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In this issue:

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Keywords: problem-based learning, information systems, self-directed learning, group collaboration, organization transformation, knowledge management

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Teaching a Collaborative Model of IS Development through Problem-based Learning

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ABSTRACT

This paper investigates the pedagogic issues of information systems (IS) education through the constructivist approach of problem-based learning (PBL). In particular, the paper presents the perspective of how a group of students could be empowered in practicing the process of IS development through the nurturing of self-directed learning and group collaboration. The discussion puts forth the ideas of how to develop PBL groups of students as collaborative learners, as collaborative problem solvers, and as collaborative supporters of individual development within the group. There are also the concerns over what methods to teach in the development of IS for knowledge work. In particular, the discussion deliberates on the essence of PBL as a model of collaboration applicable to group-based project work in IS development, which is followed by a deeper investigation of the PBL model as a pragmatic means of problem solving in the context of elaborating suitable IS support for peculiar organizational scenarios. The paper describes some initiatives in the systems thinking of group-work design to substantiate IS education in terms of creating a rich framework of pedagogic activities to help students acquire the important learning demanded of IS professionals in their future careers. The paper concludes by discussing some of the important observations in the areas of organization transformation, and knowledge management, which render tremendous implications in the education of IS practitioners if we want our students to succeed in their future endeavors of IS design, construction and management, amidst the challenge of the 21st Century knowledge society.

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1. INTRODUCTION

The workplace of the 21st century requires professionals who not only have an extensive stock of knowledge, but who also know how to keep the knowledge up-to-date, who apply it to solve problems, and who function as part of a team. Those of us who teach undergraduates in higher educational institutions are obligated to rethink how we teach and what our students need to learn in order to prepare them for this challenging time. With few exceptions, university faculty embarks upon the business of teaching with little instruction or training in pedagogy: we simply teach as we were taught, especially through lectures. This transmissive view of learning assumes that the process of good teaching is one of simplification of the truth in order to reduce student confusion. Yet, this simplification could deny students the opportunity to apply their learning to dynamic situations. Relatively recent discussions in the literature (Cobb and Yacket, 1996; Marshall, 1996; O' Connor, 1998; Vygotsky, 1978) suggest that learning is increasingly viewed as a constructive process occurring during one's participation in and contribution to the practices of the community of learners. This is supported by a current shift (Brown, Ash, Rutherford, et al., 1993) from the cognitive focus on knowledge structures presumed in the mind of the individual learner, to a constructivist focus on the learner as an active participant in a social context. Indeed, we have been witnessing classroom culture being shifted away from the obsession with knowledge reproduction, and enriched with tools such as the Web that mediates knowledge building and social exchanges among peers as participants in discourse communities (Bonk, Medury and Reynolds, 1994; Bonk and Reynolds, 1997; Fabos and Young, 1999). These communities open opportunities for learners to interact with multiple perspectives, which challenge their existing knowledge constructions and impose cognitive conflicts (Piaget, 1952) requiring negotiations and teacher's continual interventions.

In light of this, what pedagogical approach could best address these issues of teaching and learning and offer an attractive alternative to traditional education by shifting the focus of education from what faculty teaches to what students learn? This is indeed a very relevant question for those of us who are in the field of IS education. Many of today's information systems are difficult to learn and awkward to use; they often change our activities in ways that we do not need or want. The problem lies in the IS development process (Vat, 2005). Oftentimes, IS designers have to face convoluted networks of trade-off and interdependence, the need to coordinate and integrate the contributions of many kinds of experts, and the potential of unintended impacts on people and their social institutions. All these, representing dynamic problem situations, cannot be learned simply through lectures in a broadcast-oriented classroom. It has also been observed (Checkland & Holwell, 1998) that traditional textbook approaches to IS development seek to control the complexity and fluidity of design through techniques that filters the information considered, and weakly decompose the problems to be solved. In fact, within the culture of transmissive teaching, what constitutes good learning has largely been based on success in examinations designed to test the quantity and the quality of what individual students have learned, in the sense of giving back, in an appropriate form, that which the teachers taught and the textbooks told. Fortunately, the pedagogic shift mentioned earlier brings new dimensions to the notion of good learning, such as being able to find information and knowledge by oneself; of being able to look critically at what one finds; of being able to question one's teachers; of being able to collaborate with colleagues; and of being able to discuss what one knows with one's peers and with the public. Here, as the need to look at the student's work as a whole is realized, more traditional modes of educational delivery become increasingly problematic, and the notion of good teaching shifts away from the role of presenter and towards the much more complex role of guide and coach.

2. WHY CHANGE THE WAY WE TEACH?

In June of 1994, a Wingspread Conference (1994) was held in Denver, Colorado, to discuss the quality in undergraduate education in the States. The discussion that took place was based on the assertion that substantial improvement in American undergraduate education is needed to prepare students to function successfully in current business and industrial environments. The Conference developed the following list of important characteristics of quality performance expected of college and university graduates (Wingspread, 1994):

- Higher-level skills in communication, computation, technological literacy, and information retrieval to enable individuals to gain and apply new knowledge and skills as needed;
- The ability to arrive at informed judgments – that is, to effectively define problems, gather and evaluate information related to those problems, and develop solutions;
- The ability to function in a global community through the possession of a

- range of attitudes and dispositions including flexibility and adaptability, ease with diversity, motivation and persistence (for example, being a self-starter), ethical and civil behavior, creativity and resourcefulness, and the ability to work with others, especially in team settings;
- Technical competence in a given field;
- Demonstrated ability to deploy all of the previous characteristics to address specific problems in complex, real-world settings, in which the development of workable solutions is required.

Undoubtedly, what worked in the classroom a decade or two ago, will no longer suffice, for the simple reason that past approaches fail to develop the full battery of skills and abilities desired in such a contemporary university graduate. In fact, there is a growing tendency away from a traditional transmissive pedagogy in higher education, towards a pedagogy that can broadly be characterized as constructivist (Booth, 2001). By transmissive pedagogy, I mean teaching based on an assumption that students receive information from the teacher (content provider) and slot it straight into an empty place in their knowledge base, or at best, work on it later to make it their own. By constructivist pedagogy, I mean an approach to learning through a variety of knowledge building processes, and that teaching should encourage students to work actively towards understanding within a framework of personal responsibility and institutional freedom.

