Module 5: Teamwork

Topic 5.2: How to teach teamwork?

Video lesson

- https://youtu.be/0cmYXTMYxaE

Reading material

- Introductory text
- Inculcating team-based problem solving skills, part 2: Enhancing team-working skills

TEACHING TEAMWORK – PREPARATION

Introduction

In this topic, we would like to talk about the preparation of our students to the teamwork. Most of the educators who encourage teamwork in their classrooms know that students must be instructed first. Even if we think that our students know the rules it is suggested to repeat them.

Team roles

According to Belbin, teams are commonly made up of members holding appointments. Members of a team can contribute in two ways to the achievement of team objectives. They can perform well in a functional role with their professional and technical knowledge, but they also have a potentially valuable team-role to perform. Each team need an optimum balance in both functional roles and team roles. The effectiveness of a team will depend on the recognition and adaptation of the team members of their relative strengths within the team – both in expertise and ability to engage in specific team-roles. Personal qualities fit members for some team-roles while limiting the likelihood that they will succeed in others.

Through his research, Belbin introduced the following team roles, of which each member has more than one.

Task roles focus on 'what': the job in hand, and getting it done. The key 'task-focused' team roles are Shaper, Implementer, Completer-Finisher, Monitor-Evaluator, Plant and Specialist.

Process roles focus on 'how', and particularly on the people involved. They include Coordinator, Resource Investigator, and Team Worker.

The most effective team-workers are those who can see what skills are available within the group and use their skills to fill any gaps. People tend to be either task- or process-focused, rather than a mixture.

De Bono Six Hats

To communicate effectively, try to introduce the six hats of De Bono method to your students. The coloured hats are used as metaphors for the various states of mind. Switching to a certain type of thinking is symbolized by wearing a coloured hat, literally or metaphorically. These six thinking hats metaphors provide more complete and comprehensive segregation of the types of thinking than the prejudices that are inherent to the immediate thoughts of people. All these thinking hats help people to think more deeply about a certain topic.

Invitation to the topic

Now, we would like to invite you to think about creativity in general and about creativity in education. Please, watch the video we included and read the article about Creativity in Education. You can also look at the PowerPoint presentation. After that, you are invited to participate in the forum, where we would like you to share your ideas and experiences on creative teaching.

Inculcating team-based problem solving skills, part 2: Enhancing team-working skills

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Inculcating Team-based Problem Solving Skills, Part 2: Enhancing Team-working Skills

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Abstract*: This paper presents a qualitative study to understand how Cooperative Problem-Based Learning (CPBL) enhances team working skills among engineering students. The epistemology of the study is based upon interpretivist perspective. The research used the grounded theory approach to study the process, or look for explanation of the process, if it is in accordance with the intended design of the CPBL framework, which purposefully aims to promote team-based learning and problem solving. Based on the research, models of students enhancing their problem team working skills are proposed. This paper presents the analysis on how CPBL enhance team working skills in engineering students. This is the second of two papers that report on how CPBL enhanced students' team-based problem solving skills.*

Introduction

Problem Based Learning (PBL) is well known as an innovative technique that engage learners for deep learning, and develop a multitude of crucial professional skills, especially self-directed learning and problem solving [1], which are essential for engineering graduates of the 21st Century [2,3]. However, the PBL cycle implemented in medical schools in small group tutorials of up to ten students, facilitated by a tutor [11,12] is not feasible and practical for engineering courses, given the high students to faculty member ratio. An alternative is to have small groups (3-5 students in a group) in medium to large classes (20 to more than 60 students), with one or more floating facilitators. Although this approach is more feasible, it requires higher commitment and accountability on the part of students to go through the PBL cycle together in their groups.

Nevertheless, students do not automatically develop team working skills when they are assigned to groups [14,15,16]. Since having functional teams in which students can harmoniously cooperate is crucial for successful PBL implementation [17], infusing Cooperative Learning (CL) principles to purposefully drive students to work together as a team as they go through the whole PBL cycle would be essential for this setting. Cooperative Learning (CL) is known to promote accountability and cooperation which is necessary for transforming learning groups into functioning teams [18, 19]. With CL, part of the learning support is now handled by the learning team and also the whole class as a learning community. Thus, integration between PBL and CL is proposed to create the Cooperative Problem-Based Learning framework to support learning and solving problems in small student teams (consisting of 3-5 students) in a medium sized class, of up to 60 students for one floating facilitator. Designed based on constructive alignment [20, 21], the CPBL framework serves as scaffolding for guiding students through the CPBL cycle.

This paper is the second of a two-part paper that studied how CPBL enhanced team-based problem solving skills. This paper presents a qualitative study of how third year students develop team working skills as they go through CPBL throughout the semester in an engineering course.

Cooperative Problem Based Learning

PBL, which has constructivist underpinnings, has a typical cycle consisting of three phases:

- Phase 1: problem restatement and identification,
- Phase 2: peer teaching, synthesis of information, and solution formulation, and
- Phase 3: generalization, closure and reflection.

