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# AN EXPLORATION OF PEER COLLABORATION AND GROUP PROBLEM SOLVING PROCESS IN A COLLEGE PROBLEM-BASED LEARNING CLASSROOM

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## ABSTRACT

Problem-based learning (PBL) has had a significant impact across subjects and disciplines in educational practice since it was first introduced as an innovative medical education curriculum at McMaster University in 1969 (Boud & Feletii, 1997; Camp, 1996, Newman, 2006). As a learning environment "that results from the process of working toward the understanding or resolution of a problem" (Barrows & Tamblyn, 1980, p. 18), PBL focuses on setting up a learning context in which students take part in collaborative problem solving to learn beyond their potential with a deep understanding of the subject matter and to develop their higher-order thinking (Savery, 2006). The purpose of this study was to examine one group's activities in a PBL course to delineate the students' problem-solving process and to identify the collaborative patterns and issues in the process.

The study takes an instrumental case study approach (Stake 1998). The case in the study is a group of students in an undergraduate business logistics course in a northeastern university. The case study allows for in-depth descriptions of the actual activities from the perspectives of the researcher and the group members. The study uses multiple sources of evidence including direct observations, interviews, and physical artifacts to enable triangulation of the data (Yin, 1994). The study aims to increase understanding of the "collaborative problem solving" phenomenon within the specific cultural and contextual settings in a PBL course.

The findings of this study suggest that the problem solving activities that students engaged in were governed by the goals and motives derived from their roles in different dimensions in the PBL process, that is, as a learner, an international logistics consultant,

and a group member. As group members, students had different perceptions of their membership and identity, and consequently their perceptions influenced their participation in the cognitive construction. Also, the extent to which students engaged in the social negotiation of meaning was greatly influenced by the content of interpersonal conflicts, and how students interacted to resolve the conflicts. Moreover, the physical, logical and cultural constraints in the learning context caused different actions in the knowledge building activity.

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# Chapter 1

## INTRODUCTION

Reigeluth (1996) suggested that education in the information age should be designed to foster active thinkers, who can take initiative and think critically in team-based organizations, instead of maintaining conformity and compliance in bureaucratic organizations as education was designed for in the industrial age. Derek Bok (1986), when appointed president of Harvard University in 1986, examined the American system of higher education and indicated that higher education quality can no longer result from the transmission of a fixed body of knowledge to students. He asserted that a university education must help students “to master techniques of problem-solving and habits of continuous learning” (p. 5). Such demands on college graduates and the needs of professional practices in the workplace have challenged the conception of learning in higher education as information transmission from one mind to another. Instead, emphasis is now placed on learners as active constructors of their own learning and on social interaction as an integral part of learning (Reigeluth, 1996; Ryder & Wilson, 1996).

Problem-based learning (hereafter referred to as PBL) integrates small group collaboration, inquiry, and problem solving into a student-centered learning environment. PBL, as "a collaborative, case-centered, and learner-directed method of instruction" (Koschmann et al., 1996, p. 96), has been touted to motivate students to improve their problem solving skills, integrate and transfer disciplinary knowledge, and foster students’ self-directed learning and team skills (Barrows, 1985; Gijselaers, 2000; Norman & Schmidt, 1992). Such merits, echoing societal needs and changes in concepts of learning,

have advanced a growing interest in developing a PBL curriculum in higher education (Barrows, 1996; Hmelo & Ferrai, 1997; Savery & Duffy, 1995). In fact, PBL has been adopted in a variety of professional schools, including architecture, business, engineering, forestry, nursing education, law, political science, social work, and education since it was first introduced as an innovative medical education curriculum at McMaster University in 1969 (Boud & Feletii, 1997; Camp, 1996).

In a PBL classroom, students are brought into the spotlight. By engaging in group problem solving, students are responsible for generating their own learning issues, and instructors become facilitators who help students to identify what they need to know and the resources with which to obtain the needed information. The instructional principles underlying PBL have been described in a constructivist framework (Driscoll, 2000; Jonassen, 1999; Savery & Duffy, 1995). This framework proposes to embed learning in complex, realistic and relevant environments, to provide social negotiation to construct shared meaning, to support multiple perspectives and the use of multiple modes of representation, to encourage ownership in learning, and to nurture self-awareness of the knowledge construction process (Driscoll, 2000). PBL represents a fundamental shift from a teacher's delivery of a fixed knowledge base to the facilitation of a student's activity knowledge construction through collaborative problem solving.

Barrows (1996) identified six original characteristics for the PBL model: (a) learning is student-centered, (b) learning occurs in small student groups, (c) teachers are facilitators, (d) problems form the original focus and stimulus for learning, (e) problems are vehicles for the development of problem solving skills, and (f) new information is acquired through self-directed learning.

Specifically, the PBL environment consists of four major components (Barrows, 1996; Boud & Feletti, 1997; Wilkerson & Gijlselaer, 1996):

1. Authentic, complex problems: Problems are used to set up the inquisitive nature of the PBL environment, where students reason and explore their need to know in the direction of finding the direction. The problem-solving tasks simulate the ones that take place in the real world. The solutions to the problems involve a holistic understanding of the problem context and consideration of different factors and different perspectives.
2. Active learners: The descriptions of the problem scenarios provide limited but sufficient information for students to initiate the inquiry process of problem solving. They are prompted to define the problems and to identify their own learning issues. They are also encouraged to identify what information is needed and to explore a variety of resources in seeking the information they require.
3. Collaborative learning: Students are asked to work in small groups to solve problems. The problems provided in the course are ill-structured in nature, that is, requiring no single right or wrong answer but justifications of rationales and argumentations. The ill-structuredness of the problems is intended to establish the characteristics of interdependence between the group members in order to assure the mutual engagement of participants (Roschelle & Teadsley, 1996). The inclusion of peer evaluation in the grading system also serves to ensure the joint efforts among the group members.

4. Faculty as facilitators or guides: The instructor is not an authoritative source of knowledge any more. The major responsibilities of the instructor fall into monitoring, guiding, and supporting students' learning in the group problem solving process.

In PBL, problems are used as a major learning instrument. The problems are designed to engage students, with a collaborative effort (Figure 1-1), in four major tasks: understanding the problem, learning, solution, and reflection (Barrows, 1985; Hadgraft & Pripic, 1994).

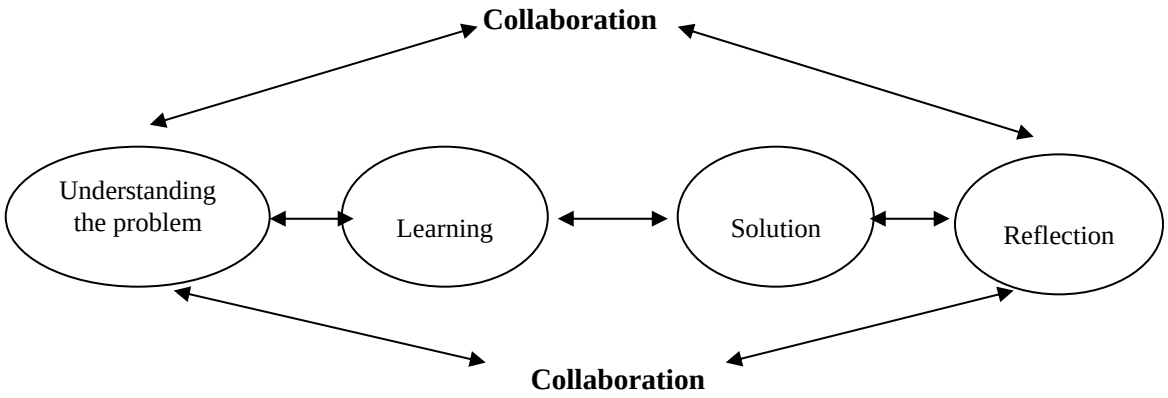


*Figure 1-1.***:** PBL Tasks

## The Problem, Purpose, and Research Questions

Lee and Kwan (2001) indicated that the PBL curriculum structure at McMaster consisted of a series of interdisciplinary blocks or units, which were designed to involve medical students in a broad range of health problems throughout their education. Flourishing in medical and professional schools on the curriculum level, the PBL approach has been adapted to be implemented for entire courses or to be used to teach certain parts of courses (Boud & Feletti, 1997; Camp, 1996). Rhem (1998), the executive editor of National Teaching and Learning Forum, recognized such adaptations in the implementation of PBL, and indicated that advocates generally accept course-long

continuity.

Some case studies on adapting the PBL curriculum model in medical education to standard college classrooms have pointed out several issues, such as different levels of college students' problem-solving expertise, different levels of motivation to learn, and the feasibility of assigning an individual tutor in each group to facilitate the process (Dahlgren, 2000; Rangachair, 1996; Ulmer, 1994). Also, when PBL is implemented, we cannot automatically make the assumption that analyzing problems will trigger the activation of prior knowledge and help to focus students' learning efforts (Schmidt, 1993). In fact, Patel, Groen, and Norman (1993) examined the knowledge and explanatory processes of students in two medical schools, and they concluded that PBL might have led to students' fragmentary structure of scientific knowledge.

Much research on PBL has focused on its effectiveness on students' learning outcomes compared with traditional lecture-based instruction (Albanese & Mitchell, 1993; Hmelo, Gotter & Bransford, 1994; Newman, 2006; Norman & Schmidt, 1992; Vernon & Blake, 1993). The endeavors to use certain objective criteria to investigate the PBL impact on learning outcomes might present evidence of the usefulness of PBL. However, as Evensen and Hmelo (2000) pointed out, PBL is "a sophisticated design that requires attention to learner and to teacher, to content and to context" (p. xi). Thus, without examining the process of how students actually act and think in relation to the learning environment, we cannot come to know how students learn or how PBL works or does not work under different conditions. Scholars have recognized the need to investigate processes as well as outcomes in order to better inform design. Much of PBL research is limited to the comparative effects of PBL (Hmelo & Evensen, 2000).

Recently, scholars have begun to study group interactions, identifying the elements and conditions that affect learning in PBL (De Grave, Boshuizen, & Schmidt, 1996; Hmelo & Evensen, 2000). The group interaction process embodies multiple facets of phenomena to be studied, such as the communicative attributes related to the constructive process of shared understanding, the conditions that vary the way people communicate, and the cognitive and metacognitve processes of individual students (De Garve, Boshuizen & Schmidt, 1996).

This study was undertaken to uncover group problem-solving activities from the time when students in a group initially encounter a PBL problem to the final goal state when they complete solving it. Theoretically, the learning process in this collaborative problem-solving learning environment is designed to be a dialectic process as well as a transformation of the individual moving toward full membership in the professional community (Evensen & Hmelo, 2000). From this perspective, the problem-solving process in the world of PBL is a process of enculturation, emphasizing the activities of the people within the socio-cultural setting. The process cannot be studied in a laboratory but in a sociological context. The activities in which people engage, the tools they use, the social and contextual relationships of collaborators, the goals and intentions that drive activities and the outcomes of those activities need to be investigated (Jonassen & Rohrer-Murphy, 1999).

Several studies of problem solving have explored the cognitive mechanisms within an individual information-processing system (Anderson, 1982; Mayer, 1991; Newell & Simon, 1972). Salomon (1993) indicates that this conception of cognitive process usually ignores the ecological aspect of problem-solving behaviors “in

conjunction or partnership with others and with the help of culturally provided tools and implements" (p. xiii).

Holding the same assertion that the examination of its process should aid our understanding of how PBL works, this study treated the practice of PBL as a phenomenon of study rather than as an experimentally imposed intervention (Koshmann & MacWhinney, 2001). The study examined the group interaction process with a focus on the problem-solving process on two different levels. On the macro-level, this study examined the activities that a group of students engaged in with the goal of delineating the students' problem-solving process within PBL. On the micro-level, this study investigated how students collaborated with one another during the process.

The research explores two primary questions related to the group problem-solving process during PBL:

1. What are the activities that students engage in to solve the problem together?
2. How do students collaborate in this process?

## Significance of this Study

The naturalistic inquiry used to examine the actual group problem-solving process and identify its attributes in relation to the learning context will help uncover how PBL works. This research can serve as a formative evaluation of the course design identifying the gap between how the group is expected to work and how the group actually works. The two research questions can help identify, define and describe how a group of students structure their learning process, how they communicate with one another, what strategies are developed and employed, and what resources are utilized during group problem solving. Therefore, the two research questions, examining group problem

solving activities and collaboration, can shed light on the attributes of college students' learning, problem solving, and communicative behavior within a PBL classroom. These findings could serve as a springboard to advance our understanding of what facilitates or prohibits the problem solving process in PBL classrooms. The study, thus, can provide guidelines for instructional practice.

Moreover, Jonassen (2000) examined the results of cognitive task analysis of hundreds of problems, and pointed out that problems are not equivalent in content, form, or process. He proposed to clarify the dimensions of problem solving in order to develop task-specific models for supporting the learning of problem solving. With its origin in medical education, PBL emphasizes a recursive process of hypothesis generation, information seeking, and hypothesis verification (Barrows, 1985; Savery & Duffy, 1995). The course content under study entails business decision-making problems, and solutions depend on the activities of identifying benefits and limitations, weighing options, selecting alternatives and justifying (Jonassen, 2000). Therefore, by recognizing differences between decision-making problems and clinical diagnosis problems, a description of the group problem-solving process in a business problem situation may unveil unique characteristics, and help tailor the pedagogical structure to better support students' learning through decision-making types of problems.

# Chapter 2

## REVIEW OF THE LITERATURE

The major factors that initiated the implementation of PBL in education are the dissatisfaction of the learners with their education, the irrelevance of the learned information to professional practice, and the learners' lack of reasoning ability to apply what they have learned to solve problems at the work place (Barrows, 1996). In order to resolve those educational issues to meet the changes in demands of professional practices, McMasters University developed a PBL program in medical education, whose key features include the analysis of a problem as way of learning, the development of self-directed learning, the use of small tutorial groups, and the presence of a faculty in each group (Barrows, 1996).

According to Barrows (1985), PBL in medical education emphasized three major learning objectives:

1. The acquisition of a retrievable and useable knowledge base: students have an essential body of knowledge and are able to use it in the clinical context.
2. Professional clinical reasoning skills: the hypothetico-deductive method, developing working hypotheses about the problem encountered, verifying the problem and causes, and developing the solution to the problem.
3. Self-directed learning: students are able to extend and improve their knowledge base as well as seek and use the resources when they face a new problem in their work.

Corresponding to Barrow's statements, Finkle and Torp (1995) defined problem-based learning as "a curriculum development and instructional system that

simultaneously develops both problem solving strategies and disciplinary knowledge bases and skills by placing students in the active role of problem-solver confronted with an ill-structured problem that mirrors real-world problems." In general, PBL is an instructional model emphasizing meaningful learning through solving problems.

Gijselaers (2000) also reiterates Barrow's statements of PBL goals as a claim that the emergence of PBL is a response to changing needs in the development of an integrated knowledge base, problem solving skills, effective self-directed learning skills and team skills. He expanded his statements and explicitly stated in a general term across disciplines that the ultimate goal of PBL is to produce graduates capable of managing academic or professional problems. Overall, the value of PBL is claimed to be its aim to motivate students to participate in the collaborative problem solving process so that students are able to improve their problem solving skills, integrate disciplinary knowledge for further transfer, and foster self-directed learning and team skills (Gijselaers, 2000; Norman & Schmidt, 1992; Barrows, 1985).

## Theoretical Foundations of Learning in PBL

PBL has been claimed to align with the constructive nature of cognition, that is, knowing is an active, constructive process — an interaction between the individual and the environment (Savery & Duffy, 1995; Jonassen, 1999; Greening, 1998). In other words, an individual defines meanings and realities through his or her interactions with the environment. The components of a PBL environment, that is, the problems, the peers, the instructor, the resources and the tools, are designed to encourage learners to be active in their learning. PBL is different from instruction with activities that mainly emphasize teacher's lectures, students' reading of textbooks, practice of the exercises, and tests

eliciting students' responses. Learning in such instruction is relatively passive: Students focus more on learning what it is, that is, the declarative knowledge, than on learning how to do things, that is, the procedural knowledge. On the contrary, the theoretical foundations of PBL, both from cognitive construction and socio-cultural theories, emphasize learners as active constructors of their own knowledge who highlight the meaning-making process via social interaction (Schmidt, 1983; Savery & Duffy, 1995; Camp, 1996; Hmelo & Evensen, 2000).

### *Cognitive Construction*

The theoretical explanations of PBL from this perspective of active cognitive construction are best revealed by Schmidt's (1983) summary of three essential principles underlying PBL:

- *Activation of prior-learning via the problem*: Problems function as stimuli for learning to activate prior knowledge and to determine the organization and nature of what is learned.
- *Encoding specificity*: Students can recall what they have learned better in the context in which it will be used. In other words, the resemblance of the problem to intended application domains facilitates later transfer. Understanding is in our interaction with the environment.
- *Elaboration of knowledge via discussion and reflection to consolidate learning experience*: Knowledge evolves through social negotiation. Moreover, elaboration of knowledge at the time or learning enhances subsequent retrieval (Norman & Schmidt, 1992).

Problems as a driving force of the learning process can be explained in Piaget's

concept of “equilibration” (1985), a cognitive construction process as a learning mechanism. Equilibration indicates an iterative learning, in which new information is shaped to fit with the learner's existing knowledge, and existing knowledge is itself modified to accommodate the new information (Piaget, 1985). The assumption is that when the cognitive structure is disturbed, it will assimilate and accommodate to generate a new structure because of its tendency toward self-organization. Problems serve exactly as anomalies of experience in PBL, and create a state of disequilibrium, which can only be resolved when a new cognitive structure is adopted.

The conceptualization of the mind as an active memory system casts doubts on the implications that are entailed in the positivist position of behaviorist and cognitive learning theories, that is, knowledge can be transferred from outside the mind to inside the mind. Wilson and Meyer (2000) stated clearly that the implication derived from the positivist belief that there is a single reality and objective knowledge to instructional design is that “the instructional designers could now think of learning in terms of taking experts’ cognitive structures and mapping that knowledge into the heads of learners” (p. 63). On the other hand, constructivism, viewing reality as individual construction, has caused a shift in the ways of thinking about what knowledge is and what learning is. From the constructivist perspective, knowledge is viewed as construction of understanding in a context (Brown, Collins & Duguid, 1989), or is located in the actions of persons interacting with their environment (Lave & Wenger, 1991). Fosnot (1996) recognized this dynamic between knowledge and social interaction as the critical element in the constructivist view of learning:

> Based on work in psychology, philosophy, and anthropology, the theory described knowledge as temporary, developmental, nonobjective, internally constructed, and socially and culturally mediated. Learning from this perspective is viewed as a self-regulatory process of struggling with the conflict between existing personal models of the world and discrepant new insights, constructing new representations and models of reality as a human meaning-making venture with culturally developed tools and symbols, and further negotiating such meaning through cooperative social activity, discourse, and debate (p. ix).

The focus of facilitating learning has shifted from how to structure instructional events in order to maximize the effectiveness of knowledge transmission as mental representations to the development of meaningful learning environments that will help students construct their understanding of information through their active engagement in meaning-making. Vygotsky's sociohistorical theory of development psychology (1978, 1986) has provided a theoretical grounding for social construction of meaning as an important part of the problem solving structure in the PBL environment.

### *Socio-cultural Construction*

Vygotsky (1978) recognized the higher psychological functions of humans, and their distinguishing mental process of signification, by which humans assign meanings to arbitrary stimuli and with which human learning is determined by the social and historical context. He believed that human development and learning occur through interactions of human beings with the environment and the other people in it. Vygotsky focused on the dialectic between the individual and society, and the effect of social interaction, language, and culture on learning. To Vygotsky (1978), learning is a

continual movement from the current intellectual level to a higher level that more closely approximates the learner's potential. This movement occurs in the so-called “zone of proximal development” as a result of social interaction. Thus, an understanding of human thinking depends in turn on an understanding of the mechanism of social experience. The force of the cognitive process deriving from the social interaction is emphasized. The role of the adult and the learners’ peers as they discuss, question, explain, and negotiate meaning is also emphasized.