Accordingly, student-centered, inquiry-based instructions fall right into line with this Wingspread philosophy, which is affirmed by the 1998 Carnegie Foundation's report, *Reinventing Undergraduate Education: A Blueprint for America's Research Universities* (Boyer, 1998). The report (Boyer, 1998, p.15) urged universities to "*facilitate inquiry in such contexts as the library, the laboratory, the computer, and the studio, with the expectation that senior learners, that is, professors, will be students' companions and guides. The research university's ability to create such an integrated education will produce a particular kind of individual, one equipped with a spirit of inquiry and a zest for problem solving; one possessed of the skill in communication that is the hallmark of clear thinking as well as mastery of language; one informed by a rich and diverse experience. It is that kind of individual that will provide the scientific, technological, academic, political, and creative leadership for the next century.*"

Seriously, it takes a certain amount of independence and determination to change the way one teaches. It also takes time and involves risks. Where do instructors acquire the commitment to get started with this change? Frequently, commitment grows out of the recurring frustration most instructors experience when they realize how little their students understand or remember from a semester of charismatic lectures. If not ignored, that frustration leads to reflection on what it means to teach and to learn.

3. THE ADOPTION OF PROBLEM-BASED LEARNING (PBL)

From the discussion built up so far, it is not difficult to foresee that the conventional approach to education remains the transmissive one, in which knowledge is perceived to flow from experts to novices; namely, to the majority of students, teachers are responsible for delivering content and the students are the passive receivers of knowledge. Graciously indeed, many a literature review has indicated that this transmissive perspective has somehow been diluted by the pedagogy of problem-based learning (PBL), considered as a promising instance of the constructivist ideas in lifting some of the illusions of the transmissive tradition (Barrows, 1986; Salomon & Perkins, 1989; Woods, 1994; Boud & Feletti, 1997; Booth, 2001; Duch, Groh, Allen, 2001).

3.1 The Background of PBL

The modern history of PBL began in the early 1970s at the medical school at McMaster University in Canada, (Duch, Groh, Allen, 2001) and ever since, PBL has been adopted in various fields such as Teaching, Engineering and Management. Pedagogically, the PBL approach uses real-world problems (Boud & Feletti, 1997) to drive the learning rather than mere lectures with the instillation of subject matter. It acknowledges the possibility of prior knowledge held by the learner. Further knowledge is acquired on a 'need to know' basis, enabling the learner to diagnose one's own learning needs. Knowledge gained is fed back into the problem in an iterative loop, allowing the synthesis of topics and know-how (Ryan, 1993; Margetson, 1994). When applied to the course setting, PBL should encourage students' active participation and develop in them self-directed learning and problem-solving skills while they interact discuss and share relevant knowledge and experience. More importantly, PBL revolves around a focal problem, group work, feedback, class discussion, skill development and iterative reporting. The instructor's role is to organize and pilot this cycle of activity, guiding, probing and supporting students' initiatives along the way so as to empower them to be responsible in their own learning.

3.2 The Essence of PBL

PBL, according to Barrows (1986), is designed to actively engage students, divided in groups, in opportunities for knowledge seeking, for problem solving, and for the collaborating necessary for effective practice. More importantly, Woods (1994) maintains that because of the way in which knowledge is acquired in PBL, links are provided with experience which help in future recall. This is invaluable for students' future professional life, especially in IS development. There are common themes in the literature on PBL. Firstly, PBL is usually conducted in small groups (Neufeld & Barrows, 1974; Barrows, 1988; Woods, 1994). Secondly, learning is self-directed, with emphasis on a learner-centered as opposed to a teacher-centered approach. Thirdly, PBL is also held to promote life-long learning, make knowledge relevant by placing it in context. Fourthly, the small group format of PBL is invaluable in the development of negotiation, communication and collaborative skills. Students also develop inquiry, thinking and problem-solving skills. Fifthly, peer-based and/or self-based assessment helps the individual to become a reflective practitioner; namely, there is an expectation that the PBL student becomes a more active partner in the educative experience as a result of planning, organizing, and evaluating his or her own learning (Boud, 1985; Woods, 1994). Lastly, the essence of PBL can be summarized by the fact that it addresses directly many of the recommended and desirable outcomes of an undergraduate education (Wingspread, 1994): specifically, the ability to do the following:

- Think critically and be able to analyze and solve complex, real-world problems;
- Find, evaluate, and use appropriate learning resources;
- Work cooperatively in teams and small groups;
- Demonstrate versatile and effective communication skills, both verbal and written;
- Use content knowledge and intellectual skills acquired at the university to become continual learners.

3.3 The PBL Cycle of Collaboration

Operationally, the PBL approach follows an iterative process, which could be referred to as the PBL cycle of collaboration, comprising the following group-based activities:

- At the outset, before the PBL group work begins, students must get to know one another and help create a comfortable climate for collaborative learning. Meeting in a small group for the first time, students typically introduce themselves, stressing their academic backgrounds to allow the facilitator (instructor) and each other to understand what expertise might potentially be distributed in the group.

- The actual PBL episode begins by presenting a group of students with minimal information about a particular problem. Students then query the given materials to determine what information is available and what they still need to know and to learn to solve the problem. Students working in relatively permanent groups attempt to define the broad nature of the problem.
- Throughout ensuing discussion, students pose questions (referred to as learning issues) that delineate aspects of the problem they do not understand. These learning issues are recorded by the group and help generate and focus discussion. Students are continually encouraged to define what they know and – more importantly – what they do not know.
- Student rank, in order of importance, the learning issues generated in the session. They decide which questions to be followed up by the whole group, and which issues to be assigned to individuals, who later teach the rest of the group. Students and instructor (more appropriately called the facilitator) also discuss what resources will be needed to research the learning issues and where they could be found.
- When students reconvene, they explore the previous learning issues, integrating their new knowledge into the context of the problem. Students are also encouraged to summarize their knowledge and connect new concepts to old ones. They continue to define new learning issues as they progress through the problem. Students soon see that learning is an ongoing process and that there will always be (even for the teacher) learning issues to be explored.