For small groups in a medium to large class settings, the support needed does not only involve cognitive coaching at different PBL phases, guidance to develop team working skills in students is also essential. While it is challenging for a floating facilitator to monitor and support all groups closely, in a proper Cooperative Learning (CL) environment, part of the monitoring, support and feedback can be attained from peers, especially team members, instead of solely relying on the facilitator.

Cooperative Learning (CL), which is rooted in social interdependence theory, is proven to promote cooperation among students resulting in improved learning quality and skills, such as academic achievement, interpersonal skills and self esteem [23]. Interaction among learners can create collaboration, leading to a significant positive impact on learning [24]. To ensure good team working, the five principles of cooperative learning [18,19] that must be emphasized and promoted throughout the CPBL cycle are: positive interdependence, individual accountability, face to face interaction, appropriate interpersonal skills, and regular group function assessment.

To infuse the CL principles into the PBL cycle, the typical pattern of CL activities are used to expand each phase. The activities in the typical pattern are: individual construction, interaction with neighbor or team member, and overall class interaction for closure. Applying the principles of constructive alignment results in the CPBL model shown in Figure 1. More detailed description of the model can be seen in Mohd Yusof, et al (2011).

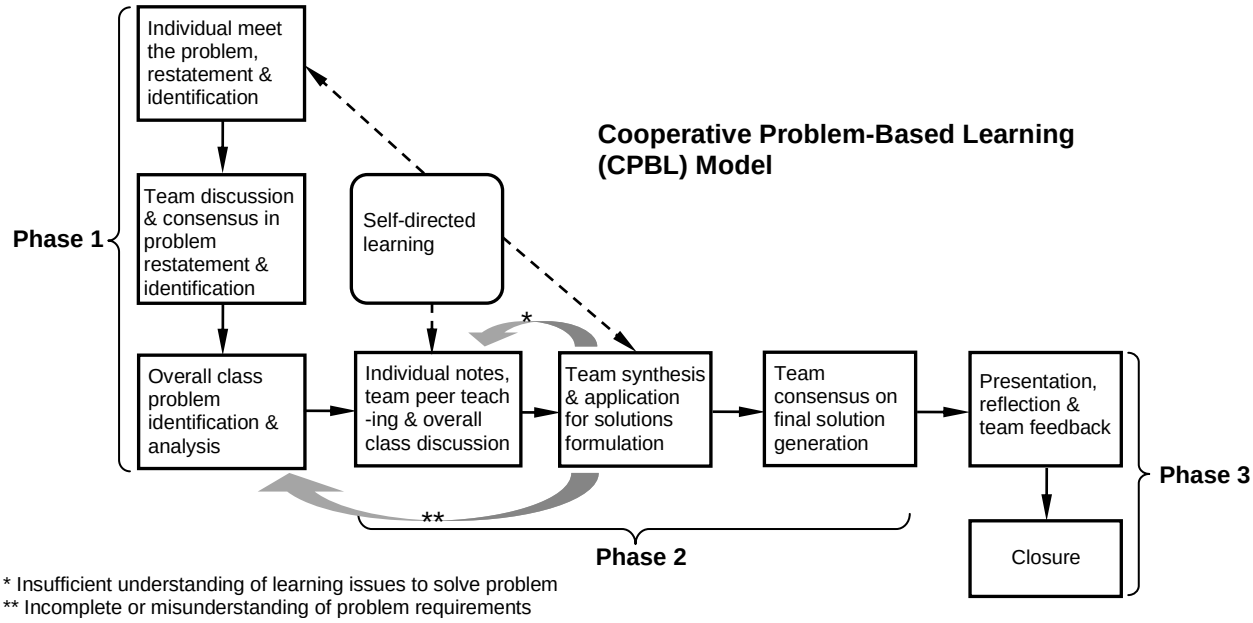

Figure 1. The CPBL framework

Based on the theories used to design the CPBL framework to promote team based problem-solving, it is only appropriate to investigate how team working skills are enhanced when students undergo a semester of CPBL in an engineering course. The research question is:

How does CPBL enhance effective team working skills among students?

The theoretical framework corresponds to the theories used to design CPBL because the main purpose of this study is to examine if the model is effective in supporting students to attain the desired outcomes that that model is designed for.

Methodology

To answer the research question, grounded theory approach was used since it offers a step-by-step, systematic procedure for analyzing qualitative data (Strauss and Corbin, 1998). Grounded theory can be used to study process, or looking for explanation of a process (Creswell 2007), which fits the research question. The methodology is the same as described in Part 1 of this two-part paper.

The research question focused on the CPBL approach, on students describing their experiences mainly through interviews and reflection journals. The participants in the qualitative research were selected based upon the pre-test result of the MSLQ score, which a questionnaire that can be used to determine students' motivation and learning strategies. There were seven students in two selected heterogeneous groups - these were the same students from Part 1. The students are third year chemical engineering students taking a highly technical and calculation intensive course. There were four problems (also called Case Studies) that students solve by going through the CPBL cycle from the beginning until the end of the semester. Students submit individual reflection journals at the end of every problem. The degree of difficulty and expectations were gradually raised from one problem to the next. The students' reflections and the interviews were analyzed using NVivo 8 and themes emerged from the reflections and interviews were analyzed. Emerging themes are considered as saturated if they were frequently mentioned (Corbin and Strauss, 2008). As a rule-of-thumb, themes emerged more than seven times is considered as saturated. The themes are considered triangulated if they emerged many times from different sources (Creswell, 2002). In this study, the researcher's role is like an "instrument" through which the reality of the students' problem solving skills enhancement is explored. The researcher's presence is acknowledged, both by the students and the lecturer.