Wertsch (1992) identified three themes that form the core of Vygotsky’s theoretical framework:

- *A reliance on a genetic development*

Vygotsky (1978) proposed two basic processes operating continuously at every level of human activity. Every complex mental function is first an interaction between people, and subsequently it becomes a process within individuals. It is the transition from the external operation to internal development that undergoes qualitative changes. This transformation involves the mastery of external means of thinking and learning to use symbols to control and regulate one’s thinking.

This conception of learning is a process of enculturation, which puts emphasis on the socio-cultural setting in which the problem arises and the activities that people engage in when they solve problems as a group. As previously mentioned, scholars and practitioners (Boud & Feletti,1997; Wilkerson & Gijlselaer, 1996; Stinson & Milter, 1996; Savery & Duffy, 1995) suggested that the design of the problem in PBL should focus on identifying problem solving tasks that are in the situated, real-world setting. In other words, problems should involve learners with the same or similar types of skills and

activities in professional practice, or mirror “the same type of cognitive challenges” (Savery & Duffy, 1995) as tasks in real world professional practice.

The relevance, authenticity, and complexity of the problem embedded in the social context intends to give students a meaningful learning experience and to provide the authentic physical and cognitive environment in which students take up the inquiry process.

Different from the typical teacher lecture and student response learning, in which students are usually given problems to solve after they have been exposed to some content knowledge from listening to the lectures or reading from textbooks, students in PBL are given the chance to pursue the information as needed and to use the knowledge in action. In the former learning situation, when students encounter a problem, students’ thinking is confined to the concepts and rules that they have just learned either from lectures or from textbooks when they encounter a problem. The design of this application type of problem is constrained with particular concepts and rules, and is more likely to be perceived as unrealistic.

The process of learning is assumed to start with the interpretive application of declarative knowledge in the cognitive stage. Then it proceeds to compile declarative knowledge into production rules during the associative stage. Gradually, the productions, a set of condition-action rules, become increasingly fine-tuned, and continually require less effort during the autonomous stage (Anderson, 1982). This hierarchical structure of learning stages in the process of skill acquisition distinguishes “knowing what” from “knowing how” and separates learning from doing. This decontextualized learning results in what Brown, Collins and Duguid (1989) criticized as inert knowledge. Students see the

purpose of learning as an accumulation of knowledge which is separated from the application to the real world situations, or which can always fit perfectly to different types of problems despite their differences in complexity and in context.

PBL, against such separation between learning and doing, calls attention to the integration of activity and situation into students' cognition and learning. Using problems to initiate students' pursuit of knowledge in PBL ties meaning to specific contexts and purposes because knowledge, a product of a meaning-making process, cannot be separated from the context of its use. It is this learning by doing in PBL that simulates Vygotsky's conception of the enculturation process in human genetic development. Students are provided with the opportunities to make the connection between external operation and internal development, a mindful and effortful learning about how to use knowledge and about why to learn it.

- *The concept of zone of proximal development, which exemplifies the claim that higher mental processes in the individual have their origin in social process.*

The zone of proximal development is the distance between the actual independent development level and the potential development level under adult guidance or in collaboration with peers (Vygotsky, 1978). According to Vygotsky's explanation, the mechanism that compels the movement in this zone of proximal development is social interaction. Vygotsky (1978) believed that human mental activity is a particular case of social experience. The development of human mental functions is not limited to independent, intrapsychological performance; it can go beyond with interpsychological functioning, which is supported by the interaction with people in the environment and in cooperation with peers (Vygotsky, 1978).

Collaboration is a critical component in PBL. The purpose of learning is no longer an accumulation of information, but "a transformation of the individual who is moving toward full membership in the professional community" (Hmelo & Evensen, 2000). Through collaboration with peers and assistance from the instructor, students are given the chance to "converse social relations into mental functions" (Vygotsky, 1981). Faidely et al. (2000) pointed out four major learning advantages of collaboration: (a) collaboration distributes the cognitive load among the members of a group, (b) collaboration results in a group's distributed expertise, (c) collaboration enhances reasoning and higher order thinking with the challenge of different perspectives, and (d) collaboration facilitates self-reflection.

The collaborative problem solving process in PBL is set up to extend the range of students' cognitive capability. By establishing a shared understanding of the problem at hand through explanations, negotiations, and argumentation, students work together to construct the solution to the problem (Evensen & Hmelo, 2000; Savery & Duffy, 1995; Schmidt, 1983). This is different from the typical teacher lecture and student response learning, which focuses more on the internal cognitive process of the individual. The PBL approach, looking beyond the cognitive processes that take place within the heads of individuals, utilizes collaborative problem solving to help students step out of their individual cognitive framework, and to reach intersubjectivity, or joint understanding, through active engagement in interpersonal communication (Duek, 1998). Thus, knowledge is no longer limited to the organizational structure residing within the learner. It is integral to the social context in which interpersonal interaction and support occur. In other words, the learning process in PBL is the interpersonal and intrapersonal

construction of meaning. Savery and Duffy (1995) identified social negotiation of meaning as an important part of the problem-solving group structure. Knowledge is socially negotiated, and students' understanding of content is constantly challenged and tested by others.

- *Mediation*

The claim is that mental processes can be understood only if we understand the tools and signs that mediate them. Vygotsky's concept of signification (1977) highlighted the importance of "learning the meaning of signs and symbols and their role in directing and regulating one's behavior" (Gredler, 1997). Vygotsky used the gesture of pointing to illustrate that learning the meaning of a pointing gesture as a sign could not be established without reaction of the other person. This, again, implies that the human's mental function initially is a social one, and that human knowledge and interaction cannot be separated from the responsive social context.

Recognizing the importance of the concept of mediation, PBL emphasizes learning in authentic contexts, in which students construct meaning via dialectical relations with the instructor and among peers, the contexts of their activity, and the activity itself. Engstrom et al. (1999) pointed out that human development is not only within the individual but also in the movement between the individual's internal and external experience, between the worlds of creating and using artifacts (Engstrom et al., 1999). Thus, the instructor not only has the responsibility to create a learning environment full of opportunities for students to explore, articulate and reflect what they learn and how they learn. The instructor also needs to support students to successfully engage in such learning actions.

Using a PBL approach requires significant work to compile comprehensive resources and tools that learners need in order to engage in solving problems. Resources can range from articles, lectures of instructors in certain topics, related cases, audio-visual materials, texts or experts in the subject. Rich sources of information are essential in PBL. Moreover, the instructor needs to provide tools for the students to engage and manipulate both resources and their own ideas as well as to support their problem-solving activities.

The characteristics of student-centered PBL do not amount to "a process of abandonment" (Greening, 1998) for the instructor to impose all the responsibilities on the students. Instead, it means that the instructor has to do more planning to support students' learning needs during their problem-solving process. Learning, from this perspective, is no more a process of transmitting information from others to learners themselves. It is instead a process of immersing learners in a problem-solving situation in which they actively develop and monitor their understanding through multi-directional interaction with the learning environment (Savery & Duffy, 1995).

### *Motivation*

One of the major values of PBL is seen in its aim to motivate students to participate in the learning process so that they are able to improve their problem-solving skills, integrate basic concepts, and foster self-directed learning and higher-order thinking skills. The definition of motivation in literature varies (Murphy and Alexander, 2000). In general, motivation is defined as either a conceptual object, such as drive, goals, engagement, will, commitment, interest, effort, and concern, or a process. Motivation has been defined as a process involving different factors, such as goals, self-efficacy, and

perceived values, that instigates “the magnitude, persistence, and quality of goal-directed behaviors” (Dweck & Elliott, 1983). The instructional structures in PBL are the notions that learning arises in solving ill-structured problems, that students need to actively engage in and monitor their own understanding, and that social negotiation is an important part of collaborative learning. All these notions imply the nature of individual evolutionary process. The nature of knowledge is individually constructed, and individual cognition defines its own realities through its interaction with the environment.

It is through this constructivist viewpoint that the PBL environment establishes relevance to students’ interest, encourages students’ autonomy, supports self-regulation, and values different perspectives. PBL seems to fit into the four conditions of motivational framework that Wlodkowski and Ginsberg (1995) proposed from an instructional perspective: (a) “establishing inclusion”: in a problem-based learning environment, the relationship between students and teachers is a collaborative one based on mutual respect instead of authoritative respect in which knowledge is passed down from teachers to students; (b) “developing attitude”: students are given power to choose their own learning issues related to their own needs in PBL so that they can develop a favorable disposition toward such learning experience; (c) “enhancing meaning”: PBL provides a learning experience that challenges students to incorporate different perspectives and values to pursue understanding of concepts and rules by engaging problem solving; and (d) “engendering competence”: students are valued as their own construction of knowledge.

## Trends in PBL Research

In recent years, research studies on PBL have emphasized questions, such as:

Does PBL work? What are the impacts of PBL on students' thinking? What elements in the PBL environment make instruction or learning experiences successful or unsuccessful? What is the structural model of the problem-based learning process? What does problem-solving learning experience mean?

Six lines of literature are delineated in Table 2-1. One is to evaluate the effectiveness on learning outcomes (Albanese & Mitchell, 1993; Norman & Schmidt, 1992; Vernon and Blake, 1993). These studies have shown mixed results. Norman and Schmidt (1992) examined several sets of experimental evidence in medical education, and concluded that there was no evidence that PBL curricula resulted in any improvement in general, content-free problem-solving skills. But it did support some of the general goals of PBL, such as retention of knowledge, transfer of concepts and integration of basic science concepts. Two meta-analysis studies of evaluative research (Albanese & Mitchell, 1993; Vernon & Blake, 1993) found that PBL medical students were engaged in learning more meaningful than non-PBL medical students were engaged in. Both found the superiority of PBL, comparing problem-based learning to traditional instruction, but the findings were mixed and could not reach conclusive results.

Another line of PBL research explores the influence of PBL on students' cognitive process and perceptions of the PBL learning process (Hmelo, Gottere, & Bransford, 1994; Rahimi, 1995; Rhan, 1993; Van Til et al., 1993). It is the qualitative changes in cognition and learning process that interest the researchers. For example, Hmelo, Gotterer, & Branford (1994) compared the reasoning strategies, coherence, learning self-assessment and learning plans of twenty medical students in an elective class in PBL with those of twenty students in the non-PBL group. They found that PBL

students were more likely to use hypothesis-driven reasoning (i.e., hypothesizing a diagnosis and later finding supporting data for the hypothesis when they provided diagnostic explanations) compared to data-driven reasoning (i.e., obtaining the data, synthesizing it, and then making the diagnosis) used by conventional lecture students. Also, they examined the patterns of learning issues and learning plans generated by students to assess the impacts of PBL on self-directed learning. Because of the differences in hypothesis-driven reasoning and data-driven reasoning, they assumed that PBL students would generate more disease-driven and basic science issues whereas non-PBL students would formulate more data-driven learning issues. They results supported the trend, but not with significant differences.

Table 2-1.

*Six Research Lines in PBL*

| Is PBL effective? | What are the impacts of PBL? | Students and faculty's perception of PBL | Design and implementation of PBL | Under what condition, is PBL effective? | Group interaction |
|---|---|---|---|---|---|
| ▪ Albanese & Mitchell (1993)<br>▪ Vernon and Blake (1993)<br>▪ Norman & Schmidt (1992)<br>▪ Van Til et al. (1997) | ▪ Duek (1998)<br>▪ Hmelo, Gottere & Barnsford (1994)<br>▪ Savin-Baden (2000) | ▪ Ryan (1993)<br>▪ Van Til et al. (1997)<br>▪ Vernon (1995) | ▪ Boud & Feletti (1997)<br>▪ Wilkerson & Gijlselaers (1996) | ▪ Van Berkel & Schmidt (2000)<br>▪ Schmidt et al. (1993) | ▪ De Grave, Boshuizen & Schmidt (1996)<br>▪ Evensen & Hmelo (2000) |

Van Til et al. (1997) investigated the effects of styles and activities of students' PBL behaviors on achievement. They found that being more active and taking initiative in using a PBL procedure in a tutorial group improved achievement. In this research, Van Til and his colleagues also explored students' perceptions of the value of self-directed learning and of their ability to carry it out. The results are discussed later.

Another example of a qualitative study of PBL's impact on students is Savin-Baden's conception of dimensions of learning experience (2000). Savin-Baden (2000) looked into the perspectives of those who were involved in problem-based programs and developed a framework of three sets of concepts that grew out of people's experience with problem-based learning. It is through examination of the nature of the learning experience in the context of different PBL environments that the researcher wants to reveal a holistic view of the interaction of the various components in learning. This intention is best described in her own explanations of why she termed the framework "Dimensions of Learner Experience":

> I have termed this framework "Dimensions of Learner Experience" to encapsulate the idea the learners do not just engage the pedagogical components of themselves in learning. Students do not simply learn the thing they are studying at the time, they also learn about people, contexts, likes and dislikes, and most importantly themselves. Learning is not a linear process whereby students who are engaged in learning are just thinking about that subject, in that context, at that particular time. Learning is about engaging different dimensions of ourselves in the learning process (p. 54-55).

Savin-Baden's viewpoint, along with the mixed results and analyses of the research on PBL, shows the complexity of problem-based learning, and that no instructional approach is inherently effective. The inclusion of all the pedagogical components in a theoretically sound instructional approach is essential, but it does not guarantee the success of its implementation and the positive effects on learning. Thus, in order to further understand an overall picture of problem-based learning, use of

experimental research seems to be incomplete, which only focuses on the control of variables in the instruction and aims to discover a relationship between the instructional components and learning outcomes. Instead, the investigation should encompass the PBL process from different aspects: the actors (instructional designers, instructors, and learners), the actions (instructional design, teaching, and learning), and the interactions among the actors and among the actions.

Another research focus lies in students' and faculty members' perceptions of PBL (Ryan, 1993, Van Til et al., 1997; Vernon, 1995). Van Til and his colleagues (1997) explored students' perceptions about the value of and their ability to carry out self-directed learning. This study focused on identifying (a) whether students within a problem-based learning course perceived as important the ability to be self-directed learners, (b) whether this perceived importance changed over time through the course, and (c) whether students' perceptions of their abilities to be self-directed learners changed over time through the course. The students were asked to rate the perceived importance and perceived ability related to self-directed learning objectives on a scale of zero to six on three occasions through the semester. The data indicated that the perceived importance and perceived ability of self-directed learning increased throughout the semester. Although this kind of one-group pretest-posttest design may show change, whether such development can be attributed to the influence of the problem-based learning environment cannot be determined.

Another two lines of research examine a relatively extensive context of PBL. One is to describe the design, implementation and evaluative processes of adopting the PBL approach into the classroom. Bound and Feletti's *The challenge of problem based*

*learning* (1997) included case studies in different academic fields. The purposes of those studies are usually to share their learned lessons by telling their experience of applying PBL into a specific context, and identify important factors promoting or impeding success of PBL by analyzing attitudes and opinions of the faculty and the students.

The other is designed to develop a structural model or identify patterns of problem based learning, either in terms of the process or in terms of its impact. The research methods to uncover the structures and patterns can be either quantitative or qualitative. For example, Van Berkel and Schmidt (2000) used path analysis to test a hypothesized model of the problem-based learning process incorporating variables such as amount of prior knowledge, quality of the problems, tutor performance, small-group functioning and time spent on learning, intrinsic interest in subject matter and commitment.

Recently, on the other hand, the shift in views of learning, from the cognitive psychological perspective to the inclusion of cognitive psychological, socio-cultural and socio-linguistic perspectives, has created more interest in the group problem solving process. The importance of group problem solving has led to the use of qualitative analysis of observations, videotaping of group work sessions, and interviews to investigate the structure of the learning process or patterns of group interaction in problem-based learning classrooms (Evensen & Hmelo, 2000).

For example, a panel representation at the 1996 Annual Meeting of the American Educational Research Association (Koschmann & Evensen, 2000) discussed the complexity of the results of analyzing group interaction. Five researchers had analyzed a six-minute data segment of a tutorial session of a group medical students and faculty

from different analytical frameworks: cognitive, socio-cultural, and socio-linguistic. Those analyses provided a better understanding of learners' meaning making process in a social context by identifying (a) how people organize their interaction, (b) how to use representations in the activity, (c) what the inquiry process is, and the skills and knowledge base revealed in the process, (d) what the characteristics are of transition communities in terms of social and cultural influence on the interaction and in terms of the conflicts and the negotiation of different identities in community, and (e) how people make meaning by different kinds of representation. Those analyses of the interaction process benefit the design of different aspects of the tutorial session in PBL, such as by providing guidelines for tutors to make decisions on how to coach and guide students' learning, by identifying patterns of argumentations and reasoning, and by facilitating the process of reaching a solution through a shared model.

Aiming to find out whether PBL leads to conceptual change, De Grave, Boshuzen and Schmidt (1996) analyzed the group verbal interaction and individual simulated recalls to identify students' cognitive and metacognitive process in the problem analysis phase of PBL. The features of prior knowledge, the availability of an alternative theory, the characteristics and the source of the anomalous data, and the strategy of data processing are all cognitive and metacognitive factors that impact conceptual change.

## Research on Collaborative Process

Collaboration is a critical component in PBL. It is through the collaboration with peers and the assistance from the instructor that students are given the chance to "converse social relations into mental functions" (Vygotsky, 1981). According to Webster's New World College Dictionary, "to collaborate" means "to work together."

However, in the research literature, collaborative learning has been given a positive connotation, in which students engage in “a process by which individuals negotiate and share meaning relevant to the problem-solving task at hand” (p. 70), and in “a coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem” (Roschelle & Teasley, 1995, p. 70). Examining the origin of cooperative and collaborative learning, Bruffee (1999) stated that these two learning designs were developed for learners of “different ages, experience, levels of mastery of the craft of interdependence” (p. 87). Cooperative learning emphasized individual accountability to facilitate the control of students’ participation in groups whereas collaborative learning emphasizes self-governance to enhance the construction of knowledge within the groups. This research viewed collaborative learning as a bigger conceptual umbrella consisting of cooperative learning as a critical interactive element.

The force that drives the recognition and acceptance of collaborative learning in higher education is explained clearly by Smith and Macgregor (1992) in its power of social and intellectual engagement of learners contrasted with the authoritative role of the instructor in the traditional one-way instruction:

> Collaborative learning is particularly timely now. In the 1980’s an avalanche of reports underscored the problems of undergraduate education: the distance between faculty and students, the fragmentation of the curriculum, a prevailing pedagogy of lecture and rountinzed tests, and educational tests, and an educational culture that reinforces student passivity, high rates of students’ attrition, and a reward system that gives low priority to teaching. In many ways,

> the academy mirrors larger social trends of fragmentation, lack of civil involvement, and undercurrents of alienation. Collaborative learning, with its emphasis on social and intellectual engagement and mutual responsibility, aims to counteract many of these educational and societal trends. (p 9)

Johnson, Johnson and Smith (1991) traced the use of cooperative learning groups in the United States back to the early 1800's, when a Lancastrian school was opened in New York City. Although cooperative learning was promoted through the following years, interpersonal competition began to dominate in education starting in the late 1930's. In higher education, a faculty member is qualified to teach as long as he or she has the content expertise, which he or she can pour into students' minds via lectures or reading assignments. The notions underlying this criterion imply that knowledge is a repository of information, and that teaching is an activity of transmitting knowledge to students. However, with the explosion of information in this rich information age and the increasing popularity of the constructivist view of knowledge, those notions have been challenged recently. The pursuit of knowledge is no longer seen as an individual endeavor, but the construction of understanding and meaning in a social context.