4. THE PBL MODEL OF IS DEVELOPMENT

In problem-based learning, students are asked to work together in small groups to analyze and resolve problems, and to communicate, evaluate, and integrate information from diverse sources. The PBL model of IS development described here is conceived as a generic model of problem solving that could be embedded with the PBL cycle of collaboration. It is meant to empower students' self-directed learning in IS-based problem solving. Put simply, the model is composed of a number of steps: 1) identify the problem, 2) represent the problem, 3) select a strategy, 4) execute the strategy, 5) evaluate the results, and 6) analyze the process. The biggest challenge to get across this model of investigation to my students is to create a safe, learning-focused classroom climate where students feel both challenged and secure to take risks, as noted by (Eggen & Kauchak, 1999). Challenge is important because it motivates students to engage cognitively in the difficult task of solving problems. At the same time, students need to feel safe to take risks as they wrestle with problem solutions. There are two goals behind introducing this model. In the short term, I expect my students to solve the problem successfully and understand the content behind the problem solution. In the long term, I expect to develop in my students their ability to understand the process of problem solving, which is a form of meta-cognition, which involves knowing what we need to know, knowing what we know, knowing what we do not know, and devising strategies to bridge these gaps. That is also the essence of self-directed learning, which develops when students are aware of and take control of their learning process.

4.1 Identify the Problem

This step in problem solving may seem self-evident; yet, many students experience problems with this process (Bruning et al., 1999). The reasons are many, perhaps, the most important of which is that students are not provided with sufficient practice with ill-defined problems – the most common kind found in everyday problems. Ill-defined (or wicked) problems have ambiguous goals and no agreed-upon strategy for solving them (Mayer & Wittrock, 1996). In fact, most teaching problems are ill-defined; how to motivate a student, manage a class, or teach a particular lesson all are ambiguous both in terms of goals and strategies. Similarly, most of the problems we encounter in real life IS development are also ill-defined. The best way to teach students how to deal with such problems is to provide them with lots of practice, including work with defining exactly what the problem is. Other problems to defining the problem include lack of domain-specific knowledge and students' tendency to rush toward a solution (Eggen & Kauchak, 1999). When students lack background knowledge for a problem, they will encounter difficulties in clearly identifying what the problem requires. Another problem my students encountered at this stage is to jumping to a solution before they have considered all the complexities of a problem. Experienced problem solvers always take more time at the beginning of a problem, evaluating what is given and what needs to be done (Bruning et al., 1999), before attempting any solution.

4.2 Represent the Problem

It is always a challenge to teach students how to represent their problems. No matter which specific method is used, the important lesson is to bridge the conceptual gap between defining a problem and selecting a strategy. Students are often overwhelmed at this stage of problem solving, and strategies like drawing a picture diagram and listing 'knowns' and 'unknowns' often help. The representation itself involves a lot of abstraction exercise from my students; they need to select the most important details to study and learn how to ignore, at least, temporarily other details deemed irrelevant in their current endeavor in pursuing a possible solution to the problem. They have to learn the idea of constraints, and the meaning of tolerance, too.

4.3 Select a Strategy

In searching for any solution for IS development, students need to choose an appropriate strategy for their problem. One consistent phenomenon observed is that they tend to grab onto the first solution that arises without thinking about alternate solutions. This often gives them an immediate answer but fails to place the problem in a larger context. The result is that students may sometimes get the right answer but fail to understand why it works, or fail to relate this problem to similar ones they will encounter later. To help my students to be more reflective at this important step, I often encourage students to use some heuristic strategies (Mayer, 1997), such as the means-end analysis, and the drawing-analogies method. The former is simple: we identify our ultimate goal and then work backwards in sub-steps. The latter is straightforward: we ask students, "What is this problem like? What does it compare to?" then we invite students to think up a suitable and applicable problem-solving strategy.

4.4 Execute the Strategy

This step allows students to try out or reality-test the quality of their thinking in the previous three steps. In practice, this step is a natural extension of the above three steps, and provides students the opportunities to implement and experiment with their ideas. In case, it does not flow smoothly from the other three, it is important for the teacher to provide scaffolding through supporting questioning. Sometimes, students get so close to a problem they would fail to see the logical next step. I often suggest my students to step away from their immediate problem, reflect on what they are doing and why, and then return to the data or chore at hand. Teachers' intervention in terms of questions and support are always needed here.

4.5 Evaluate the Results

This step is meant to judge the validity of the solution produced by the students. Ego is often the problem encountered at this stage. Since they have put in so much effort into the solution, they tend to have a deep affect on their work. Other times, students are eager to complete or wrap a problem up and get on with other things, even if the solution does not measure up. Getting an answer, regardless of whether or not it makes sense, is all too often the students' goal. Some students simply wanted to finish the assignment, and so, they rushed through.

4.6 Analyze Problem Solving

This step is very important in terms of the long-term goal in using the model. It is to help students become more systematic and analytical problem solvers and more aware of their own thinking as problem solvers. It is expected that students, in response to such question as "What did we learn about problem solving?" after some PBL cycle of activities, would indicate their experience along such lines as: 1) that any problem can have more than one solution, 2) that problem solving can be pursued systematically, and 3) that problem solving is hard work. Such are valuable insights and worthy outcomes for problem-solving lessons.

