa itu alasan biasa. Adakah it's more than that? Adakah sebab mereka tak tahu?

R: Tak tahu macam mana nak integrate.

J: Tak tahu macam mana nak integrate, (tak tahu) apakah maksudnya integration.

F: I suspect TPCK tak integrate lagi.

J: Itu suspect lah, kan? Itu prediction kita lah.

F: Probably survey itu a bit about IT knowledge.

J: Ya, 'what you know and why is it so difficult for you to corporate?'

(Instructor rejoins group)

I: What's the decision? Give me a one minute briefing.
[21:35]

F: We kind of identify the problem. How do we help teachers to develop TPCK? Because the target is teachers, I've got to go back to…going back to the KND table, I've got to supply more info on the K. (referring to the KND table) I've got to verify the figures there (*pointing to the whiteboard) and then…

I: So how are you going to verify it?

F: I've got data on this.

I: Existing data?

F: Existing data. How many has got the Intel Teach Program Certs, how many has been using technology and how many years of services most of them have teaching in certain language…

I: Caution. Just because somebody has taught for 1 hundred years, it doesn't mean the pedagogy is top notched. So, again, don't…be careful of the assumptions, OK? Good, there is existing data. You don't have to go out and take a lot of time, it's all there. What else?

R: For the non-existing data, because we want to know more about the underneath reasons why actually the teachers don't use. Also to find out their TPCK…

I: So, how are you going to find out those information?

R: That's why me and kak J will find if there are surveys on measuring teachers' TPCK. If they are existing surveys so we want to find out…

F: Probably they don't even know their TPCK level.

R: That's why want to do survey la.

F: And then we survey on that and probably get to design from existing surveys in the existing ones. Probably there are something we have to design or tweak here and there or something that can really help us to understand from the perspectives of the teachers and …

(telling the details of their plan)

I: One gap I would identify here at this point is whether you can begin to research on this question. Not just how to measure but also what can studies tell us about the development of TPCK. Then that would also help you begin to understand some of the key components that you need to keep track of, to be aware of as you progress in this case. OK, that's one item to think about.

(END of Video 6E at Time 27:11)

- END of transcripts –

APPENDIX 7: Email communication to solicit feedback from the PBL participants.

EMAIL MESSAGE

SENT: March 6, 2014

RE: Case Study Review – Your Feedback Needed

Dear _____,

I trust that you are keeping well. This is Swee Chuan, the doctoral student who was doing a study in your instructional technology course taught by Dr Tee Meng Yew. I am in the final phase of the research that requires me to make the draft case study available to you so it can be reviewed for credibility, accuracy and anonymity.

As you review the case study (attached), do consider the following questions:
1) Is it a CREDIBLE account/description of your instructional technology course?
2) Are there any FACTUAL ERRORS in the case report?
3) Are there any INTERPRETATION ERRORS in the case report?
4) Are there any BREACHES OF ANONYMITY of individuals or organizations in the case report?

Please make a note if you see any issues pertaining to the questions listed above. It will be helpful if you could tell me where and what the issues are, and offer alternatives or suggested changes. You can provide your feedback on the document itself (you can use the "sticky note" feature in the PDF) and send it back to me as an attachment via email. You can also send general feedback via email or we can arrange a time to talk on the phone.

Since the document is lengthy, I would suggest that the sections from page 103 (section 4.1.1.5) to page 141 are the sections in the case where your feedback is most critical. So, if you don't have the time to read the whole case study, please do take some time to review the suggested sections.

If you can provide your feedback before March 21, 2014, I would most appreciate it. Please do not hesitate to contact me if you have any questions.

Yours sincerely,

Swee Chuan

P/S: Note that pseudonyms are used to protect the anonymity of the research participants. For example, your name was changed to "R", and _____ was changed to "I".