To meet the challenge and the needs of professional practice, college graduates are now expected to develop reasoning and problem-solving skills, and a high level of communication skills and abilities to work with others. Also from the constructivist perspective, the function of education no longer lies in knowledge transmission from the outside of the mind to the inside of the mind. Instead, the ultimate goal of learning is to facilitate active cognitive reorganization in learners, and their active engagement in the world. All these changes in higher education contribute to the shift of the design focus

from how to effectively transmit knowledge from the instructor to the students to the development of meaningful learning environments where students are able to interact with others and engage in meaning-making. Ryder and Wilson (1996) explained these paradigm changes with similar remarks:

> As our society continues to diversify, as the need for technical skill increases, as the world changes faster than textbooks and lesson plans can keep pace, the emphasis on curriculum content is giving way to a focus on the learning process. Constructivism, considered radicalism a decade ago, is the dominant perspective at most educational conferences. Content objectives are giving way to a focus on skills development, instructional designs are giving way to learning environments where students define the central tasks, including how the learning should be monitored, assessed and adjusted to achieve the desired outcomes (online resource.)

Collaborative learning is increasingly acknowledged as an effective way of learning (Bruffee, 1999; Bosworth& Hamilton, 1994; Dillenbourg, et al., 1996). Dillenbourg, Baker, Blaye and O'Malley (1996) categorized three paradigms of research in collaborative learning: effects, conditions, and interaction (See Table 2-2.). Research in the paradigm of effects investigates the question of whether collaborative learning is more efficient than learning alone. This type of research yields contradictory results although most of the studies showed that collaborative learning could be beneficial to achieving students' academic and affective outcomes (Johnson & Johnson, 1989; Johnson, Johnson, & Smith, 1991).

Table 2-2.

*Three Paradigms of Research on Collaborative Learning*

| Effects:<br>Is collaborative learning more efficient than learning alone? | Condition:<br>Under which condition is collaborative learning efficient? | Interaction:<br>Which interactions occur under which conditions and what effects do these interactions have? |
|---|---|---|
| ▪ Johnson & Johnson (1989)<br>▪ Johnson, Johnson, & Smith (1991)<br>▪ Slavin (1983) | ▪ Good & Marshall (1984)<br>▪ Slavin (1983) | ▪ Andreassen (2000)<br>▪ Arneseth & Soleim (2002)<br>▪ Baker (1995)<br>▪ Barron (2000)<br>▪ Chi et al. (1994)<br>▪ Jeong & Chi (1997)<br>▪ Kaptelinin & Cole (1997)<br>▪ Roschelle & Teasley (1995)<br>▪ Webb (1985) |

Johnson and Johnson (1989) conducted a meta-analysis of the results of 137 experimental studies that compared cooperative, competitive, and individualistic efforts at the college and adult levels. They listed twelve learning outcomes promoted by cooperative learning, that is (a) higher achievement and increased retention, (b) more frequent higher-level reasoning, deeper-level understanding, (c) more on-task and less disruptive behavior, (d) greater achievement motivation and intrinsic motivation to learn, (e) greater ability to view a situation from others' perspectives, (f) more positive, acceptance, and supportive relationships with peers regardless of ethnic, gender, ability, social class, or disability, (g) greater social support, (h) more positive attitudes toward teachers, principals, and other school personnel, (i) more positive attitudes toward subjective areas, learning, and school, (j) greater psychological health, adjustment, and well-being, (k) more positive self-esteem based on basic self-acceptance, and (l) greater

social competencies.

Another research paradigm examines the conditions under which collaborative learning is effective. The independent variables include the composition of the group, the features of the task, the context of collaboration and different communication media. The results in this paradigm emphasize what Slavin (1989) concluded in his review of the achievement effects of cooperative learning methods:

> Collaborative learning can be an effective means of increasing student achievement, but only if group goals and individual accountability are incorporated in the cooperative methods (p. 151).

In the literature of cooperative and collaborative learning, scholars identified positive interdependence as one of the essential elements for successful learning (Johnson & Johnson, 1989; Johnson, Johnson, & Smith, 1991; Slavin, 1989; Bruffee, 1999). Johnson, Johnson, & Smith (1991) explained that students must believe that no one can succeed unless the other members of the group succeed, and vice versa. Salomon (1992) used the term “genuine interdependencies” to emphasize the importance of social interaction in instructional design. The characteristics of genuine interdependence include the need for sharing necessary information, meanings, conceptions, and conclusions, the need for polling different shares of labor and roles, and the need for joint thinking (Salomon, 1991). The level of collaboration is determined by the extent of the needs for interdependence perceived by the participants.

Dellenbourgh, Baker, Blaye, and O’Malley (1996) pointed out that efforts in research have shifted from building the causal relationship between the effects of collaboration and independent variables to understanding the roles such variables play in

mediating interaction. They proposed an “interactions” paradigm as a framework for analyzing and modeling interaction. The proposed categories of interaction for analysis, such as social/cognitive, cognitive/metacognitive and task/communicative, provide an analytic framework for understanding the patterns of communication, negotiation, and argumentation from data collected from observations, video-recording or verbal exchanges when people are in a conflict situation.

The research under the interaction paradigm pays attention to the micro-genetic features of interaction, such as self-explanation (Chi et al., 1994) and genuine interdependence (Andreassen, 2000). Andreassen (2000) studied intra-group collaboration in a tele-learning scenario and proposed that the nature of the task provided as well as the nature of the task agreed on by group members changed the way that members interacted with one another. He observed that the collaborative effort grew gradually less genuinely interdependent through the design activity. He found that the need to share information was reduced when the design task was divided in a way that each group member could complete the task without contribution form other members.

The analysis of verbal information is also a major focus of the research on group interaction related to collaborative process (Baker, 1995; Barron, 2000; Roschelle & Teasley, 1995). Those studies investigate communicative attributes related to the constructive process of shared understanding in interactive episodes undertaken in the problem solving process. On the basis of the argument that “collaborative problem solving takes place in a negotiation and shared conceptual space, constructed through the external mediational framework of shared language, situation, and activity – not merely inside the cognitive contents of each individual’s heads” (p. 70), Roschelle and Teasley

(1995) used a microanalysis of one day's work in a computer-based environment to examine the construction of shared knowledge. They proposed that collaborative problem solving consists of two concurrent activities, solving the problem together and building a "joint problem space" (JPS). In order to build a JPS, students have to engage in (a) introducing and accepting the JPS, (b) monitoring ongoing activity for evidence of divergences in meaning, and (c) repairing divergences that impeded progress of collaboration. Their research provided an understanding of how collaboration is realized in students' discourses and activities. They observed that students were making conscious efforts to use coordinated language and action to establish shared knowledge in the collaborative process. Students were able to recognize the divergence from shared knowledge; they were also able to use the overall turn-taking structure of talk and specific discourse forms to rectify misunderstanding that impedes joint work.

Baker (1995) analyzed the dialogues generated by sixteen-and seventeen-year-old students who attempted to solve a mechanical problem in physics. He viewed the process of construction of problem solving in dialogue as a type of negotiation, "a process designed to achieve agreement between agents, whether the initial starting point is one of conflict or whether it is simply one of "absence of agreement" (p. 42). Baker categorized four types of dialogue units (a) interactional units dealing with coordination of the dialogues, (b) hierarchical-functional units, such as question-answer, offer of acceptance-rejection, and affirmation-acceptance, (c) argumentational utterances of a proponent and opponent, such as attack, counter-attack, protective defense and counteractive defense, and (d) domain-task expression about how solutions are co-constructed. His analysis modeled how joint solutions are constructed in dialogues and how students establish

agreement with respect to solution.

## Problem Solving

Problem solving can be viewed as a learning outcome (Gagne, 1996) or as a process (Mayer & Wittrock, 1996). As a learning outcome, problem solving is a unique human capability by which the learners are able to synthesize their knowledge base to find a solution in a novel situation. On the other hand, Mayer (1991) defines problem solving as cognitive processing directed at achieving a goal when no solution method is obvious to the problem solver. Mayer and Wittrock (1996) pointed out that the characteristics defining problem solving include being cognitive, being a process, being goal-directed, and being personal. Cognitive psychologists have studied how people solve problems in terms of process, methods and strategies, and types of knowledge needed.

### *Cognitive problem solving process*

Putting the problem solver in the foreground of the problem solving process, Polya (1957) developed a set of general strategies to be used to solve the problem: understanding the problem, devising a plan for solving the problem, carrying out the plan, and looking back. The conception of problem solving as a form of means-ends undertaking (Simon, 1969), which aims to discover a process description of the path that leads to a desired goal, set the way for Newell and Simon's (1972) problem space hypothesis, that is, the problem solver translates a problem into a problem representation and searches for a path through the problem space from the given to the goal state. Problem solving is thus viewed as the interaction of search and understanding processes directed at a goal. The problem solver has to identify the elements, recognize the initial and the desired arrangements of the elements, and consider all the possible operators

within the constraints in a problem. This hypothesis points out the nature of goal-directed thinking in problem solving, and the importance of the problem solver's perception and understanding of the problem.

Anderson's ACT learning theory (1982) also looked at problem solving as a goal-directed process. According to this theory, problem solving involves setting goals, recognizing whether conditions are met, and carrying out actions. The problem solving is organized in goal structures, in which production applications are involved.

Recognizing the importance of the evaluation and monitoring process in problem solving, Bransford and Stein (1993) proposed an IDEAL model to include five major activities in the problem-solving process: to identify problems and opportunities, define goals, explore possible strategies, anticipate outcomes and act, and look and learn. This framework highlights the role of metacognition in problem solving, that is, planning, monitoring and modifying (Pintrich & DeGroot, 1990). Flavell (1976) defines metacognition as "one's knowledge concerning one's cognitive process and products or anything related to them" (p. 232). The definition classifies two aspects of metacognition: knowledge about cognition, and regulation of cognition. Knowledge about cognition concerns knowledge about one's own cognitive resources, and regulation of cognition concerns self-regulatory mechanisms used by an active learner during ongoing attempts to solve problems.

Problems in PBL are designed to be ill-structured. Ill-structured problems have multiple solutions, solution paths or no solutions at all (Kitchner, 1983). Integrating Newell and Simon's problem solving space hypotheses (1972), the IDEAL model (Bransford & Stein, 1993), and Sinnott's emphasis on generating possible solutions and

selecting the best solution (1993), Jonassen (1997) proposed a process of solving ill-structured problems, including (a) articulating the problem space and contextual constraints, (b) identifying and clarifying opinions, positions, and perspectives of stakeholders, (c) generating possible problem solutions, (d) assessing the viability of alternative solutions by constructing arguments and articulating personal beliefs, (e) monitoring the problem space and solution options, (f) implementing and monitoring the solution, and (g) adapting the solution.

Those problem solving models offer a generalized representation of different problem solving stages where problem solvers engage in different activities. Jonassen (2000) pointed out that problems are not equivalent in content, form or process and that research needs to be cautious not to treat problem solving as a uniform activity. Different thinking and activities are expected to lead to different characteristics of the problem at hand. Moreover, those problem solving process models do not take collaboration into consideration. It is natural to assume that collaborative structure in problem solving must entail certain communicative attributes to the dynamic of group interaction and certain ways that people solve the problem.

### *Analogical Reasoning Process in Problem Solving*

On the other hand, case-based reasoning (CBR), which originated from the field of artificial intelligence, viewed problem solving as a process of remembering a specific problem-solving episode, adapting the solution to fit the current situation, and storing the adapted solution in memory. CBR is a computational model that uses prior experiences to understand and solve new problems. The foundation of the CBR system is laid on Schank's arguments on the role of reminding (1982), which coordinates past events with

current events to enable generalization and prediction. According to Schank (1990; 1992), human memory is story-based. What people know is stored in memory as stories. People are reminded of past experiences by current ones, and they use those past experiences as a guide to help process new experience. Learning occurs when people process new experiences in light of old ones (Schank, 1990). The solved problems with adapted solutions can be indexed as new cases into learners' memory for future use.

From this perspective, the problem solving process emphasizes the performance of analogical reasoning between the prior problem solving episode(s) and the current problem. Problem solving consists of searching out the nearest case and then adapting it to the specific problem solving situation in hand. Problem solving is a learning process which extends one's knowledge by incorporating the new problem solving experiences into memory, by re-indexing old experiences to make them more accessible, and by abstracting out generalizations from experiences.

Moreover, studies on the nature of expertise all show that experts differ from novices in the amount of their knowledge, the organization and accessibility of the knowledge, and the methods used to apply the knowledge (Chase & Simon, 1973; Chi, Feltovich & Glaser, 1981; Gobbo & Chi, 1986). Chi, Feltovich, & Glaser (1981) found out in their study of novice-expert differences that novices concentrate mainly on the salient feature whereas experts concentrate on the inferred attributes of a problem description. In other words, novices rely more on surface features while experts look into the underlying problem solving structures. Moreover, problem solvers are not necessarily reminded of the most relevant prior cases and may fail to notice important similarities between old and new cases. Click and Holyoak (1980) found out that not until the

participants provided their own solutions to the military problem were they able to generate an analogous solution to the medical radiation problem. Also, not until the participants were encouraged to use one of the problems as an analogous solution could they transfer the solution in the military problem to the medical radiation problem.

### *Group Problem Solving Process*

The fields of artificial intelligence and communication have contributed many studies to the understanding of group problem solving. The artificial intelligence studies appear to focus on the development of a multi-agent system. The design of the system aims to develop the ability to integrate different agents of different responsibilities and knowledge bases, the ability to relocate or even re-invent different responsibilities back to different agents as well as the ability to create a new agent to take a new responsibility in order to complete a problem-solving task. The focus of collaboration is found in the construction of shared knowledge. Two notions can be drawn from this field of studies for the analysis. One is that there would be a quality change in the constructed shared knowledge. The constructed shared knowledge is not an overlapping of knowledge from two different sources; instead it undergoes transformation depending on the needs emerging from the interaction with the received data and the operational structures in the environment. The other notion is the labor of distribution. Similar to the construction of shared knowledge, the tasks and the rules of distributing the tasks evolve.

Human interaction is the major topic in the field of communication. A number of group decision-making and group problem-solving models have been developed. For example, Bales and Strodtbeck (1951) delineated six types of problems that group members have to deal with while trying to solve a problem-solving task together:

orientation, evaluation, decision, integration, tension management, and control. The first four are related to the attempts to accomplish the task; the last two are the social emotional reactions to what has been happening in the group interaction dealing with the tasks or the group itself. Such a classification indicates different operations related to maintain the group's function as a joint problem solver. It provides a baseline to uncover the functions underlying the observed behaviors and to distinguish behaviors according to the efforts that the students put into the operations and their reactions.

Hirokawa (1980) integrated different coding systems, and examined three dimensions of group interaction: task-oriented behaviors, procedure-oriented behaviors, and socio-emotional behaviors to identify patterns of interaction within effective decision-making groups. Later, Hirokawa (1985) suggested five major critical functions for effective group decision making: (a) establishment of operating procedures, (b) analysis of the problems, (c) generation of alternative solutions, (d) establishment of evaluation criteria, and (f) evaluation of operating procedures.

Poole (1981) compared two models of decision development in small groups: the unitary sequence model and the multiple sequence model. The study results support the multiple sequence model, which assumes that different groups follow different sequences. Poole (1983, 1985) noted that group members adapt their activities to the contingencies of the decision task, the nature of the group structure, and the demands of the group's environment to make the most effective decision possible. According to Poole (1985), the structure and sequence of group decision development falls into three types of activities: (a) task process activities, including problem analysis and solution evaluation, (b) relational activities, such as conflict, focused work and integration, and (c)

topical focuses related to issues or concerns of a group. Those structural models provide descriptions of the phases by which small groups progress when their members work and learn together.

## Research Inquiry and PBL

Koetting (1996) stated that the philosophical positions about ontology, epistemology and axiology would direct how people make decisions about education and research inquiry. The views regarding the nature of reality, knowledge and value have influenced the conceptions of instruction and learning, and further impacted the methods in the instructional systems design process in the IT filed. For example, traditional cognitive theories, derived from the belief that there is a single realty and objective knowledge, imply that knowledge can be transferred from the outside of the mind to the inside of the mind. On the other hand, the focus of instructional design in the constructivist paradigm has shifted from maximizing the effectiveness of information transmission to the development of a learning environment that will facilitate students' own construction of understanding the subject matter under study.

However, although more and more instructional design methods align with the constructivist view of knowledge, the research in the field of instructional technology is dominated by experimental studies (Driscoll & Dick, 1999) whose endeavors are usually to investigate the causal relationship between independent variables, e.g., design of certain instructional components or strategies, and dependent variables, such as learning outcomes or students' attitude. Such endeavors are based on the assumption that there is an absolute reality out there that can be objectively measured and conceived. The contradictions between different epistemological orientations that dominate in the ID

practice and research is puzzling and challenging. The puzzlement lies in whether those paradigms have to be excluded from each other in the field of instructional technology or whether the field can somehow accommodate those different paradigms and become multi-paradigmatic as Dill and Romiszowski (1997) proposed:

> Right now a great many new and older but revised paradigms are being introduced into the field. … We believe this is a healthy situation, because it provides the instructional developer with new tools not previously possessed, and new ways of understanding instructional problems not previously available. We believe that with the new paradigms, current anomalies will fall to scientific advances, better theories will be developed, and practice will jump ahead in quantum leaps…There are difficulties, however, with the process as it is currently occurring. Many of the paradigms are incompatible, especially philosophically. But they are being accepted as technological alternatives. Perhaps they can be practiced together, or alternately by the same person, but only by treating them differently than their internal structure would dictate. ... In the end, if the field becomes multi-paradigmatic, many of these paradigms will survive into the final mixture, come as general-purpose approaches to instructional development, some surviving only in specialized niches and for specialized application. Others will disappear altogether. Many years may be required for this puzzle to sort itself out fully (p. 23 –24).

The emergence of constructivist orientations also challenges us to re-examine our own philosophical assumptions in research inquiry. To broaden the scope of educational research, Koetting (1996) proposed that “doing philosophy is doing research,” and stated

that the ultimate purpose of doing research is “to gain a clear/clearer perception of reality and our relationship to that reality.” (Koetting, 1996). His propositions encouraged researchers to confront themselves more critically: Where do I place my value of research? Which should precede, hypothesis testing to verify what works in classrooms or the naturalistic inquiry to understand what is going on in classrooms? What should focus my research inquiry?

As it has been remarked, the implementation of the PBL approach has changed the phenomenon of teaching and learning in the classroom. A different belief system has been brought into education. When Roehler and Cantlon (1997) discussed the role of scaffolding from the position of educators, they recognized the changes from a teacher’s delivery of a fixed knowledge base to a student’s active construction of knowledge:

> We believed there was a fixed knowledge base, and a teacher’s responsibility was to give that knowledge. … However, this way of thinking about teaching and learning has changed to a conception that students actively construct their own knowledge and understanding. … Instead of learning a set of knowledge bases, students develop evolving knowledge based through interactions with others, requiring an active involvement in learning (p. 7).

Problem-based learning, with this conception of learning, goes beyond a cognitive process that integrated new information with individual prior knowledge structures, and views the learning system as an interactive, social process. Learning in PBL emphasizes “a participatory process of active knowledge construction” (Salomon & Perkins, 1998), and the dialectic between the individual and society and the effect of social interaction, language and culture (Vygotsky, 1978). The understanding of such an interactive process

demands a variety of research methods. The experimental research, with artificial control of independent and dependent variables, intends to establish the inference of causal relationship. It does not investigate the meaning of learning experience. Neither does it examine the social and cultural patterns in the learning process, the essential structures of a constructivist view of learning as an enculturation process (Vygotsky, 1978; Lave, 1988; Brown, Collins, & Dugid, 1989).