5. THE PBL STRATEGIES OF DESIGNING GROUP WORK

Undeniably, setting up an organizational information system is a social act in itself, requiring some kind of concerted action by many different people. The PBL strategies of designing group work, in light of this fact of life, is to introduce a new social structure to the classroom, i.e., one of negotiated relationships between students, and between student groups and the instructor, helping students to become articulate, autonomous, and socially mature (Michaelson & Black, 1994). As Felder and Brent (1996) pointed out, although student-centered instruction can yield tangible benefits, "they are neither immediate nor automatic." There are many ways groups can fail (Feichtner & Davis, 1985). For that reason, it is important to develop and maintain functional groups in the classroom – groups in which all members work effectively to enhance each other's learning.

5.1 Forming Groups

On the first day of class, in order to help evolve the class into its team-based organization in terms of a number of groups, typically each being composed of 4 to 6 students, I would invite my students to complete a simple questionnaire, detailing their background knowledge such as grades earned in some of the pre-requisite courses, and their personal preferences in choosing team-mates, say, name three students from the same class whom he or she would like to work with, and then indicate a number preference for each named, say, using only once of the numbers (1, 2, 3) respectively for most wanted, second most wanted, and third most wanted. Besides, the questionnaire also gathers some data items such as proficiency in programming using a particular programming language, or experience in teamwork in practice. Then heterogeneous groups are created concurrently by picking randomly a seed-student for each group from the class, and grow the group by adding individual member from the questionnaire of the seed member using his or her most wanted teammate if available. If not, choose second most wanted. If still not available, choose third most wanted. If all three preferred students are not available, randomly select one from the class, and start growing the other group members using this newly added student's questionnaire. Depending on the number of students in class and the expected number of students in each group not exceeding six, a class of less than or equal to 30 students could easily be turned into six groups of students with a relatively even distribution of personal preferences in each group.

5.2 Monitoring Groups

Group monitoring is a function performed by the instructor and the members of each group. The instructor's interaction with any group should allow for spontaneous and informal interventions that continually fine-tune the reasoning process of PBL, assure evenness of participation, keep the group moving forward in the problem, promote good interpersonal relationships, and help the group learn how to direct its own learning. The instructor must be particularly sensitive to obvious signs of group dysfunction, such as conversations that are off task; students not taking part in the discussion, or students dominating the discussion; and physical behaviors like intentional ignoring of partner's discussion or showing indifferences. The group members themselves are also empowered to monitor their group-work through the installation of ground rules, group roles of responsibility, and confidential peer-based evaluation of individual performance within the group.

- *Ground Rules*

One way to encourage students to take ownership of their effective performance as a group is to ask them to establish and enforce group ground rules in the first week of class (after their group identity is acquired), before any negative behaviors have a chance to take root. This set of standards and expectations, written after groups have discussed the behaviors that they will not tolerate, helps to establish norms for group behavior. Examples of rules that are minimally essential for good group function include: 1) come to class and group meetings on time, 2) come to class and group meetings prepared, 3) notify members of the group ahead of time if meetings or class must be missed for any reason, 4) respect the views, values, and ideas of other members of the group. There must be stated consequences for violators, such as to have the instructor lower the violator's grade (to zero if appropriate) for assignments to which he or she did not contribute. In practice, groups are asked to sign two copies of their ground rules and consequences, give one copy to the instructor, and keep one in a group notebook.

- *Group Roles*

One way to promote individual accountability and low barriers to participation is to ask students to take on roles of responsibility in their groups. Common strategies include formulating a role for each student in the group and asking students to rotate the roles among group members after every problem or assignment. This discourages students from sticking to roles that come to them easily and gives them additional experience in those that they find more challenging. Commonly assigned roles include the following: 1) group leader, who keeps the group on track, and maintain full participation; 2) group scribe, who records assignments, strategies, unresolved issues, meeting minutes, and convenes group meetings outside of class; 3) group reporter, who reports during the class discussion or presentation, and writes the final draft of assignments; 4) group tracker, who checks group understanding, finds resources, and keeps track of individual members' work in progress.

- *Peer Evaluation*

Typically scheduled at the end of each problem (at least two to three times a semester), feedback session will be held as an important strategy for reinforcing positive group behaviors and maximizing individual accountability. In the feedback session, each individual in the group discusses what the group did well since the last session and how he or she thinks the group needs to change or improve to function better. After the overall functioning of the group has been discussed, students are asked to rate their individual contributions to the group effort using written evaluation forms (Allen & Duch, 1998). In my current practice, each student fills out the form in a confidential manner, rating the effort of every other members of the group as well as himself or herself on a scale of one to five and writing a few sentences of specific comments for each individual member. As instructor, I then compile the average ratings and summarize all comments to be given to each student, ensuring that students can be candid in their comments. The results of the ratings would then be factored into each student's grade. This feedback is not only an important reality check for students, but is invaluable in helping the instructor detect signs of a malfunctioning group. When evidence that group members are not contributing well presents itself in these forms, timely intervention is possible.

5.3 Developing Groups

In a problem-based learning course, students gradually become accustomed to discussing learning issues within their group, doing research, and teaching each other in order to work through a problem. Thereby, the instructor, in preparing students for such activities, has to conceive assignments structured such that all group members will be involved. It is important to design group assignments each of which does not allow simple division into parts to be taken up by individual students who then simply join their parts into a coherent whole. Instead, the completion of assignment must require students working together within the group to integrate their contributions into the coherent whole.

Students should come to experience that concerted group effort is invaluable in this type of assignment, since individual members' input is such a valuable resource. Meanwhile, it is essential to make provisions to ensure individual accountability in group-assignments. One suggestion is to invite student groups to clarify work done individually, work done cooperatively (different parts done by different students before integration occurs), and work done collaboratively (same portion of work done jointly by several students to accomplish the assigned task). Nonetheless, the goal of group work is to have students work together to think about, discuss and internalize their learning. To help students transition into effective group-work, the following in-class exercises involving learning pairs have proved useful: a) think-pair-share, b) pairs-check, and c) combining pairs.