# Chapter 3

## RESEARCH METHOD

This research study employed a naturalistic inquiry to study the interaction of a group of college students in a PBL classroom while they were working on a series of international logistics problems. Specifically, an "instrumental case study" (Stake, 1995) was used to investigate the group problem-solving process to address the following two questions:

1. What activities do a group of students engage in to solve a problem together?
2. How do students collaborate with one another?

Creswell (1998) defined a case study as an exploration of a bounded system. In the current study, the focus of interest was on the group problem-solving process within the PBL course. To pursue understanding of such a phenomenon within a reachable scope, the case under study was identified as the group of college students who were required to participate in problem-solving tasks together within a PBL environment. The interest of this study was not in the case itself, that is, the group of college students. This study was instead interested in the pursuit of an understanding of the group problem-solving process and collaboration by studying the case. This research did not attempt to establish a generalized portrayal of group problem solving despite different characteristics of different groups and different problems; instead, the study intended to provide a comprehensive description and a thorough examination of group behaviors and interactions in order to precisely describe those phenomena in a specified condition

### The Case

The case study centered around a PBL business logistics course in an upper-level

undergraduate program at a university in the Northeast. The international logistics course under study was a course designed (a) to help students to apply their knowledge of international supply chain management to international/global problems; (b) to find sources of information useful in international/global supply chain management; (c) to relate current events to international/global supply chain management; and (d) to work in groups to identify issues and develop solutions to international logistic problems. Students were asked to complete course readings, to attend classes for mini-lectures and classroom discussions, to complete individual homework assignments, and to work in groups to develop solutions to four team problems in a business logistics case.

### *Course Structure*

At the beginning of the course, the instructor went over the syllabus, the grading policies, the orientation to PBL, and the importance of teamwork. The course met twice a week from 8 a.m. to 9:15 a.m. for 16 weeks. During the course, students interacted with their group members, and completed four group assignments. The four team assignments were presented in an increasing level of complexity in scope dealing with different issues and dimensions in international logistics — an overall export plan, a choice of two different sourcing options, a decision on the mode of transportation, and a supply-chain strategy recommendation based on the selection of the assembly location. Figure 3-1 depicts the overall structure.

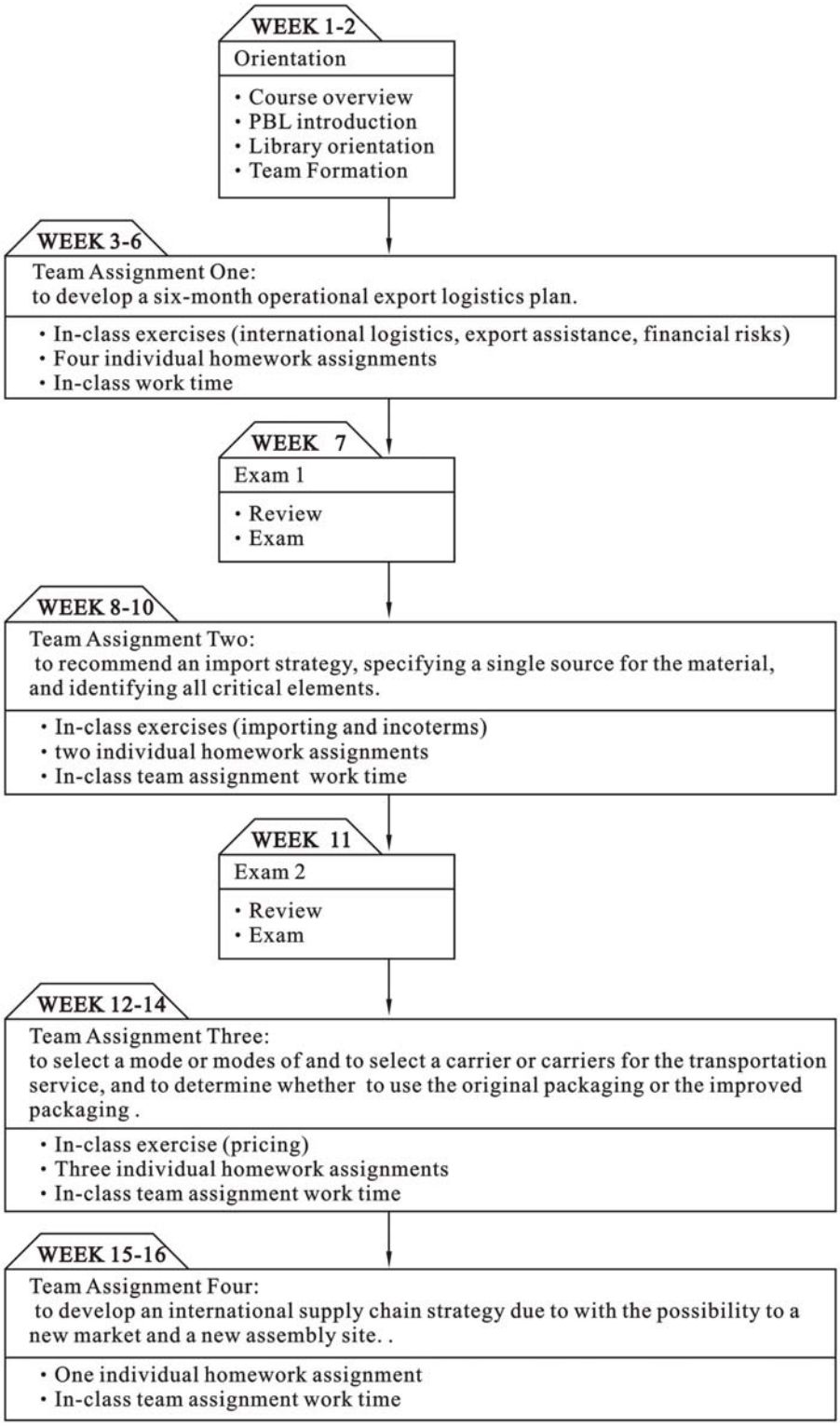


*Figure 3-1* Course Syllabus Structure

Barrows (1986) used two major variables in instructional components, that is, the

nature of case, and the locus of control of learning, to determine six different levels of PBL. These levels are shown in Table 3-1.

Table 3-1

*Different Levels of Problem-Based Learning*

| Levels | Nature of Case | Locus of Control |
|---|---|---|
| Level 1:<br>Lecture-based cases | Complete case or case vignette<br><br>The instructor presents the students with information in lectures and then a case or two to demonstrate the relevance of the information | Teacher-directed Learning |
| Level 2:<br>Case-based lectures | Complete case or case vignette<br><br>Students are presented with case vignettes or more complete case histories before the lecture. The cases highlight materials to be covered. | Teacher-directed Learning |
| Level 3:<br>Case method | Complete case or case vignette<br><br>Students are given complete case for study and research in preparation for subsequent class discussion, which is facilitated by the instructor. | Partially student directed & partially teacher-directed |
| Level 4:<br>Modified case-based | Partial problem simulation<br><br>Students are given an initial presentation of the problem and have to assemble the important facts through inquiry. Inquiry may be limited by the instructor. | Student-directed learning |
| Level 5:<br>Problem-based | Full problem simulation<br><br>Inquiry is fully initiated and completed by the students with the facilitation of a tutor. | Student-directed learning |
| Level 6:<br>Closed-loop problem-based learning | Full problem simulation<br><br>This method required students to evaluate the information resources, and to return to the original problem to evaluate their problem solving process, and to see how they might have gained better understanding. | Student-directed learning |

*Adapted from H. S. Barrows (1986) "Taxonomy of Problem-Based Learning Methods"*

A full problem simulation was not presented to the students in this course. Based

on Barrow's taxonomy, the course should be classified as a modified case-based PBL — that is, a complete, organized problem was presented to the students, but the instructor and students shared their responsibilities in directing the learning experience**,** in which a number of facts were provided, but students chose actions and made decisions from limited alternatives. Although students decided on their inquiry actions, they were provided with cues, which might have restricted their inquiry process. The instructor matched up learning objectives with each of the four team assignments. Prior to each team assignment, students were asked to do in-class exercises and to work on individual homework assignments, which provided students with basic content knowledge about international logistics to prepare them for subsequent team assignments. During students' inquiry for each team assignment, several mini-lectures served as a supplemental information resource to emphasize key concepts, to build a framework of ideas, and to relate issues to the case.

***Team Assignments, Tools and Resources***

ANGEL, a course management system, provided an information space where all the course-related information resided, that is, course syllabus, handouts for assignments, grading rubrics, and peer evaluation forms. Students also needed to submit their papers directly to the drop boxes in the system.

Students were asked to work in groups to identify issues and develop solutions to a series of international logistics problems. Four team assignments were given regarding different international logistics problems for ECI, a pseudo company in the United States that encountered different decisions to make on importing, exporting, modes of transportation, and supply chain management issues. Students were required to develop a

six-month operational export logistics plan in Team Assignment One, to recommend a sourcing and import strategy in Team Assignment Two, to select a transportation strategy in Team Assignment Three, and finally to develop an international supply chain strategy with some potential sourcing and marketing opportunities in Europe in Team Assignment Four.

### *Participants*

The participants included a group of four students who worked together in the business logistics course. This group was part of a larger business logistics class with 51 students. The instructor divided the class into twelve groups. The division attempted to establish groups with a heterogeneous mix in the levels of experience in internships and work among students. After the researcher explained the research process and the purposes of the research, all of the groups were willing to participate. After removing one group from consideration because it included a graduate student, the researcher randomly selected one group for her study by casting lots. The group comprised three female students and one male student: Andrea, Beth, Chris, and Dong. [Notes: The names have been changed to ensure confidentiality].

#### *Andrea*

Andrea was in her 10$^{th}$ semester at the university. Her study area was management science and information systems in Business Administration. She had prior internship experience as an administrative assistant and a network administrative staff. She studied abroad in Rome and Italy. Because of her computer skills in Microsoft Office tools, she typically took control of the group documents. She typed in new information and formatted the documents during the group meetings.

She considered herself a group leader in most group projects from other courses. But with this group she said that no one person emerged as the role of a leader because all four people in the group felt strongly about the direction of the assignments. However, she acknowledged that she was a mediator on the group. She asked a lot of questions during the group meetings, and tried to get input from everyone.

***Beth***

Beth was in her 7th semester at the university. Her study area was marketing in Business Administration. She had no foreign or overseas experience. She held a work-study position at a college institute for the study of business markets. She said that she did not get along with the other group members. She said she felt that her points of view were not accepted or respected.

She commented that she did not have a significant role in this group. She said she wanted to be part of this group. However, it got to a point where she felt that the other group members did not want her input. She felt that there were too many leaders and not enough members in non-leadership roles. Most of her participation took place during the first team assignment. She missed several group meetings. She commented that she disassociated herself further from the group as each project and the semester advanced.

***Chris***

Chris was in his 9th semester at the university. His study area was finance and international business in Business Administration. He had internships at a building material manufacturer, one of the world's leading financial management and advisory companies, and at the university trading room. He also studied abroad in Rome and Italy. He was present at every meeting; however, he did not participate much in discussions at

the meetings. He often worked on his own, joined the discussions, wandered off, and came back again. Because of his background in finance, he was tasked on all of the financial aspects of the team projects.

He was the only group member who perceived that he was the leader of the group insofar as he set up the times that the group could meet, always submitted the projects, made suggestions on the papers, and brought everyone together toward consensus. In fact, he was the one who organized the group's papers before and after meetings. After meetings, he made changes to the papers, highlighted them, and brought them back to the other group members for their input on his changes.

***Dong***

Dong was in her 8th semester at the university. Her study area was business logistics in Business Administration. She had prior internships with an international pharmaceutical company and a Swedish manufacturer. She had traveled to Vietnam twice, the homeland of her parents.

She always sat with Andrea in front of the computer, reading and trying to edit with her. However, she said she felt that her ideas were frequently dismissed, so she started to disengage from the group. Also, she said that she did not take a leadership role because she believed the group should be "all about discussion, all about communication," and shouldn't be led by one person.

## Research Design

The group problem-solving process within a college-level PBL classroom was examined as a case study. The case study gathered descriptions of the actual activities that a group of students engaged in as they worked together to solve the assigned

problems and as they revealed how they collaborated with each other. This case study took an interpretative, naturalist approach (Creswell, 1998; Denzin & Lincoln, 1994; Rossman & Fallis, 1998).

Denzin and Lincoln (1994) offered an initial generic definition of qualitative research: “Qualitative research is multimethod in focus, involving an interpretive, naturalistic approach to its subject matter” (p. 2) Creswell (1998) also defined qualitative research as a study in a natural setting. Gall, Borg, and Gall (1996) claimed that qualitative methodology was to discover these meanings and interpretations by studying cases intensively in natural settings through an analytical induction of data. Generally speaking, qualitative research is oriented toward the understanding of a natural world, and is highly interpretive in nature. Rossman & Rallis (1998) pointed out that qualitative researchers seek answers to their questions in the real world. It is from what they see, hear and read from people, places, events, and activities that they uncover their understanding of the world. Qualitative research focuses on understanding how people make sense of their world. It provides both the researchers and the participants with a discovering experience.

The characteristics of naturalistic inquiry fit the purpose of the current study. The study analyzed an observed phenomenon, that is, students’ interactions within PBL, and identified group problem activities and collaborative patterns to advance an understanding of the group problem-solving process and to add more knowledge about students’ learning through the collaboration process. The study design was both descriptive and interpretative.

Exploration of the group problem-solving process relied on different data sources

consisting of students' explicit and implicit behaviors. Explicit behaviors included verbal and nonverbal actions: the verbal actions were oral communications taking place between group members; and the nonverbal actions were physical movements and gestures. The implicit behaviors were unobservable cognitive processes related to the intended purposes of the actions directed to problem solving.

### *Data Sources*

Consistent through qualitative methods, the researcher gathered data from multiple sources including (a) participant observation, (b) video recording of team assignments, (c) interviews, and (d) document analysis. The overall organization of the data sources and technique in relation to each research questions is summarized in Table 3-2.

#### *Participant Observations*

During the 16-week course, the researcher visited every class, except for two times that the group under study decided to go to the computer lab to work on their team assignments. The in-class activities included the instructor's lectures, two guest speakers' presentations, group presentations, two exams, and group work time.

For each team assignment, students used some of the in-class time, and scheduled meetings outside the class to complete it. The researcher observed and videotaped every group meeting: Students held four meetings for Team Assignment One, eight meetings for Team Assignment Two, five meetings for Team Assignment Three, and three meetings for Team Assignment Four.

Table 3-2.

*Research Questions, Data Collection Techniques, Data Sources and Analysis Focus*

| Research Question | Technique | Data Sources | Data Content Analysis Focus |
|---|---|---|---|
| 1. What are the activities that students engage in to solve a problem together? | ■ Participant observations<br>■ Videotaped recordings<br>■ Triangulations of<br>o Interviews<br>o Document analyses | ■ Observation notes<br>■ Audio transcriptions of verbal exchanges in the group meetings<br>■ Audio transcriptions of individual interviews | ■ To obtain verbal and nonverbal interaction among group members<br>■ To obtain information on students' thinking and reasoning<br>■ To identify who did what, and what tools/strategies they used<br>■ To delineate a structure pattern of group problem solving process |
| 2. How do students collaborate with one another? | ■ Participant observations<br>■ Videotaped recordings<br>■ Triangulations of<br>o Interviews<br>o Document analyses | ■ Observation notes<br>■ Audio transcriptions of verbal exchanges in the group meetings<br>■ Audio transcriptions of individual interviews | ■ To obtain verbal and nonverbal interaction among group members<br>■ To identify how students engaged in knowledge construction<br>■ To identify opportunities for and obstacles to collaboration |

The participation of the researcher in classroom activities was limited to the role of an observer. At the beginning of the course, the instructor introduced the researcher, and the researcher explained the purpose of the research to students and solicited students' participation in the research. The researcher observed and interacted with students without participating in the activities constituting the core of group membership.

Emerson, Fretz and Shaw (2001) claimed that producing written accounts and descriptions is part of participant observation. In this case, an observation protocol was

developed to guide the process (Appendix A). The observer described the physical environment, and the activities and the interactions among people in the classroom. The in-class observations enabled the researcher to immerse herself in the learning environment, and to record the events taking place in the classroom and the group meetings. By doing this, the researcher picked up contextual data beyond what was recorded on the tapes, which provided a contextual understanding of the students' learning environment. The researcher also recorded her comments on observed events, her analytical insights and questions about the group problem-solving process.

***Video Recordings of Group Meetings***

Video recordings of the group meeting sessions were a primary data source for capturing what was happening during the group problem-solving process. A camcorder was set up to record the conversations and interactions taking place during the group meetings when students worked together on the four team assignments.

The instructor asked the students to work on a series of problems together throughout the semester. This structure provided an opportunity to observe the interactions of the same group over different problem solving episodes and to examine whether the group problem-solving process changed over time and how. However, the researcher used the video data from the group meetings for only the first and second group assignments because, according to interviews with the students at the end of semester, the students all declared that they went through the same group work process with different assignments, which was also consistent with the researcher's observations.

***Interviews***

In order to get a closer look and to accurately describe the context and the

behaviors of the students, the insider's perception of reality about what was happening and why was instrumental (Fetterman, 1998; Bolye, 1994). The researcher conducted interviews with each of the four group members after they completed all four team assignments.

Patton (1990) stated that the purpose of interviewing is "to find out what is in and on someone else's mind." The interviewed aimed to identify the group problem-solving process and underlying cognitive processes from the student's perspective. Moreover, students' descriptions were used to check the consistency of findings generated by the researcher. The researcher used semi-structured interviewing as a key data collection technique. The interviews consisted of some common questions focusing on the students' perceptions of the PBL environment, including the assignments, the group work, the group members, and the instructor, as well as questions to elicit reflections of the group problem solving process (see Appendix B.) However, to engage in a natural dialogue, for each interview, the researcher made adjustments to the sequence of questions, and added more questions to restate, to clarify, and to ask for elaboration based on the students' responses.

***Document Analysis of Handouts and Team Assignments***

Document analysis was an essential part of the process of understanding and contextualizing the phenomenon under study. The data sources for this analysis included the written instructional materials, and students' written work produced for the group problem solving tasks. The analysis included the nature of the document, when it was created and by whom, the purpose of the document and what information it entailed related to group problem-solving processes. It intended to establish an understanding of

the course context and to examine the artifacts produced in the process.

### *Procedures*

Research for this dissertation consists of four main phases: (a) entering the field, (b) collecting data in the field, (c) managing, analyzing and interpreting data, and (d) writing the results. An outline of procedures is diagrammed in Figure 3-2.

With the approval of the Office for Research Protection, the researcher obtained permission from the course instructor to observe the class and recruit participants. The researcher recruited the participants when students formed their groups in the fourth class of the semester. The researcher explained the study purpose and described the tasks that students would be involved in during the semester. The group selected for in-depth study was randomly selected.

The researcher visited every class during the semester. The data collection phase involved the tasks of collecting and reviewing the assignments, observing classroom activities, videotaping problem-solving group meetings, and interviewing students at the end of the semester.

Data were available in different forms: descriptions of in-class and group meeting observations, videotapes of group meetings, digital audio files of interviews, course handouts, and team papers. After the researcher collected data in the field, she reviewed the videotapes. Using the observation notes produced during the participant observations as a starting point, the researcher added more detailed information regarding the activities and interactions among the students recorded on videotapes.

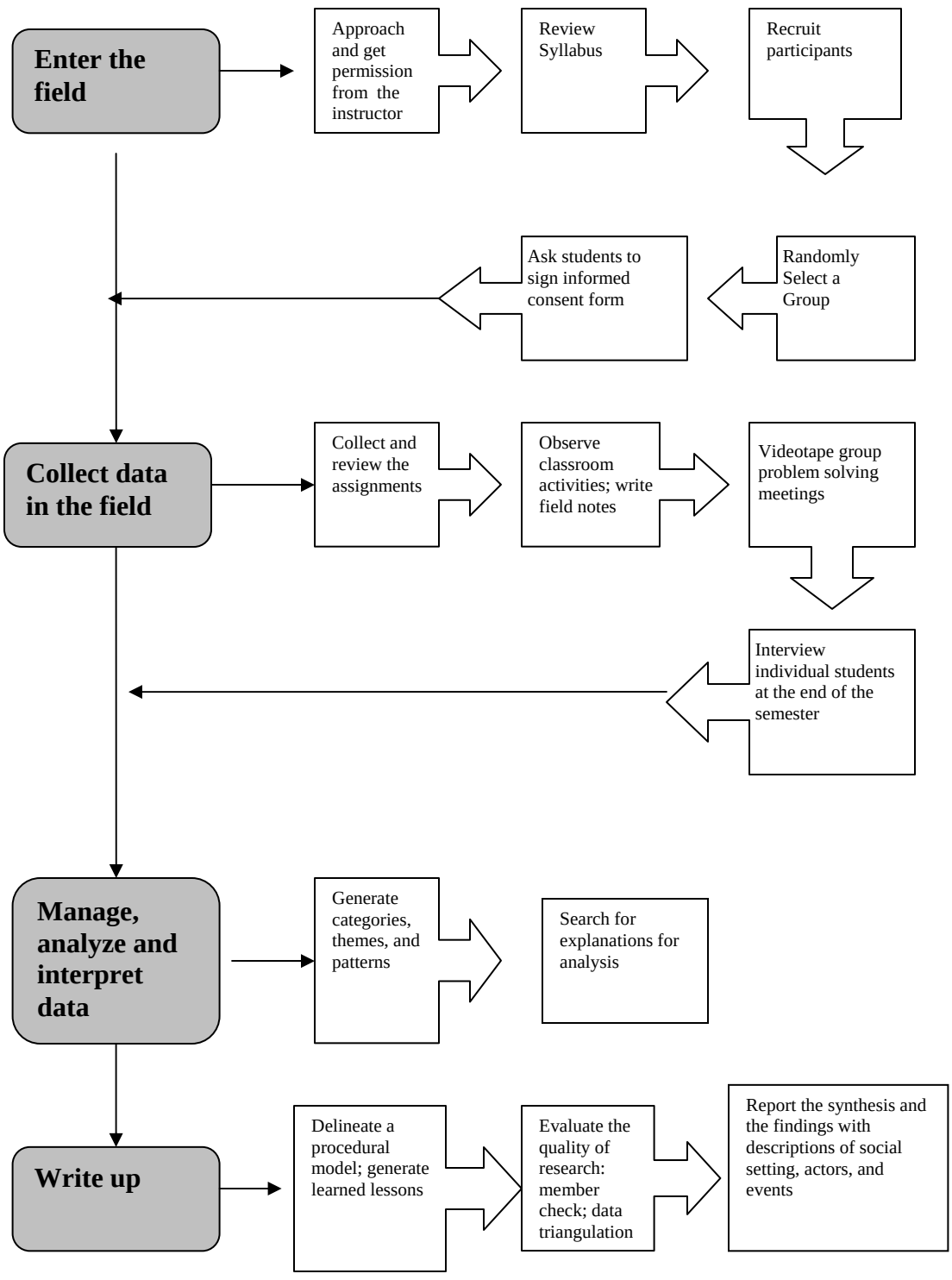


*Figure 3-2* Flowchart of Research Procedures

The researcher also identified episodes in which students engaged in more

discussions to be transcribed for analysis. The interviews were also transcribed to compare against the results of the researcher's analysis of the group problem-solving process, and to augment the understanding of the collaboration among the group members. The observation notes and the transcripts of verbal interactions and interviews were used as the foundation for data analysis (See Table 3-3). The researcher used NVivo, a qualitative data analysis tool, to store, code and retrieve data documents, that is, observation notes and interview transcripts. NVivo was chosen because it integrates codes with the functions of linking, coding and retrieval.

Table 3-3

*Data Sources*

| **Group Meeting Data** | |
|---|---|
| ***Team Assignments*** | ***Time Length*** |
| 1 | 4 meetings – 5 hours 3 min. |
| 2 | 8 meetings – 10 hours 15 min. |
| 3 | 5 meetings – 5 hours 21 min. |
| 4 | 3 meetings – 3 hours 45 min |
| Total | 24 hours 37 min. |
| **Interview Data** | |
| **Students** | **Total Minutes** |
| Andrea | 113 |
| Beth | 81.25 |
| Chris | 56.53 |
| Dong | 67.13 |
| Total | 239.31 |

### *Analysis*

Analysis is a continuous coding process, and coding is an act of conceptualization. According to Morse and Richards (2002), codes are labels and analytical, categorical mechanisms for linking data and ideas. The researcher started the data analysis with microanalysis in the grounded theory methodology, a combination of

open coding and axial coding, to discover categories with their properties and dimensions (Strauss & Corbin, 1998). The analysis began with open coding, a data conceptualization process. The data were broken down into discrete parts through close examination, and each discrete part was given a conceptual label. This coding analysis refined and specified the extant concepts in the literature and aided in identifying concepts that emerged directly from data, searching for similarities among students' behaviors and events in the process to identify specific activities and interactions.

Following open coding was the analysis of axial coding, which aimed to make conceptual connections between a category and its subcategories. Specific to this research, the major task involved in this step was to identify the variety of conditions, students' actions and interactions, and consequences associated with the group problem-solving process and collaboration. During this stage of analysis, the researcher asked questions, such as why, where, when, how, with what results, in order to sort, compare, and contrast the categories until a series of evolving sequences of actions and interactions and their patterns could be identified. The researcher also wrote analytic and self-reflective memos to document the analytical process to make implicit thoughts explicit and expand the data. Table 3-4. describes this two-step analysis process.

***Formation of Categories***

Categories were derived during the analysis of the data from three sources: (a) Some were borrowed from existing theoretical frameworks from problem solving, collaboration and problem-based learning, (b) some emerged from the data, that is, "in vivo", and (c) some were created by the researcher. This formation of categories was developed through a cyclic process. Before collecting and analyzing data, the researcher

initiated this research inquiry with a theoretical framework to identify discernible and discrete categories. During the data collection and analysis, the researcher began forming the categories directly from the data. The researcher also went back to the literature for more categories when the data required further examination. To help delineate a process that portrays a sequence of activities that a group of students performed in order to come up with solutions to the problems, the analysis of the process utilized existing descriptions of the IDEAL problem-solving process proposed by Bransford and Stein (1993), and the prescribed "seven jump" process of PBL at Maastricht (Schmidt, 1983).

Table 3-4

*Data Microanalysis – Excepted from Strauss and Corbin (1998)*

| Open Coding:<br><br>The analytic process through which concepts are identified and their properties and dimensions are discovered in data. | Axial Coding<br><br>The process of relating categories to their subcategories, termed axial because coding occurs around the axis of a category, linking categories at the level of properties and dimensions. |
|---|---|
| ■ Scan and line-by-line: the analyst develops analytic abstractions that are nevertheless grounded on close inspection of the data<br>■ The analytical operations include word-by-word inspection, the generating of theoretical questions and possible answer to them, the use of simulating internal and external comparison, and the exploration of similarities and differences.<br>■ The analyst uses her technical knowledge and theoretical sensitivity, her experiential knowledge and her research knowledge. | ■ A subcategory is also a category. However, rather than standing for the phenomenon itself, subcategories answer questions about the phenomenon such as when, where, why, who, how and with what consequences, thus giving the concept greater explanatory power.<br>■ To code more intensively and concertedly around single categories.<br>■ How to build up a dense texture of relationships around the axis of the category being focused upon:<br>1. Lay out properties of the category<br>2. Hypothesize about and specify varieties of conditions and consequences, interaction, strategies, and consequences that are associated with the appearance of the phenomenon referenced by the category. |

These two process models served as the initial coding categories to segment the observation notes and videos into different activity episodes (see Figure 3-3). During the analysis, based on the specific nature of the problems that students encountered and the

specific form of the solution, the researcher also looked into the group decision-making process model and the writing process to help identify the activities.

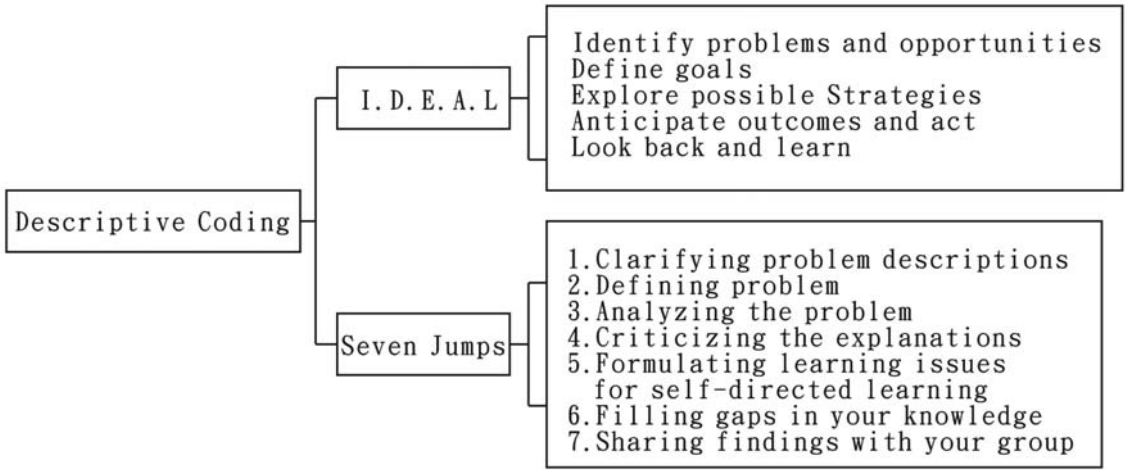


*Figure 3-3* Problem Solving Process Descriptive Coding

On the other hand, to help understand how students collaborated in the group problem-solving process, the researcher aimed (a) to identify how students engaged in knowledge construction, and (b) to identify opportunities for and obstacles to collaboration. Collaboration was analyzed from three aspects: cognitive, communicative, and social. The cognitive analysis focused on the process of knowledge construction. The researcher distinguished three categories of group interaction: planning, negotiation, which was based on the coding scheme developed by Beers et al. (2007), and monitoring/evaluation (See Table 3-5). The categories helped to identify the segments of knowledge construction. Once the segments were identified, the interactions in those segments were further analyzed to discover communicative strategies and tools that students utilized to deliver, to organize and modify the information among each other.

Table 3-5

*Cognitive Coding Categories of Knowledge Construction*

| Category | | Description |
|---|---|---|
| Planning | | An effort to propose further actions |
| Negotiation | Contribution | A new topic of conversation that has not been discussed before is introduced |
| | Verification | Information is directly or indirectly requested about the intended meaning of a contribution or elaboration |
| | Clarification | A reaction to a verification or a perceived lack of understanding, in which the intended meaning of a contribution or elaboration is elucidated |
| | Acceptance | A reaction to a contribution in which the contribution is judged intelligible and/or correct. |
| | Rejection | A reaction to a contribution in which the contribution is judged unintelligible and/or incorrect |
| | Agreement | A reaction to a contribution in which the sender voices his/her agreement with the contribution |
| | Disagreement | A reaction to a contribution in which the sender voices his/her disagreement with the contribution |
| Monitoring/Evaluation | | An effort to reflect on past, current and future actions |

Also, the researcher examined the social aspect to better understand the group dynamics in terms of the group's shared goals, individual group member's roles and responsibilities, and individual group member's characteristics. Johnson, Johnson and their colleagues (Johnson & Johnson 1991; Johnson, Johnson, & Smith, 1991) identified five essential elements for successful cooperative leaning: (a) positive interdependence, (b) face-to-face promotive interaction, (c) individual accountability, (d) social skills, and (e) group processing. Those five elements functioned as the analytical framework to evaluate the group interaction from the social aspect in order to identify opportunities for and obstacles to collaborate

## Quality of Research

In quantitative research, reliability, validity, generalizability and objectivity are the criteria to judge the quality of the research. For judgment criteria in this qualitative

study, the researcher followed the principles proposed by Rossman and Rallis (1998):

1. The truth value of the research: to judge the truth value depends on how adequately multiple understandings are presented and whether they ring true, that is, have face validity. Three strategies were employed to obtain this truthfulness: (a) gathering data over a period of time or intensively rather than in a one-time-only manner, (b) triangulating, that is, to draw from several data sources, methods, and theories to strengthen the robustness of the analysis work , and (c) contextualizing the findings to the specific setting and participants, that is, the conclusions are bounded by time and space.
2. The rigor of the research: being replicable is one of the criteria to judge quantitative research. In qualitative research, the thinking process of the researcher is paramount. The researcher kept asking herself questions, such as: Was the study well conceived and conducted? Are the decisions clear? Was sufficient evidence gathered and presented? Was the researcher rigorous in searching for alternative explanations for what was learned? Are different interpretations put forward and assessed?
3. The significance of the research, that is, its applicability to other situations. The research should establish the usefulness of a study and provide a thorough description of its theoretical and methodological orientations (Rossman & Rallis, 1998).

***Triangulation***

Triangulation is a tool to support the researcher's construction. It is a process by which the researcher can guard against the accusation that a study's findings are simply an artifact of a single method, a single source, or a single investigator's biases. The function of triangulation is to locate and reveal the understanding of the object under

investigation from “different aspects of empirical reality” (Denzin, 1978). Denzin (1978) has identified four basic types of triangulation:

1. Data triangulation: Checking out the consistency of different data sources. The research compared observational data with the interview data to ensure data triangulation, that is, comparing and cross-checking the consistency of information derived at different times and by different means within qualitative methods. However, such comparison does not always mean to find the consistency. Instead, the comparison sometimes helps to study and to understand when and why there are differences.
2. Theory triangulation: The researcher examined the data from the perspectives from the perspectives of different group members, and looked into multiple theories to interpret the data.
3. Methodological triangulation: It is the application of two or more research methods in a single study. Often it refers to the combination of quantitative and qualitative methods. The researcher only examined the consistency of the data generated by observation notes and videotaping of group meetings.
4. Investigator triangulation: The researcher did not use several different researchers or evaluators to review the findings in order to reduce potential bias.

***Thick Descriptions with Analytical Inquiry***

The issues for qualitative research are more about transferability, faithfulness, and dependability than reliability and validity. The researcher engaged in giving thick descriptions so that readers are able to make decisions to see whether the results of the

inquiry are transferable. The conceptual analysis was derived from the data and was checked against the consistency of different data sources. Moreover, because meaning in communication depends on knowing the relevant context, and contexts are consciously designed to evoke multiple meanings (Dye, 1998), the researcher provided comprehensive descriptions of the context.

With trustworthiness, the researcher poses questions about neutrality: How can one establish the degree to which the findings of an inquiry are determined by the participants and conditions of the inquiry and not by the biases, motivations, interests, or perspectives of the inquirer? (Lincoln & Guba, 1985) Trustworthiness does not mean that there must be exclusion of presuppositions. Rather, the researcher did recognize her thoughts as an inalienable factor that guided her interpretation. The recognition of the inevitability of subjectivity also yielded the process of triangulation, which utilized multiple sources, methods, and theories (Creswell, 1998, Lincoln & Guba, 1985; Patton, 1990) to ensure the credibility of the research.

# Chapter 4

## RESULTS AND DISCUSSION

This study examined students' collaborative problem-solving process in a problem-based learning environment where students worked in small groups on international logistics problems. Specific to the participants in this study, whose names have been changed to protect their identity, the analysis produced a delineation of a process consisting of a sequence of activities that a group of four students performed in order to come up with solutions to the problems. The analysis also resulted in findings related to collaborative patterns and issues within the physical and social context in this particular PBL course.

This chapter presents the results and discussion of those findings from the analysis of field notes, videotapes of group meetings, and interviews of each individual student.

### Collaborative Problem Solving Process

Four phases of the collaborative problem-solving process were identified in this study: understanding the team assignment, forming a plan, conducting individual research, and producing the final solution (see Figure 4-1). In each phase, students engaged in different activities, each of which was directed to fulfill a certain objective. Students worked through those phases, but not in a linear step-by-step process; they also cycled back to earlier phases as needed. For example, while they were writing the paper, that is, producing the final solution, the students went back to clarify their understanding of the team assignment, then identified a new topic for further research, and finally made changes to their paper with the new information. In other words, the overall collaborative

problem-solving process is more recursive than sequential.

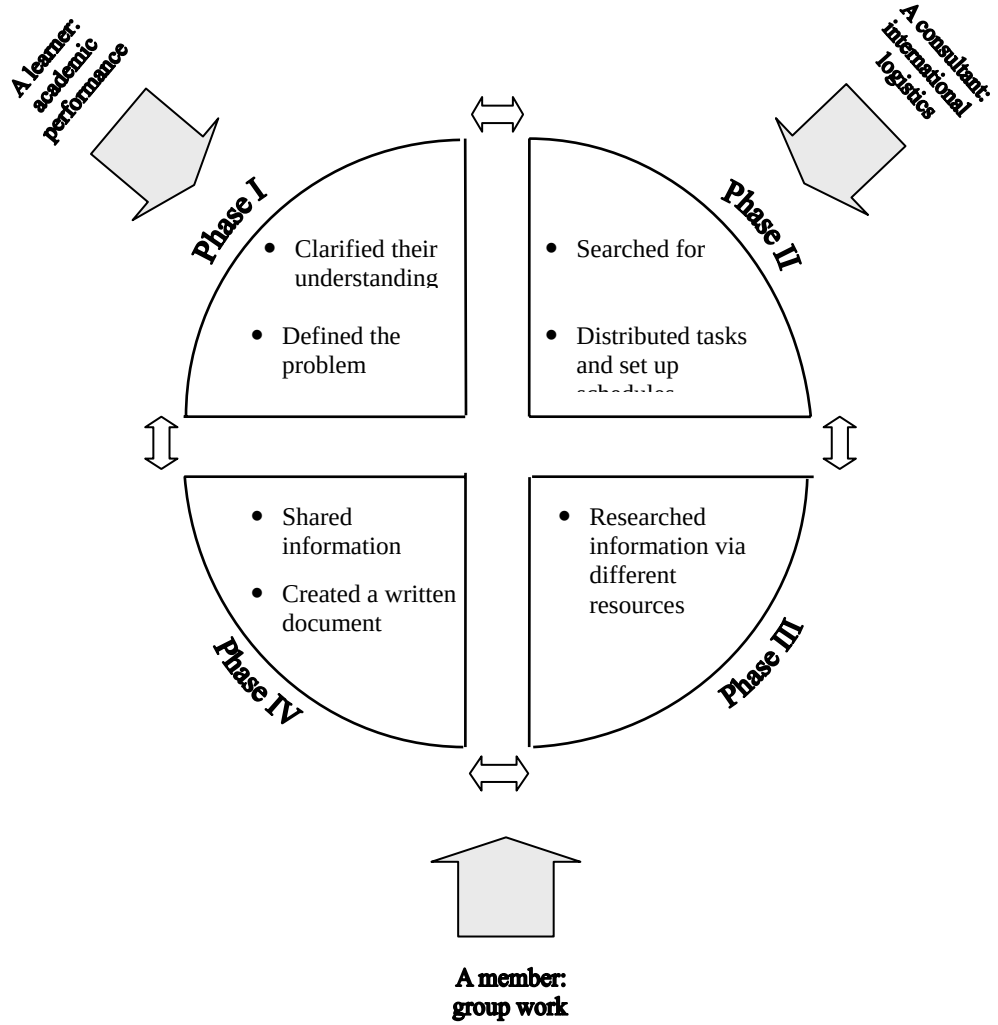


*Figure 4-1* Collaborative Problem-Solving

### *Phase One: Understanding the Team Assignment*

After students were presented with a team assignment, they read the descriptions and the grading rubrics in order to figure out what the assignment was all about. Students started the group problem-solving process trying to understand the team assignment —

they clarified their understanding and defined the problem.