- *Think-Pair Share*

This group-work strategy asks individual students in learning pairs to do two things: first answer a question and then share it with a partner (Kagan, 1994). It is most effective when embedded in whole-group, teacher-led instruction. In using this strategy, the teacher asks a question as he or she normally would but then, instead of calling a particular person, asks all students to think about the answer and discuss it with their partner. After a short while, the teacher asks a person in each pair to share his or her thoughts with the whole class. There are, at least, three factors contributing to the effectiveness of this strategy: Firstly, it elicits responses from everyone in the class and promotes active learning. Secondly, because each member of the pairs is expected to participate, it reduces the problem of free riders. Thirdly, it is relatively easy to plan for and implement and can help learners make the transition to more complex group-work activities.

- *Pair-Check*

This group-work strategy involves student pairs in seatwork activities focusing on problems with convergent answers. This strategy usually follows instruction in which a concept or skill has been taught. It provides students with opportunities to practice on the topic by alternating roles between "solver" and "checker." Typically, pairs are given handouts containing convergent problems or questions. One member of the pairs works two or three problems, the second member checks the answers, and then the roles are reversed. As the students work, the teacher monitors the process and encourages the students to discuss, when appropriate, the reasons why the answers are correct. If they do not discuss, pairs check amounts to little more than individual students checking answers at the back of the book. In addition, time must be reserved at the end of the activity to allow whole-class discussion on areas of disagreement or confusion.

- *Combining Pairs*

This is a group-work strategy that uses learning pairs as the basic unit of instruction but provides opportunities for the pairs to share their answers with others. It has the advantage of encouraging the active participation of pairs while simultaneously helping students develop social skills. It is applicable to both interactive teaching and seatwork activities. To begin with, the instructor needs to identify both the learning pairs and the groups of four. Then the class divided into groups each of two pairs (4 members) is seated group-wise together. And each member of a group is assigned a number from 1 to 4, which identify the students to be called on. In the setting of interactive teaching, the instructor asks the class a question with a convergent answer, such as the solution to a problem. The teacher then asks each group to work on the solution and make sure everyone in the group knows the answer. Then the teacher asks all the numbers 1s (or 2s or 3s or 4s) to raise their hand and calls on a student to explain the answer. In the setting of seatwork activities, students are given convergent problems to complete, and members of the pairs compare their answers. If they agree or can resolve disagreements, they continue. If they cannot resolve disagreements, they confer with the other pair in their group. When a dispute arises in the dyads, the pair then compares their answers with the other pair. The teacher intervenes only when disagreements among the four students cannot be resolved. Similarly, we can extend the number in a group to six students, comprising three pairs.

6. THE CHALLENGE OF TEAM-BASED COLLABORATION IN IS WORK

Today those who are engaged in the attempt to build IS support for any user situation, are involved in the delicate business of team-based collaboration. This endeavor requires the effort and commitment on the part of everyone involved, as well as a good imagination in the mind of those charged with directing its implementation. The project team members need to thoroughly know their organization as it currently exists and they also have to understand the vision of what its own members, desire for it to become in the future (Fisher, 2000; Ginac, 2000; Gregory, 2000). In the specific instance of a project team charged with the mission of creating IS support for collaborative project development, what makes the teamwork tick is people's mutual understanding of their own and others' interests and purposes, and the recognition that their interests are somehow bound up in doing something to which they all contribute.

In a strict sense, organization is found in the interaction among people and teamwork is an emergent phenomenon. It is in the course of interaction that people's sense of purpose and even their contributions, come to be defined. From this standpoint, collaboration enables organizations to generate emergent results. And a collaborative group's role is to create an environment in which emergent outcomes occur. As collaborators in an IS team, we face the tremendous challenge of how team members move from being individual spokespeople to a unified, collaborative body. In his book on group decision-making, Sam Kaner (1996) calls the transition from the divergent zone of the individual to the convergent zone of the team member the "groan zone."

In a team, even though every member wants to contribute to success and to get the project going, each has a different perspective, a different experience, or a different context to bring to the project. Each person's thinking is divergent, bringing diversity to the process, but not much agreement. Convergence occurs as the individual ideas of the group are integrated into a whole solution. This process of integration does not entail compromise (Fisher, Ury & Patton, 1991), in which every one gives up something and no one is happy with the result, nor does it mean that everyone is in complete agreement. What convergence means is that everyone has participated and will support the final decision. Kaner calls this period between divergence and convergence the groan zone because it is the time during which team members groan and complain.

In the divergent zone, most group members voice their opinions to make sure their ideas being heard by the group. In the groan zone, however, an individual digs behind other people's ideas to try to uncover their reasons, assumptions and mental models. Difficult problems and wrenching decisions cause teams to spend time in the groan zone because of the required interchange, sharing, and resolution of ideas, and viewpoints. Likewise, the groan zone is also used to describe the transition zone in which innovative, emergent results are generated. Indeed, collaborative groups, especially those in fast-paced environments, groan a lot. They struggle to create the services that converge on the mission profile. They struggle to integrate their own, and others' diverse perspectives.

7. THE SCENARIO OF IS DEVELOPMENT THROUGH TEAM-BASED COLLABORATION

To allow my students to experience the transition of the groan zone in their studies, at each semester when problem-based lessons are planned, students typically embark on the PBL cycle of learning through organized groups each of 4-6 members. In the context of IS development (Vat, 2004b), each PBL group will be given a dual role to explore as client and as developer within a specified period of time. Namely, each team, acting as the developer, is to complete an interactive system design and prototype for another team acting as the client. Yet, the same team is the client of another group, responsible for clarifying the project, and resolving ambiguities as they arise, but in any pair of PBL teams (say, A and B), they cannot be the client and developer of each other at the same time. It should be noted that an even number of teams is important to facilitate pair-wise client-developer interaction. Meanwhile, the instructor, more appropriately called the facilitator, acts as project sponsor for each client team, and as project supervisor for each developer team. Each client team is handed a design project by the sponsor. It is then given some inception time to elaborate on the specifics of the project. At the end of the inception period, each client team is assigned a developer team from among the remaining client teams. After a developer team has been identified, the working and performance of the developer team is guided and monitored by the project supervisor played by the instructor. In a typical semester, there might easily be six to ten PBL teams of students, with each team composed of four to six members each.