**Clarifying their understanding**

While reading the handouts, students asked and answered one another's questions to clarify their understanding of the assignment. They shared with each other what they understood as well as what they did not understand related to the assignments. Sometimes they were able to answer the questions directly from the information from the assignment handouts to clarify any confusion, sometimes they had to negotiate their understanding, and sometimes they sought clarification from the instructor.

For example, it was clear to them that they had to develop an export plan for the first assignment, but Chris was not sure for whom they should make the plan. After Beth and Dong gave different responses, they sought the instructor's explanation, and came to an agreement.

**Defining the problem**

In the process of clarifying their understanding of the assignment, students were also searching for the goal that they should be pursuing. But, how they defined the problem affected how they set the goal.

One of the two basic elements in PBL is "the analysis of authentic problems in a professional context as a starting point for learning" (Ronteltap and Eurelings, 2002). Hmelo and Evensen's statements (2000) about the function of problems in the PBL approach — that "problems … trigger the cognitive processes of accessing prior knowledge, establishing information into knowledge that both fits into and shapes new mental models" (p. 6) — echoes Piaget's concept of equilibration, a dynamic process of cognitive development. Underlying the concept are the assumptions that cognitive

structures generate new possibilities when disturbed, and subsequent reflection brings about a structural change.

Thus, students in this PBL course were asked to act as consulting experts to provide advice on the export plan, the import plan, the selection of transportation modes and the selection of the assembly site. They were expected to identify different learning issues related to international logistics by examining the contextualized situations of problems that a company was facing. The problems were situated and represented in a way so that they could present the same types of cognitive challenges as those in the real world (Jonassesn, 1999) and they could be interesting and relevant to students so that they could engage in solving the problems.

For example, in Team Assignment Two, students were instructed to develop a sourcing and import strategy for a company. Students were expected to view this assignment as a strategic planning problem, so they could learn about the elements involved in making international sourcing decisions, and the procedures and documents entailed in the import process.

However, instead of simply framing the team assignment as an international logistic decision-making problem, students identified the problem from three dimensions: academic performance, international/global supply chain management case, and group work.

*Academic Performance Problem*

After students received the assignment, they focused on what the instructor expected them to do with the team assignment first. Dong recognized that in order to perform the project, they had to ask what it was the company needed to accomplish.

However, the group always looked at the assignment from the instructor's viewpoint because of concerns about their grade:

> But I think with every group project there is always that: Well what does *the instructor* want. Because in the end it's a class and everyone wants to do well and do well on the project.

Andrea clearly stated her awareness of the influence of the academic goal on her participation in the group:

> [I]f you're in a group you think to yourself, how can we get an "A" on this project. So when you are in your group meeting you are just thinking how can I get all of the information into a paper so that we can get an "A" on this paper?

To students, how to complete the team assignment to meet the instructor's expectations was a main focus of the problem. Defining the problem from an academic performance dimension, students always first asked: "What should we do for this assignment?" They next looked for the components of the final product, and the grading criteria associated with the final component, to guide their subsequent actions in order to produce what the assignment required them to do.

Bransford (1993) claimed that different goals reflect differences in how people understand a problem. Goals are the driving forces that direct people's behaviors and activities. Different goals can lead people to explore different strategies for solving problems.

In PBL, students were expected to identify gaps in their understanding and to set goals for learning (Hmelo & Coté, 1996). However, the group under study focused more on a performance goal instead of learning goal. Dweck and Leggett (1988) identified two

types of achievement goals: performance-goal oriented and learning-goal oriented. They examined the effects of these two types of goals on students' cognitive, affective, and behavioral patterns. Students with performance-goal orientation are more concerned with "gaining favorable judgment of their competence" (p. 256), and students with learning-goal orientation are more concerned with "increasing their competence" (p. 256). As a group, students were more oriented toward a performance goal. The outcome became a major source of information for students to measure their ability to bring contribution to the group. They primarily focused on the instructor's expectations for the final outcome.

***International/Global Supply Chain Management Case Problem***

The group was also required to play the role of an international logistics expert. For example, in Team Assignment Two, students were asked to provide consultation on the procurement plan. It required students to choose one of two possible sourcing options. In the process of making the decision, students went through the following tasks:

1. They examined the assumptions about the company provided to them, that is, the location of the manufacturer, the utilization of a customs broker house, the option of two qualified suppliers, the same unit cost for both suppliers, and the existing conditions for each supplier — a JIT environment with four-week lead time for one, and the imposition of a 25% duty for the other.
2. They researched information regarding the importing process, customs regulations, documentation, duty, mode of transportation, and cost.
3. They looked into the course of actions for each of the recommended sourcing strategies in the process, predicted the outcomes, and made assumptions regarding the company to justify their choices. In this case, the group made assumptions regarding

the drawback, the Incoterms for both options, the modes of transportation for both options, and the market demand.

4. They evaluated the probable consequences of the alternatives in terms of costs, benefits, and risks due to the constraints of the situation.
5. They compared pros and cons of each option and made the decision of their choice with rationales.

In this process, students did not explicitly identify the nature of the problem as a decision-making problem. Because they were provided with two options, students immediately were drawn to project the outcomes for each sourcing solution, to evaluate the solutions, and to support their decision.

Andrea talked about how the group worked toward putting information together with the emphasis on the justification:

> If you were exporting somewhere you had to be explaining why you were exporting, justifying your reasons to export to somewhere and whatever decisions you were making.

PBL, an approach that emphasizes case-based instruction, was pioneered and widely used in medical education. One of the goals in medical education is to facilitate the development of clinical-reasoning skills (Hmelo, 1998), in which students identify the cause of the disease and prescribe a solution to treat the disease. The Association of American Medical Colleges (AAMC) developed medical school objectives, and pointed out that a student must demonstrate “an understanding of the power of the scientific method in establishing the causation of disease and efficacy of traditional and non-traditional therapies.” (p. 5)

Thus, students in medical education focus more on the generation of the alternative causes, and the identification of the medical conditions. Once they conclude the diagnosis, the treatment can be easily derived as a solution to the clinical problem. The diagnosis-solution problem has finite faults and outcomes (Jonassen, 2000).

Although problem-solving skills are desirable learning outcomes across disciplines, students in business education face different types of problems from those in medical education. Wharton, one of the most prestigious business schools in the United States, states (University of Pennsylvania, 2007):

> [T]he school gives you an analytic framework for viewing the world and solving problems — regardless of the industry, career, or country you're in. You'll learn how to analyze your environment; weigh the needs, concerns, and goals of all the parties involved; think of creative, effective, and efficient solutions; and map out the best ways to implement strategy.

Different from concluding diagnostic explanations via hypothesis-driven reasoning in medical problem-based learning programs, students in this business logistics course did not engage much in generating hypotheses regarding the causes of problems, and finding data to support their hypotheses. They engaged more in generating and choosing solutions. They gathered information on the operation components in international logistics, considered alternative solutions based on the analysis of information and assumptions, predicted and evaluated the consequences of different strategies and plans, and finally justified their selection. Their thinking process was more data-driven reasoning — a forwarding reasoning, which starts from available information and uses if-then logic to infer new knowledge or alternatives, choosing an appropriate

model for predicting or analyzing problems (Morton, 1971).

*Group Work Problem*

Learning in PBL involves collaborative learning, "a learning to learn from others, learning to learn with others" (Salomon & Perkins, 1998). Through collaboration, students build knowledge by sharing, negotiating, and evaluating ideas and perspectives among group members. The team assignments in the course under study required students' participation in making efforts to complete the solution together. All four students recognized the group work as part of the requirement for the course.

When asked to explain why she did not go to the instructor for help regarding the conflicts among group, Andrea said she felt that the group process is part of the problem that she should deal with on her own for the course:

> I would have felt like she [the instructor] would have looked at it as, there's lots of different groups and there's lots of different personalities and this should be something that you should be able to work out on your own.

Beth explained the way of learning in the class was set up through the group:

> In the beginning, well, that's the only way we learn in this class 'cause that's how she does the whole class.

When talking about the peer interaction in the course, Chris recognized the group work as a required element:

> [I]n this class you had to meet every day with your group and talk about different issues and then meet outside of class as well to work on another project and different issues with that as well.

Dong commented on how the team assignments helped learning about both the

subject of international logistics as well as how to manage relationships with the group members. She identified “group work” as part of the course setup:

> [W]e are forced to get together, we are forced to look up the information ourselves and it’s a different spin when you have to be able to find it yourself and then you are constantly working with your group about the same information.

Students understood that they had to deal with the diversity of the individual members; they were also aware that the assignment had to be completed with a joint effort. When asked about the group learning process, Chris responded that working in a group really showed him how to work better within a group, and he also emphasized consensus as the learning mechanism in the group process:

> Just making sure that the group was in agreement most of the time on what we had to say in our paper.

Jonassen, Peck, and Wilson (1999) stated that learning communities emerge through “a common cause of mutual support and learning, and by shared values and experiences” (p. 4). Wilson et al. (2004) recognized that a learning community in a course does not spontaneously form; it is a bounded learning community, which can “develop in direct response to guidance provided by instructors and supervisors, supported by a cumulative resource base” (online resource).

The learning community in the context under study was not only bounded by the expectations inducing participation, but also by the timeframe of a course. The students thus found themselves in a situation where they operated under the parameters of a bounded learning environment that Wilson et al. (2004) pointed out: (a) they were required to participate in order to obtain a desired end, (b) the choice of classmates and

instructor was not theirs, (c) they had to commit to a fixed length of time, and (d) an explicit effort to connect with others is expected, e.g., attending meetings and shared information.

Viewing this assignment from the perspective of a group work problem, students focused the solution to the group work more on (a) distributing the tasks, (b) coordinating individual efforts toward achieving a common and explicitly recognized goal (Blau & Scott, 1962), and (c) communicating with each other to achieve consensus.

### *Phase Two: Forming an Action Plan*

Once students defined the problem, they explored possible solutions. Students then examined the constraints and the opportunities, including resources and tools in the learning environment to identify the solution. During inquiry to solution, students formed an action plan to distribute and to coordinate the efforts of gathering and sharing information among the group members.

#### *Searched for the Solution*

Problems in PBL function as stimuli for activating a learner's prior knowledge (Schmidt, 1993) and as an organizer for learning (Savery & Duffy, 1995). Students were expected to view the team assignments as an international/global supply chain management problem, so that they could learn about the components of the international supply chain management system, such as the processes, procedures, and documents entailed in importing, exporting, sourcing, procurement, and logistics management.

In order to solve this problem, students were encouraged (a) to define the problem on the basis of their understanding of the description, (b) to identify the information that they needed to learn about in order to understand the problem and develop the solution,

and (c) to assign the tasks on the basis of the learning issues identified for the next meeting. The process of identifying learning issues was aimed at defining the knowledge gap between the known and unknown to determine what needed to be learned.

However, the observation and interview data indicated that the learning issues were not initially formulated as a result of identifying a knowledge gap. Students took a goal-based approach, a general means-ends strategy because they tackled the task directly from the academic performance angle. They started to identify the components of the final outcome as the goal of the problem and worked "backwards" to the given information.

During group meetings for the Team Assignment One, students submitted their learning issues. The issues consisted of inquiries specific to the company (such as the size of shipment, the product, the value of shipment, the import/export ports), the regulations and documents (such as the export and import regulations, customs, letters of credits), and use of the resources (such as pros and cons of using intermediaries/distributors, financing options). However, those learning issues were not defined as a group decision and were not ones that students took on as an individual task for further research.

Instead, students identified the steps of the export process as the components of their written export plan, and used them as a guideline for the information that they should look for. The steps included the choice of intermediary, export financing decisions, export compliance regulations/import country requirement/custom valuation/tax and tariffs, and County standards.

Students also expressed to the researcher that filling out the matrix was just “busy work”; they did not use those issues to guide their research for the assignment and the

next meeting. As a result, students stopped producing the matrix for the rest of the assignments. Moreover, the instructor had not required it.

Except for the first team assignment, the group identified the research topic by reading what the instructor had laid out for them in both the descriptions of the assignments and the grading rubrics. When asked how they determined the research topics, Dong responded:

> A large part of it was from following her guidelines, but also from paper flow...When we researched those individual areas, I think that's when certain issues came up and that's when we decided should we include this or should we not.

Andrea also explained how they determined the research topics, and how new learning issues emerged from the new information they found besides the main research topics that they identified at the beginning of the project:

> Yeah, it was totally based on whatever she gave us. After we would look at one of her numbered topics and then go … we found the information about the drawback. I think we were going to do that because we felt that that was what she wanted us to do, she wanted us to find the drawback.

***Distributed Tasks and Set Up Schedules***

In terms of how the group worked together to complete the assignment, students took to a divide-and-conquer strategy once they came to an agreement of what components the final outcome should consist of. There were no certain criteria to assign the research topics; students just chose what they wanted. Dong said:

> It was a free for all. However, I think Chris always started off. It's always one person that starts off with what they want to do, and then everyone else just picks up anything else. It's no real process in choosing what we want to do.

At the beginning of each meeting, and the end of each meeting, they discussed what they had worked on and what they needed to work on next. They also checked with everyone's schedule and set up follow-up meetings.

Gick (1986) reviewed research on problem solving strategies. She distinguished general strategies from specific strategies, and pointed out the expert-novice differences in problem solving strategies. The reviewed research indicated that novices applied general search strategies whereas experts used more schema-driven domain-specific strategies. Consistent with Gick (1986), students in the group under study were found to use a general problem solving strategy, a working-backward strategy following a means-ends analysis to reduce the differences between the current and the goal state.

First, students searched for the solution. They identified the main information components in the final outcome that they should produce together for the assignments. They were strategic to figure out what the instructor expected to be included in the final outcome from the descriptions of the assignments, the grading criteria, and discussions with the instructor. Schmidt and colleagues (1993) described that early PBL students relied more on their facilitators for content knowledge and directions.

Once they identified the components that should be included in the solution, the knowledge deficiency (Koschmann et al., 1997) of those components prompted students to engage in information-seeking activities so that they were able to move forward toward the final outcome. Students used a divide-and-conquer strategy. They distributed

the components among the group members, and pieced them together. As a result, an action plan was verbally agreed upon, correlating individual responsibilities for different components and meeting schedules.

***Phase Three: Conducting Research***

In this phase, the students took the learning topics that they chose, and researched information in the textbook, journals, and the Internet.

When the researcher asked her to describe the group work process on the assignment, Andrea replied:

> [W]e would do outside research either finding [information] in the book, looking on the Internet, looking [in] the Journal of Commerce and sometimes we would write up stuff outside of class…

Chris also mentioned research as an individual task:

> [W]hen you're on your own [we are each asked to] do this research, do that research and when we meet again we can bring it all together, and work on the paper.

This research process took place outside the meeting and during the meeting. Students usually took the assigned topics, researched them, wrote down what they had learned about the assigned topics and brought it to the meeting. This observation was consistent with what Andrea explained about the process:

> *Chris* did a lot of writing and he would bring it already on a Word document. But sometimes I would have the research already done so when I got there I would just type up my own paragraph and it would depend on what it was. For one of the assignments, I know I was specifically assigned to look up the HTS schedules.

> So on my own I found that schedule on the Internet and I wrote up a paragraph about that and then I brought that to the meeting.

However, in this self-directed learning, students did not limit their research to their assigned topics only. They would do research on what they felt necessary. When they came across the other group members' topics, they shared those pieces of information with them, too. Beth said she was trying to do more:

> I would even, if I found research about one of their parts or maps or something like that, I would say, "Oh I found this map or I found this information if you would like to use it." I would try to make it easier on them and be more proactive with what they were doing.

The pursuit of the learning issues is a powerful learning mechanism in PBL. Hmelo and Lin (2000) summarized the self-directed learning activities that students are usually prompted or encouraged to carry out in a PBL environment: (a) assessing knowledge relative to problems being faced, (b) formulating learning issues, (c) developing and implementing plans to address learning issues, (d) using new knowledge in problem solving, and (e) evaluating whether the goals are met and deciding whether to formulate more learning issues. The phase of conducting research produced content knowledge that served as a basis for students' discussions for their collective solution. However, how each individual student managed to plan and carry out his or her own self-directed learning was not observed in this research.

### *Phase Four: Producing the Final Solution*

The final outcomes for all four team assignments were written documents, the concrete objects on which the students' shared task centered. Writing activities became

the core of this production phase. Andrea talked about how they put the information together from their research to produce a paper:

> (I)t was a matter of taking all the pieces of research, putting them into a Word document. They didn't make sense at that point, so it took a lot of discussing and group work and going over all these pieces of information to get it to look like a unified thought process.

***Sharing Information***

The research process was a pre-writing stage for students to gather information that could be put into to the final paper. After students researched the assigned topics, they came to the meeting with their own paragraph(s): Sometimes they put them on a disc; sometimes they had sent it out to the group via email before the meeting; sometimes they wrote them during the meetings. Information sharing was the beginning of the production of a collective work that represented the solution. The production consisted of three major tasks: drafting, revising, and editing.

***Drafting***

When the group came together, they created their first draft by merging individual information into a single document, that is, copying and pasting all the individual work into a Word document. Andrea described the process:

> We always started with one version and we would take the pieces and add it to the main version. At the end of every group we always made sure we had one document saved with all the stuff that we had worked on.

***Revising and Editing***

Once a draft was created, the group members usually sat in front of the computer

together, and started to revise and edit the draft. Andrea always took control of the keyboard. Andrea often read the sentences aloud and elicited feedback from the group. But sometimes the group members read the paper silently until someone offered input and sought agreement from the others. The revising and editing process engaged students in elaborating, evaluating, generating, and organizing the content. With these discussions as starting points, students made decisions to research more topics (a) when one asked for clarification of a concept or term, e.g., *drawback*, *supply chain management*, and *just in time*, but no one could really provide it, and (b) when students found new, relevant and important topics, e.g., *letters of credit* and *packaging*, which the group members agreed to elaborate on.

When asked how the group made the decisions on revising and editing the information, Dong replied:

> A large part of it was from following [the instructor's] guidelines, but also from paper flow. If we read through it and that part had nothing to do with this part, or it didn't apply, then we would just take it out, and even so we would discuss it and it wasn't extensive discussion. But it was like, "Do you like that?" "Well, no, not really." "Oh, take it out." "Are you sure? Do you want to take it out?" "You can take it out if you want." "OK, we'll take it out."

Dong also explained why group members focused on the structural elements of the paper rather than on the content and ideas:

> Once we get down to details, no one really understands what each other's parts are, and if this information is correct or not. So we can't really sit there and edit content, or ideas. But a lot of times when we are sitting down, it's [about] does it

flow well, does it include everything that we are supposed to include, is it good grammar, are there spelling errors? Just basic grammatical English stuff.

Some efforts to integrate ideas were made in selecting and sequencing information and in transitioning from one topic to another. For example, for the export plan, Beth proposed to add material on the impact of 9/11 to the paper. The discussion focused primarily on where the information should be put, and it consequently led to some interpretations of how and when those ideas were relevant:

Andrea: Put the stuff about 9/11 … like where do you want to? I'm not sure where that is going to fit in. But I think we should mention it but I don't really know where.

Beth: We talk about, um, transportation…

Andrea: Like regulations? [Can we do that] section because regulations have changed because of it. But I don't know of any specifically that have changed because of it.

Beth: If we go into a section where it talks about our intermediaries and how we're going to use ocean for it if we decide to do that as one of our options, there have been issues with containers. Like they do container searches now, um, because of 9/11. Before it was just kind of like you had to know what's in it, you know.

Andrea: OK, we could stick it in there. And then the rest of the stuff probably has to go like right on the main copy, like the little paragraph we just need to stick in there somewhere about the Journal of Commerce, and

> then we need to go over that one and make sure it sounds like one person wrote it and then make sure the citations are on that copy, too.

Overall, these activities focused on integration of the content as well as reaching consensus as to (a) what information should be added or deleted, (b) how the paper should be organized, and (c) transitions. The group members also spent time ensuring that the tone and the style were consistent from start to finish, and that spelling, grammar, and formats were correct.

***Finalization***

The group made the decision when to stop the revision process. Usually in the last meeting, students would come into an agreement about the final draft. They used the assignment descriptions and grading rubrics as the mechanism to check whether they had completed everything. To illustrate, Andrea mentioned that the group stopped revising "once we felt we had met all the criteria."

The papers were not only the outcomes of the group problem-solving process, the concrete representations of students' collective knowledge, but also the artifacts that mediate thoughts and behaviors. The goal of writing papers was to deliver the solution that the students came up with, but at the same time, writing became a tool that directed students' collaborative efforts in information sharing, negotiation and knowledge construction.

In sum, students went through a problem-solving process similar to what the literature describes: They clarified the problem descriptions, defined and analyzed the problem, explored strategies for solutions, formulated different topics for research, researched information individually, shared and negotiated information with group

members, and finally developed the solution. However, students engaged in the activities with different goals and motives because they played three different roles: a learner focusing on academic performance, a consultant providing service in international logistics in a practice case problem, and a member expected to participate in group work.

The examination explicated the roles of students as problem solvers, but they used only general strategies. They did not employ reflective thinking to monitor or regulate their learning. As the analysis showed, students focused more on the quest for information, such as facts, figures, policies and procedures, and the pros-and-cons argumentation mechanism, than on the conceptual framework of the international logistics process. Moreover, as problem solvers in business education, students focused on problems oriented more toward generating and selecting solutions than toward identifying underlying causes of the problems. The students employed more data-driven reasoning to identify and analyze the contextual factors.

## Patterns and Issues in Collaboration

Different from a traditional classroom, an instructor in a PBL environment is no longer the sole, authoritative source of information and knowledge. Students in PBL are empowered to take a responsible role for their learning. They have to take the initiative to inquire and learn. The instructional principles of PBL have been based on the assumption that learners are constructors of their own meaning. Students are expected to become responsible members of a learning community through active participation to pursue a solution together to a given problem in the PBL process.

The underlying learning mechanism of PBL is the socio-cultural conception of learning as a collective, participatory process of active construction (Salomon & Perkins,

1998). From a Vygotskian perspective of learning as a social-cultural process (1978), human development and learning occur through interactions with the environment and the others in it. Students in this course-based learning community were expected to be interdependent on one another to solve the problem, to engage in active knowledge building by sharing, constructing, and negotiating information and ideas, and to take control of their own learning. The following section analyzes the data according to these theoretical assumptions, highlighting the following facets: (a) group membership and identity, (b) cognitive and group conflict, and (c) affordances and constraints.

### *Group Membership and Identity*

In this bounded learning community, the familiarity of group dynamics was part of the learning objectives. Students were asked to take turns to play a role as a discussion leader, a reporter, a recorder, and a member. The discussion leader was asked to keep discussion on track and ensure everyone has a chance to speak. The recorder was asked to record information during the meeting, the reporter was asked to present the results/conclusion in class, and the member was asked to participate in discussions. Students were expected to "make a conscious, continued effort to coordinate their language and activity with respect to shared knowledge" (Roschelle & Teasley, 1995, p. 94).

Although students put down different assigned roles on their papers for each team assignment, the interactions among students at the group meetings were not governed by their particular assigned roles. Instead, the roles of group members emerged from the interaction (Wilson & Ryder, 1996).

Chris commented that the assigned roles had no effect on the interaction among

group members:

> I know that we had four different roles assigned for the group. But it seemed, even though we had different roles assigned each time, that everyone still did what they were doing the first time.

Andrea explained that as long as the group completed the work, she did not find it necessary to have different roles in a group. She also recognized that the personalities of the group members impacted how the group worked:

> I don't think we could have possibly had group roles in this group. … I couldn't' see *Beth* letting us be one of the official group leaders. … But I don't think you have to have roles in a group. I think we got the work done. I don't think it [group roles] necessarily works out well.

Dong had the same view regarding the impact of the group members' personalities:

> I'm aware of what I'm doing with this group. I felt that I didn't have as large of a part as I might have with other groups. But there were four really strong personalities, and I just didn't want to add to that and end up causing a fire where there didn't need to be one.

When the researcher asked her about whether she was comfortable with learning from other group members, Dong said that the social dynamics varied from group to group, and the dynamics impacted how group members interacted with one another in expressing their ideas:

> For one of my other classes, our group would actually meet and go out on a social level, but with this group it's not very social at all. … With my social group it was

> more. You put your foot down and then they sit there and you are being stupid and they say, "Well, you are being stupid [and] we don't agree with that." There's no inhibition to actually speak what you are really thinking. … But I think more with our group I was, not afraid, but more I didn't want to cause any [conflict] by putting out an idea and really fighting for my ideas.

Beth, who had been somewhat disregarded by the other group members, seemed to think whoever dominated the writing had a role in the group:

> I didn't have much of a role; it was just to get the information and give it to the people who did have a role. Dong didn't really have a role and I didn't really. Andrea's specific role was put the paper together; Chris's was to take it apart.

She also withdrew herself from this group work process:

> [B]ecause everyone was fighting to be in the spotlight and [it] had to be done their way, I just didn't want to be part of it anymore. I don't want to argue between them.

Being in a group had provided students with an opportunity to examine the problems from different perspectives, and to elaborate their own understanding to other group members. Students also said that they learned from the other group members. However, the analysis of the observations and the interviews indicated that domination of students' leadership as well as exclusion from the group created a dynamic that discouraged some students from sharing, communicating and negotiating ideas. Roschelle and Teasley (1995) stated that "collaboration does not just happen because individuals are co-present; individuals must make a conscious, continued effort to coordinate their language and activity with respect to shared knowledge" (p. 94). How

the students perceived their roles in the group and their relationship among the group members influenced their participation in the group.

In the course at the basis of this study, different procedures were implemented to ensure students' efforts to participate in group work. At the start of the course, the problem-based learning process and the importance of team work and group dynamics were explained. Also, peer evaluation was included as part of the final grade and peer evaluation rubrics were presented in order to motivate students to take responsibilities in the collaborative process.

Tuckman (1965) proposed a four-stage team development process model: forming, storming, norming, and performing. His model suggested a developmental sequence: A team would start a stage of "orientation, testing and dependence," pass through a stage of "conflict and polarization of interpersonal issues," reach a stage of "in-group feeling and cohesiveness," and finally function as a supportive team on task performance.

The group under study went through a similar process; however, Tuckman's model is linear and successive, which did not fit well with what actually took place in the group. The cyclical model that Bales (1965) proposed suggested that the group process moves between norming and performing as a result of seeking a balance between two different goals, that is, accomplishing tasks and building interpersonal relationships. At the beginning, they tested one another's capabilities. Chris characterized the testing period as identifying the boundaries of both interpersonal and task behaviors at the outset. He said:

> [N]o one really knew one another and we were just starting to explore everyone's capabilities within the group and see who could do what and how reliable they were.

When the group members worked together on the tasks, they started to run into conflicts, in which group members struggled with different ideas and different personalities. In this time-dependent and goal-directed PBL environment, the group had to focus more on completing tasks. Dong was aware of the conflict among the group members, but decided to step back to reduce the conflict:

> So with this group, if I put out an idea and they [didn't] agree, they would sit there and say, "I don't agree, *Dong*, that doesn't make sense." … Then they will give their points, but I think more with our group I was, not afraid, but more I didn't want to cause any issues by putting out an idea and really fighting for my ideas.

The reality was that a hierarchical structure of responsibilities or authorities did not exist as it would in a work place. Moreover, the group interaction never took place in a vacuum. Students came to the group with different values, different personalities, and different knowledge and skill sets. The extent to which each individual student sustained her or his accountability and participation was greatly governed by how each perceived and located her or his own role, identity and personality among the others in this particular group.

### *Cognitive and Group Conflict*

Social negotiation of meaning is an important part of the problem-solving group structure; students' understanding of the content is constantly challenged and tested by

others (Savery & Duffy, 1995). In Piaget's concept of "equilibration" (1985), the cognitive conflict between the learner's existing knowledge and new information will result in assimilation and accommodation to generate possible new structures. The different perspectives among the group members in PBL are considered to be a powerful learning mechanism to extend students' understanding of new information.

Johnson and Johnson (1995) classified four different conflicts in schools: (a) controversy, an interpersonal disagreement on ideas, information, theories, and opinions (b) conceptual conflict, a cognitive conflict within an individual when facing ideas that are incompatible with the ideas that the individual originally has, (c) conflict of interests, an interpersonal conflict on personal goals, and (d) development conflicts, an individual conflict in a developmental process between adult and child activities. To them, two sources of interpersonal conflict are controversy and interest. Johnson, Johnson and Smith (1996) acknowledged that one of the most powerful instructional procedures available to college faculty is arousing intellectual conflict. Intellectual conflict occurs in controversy, "when one student's ideas, information, conclusions, theories, or opinions are incompatible with those of another" (Johnson, Johnson, & Smith, 1996).

In a PBL environment, students are expected to engage in a constructive process of conceptual understanding of the problem context and solutions to "equilibrate" the controversy, a process similar to "constructive controversy," in which students seek new knowledge and accommodate others' perspectives (Johnson, Johnson, & Smith, 2000).

Based on observations of the group work process in this study, controversy was apparent in (a) the determination of a solution to the problem, and (b) decisions to include and delete information.

***Solution to the Problem***

Differences emerged among the group members when the group engaged in making decisions on the solution, including the organization framework, specific selections of different options, and the argumentation to support their solution.

For instance, Andrea recalled the conflict when the group discussed how to frame certain aspects of the export plan in the first assignment:

> That was where we started running into problems right in the beginning because I think *Chris, Dong* and I we really wanted to follow that [supply chain] model. It was one of the first pages in that export chapter … and that was kind of the idea of the supply chain. You needed to do each one of those steps. But there was another section in the document where [the instructor] listed learning objectives. And *Beth* really wanted to set up our whole document based on learning objectives. But I don't know. Those learning objectives needed to be somewhere in your paper, but I think you needed to set it up following that supply chain.

***Inclusion and deletion of information***

Observations pointed to conflicts around the depth, breadth, and clarity of information, such as word choice and format. For example, for the second team assignment, students had different ideas about how much detail they needed to put into the paper regarding the port of entry. Andrea recalled a conflict with Beth's position:

> [S]he was so concerned about actual airlines I think she was actually trying to call that airport to find if she could [get] a flight directly from Belgium to Virginia Beach, and I didn't feel like we needed to go into that much detail on our paper. That particular paper had a ten-page limit, and we were already around ten or

> eleven pages, and I just didn't think that we needed to get that detailed. I don't think that *the instructor* was looking for something [so] detailed that we needed an actual flight schedule. I think she just wanted to know the name of the airport, how it was going to leave their customs exit, and we had that information. I think we just needed the name of the two local airports, really.

Chris also explained how the decisions were made about whether certain information should stay in the paper:

> [S]hould we leave this in or should we take it out, and most of the time people, we would kind of not vote, but we would be like three against one or two against two and we would decide. But sometimes … we really wouldn't care if the sentence was in there or not and then say, "I don't care, do what you want, keep it in if you want to or take it out if you want." So sometimes it was a group decision and other times it was an individual decision.

Hausman, Chi, and Roy (2004) identified three potential mechanisms responsible for learning during collaboration based on prior research: (a) other-directed learning, in which "one peer instructs or explains to another partner how to solve a problem;" (p. 547) (b) co-construction, a joint construction of knowledge with elaboration or critical evaluation of the other members' contribution; (c) self-directed learning, in which a student "talks out loud while solving a problem while her partner listens." (p. 547)

In this study, after students came to a consensus on decisions that identified the solution, the selections of options and argumentation as well as the amount of information, they usually agreed with the content that the members provided because students relied on the group members' research and knowledge of their assigned subject

matters. Students seldom elaborated on or critically evaluated other members' contributions; however, students got more opportunities to explain what they found out. Also, instead of talking aloud, students wrote paragraph(s) to present the information that they researched. The group members commented that reading what the other group members wrote was part of their learning process during collaboration.

In terms of conflict resolution, the following observations were made:

- Students frequently went back to check against the grading rubrics and assignment descriptions. When discussing how the decision was made when there were different opinions, Beth asserted what the researcher had observed:

  It's … whatever *the professor* indicates should be our main focus. That would be what we [would] choose, but we [would] choose it in the first meeting and then we each split up and … find supporting evidence for that.

- Students presented their opinions and asked for approval, typically through a form of majority rule. Andrea described her view of this process:

  [W]hen you want to make a change and there are four people working on it, you can ask for your change. But if the other three people don't want to put it in there, I don't think that you can really fight for it. There were some things that I would see in there that I would think, OK, that's not the way it should be, and I'd mention it. But if somebody was like, "No I think it's fine," I would just — there was no saying I was right either. So if there were three that wanted something and there was one that's not, you might just have to go with what the group wants to do.

- Students sought mediation from the instructor: When the conflicts couldn't be resolved, the group asked for confirmation/clarification from the instructor.
- Persuasion: Students went back to the textbook or sources, and elaborated the information and provided more evidence to support their viewpoints.
- Students Ignored: The emotional impact was too great. Students just avoided the conflict. It was too consuming. They felt that they didn't have time to deal with it. Beth, who had the most conflicts with the group, expressed her frustration:

  I wanted to be a part of this group and it got to the point where, because I didn't have a role, … I was like, you don't need me. I'm just going to hand in my work and I'll leave, I'm not going to argue, I'm not going to fight, I'm not going to try to put in my views about the paper or about information because they were like, we don't want to hear it, we're going to finish it, just sit there. So I would just leave.

  There was no sense in me just sitting there watching them type papers.

Another interpersonal conflict that Johnson, Johnson, and Smith (1996) classified is conflict of interest, an interpersonal conflict on personal goals. The conflicts in this study were not due to differences in students' interest to get involved in the group projects; instead, the conflicts took place because everyone wanted to get involved in the process. Everyone wanted to do well, and everyone wanted his or her ideas to be acknowledged and respected.

Andrea made the comparison between one of the groups she worked in during the same semester and the group under study, and pointed out that caring actually was the issue:

> I've never had a group where all four people felt really strongly about what was going into the paper and I think that's where a lot of our problems came from. ... Everybody was concerned about what was going to be in the final projects, and so that was the first time I'd been in a group where all three people cared about what was going on in the final projects.

Dong described a similar feeling:

> I think we were all — we really cared about it and we didn't want to do poorly. But it was just very involved. It was a lot of together time.

Andrea said that because each group member strongly adhered to his or her own opinions, it was extremely difficult for anyone to be led by any other group member:

> I couldn't' see *Beth* letting us be one of the official group leaders. I don't even know if I could have seen myself letting somebody else be the official group leader. I think we all went into it feeling like we could be the group leader, and I think that was part of the problem and that was just our own personalities. I think we were just opinionated about what we wanted in the paper. We were that way about our own writing, and so that made it a little bit more difficult.

It is difficult for students to separate the people from the problem. Dong recognized that she was not able to take an unbiased viewpoint toward another group member's opinion:

> [I]t came to the point that I got so frustrated that I didn't even want to listen any more. Even if what she said made sense and was a great idea, it just came to the point where I was just so fed up…

Construction of collective knowledge does not only involve cognitive integration of different perspectives, but also social cohesion (Van de Bossche, Segers & Kirschner, 2006) and effective communicative structure and strategies (Lowery, 2002; Hmelo-Silver, 2004; Wilson et al., 2004). Van de Bossche, Segers, and Kirschner (2006) employed research in organizational and social psychology, and identified several crucial social aspects that drive team work in a collaborative learning environment: interdependence, cohesion, psychological safety, and group potency. They indicated both task cohesion and social cohesion are critical aspects of group functioning. As the analysis showed, task cohesion was present in this PBL group. Students shared commitment to achieve a goal, and the goal required the collective efforts of the group. However, students seemed to lack emotional bonds among the group members. Moreover, students employed only basic questioning strategies to seek explanations and agreement, such as “What it is?” and “Should we?”

### *Affordance and Constraints*

Students in this PBL environment were put into a consulting agent position to provide plans for exporting and importing as well as suggestions for the transportation mode and the supply chain management strategies. The authentic problem context was developed to help students engage in activities similar to those practiced by international logistics professionals. However, the context for this environment could be characterized more as a “practice community” rather than a “community of practice” (Barab & Duffy, 2000). Although the problem context was authentic, the activities nonetheless took place in a school-based context that maintained different operational mechanisms from a real work community of practice. How students performed the knowledge-building activity

reflected this reality.

Unlike Gibson's (1977) ecological viewpoint on affordances, which claimed that the possibility of interaction is objectively measurable and dependent on the qualities of the physical world and the capabilities of an actor, Norman (1988) defined an affordance as something of both actual and perceived properties. Norman (1988) proposed that affordances are not only dependent on the physical capabilities of an actor, but also on other factors, such as the environment, culture, instinct, and the user's mental model.

Norman (1988) made distinctions among three kinds of behavioral constraints: physical, logical, and cultural to expand the concept of affordance in the context of human-computer interaction. Taking those constraints into consideration for interface design is valuable in guiding user's behaviors. Norman (1999) stated that those constraints are powerful design tools. For example, restricting the cursor to exist only in screen location where its position is meaningful is a physical constraint, and making the fundamental design model visible helps users logically determine what actions are required.

The examination of the collaborative problem-solving process of the group under study revealed the impacts of those constraints on the actions possible in the knowledge building activity.

***Physical Constraints***

Students' collective knowledge base was represented in writing. Several constraints were related to this particular representation:

***Document and facilitation constraints***

Only one person could control the paper at a time with face-to-face negotiation.

Whoever controlled the paper had great impact on the quality of the group interaction. Ultimately, that student needed to be equipped with a facilitator's skills to engage all the members of the group, to take an active listener role, to monitor the negotiation process, and to direct students to justify and reflect on their thinking (Hmelo-Silver, 2004). Andrea, who controlled the writing at meetings in this case, did show some of these qualities. She read aloud to draw other members' attention, and she ask questions to elicit their ideas. However, as a first-time PBL learner and a novice in international logistics, she was not able to facilitate the group as the instructor would have. The sole control of the document also resulted in an unequal participation.

***Artifact production constraints***

Writing as an artifact made students' thinking process more explicit to one another. However, it also controlled the scope of students' discussions. Students directed a lot of their energy on transitions, grammatical corrections, and word choices. Also the page limit prevented them from further exploration and elaboration of ideas.

***Logical Constraints***

There is an assumption that the classroom can function as a knowledge-building community similar to knowledge-building communities in professional practice (Scardamalia & Beriter, 1994). However, in a course-based learning community, the mutual goal for students lies primarily in obtaining good grades, not in optimizing a best plan or suggestions to a client; thus, students stopped refining their knowledge through further argumentation once the final product met the grading criteria. Since their plans or suggestions were applied only to practice problems, and were not implemented in a real world setting with consequences beyond grades, students seemed to be prohibited from

persisting in their ideas when there were conflicts. The lack of the implementation of their solution also took away an opportunity for students to get feedback and modify their solutions.