Essentially, each design project invites our PBL student-groups to embark on a journey to develop some interactive IS support that meets customers' real needs in Web-based development. The general requirement is for each PBL team to create and maintain a review Web-site to keep all team members up-to-date on all possible aspects of the project. It is also where the PBL team will work (report) collaboratively on the project. Through the review Web-site, our PBL teams can conduct reviews with their clients, who can view their project in progress, give feedback on a design, get in touch with the developer PBL team, and check the project schedule. The review Web-site contains numerous information such as: the roles and responsibilities of the project team, contact information for all team members, the project mission, the vision document, the project schedule, and all design reviews.

It is designed that the first thing our PBL teams have to learn is a systematic approach (Carroll, 1995) to eliciting, organizing, and documenting the requirements of the system to be built for the client team. Also important is a process that establishes and maintains continuous agreement between the client and the developer teams (Curtis, Krasner, & Iscoe, 1988) on the changing requirements of the system. Individual PBL teams have to understand users' problems in their culture and their language and to build systems that meet their needs. Practically, the IS context for the course is designed around four core development processes to be experienced by our PBL student-groups within the semester's duration constraint.

7.1 Analyzing the Problem

This involves a set of skills to understand the problem to be solved before application development begins. It is the process of understanding real-world problems and user needs and proposing solutions to meet those needs. We consider a problem as the difference between things as perceived and things as derived (Gause & Weinberg, 1989). Accordingly, if the user perceives something as a problem, it is a real problem, and it is worthy of addressing.

7.2 Understanding User Needs

Software teams are rarely given effective requirements specifications for the systems they are going to build. Often they have to go out and get the information they need to be successful. Typical methods include interviewing and questionnaires, requirements workshop, brainstorming, idea reduction, storyboarding, role playing, and prototyping. Each represents a proactive means of pushing knowledge of user needs forward and thereby converting fuzzy requirements to those that are better recognized.

7.3 Defining the System

This describes the process by which the team converts an understanding of the problem and the users' needs to the initial definition of a system or application that will address those needs. Our PBL teams should learn that complex systems require adaptive strategies to organize information for requirements. This information could be expressed in terms of a hierarchy, starting with user needs, transitioning through feature sets, then into the more detailed software requirements.

7.4 Managing the Project Scope

Project scope is presented as a combination of the functionality to be delivered to meet users' needs, the resources available for the project, and the time allowed in which to achieve the implementation. The purpose of scope management is to establish a high-level requirements baseline for the project. The team has to establish the rough level of effort required for each feature of the baseline, including risk estimation on whether implementing it will cause an adverse impact on the schedule.

Throughout the course delivery, each PBL team is required to present their work in progress, and lead class forums to elicit students' discussions. The team leader, equivalent to project manager, has to coordinate the team activities, and ensure effective team communications. And team members have to help set the project goals, accomplish tasks assigned, meet deadlines, attend team meetings and participate in editing project documents and integrating work-products to be combined as the final project report. At the end of each project milestones, each member of the respective PBL teams is required to make a presentation of his or her project involvement, with a question and answer session for the client team and the whole class. The instructor, acting as the project sponsor for each client team, and as the project supervisor for each developer team, designs the necessary scenario details (Whitten, 1995) to guide, motivate and provide feedback to the PBL groups. Also, the instructor has to evaluate how well students perform in the PBL groups (Doyle & Straus, 1982), and how well such groups behave as SDWTs (self-directed work team) in managing software requirements (Conklin & Burgess-Yakemovic, 1991), and provide the necessary adjustments following the ideas of contextual design such as soft systems methodology (SSM) (Checkland & Scholes, 1999; Wilson, 2001).

8. THE PBL CONTEXT OF GROUP COLLABORATION

A very important activity for each developer PBL team is to actively engage its client PBL team in helping solve each of the four core processes described in the previous section to ensure the quality and timeliness of the software outcomes. However, getting users' work right involves capturing and accommodating users' emergent analytical activities, which are open-ended yet integrated and opportunistic yet coherent. IS developers must understand the intertwined regularities and idiosyncrasies of open-ended inquiries and create software that support the right moves and degrees of agility at the right times and places and for specific purposes. In this regard, the PBL context of group collaboration becomes important. Through team-based collaboration, the IS development context of understanding, designing, evaluating and implementing interactive IS support to match the needs of people, can be interpreted as a situation that inspires a goal for which there is no clear path to reach it.

In particular, PBL students are expected (and trained) to approach this type of ill-defined problem as a collaborative team, generating hypotheses and inquiring against them using appropriate strategies and sources. As they work through the PBL process, group members, perhaps helped by the facilitator's strategic probing (Schon, 1983, 1990), note the knowledge and skills that the problem demands, assess their own competency with respect to these, and identify as learning issues that about which they need to learn more. Subsequently, it may be useful to examine the collaborative roles of the PBL groups underlying the investigative transition of the groan zone mentioned earlier.

8.1 As Collaborative Learners

The term *collaborative learning* is often referred to the process through which individuals, working from multiple perspectives, come to an understanding of rich, complex concepts (Koschmann, Kelson, Feltovich, & Barrows, 1996). Moreover, Roschelle (1996) reported that students working collaboratively are observed being able to construct increasingly sophisticated approximations of scientific concepts through the process of gradual refinement of ambiguous, figurative, and partial meanings. He proposed that through an iterative cycle of displaying, confirming, and repairing shared meanings, students collaborating in learning can move from idiosyncratic commonsense notions about the meanings of concepts to meanings and understandings shared by the scientific community. Put more simply, in order to develop a PBL group of students into collaborative learners, it is important to consider the interrelationship between the problem and the students' responsibility for collaboratively attuning to the problem solving and learning affordances of the problem with members of the same team (Bransford, Sherwood, Vye, & Rieser, 1986; Gibson, 1982; Gibson, 1977). The term *affordance* of a problem refers to the learning and problem solving needed to reach an optimal resolution of the problem, which necessitates the knowledge and skills of the problem solver(s). In the sense of cognitive science, reaching optimal resolution of a problem demands that the problem solver(s) be attuned to the problem's affordances, assess his or her or their own competence with respect to these affordances, resolve any competence deficiencies, and readdress the problem newly armed with the necessary knowledge and skills.

8.2 As Collaborative Problem Solvers

Since most problems that challenge the inter-relation of reasoning, knowledge, and skills are complex, they have multiple dimensions, demanding strategic inquiry for their resolution. More severely, the complexity of multiple affordances, and the uncertainty of multiple solution pathways, can be overwhelming. It can easily trigger a natural tendency toward reductivism (Feltovich, Spiro, Coulson, & Myers-Kelson, 1995) that is opposite to the development of the reasoning process, and the skill of attuning to and addressing the problem's multiple affordances. Thereby, it is important to develop the PBL group as a group of problem solvers, engaging in collaborative problem solving that avoids the tendency of coming to simplistic resolutions out of our present state of ignorance. In practice, the collaborative problem-solving group provides the ideal situation for remedying this situation, while developing expertise in problem solving through the interaction between reasoning and attuning to problem affordances. Individuals bring varying expertise to the group, seeing different facets of the complex problem. A group of such collaborative problem solvers, committed to a common goal – the problem's optimal resolution – can therefore collectively enlighten one another regarding multiple perspectives, complex affordances, and reasonable versus reckless uncertainty.

8.3 As Collaborative Supporters of Individual Development

The development of the individual within a PBL group is made possible if each member assumes responsibility for the others' excellence. According to the Barrows (1992) model, each problem solving should end with a period of reflection on individual performance. Each group member provides an assessment of his or her work with respect to the stated goals set up earlier. This is followed by input from every other student member in the group, as well as from the facilitator. In particular, students are advised to cite specific evidence for evaluative statements both in their self-assessment and in the assessment of their peers. They are encouraged to state goals for future improvement and the group is encouraged to enter into planning for reaching these goals as well as for monitoring progress toward them. It is important that every student in the group is entitled to this level of formative assessment. If any of the students has a problem, it becomes the group's problem. This climate of mutual support enables students to be precise and honest both in their self-assessment and in their assessments of others in the group.

9. A CRITICAL REFLECTION ON IS CONTEXT FOR COLLABORATIVE DEVELOPMENT

Group-based project work in IS development often requires the collaboration of team members possessing a variety of knowledge and skill. Yet, organizing a group of individuals to work together is a difficult problem in any type of undertaking. It takes time for team members to pool their knowledge in discussions, negotiate decisions, coordinate their efforts, and incorporate the work of others in their own efforts. This is especially imminent in the context of IS work for collaborative project development in the domains of organization transformation, and knowledge management. The following serves to briefly point out some of the knowledge contexts for IS work behind these two specific domains of interest.

9.1 Reflecting on the Impact from Organization Transformation

In their 1977 publication, *The Management of Innovation*, Tom Burns and G.M. Stalker, argued that the form of an organization should be dependent on the situation in which it is trying to operate. They proposed two polar ideal types of organizations respectively known as the mechanistic and the organic systems. The former "mechanistic" system carries such features as hierarchical differentiation, vertical communication, and centralized authority, and they are often viewed as appropriate to stable conditions. By contrast, the latter "organic" system is characterized by an emphasis on the holistic tasks of the organization, collegial relationships, decentralized authority and horizontal as well as vertical communication. Such systems are considered as often appropriate to conditions of change or uncertainty, such as those prevailing in today's knowledge economy. This perspective from Burns and Stalker, has given IS designers the necessary organizational context required for aligning the various organizational pieces (called domains or constructs) such as strategy, people, resources, structure, goals and process. An example of the alignment is that there must be some strategy to combine people and resources in a suitable way in a particular structure, to create some process in order to achieve some defined goals compatible with the organization.

In fact, dominating IS work today is a set of assumptions which sees organizations as goal seeking (Checkland and Holwell 1995; Zwass 1992), a characteristic of the command and control mechanistic model. The prime organizational activity is then decision-making in pursuit of goals, objectives or some longer-term mission. Information required by the organization is then that which supports and services decision-making. It is not difficult to criticize this view of the world, and there is currently some growing recognition in IS that an alternative strand of thinking is also relevant (Vat, 2003, 2004a). Namely, people feel that being a member of an organization is more like being part of a family than being the servant of a rational machine. For such people, social reality is constantly being constructed and reconstructed in a social process in which meanings are negotiated. For them, an organization does not exist as an independent entity but is part of sense making by a group of people engaged in dialogue, an essential characteristic of the organic model. This makes the idea of information, and information system much more problematical, since information is now obviously related in some profound way to meaning attribution and sense making. Equally, this view will not automatically embrace would-be-scientific methods of investigation and research, based on systematic data collection aimed at hypothesis testing. It will seek alternative processes of inquiry in such areas as interpretative action research (Anderton 1991; Boland 1986; Checkland, 1981; Galliers 1992). The difference between these schools of thought in IS work could be captured in the words 'hard' (for the objective scientific view) and 'soft' (for the subjective interpretative view). In the IS context, the hard approach assumes that organizations are systems with information needs which IT can supply; the soft approach takes a process view of organizations and explores, using soft systems ideas (Checkland and Scholes 1999; Ciborra, 1987) to structure action research, the way in which people in organizations inter-subjectively attribute meaning to their world and hence form a view on what information is relevant.