***Cultural Constraints***

Barr and Tagg (1995) recognized a paradigm shift in American higher education from teaching to learning. A college becomes "an institute that exists to produce learning" instead of to provide instruction. Students' readiness needs to be considered. In PBL, students are not passive information receivers. They are expected to more actively engage in their learning process. In other words, the PBL approach puts the responsibility of learning into the hands of students. Students who are used to structured and sequenced information presentations from an instructor may fail to make progress in learning and the requirements for self-directed learning.

Research on students' perceptions of PBL has reported that students' concerns about PBL include unfamiliarity with PBL formats, dramatic differences between competitive and collaborative learning, demands on time and self learning, and ambiguous learning situations with direct instruction. Kingsland (1996), in his evaluative study of the architecture program at the University of Newcastle, reports students' reactions to the time issue in problem-based learning:

> Architecture 1 students maintain Reflective Design Journals to aid in the development of design and critical analysis skills. Comments in these journals highlight times of high stress due either to the accumulation of assignment or to time management problems.

MacPherson-Coy, Sullivan and Story (2000) listed students' response to a

question: “What did you like least about the PBL program?” Stress over lack of time to complete everything and stress over getting familiarized with the PBL format topped the list of responses. That tendency is similar to what was observed in this study.

All four students commented that this was their first PBL course, and that they were challenged by the large amount of time required to complete the assignments. Students were dependent on each other to complete their assignments. Such interdependence demanded that students spend more time communicating with each other in order to establish a shared understanding of the problems as well as solutions to each assignment.

Wilson et al. (1994) indicated that while parameters in a course-based learning environment are normally thought of as constraints, they also may serve as affordances that enable certain kinds of learning and activities to happen. In this study, because students were not in a real work environment, students were able to make assumptions, share viewpoints, and manipulate contextual variables in the problem case more freely. But, conversely, students were also driven by the assignment and grading rubrics, and hence may not have persisted in developing their ideas as much as they might have in authentic practice.

# Chapter 5

## CONCLUSIONS

College education has undergone a shift from the instructional paradigm to the learning paradigm (Barr & Tagg, 1995; Schuyler, 1997). This shift has refocused education from the production of learning through the provision of instruction and the transfer of knowledge from instructor to students to the creation of a learning environment for students to take the responsibility to discover and construct. Problem-based learning is adapted to face the challenges of such changes. PBL aims to situate students in a context that approaches the authentic, in which students engage in solving realistic, meaningful problems, and in interacting within a learning community to construct knowledge via searching, providing, explaining, proving, justifying, and communicating their ideas to others in the community. This study investigated a PBL group's problem solving process and the collaborative participation of its student members to better understand how they responded to this particular learning environment and to provide ways to support and facilitate learning.

The investigation of the activities that students engaged in to solve a problem together revealed four phases in the group problem-solving process: understanding the team assignment, forming a plan, conducting individual research, and producing the final solution. Students approached the problem-solving process from three different dimensions along with their multiple roles in this PBL environment: a learner, an international logistic consultant, and a group member. The activities they engaged in were governed by the goals and motives derived from each dimension, but were more dominated by the pursuit of academic performance as a learner. Also, students in this

business course engaged more in generating and choosing the solutions to the problem than the hypotheses to the causes of the problems. Moreover, writing took up most of the collaborative efforts because the team papers were chosen to represent the solutions. Writing became a tool for learning, for communication, and for assessment.

The analysis of collaboration among group members indicated that students did not carry out their assigned roles in the meeting. Each of the four group members had a strong personality and each was used to leading and resisted being led. Their perceptions of their group-oriented identities and memberships, that is, their roles and relationships within the group, led them either to exert dominance over the rest of the group members or to limit their participation in the group. Such imbalanced participatory efforts were also caused by students' intentional avoidance of rejection and tension. The analysis also revealed that the pursuit of consensus engendered students' elaboration and justification of their ideas when students held different perspectives. Such a negotiation process was a driving force in this PBL study. Students recognized that they had learned new information from their group members and had extended their understanding of international logistics. However, the group members relied on the information provided by their fellow members responding to assigned topics, so students seldom challenged that knowledge of the subject matter. The cognitive conflicts among students were limited to how to frame the solution to the problem and whether to include or delete specific information.

Moreover, the physical, logical and cultural context of a PBL course as a "practice community" rather than a "community of practice" provided students with the opportunity for concrete, contextually meaningful learning experience. However, it also

imposed constraints on students' learning through collaboration. As discussed above, students spent a lot time writing together. The face-to-face negotiation over a Word document in a lab setting created unequal participation because only one person at a time was able to control the computer. Also, substantial efforts were made to ensure the quality of the mechanical aspects of the writing, and were directed by the grading rubrics. The type of goal oriented toward getting a good grade also undermined the dynamics of group collaboration in learning. Instead of optimizing a best solution to the international logistics problem at hand, students ceased developing and refining ideas once they felt that they had fulfilled what the instructor required them to do. Also, with this course as the first and the only PBL experience that they had, students were overwhelmed with their responsibilities in learning and the amount of the time that they had to commit to the group meetings.

On the basis of this acquired understanding of the group problem solving process and collaboration in a PBL group, the design of PBL should not only focus on the development of an authentic problem context on the subject matter. Because students viewed the assignment as an academic performance problem as well as a group work problem, the PBL designer should also focus on how to design tasks that can engage students more in learning and collaboration. Also, anyone interested in using PBL in their courses could benefit from taking a closer look at knowledge construction in regard to the PBL learning mechanisms: active cognitive construction, social interaction, and contextual affordance. Such a closer look could lead to improved tools to support and promote effective communication, foster positive participation, and develop problem-solving strategies and skills. The tools and support should empower students to engage in

group problem solving more proactively.

## Implications for Enhancing Collaborative Learning

When students defined the problem mainly from an academic assignment dimension, they primarily focused on the instructor's expectations for the final assignment instead of the learning outcomes. Students' collaborative efforts were then directed to the production process instead of the learning and thinking process. Goal orientation is important in problem solving because it guides students' intrinsic motivation in solving problems (Song, 2004). Research on motivation has found that a learning-oriented goal has more positive effects on students' intrinsic motivation and problems-solving skills (Deci & Ryan, 1990; Ames & Archer, 1988; Meece et al., 1988). Considering goal orientation as a static trait, researchers have controlled the situational variables to induce goals and behaviors (Dweck & Leggett, 1988, Song, 2004). Song (2004) generated strategies to manipulate three essential contextual attributes to promote goal orientation: task design, distribution of authority, and evaluation practice. In terms of task design, he proposed to provide variety and diversity in tasks as well as provide tasks with messages that emphasize the intrinsic value of learning.

### *Task Design*

In this particular PBL course, the team papers, as the outcome of group work, enabled students to establish a shared goal because of their concrete structures and forms. Written papers were artifacts to represent a collective understanding, and an instrument to mediate the interaction among the team members. The performance-oriented goal directed the substance of negotiation among the group members to the organization of the components and to the conformation of the standards of writings instead of the

integration of ideas and perspectives related to design and decision-making on the international logistics process. To mediate this focus on task requirements, students should be provided with various and diverse representations of their solutions to the authentic problems in the international logistic field. For example, instead of completing a written presentation, developing a decision-making model can be an alternative task for students to present their analysis of the international logistics system, and to identify the factors that had impact on the decisions and their interrelation. Students also can present their solution in debate format and make all the conflicting viewpoints and the negotiation process transparent. Students can also create a fact sheet consisting of results from the different options, or a FAQ list that the company in the case scenario would need to know regarding the procedures, documentations, and rules from different perspectives to support their argumentations during the debates.

Meece et al. (1988) showed that students oriented toward performance goals report lower levels of cognitive engagement, using only surface cognitive and metacognitive strategies, whereas the students who placed greater emphasis on learning goals report more active cognitive engagement and use deeper cognitive and metacognitive strategies. To help students become more aware of their own learning, students should be encouraged to develop a list of learning objectives themselves as a checklist to monitor and regulate their learning.

Overall, the challenge to the task design of PBL is to provide different ways to represent students' collaborative efforts so that students can engage in meaning making to focus on the learning and thinking process so that they can be transformed into active learners, problem solvers, and effective collaborators.

***Grouping Strategies***

One of the strengths of the collaborative learning in PBL is that the range of students' cognitive capability can be extended with the challenge of different perspectives. It is through explanations, negotiation, and argumentation that students' understanding of the subject matter evolves. To enhance such cognitive construction, the collaborative learning approaches prefer a heterogeneous grouping strategy so that students can mostly benefit by interacting with students with different experiences, interests, and skills (Johnson, Johnson, & Smith, 1996; Slavin, 1990).

Hmelo-Silver (2004) cautioned problem designers to provide a developmentally appropriate, interesting problem for a heterogeneous group of less-skilled students. In this case, the problems were appropriate and interesting for learners. However, when students are less knowledgeable in a certain domain, they lose the power to negotiate -- they only can accept what their group members present them because they do not have sufficient topic knowledge to co-construct their understanding of the full range of issues. This loss of power may lead to a predominance of personality strength in the group learning process, instead of a predominance of mutual learning. Moreover, when a PBL course is isolated in a curriculum, apart from a consistent application of PBL across the curriculum, students may lack prior knowledge and strategies to explore learning issues.

Based on three learning mechanisms during collaboration suggested by Hausman, Chi, and Roy (2004), students need to be exposed more to other members' contributions in order to engage in joint construction of knowledge with elaboration or critical evaluation. Wilson et al. (2004) also identified "mutual appropriation," a process in which the learning community members are both learners and teachers. Drawing from the

work of Brown and Campione (1995) on Fostering Communities of Learners, Wilson et al. (2004) proposed to use a “jigsaw” collaboration activity, where each student specializes in one subtopic, shares his or her knowledge with the group, which then combines the individual pieces of learning to address a complex task or problem.

### *Jigsaw Grouping*

Peer teaching in the jigsaw method may be adapted to engage students to reflect on their understanding of content and foster a sense of interdependence of learning within the group. Two types of teams could be assigned: (a) a problem-solving team, in which students work on the team assignment as a whole, and each student takes responsibility for different topics; and (b) an expert team, which consists of students who investigate the same topic from different problem-solving teams. Within this structure, students would enhance their’ elaboration and critical evaluation of others’ contributions. However, this group structure is applicable only where there is a common core of learning issues that could be identified for each problem. Under the condition where learning issues are not the same across different groups, an expert group can be developed within the same group — that is, two students would take the same learning topics to discuss between them first before they teach what they have learned to the other team members.

Overall, the challenge to the task design of PBL is to provide different ways to represent students’ collaborative efforts so that students can engage in meaning making to focus on the learning and thinking process so that they can be transformed into active learners, problem solvers, and effective collaborators.

## Implications for Scaffolding the PBL Process

To adopt a medical PBL environment to a business education context, we have to acknowledge that different problems require different knowledge and processes to solve them. Jonassen (2000, 2004) identified eleven different types of problems based on their structuredness, complexity, dynamicity, and domain specificity or abstractness. According to this typology (Jonassen et al., 2003), diagnosis-solution problems in medical education usually start with a fault state. It is through the process of data collection, hypothesis generation, and testing that the students focus on a specific problem and suggest a solution. On the other hand, case problems in business are not always clear at the beginning. Students are required to articulate the nature of the problem, to analyze contextual factors from different perspectives, and to argue for and justify their solutions. The hypothetical-deductive reasoning is an appropriate strategy for medical problems (Hmelo-Silver, 2004) whereas the identification and analysis of contextual factors may serve a better strategy for business problems. The design of PBL in business education should be tailored to support the cognitive processes and skills that students need to engage in solving business problems.  Indeed, cognitive skills are context-bound (Brown, Collins, & Duguid, 1989).

### *Question Prompts in Problem Solving Process*

In order to engage students in more aware of their own learning, researchers investigate the effect of different types of questions on students' cognition and metacognition (King, 1991; King & Rosenshine, 1993; Ge & Land, 2004,; Ge, Chen & Davis, 2005, Chen & Bradshaw, 2007). King (1991) provided three categories of questions: planning, monitoring, and evaluation. Those questions are more generic in

helping students to pay attention to their problem solving process, to monitor their progress, and to reflect on their learning. To be more domain-specific and support ill-strucctured problem solving process, Ge and Land (2003) used four different types of question prompts to facilitate students' problem solving: (a) problem representation prompts, (b) solution prompts, (c) justification prompts, and (d) monitoring and evaluation prompts. Taking into consideration the specific type of problem that students face in the course, students should be guided with question prompts regarding designing and decision making. The questions should be developed in order to help students (a) to look into what alternatives they have in making plans and decisions, (b) to identify the perspectives to be considered in finding a solution, (c) to elaborate the contextual factors related to each perspective, (d) to compare and contrast the advantages and disadvantages of each solution, and (e) to justify the selection of a particular solution.

***Communication in Groups***

As Roschelle and Teasley (1995) pointed out, the existence of a group does not ensure the act of collaboration. Collaboration requires a conscious effort. Johnson, Johnson and their colleagues (Johnson & Johnson 1991; Johnson, Johnson, & Smith, 1991) identified social skills as one of five essential elements for successful cooperative leaning. They proposed to teach students social skills to establish mutual knowledge and trust, and communicate effectively with one another. One of the goals in PBL is to help students develop effective collaboration skills (Hmelo & Evensen, 2000; Hemlo-Silver, 2004). Several strategies were provided in the literature: reflecting on group sessions to describe what actions were effective and ineffective (Johnson et al., 1991), the use of an observational and self-report instrument to help focus on group-processing behaviors

(Faidley et al., 2000), assigning cognitive roles (Hmelo-Silver, 2004), and computer-supported collaborative tools for "communicating each person's ideas, structuring group dialogues, and decision making, recording the rationales for choices, and facilitating collective activities" (Dede, 1996, p. 6).

Construction of knowledge was inhibited because of negative reactions to conflict. Students disengaged from the effort once they perceived that their opinions were ignored. Cognitive dissonance among group members can help stimulate learning only when students perceive that their ideas are respected and when they have a similar level of expertise toward the topics. The introduction of the PBL process and the explanation of the different roles aimed to encourage students to participate in this course-based learning community as well as to provide a group interaction model to facilitate the learning process. Peer evaluation was imposed to ensure individual accountability. However, the findings from this study showed that more scaffolding was needed for the group communication process. Although individual learning had been the focus in education, perhaps it is time to consider a greater shift in emphasis toward group learning, "a process through which a group creates knowledge for its members, itself as a system, and for others" (Kasl, Marsick, & Dechant, 1997, p. 229). Students do not only take up responsibility for their own learning but also in team members' learning.

Sunwolf and Frey (2005) explored methods to facilitate group communication. They categorized the group communication facilitate techniques into two types: relational communication and task communication. The relational group communication focuses on facilitating group formation, relationship in diverse group, social support and group conflict management. On the other hand, the task communication focuses on facilitating

structure, analysis, creativity, agreement and team. Those techniques have been found to generally show the positive effects from both laboratory and field studies.

Shockley-Zalabk (1991) identified task roles and communication skills that help group members to accomplish their goals. The task roles include problem analysis, idea generation, idea evaluation, abstract ideas/vision identification, solution generation/implementation, goal setting, agenda making, discussion clarification, disagreement identification and consensus identification. The communication skills consist of initiating, questioning, interpreting, suggesting, facilitating, clarifying, summarizing, terminating, evaluating, active listening, confronting, positive blocking, modeling, reflecting feeling and supporting, and empathizing. Those communication skills seem to be essential in enhancing individual participation and help students to become better learning partners in the knowledge construction process. However, how to incorporate those techniques in the design of PBL to help students to become better collaborators needs to be explored.

***Use of Case Based Reasoning (CBR)***

One issue that emerged from this study is the role of the facilitator. In a large class such as the one under study, the instructor was not able to facilitate every group meeting to provide immediate help and guidance. Use of case based reasoning (CBR) may be able to compensate for the absence of the facilitator. In the PBL environment, a case describing a problem situation establishes a context of learning. The power of this approach lies in its creation of a problem-anchored learning environment for learners to take up the natural process of inquiry to pursue and use knowledge. On the other hand, case-based reasoning (CBR), which originated from the field of artificial intelligence,

also promotes learning through cases. In fact, Kolodner, Hmelo, and Narayanan (1996) proposed to incorporate CBR with PBL to enhance learning. They suggested that a library of cases that cover an adequate variety of the problem-solving experiences from others with more expertise should be accessible at moments when the cases are needed. It is expected that a case library, providing the experiences that human learners lack, will be able to augment learners' memory and thus enhance learners' problem solving and reasoning skills.

## Limitations of the Study and Suggestions for Future Research

The current study has certain limitations that need to be taken into account. First, the study involved the selection of a single group; thus, and therefore, the result analysis can only establish a basic for understanding the group problem solving process and can be transferred to other contexts or settings by the readers' own judgment even through the in-depth descriptions of this particular case. were able to shed light on the collaborative problem-solving process. Further study of multiple cases would aid in establishing a broader conceptual framework regarding this process in PBL.

Another limitation of this study was the perspective adopted. Despite an attempt to integrate different perspectives on this PBL process, the analysis has been primarily limited to the researcher's perspective. Although the study has also taken into account the students' perceptions from the basis of interviews, and the theoretical explanations in the literature, the main perspective from which conclusions were drawn is that of the researcher. This can be seen as a limiting factor in this study. One of the future changes to the study will be to ask several different researchers or evaluators to review the findings in order to reduce potential bias. Moreover, to further understand the

collaborative problem solving process, investigating the students' conceptual changes in PBL with a combination of analysis of verbal interaction and of the simulated recall protocols obtained immediately after the group meeting could be more instrumental.

The conclusions as well as the limitations of this study also bring forth some implications for future research in relation to the processes of how group members learn from one another, how the group as a whole adapts itself to move advance the work, and how the group's knowledge can be captured in this continuous problem solving process. A promising possibility to explore the interactions of PBL groups, as suggested for research in collaborative learning, is "to exploit selective branches of linguistic research on models of conversation, discourse or dialogue to provide a more principled theoretical framework for analysis" (Dillengbourg, Baker, Blaye, & O'Malley, 1996).

The most important avenue for future research obviously lies in continuing the elaboration of the essential elements and activities in the collaborative problem solving process in a course-based PBL environment. A more thorough understanding of the process from the learner's actual behaviors, thinking, and perspective can better support students' learning.

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# Appendix A

## Classroom Observation Protocol

| Class Information | |
|---|---|
| Date: _____<br>Classroom: _____ | Time: _____<br>Session: _____ |

| Classroom Layout | |
|---|---|
| Size: | Sitting Arrangement: |

| Technological Support |
|---|
| Equipment: |

| *Classroom Activities* | | | |
|---|---|---|---|
| What's going on in today's class? List the activities, record the times and give detailed descriptions of who participates and students' actions. | | | |
| **Activities** | **Time** | **Participants** | **Actions** |
| | | | |

## Appendix B

## Interview Questions

I. Group problem solving process:
- What do you think of the team assignments?
- Recall as much as you can, how did your group work together for the team assignment?
- How did you think that you contribute to the process?

II. Group Dynamics
- What was your role in the group?
- How did it affect the way that you work with your group?
- How was the group process related to your learning?

III. Experience with Problem-Based Learning
- Describe to a friend what it is like for you to be in a problem-based learning classroom
- If a teacher comes to you, and ask your help about using a PBL approach in his or her class, what will you suggestion?
- Did this learning experience differ from their other c

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