9.2 Reflecting on the Impact from Knowledge Management

Currently the view that knowledge is a valuable organizational resource has become widely recognized and accepted in the business community (Spek and Spijkervet, 1997). This is largely due to the emergency of the knowledge economy (OECD, 1996) characterized by a highly competitive and turbulent business environment. One consequence is the increase in organizations' efforts to deliberately manage knowledge. Organizations are realizing that their competitive edge is mostly the intellectual capital (brainpower) (Stewart, 1997) of their employees, and they are particularly interested in harnessing their human resources in order to stay ahead of the pack. The soaring attention on knowledge management (KM) (Malhortra, 2000) has propelled many enterprises to embark on their journeys of organizational transformation in order to tap the intellectual assets belonging inherently to their people. The proliferation of ideas on knowledge management reveals two distinctly different approaches to this topic.

In one, knowledge is identified as something physical and is described as an asset. Knowledge is thereby considered as a thing that can be possessed, stored, processed, and readily distributed to people who are designated as users of knowledge. This approach of treating knowledge as a possession of organizations, affirms conventional management thinking. The idea is to control and direct knowledge to serve the organization's goals. The other approach focuses on knowing, a process involving the interaction or engagement of different people over particular issues. The underlying premise is that knowledge is what happens in the process of peoples' interaction and that the way to facilitate the creation and use of knowledge is by encouraging people to interact, to participate, and to generate and share ideas (Cook & Brown, 1996). The focus is people with diverse capabilities, different experiences, and varied perspectives, in the form of networks, teams, or communities of practice. At present, the knowledge-as-asset view is the more popular one. But, quite different views are also being accepted today, as evidenced by the increasing interest in learning organizations.

The idea of a learning organization (Senge, 1990; Garvin, 1993), which emerged in the past decade, is to continuously transform an organization by developing the skills of all her people and by achieving what Chris Argyris (1990) has called double-loop learning. This is the questioning and rebuilding of the organization's existing perspectives, interpretation frameworks, or decision-making premises on a daily basis through a continuous process of knowledge creation (Nonaka & Takeuchi, 1995; Argyris & Schon, 1978). Indeed, such ideas imply some organic mechanisms, which could transfer learning from individuals to a group, provide for organizational renewal, keep an open attitude to the outside world, and support a commitment to knowledge. The key structural element in these mechanisms is the use of organizational networks, clusters, projects, teams and taskforces, where the underlying assumption is the arrangement among different organizational units, which should leverage their separate competencies and capabilities, as a network of collaborating experts to accept joint responsibility, and to use their initiative to work flexibly towards the organizational goals.

10. REMARKS FOR CONTINUING CHALLENGE

The adoption of PBL in the teaching of collaborative IS development, based on a team-based process to work out possible solutions for specific real-life problems, has been described in the paper. However, one controversial aspect of problem-based learning is whether or not a specific algorithm for problem solving should be taught and whether students should be held to it. In this regard, I identify with Barrows (1992) who argued that regardless of the source and variety of inquiry forms, the cognitive processes across all forms of problem solving are similar. Namely, the problem initially presents itself and hypotheses spring to mind or a cognitive search for hypotheses is initiated. In rapid synchronicity, questions or strategies that will test the hypotheses also spring to mind, or the cognitive search for such questions or strategies is initiated. Inquiry addresses these questions, and a rather systematic, but distinctly nonlinear process of testing the hypotheses against the accumulating data takes place. As the process continues, hypotheses may be ruled out, new ones may be generated and new questions or strategies to further test the hypotheses may suggest themselves, calling for further inquiry. This iterative process continues until something constrains it. Sometimes, the process exhausts itself with a firm conclusion. At other times, and perhaps most often, a need for action demands that a best possible decision be made based on the evidence at hand, incomplete and ambiguous though it may be. This process is a naturally occurring process in problem solving. Students merely need to be given free reign with a problem to engage with this process. The instructors of this view would have to record the group's hypotheses, facts, and learning issues generated, and provide opportunity for reviewing the hypotheses as new data about the problem are gathered. This is indeed an important part of being a coach in the PBL process.

Nonetheless, in the specific context of IS development, the controversy over which method to teach in the PBL process of problem solving can somehow be resolved by examining the meaning of the word *methodology*. Today, it means not only the originally defined 'the science of method,' but also 'a body of methods used in a particular study' (*Concise Oxford Dictionary of Current English, 1996*). As the structure of the word *methodology* indicates, it is the logos (principles) of method, when properly considered. When those principles are used to underlie, justify and inform the things which are actually done in response to a particular problem situation, those actions are at a different level from the overarching principles. Methodology in that situation leads to 'method', in the form of the specific approach adopted, the specific things the methodology user chooses to do in that particular situation. If the user is competent then it will be possible to relate the approach adopted, the specific method, to the general framework, which is the methodology. And if the methodological principles are well thought out and clearly expressed, then a repertoire of regularly used methods that are found to work will emerge over time as experience is gained. According to Checkland and Scholes (1999, pp. A31-A34), since methodology is at a *meta* level with respect to method (i.e., about method), the above argument means that no generalizations about methodology in use can ever be taken seriously.

In fact, whenever a user knowledgeable about a methodology perceives a problem situation, and uses the methodology to try to improve it, there are three elements closely of interest: user, methodology as words on paper, and situation as perceived by the user. Any analysis of what happens (carried out by an outsider) would have to embrace all three elements and the interactions among them. Briefly stated, we have a user, U, appreciating a methodology, M, as a coherent set of principles, and perceiving a problem situation, S, asks himself or herself this simple question: What can I do? He or she then tailors from M a specific approach, A, regarded as appropriate for S, and uses it to improve the situation. This generates some learning, L, which may both change U and his or her appreciations of the methodology. Future versions of all the elements L, U, M, A, and S may be different as a result of each enactment of the process. All the problem solving done by a PBL group could indeed be seen as enactments of this LUMAS process, which accepts that what the user can do depends upon the nexus consisting of U, U's perceptions of M, and U's perceptions of S (Tsouvalis, 1995). It should be interesting to note that any methodology itself can hardly lead to improvement of the problem situation. Though the methodology may help the PBL group to achieve better improvement than they could without its guidelines, different users tackling the same situations would achieve different outcomes, and an outside observer can form sensible judgments not about M, as if it could be isolated and judged on its own, but about LUMAS as a whole.

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