Results and Analysis

Data were taken from a series of four reflections (one after Problems 1, 2 and 3, and a meta reflection at the end of the semester) and interviews with the seven selected students. Themes emerged in the analysis are classified into five categories, which are face-to-face interaction, individual accountability, interdependent, interpersonal skills and regular assessment, with respect to Johnson, Johnson and Smith's (2006) cooperative learning principles. The themes that emerged for the open coding are discussion, learning, commitment, shared value, tolerance, communication, leadership, managing conflict, time management, peer review and reflection. For example, Table 1 illustrates an example that shows an open coding and numbers of repetition of themes for interdependence. As shown in the table, all the themes related to interdependence are mentioned several times. Commitments are mentioned the most, followed by shared values and tolerance. The students appreciated the way CPBL enhance their interdependence skills, especially in increasing team commitments and their shared values, thus, enhancing their team work problem solving skills. The themes are classified further into axial coding as follows: a) Communication, leadership, and managing conflict are classified as interpersonal skills; b) commitment, shared value and tolerance as interdependence; c) discussion as face-to-face interaction; time management and learning as individual accountability; and d) peer reviews and reflections are as regular assessment.

Table 1: Open coding and repetition of the themes for interdependence as the axial coding

Interdependence	**Reflections**				**Interviews**		$\sum$
	Problem 1	**Problem 2**	**Problem 3**	**Meta**	**Group 1**	**Group 2**	
Shared Value	3	2	4	3	2	3	17
Tolerance	1	1	3	3	1	0	9
Commitment	3	5	6	4	1	4	23

The themes are classified into five elements to become the selective coding. The elements are based upon the CL principles, which are face-to-face interaction, individual accountability, interdependence, interpersonal skills and regular self-assessment. All these are very important elements in CPBL that will contribute to the enhancement of team based engineering problem solving skills. Table 2 shows samples of open coding for team working for two of the elements: individual accountability and interdependence.

Table 2: Samples of open coding for two elements in team working

Elements	**Sample Data**	**Open Coding**

Individual Accountability	After discussing in team, standard block diagram was used instead of followed the process in diagram. I do my study on block diagram after meeting with teammates again. It make stronger concept to me after revision done	Learning
Interdepen-dence	In my team, everyone cover up every weakness in others to make our team complete.	Commitment
	Overall, I am satisfied with myself and my team performance and I feel that my team is a Cooperative Learning Group. All my team members willingly spend their weekend to finish the report of Case Study 2 and they are full of commitment. We work as a team and I can say that 'if you jump, I jump and we jump together'	Shared Value
	At first, we were just like a traditional group, but doing a little more than a traditional group. But as time goes by, we improved and performed better, and were more like a cooperative team. We shared with each other and worked with each other. From there, we learnt from each other. Though we are all of different backgrounds, we still worked together very well. I hope this can be a preparation of what I am going to face when I am working.	Tolerance

Discussion

The analysis from students' reflections and interviews revealed five categories of themes, which correspond to the five principles of Cooperative Learning. Altogether, ten themes emerged from the analysis, with nine of them considered as important since they are saturated.

Themes that emerged in the analysis which were classified into interpersonal skills are conflict management, communication, and leadership. The most mentioned is conflict management, followed by communication, then leadership. All these themes are considered important. An example of conflict management, on trying to build his friends' trust back after a small conflict, one of the students remarked, *"In case study 3 I tried my best to win my teammates' heart back. What I had tried was not just for them, it also for myself. I tried what I could do for the case study 3. I had participate all the meetings and learned deeper of the tuning. Yeah! I could help my team to solve some of the problems. I think I had improve my attitude if compare with case study 2."*

When teams become matured, it develops trust. Poor teams will try to ignore conflict hoping that it might go away. Good teams will change conflict into opportunity, because from conflict will come better decisions (Woods, 2000). In CPBL conflict cannot be avoided. But, the beauty is, students learned how to manage it!

Another theme in this category is communication. Good communication is vital in interpersonal skills. A basic skill for effective interpersonal skill is the ability to listen and respond (Woods, 2000). Communication is the heart of effective teamwork (Smith and Imbrie, 2004). Through CPBL students learn to communicate extensively, especially during team discussion, peer teaching, and overall class discussion. As one of the students revealed her enhancement in the skill, "*I managed to pick up the skill to make others talk or initiate a conversation.*" Another frequently mentioned in the reflections and interviews is enhancement in leadership, which developed the students' interpersonal and problem solving skills. In The Leader's Handbook, Scholtes (1998) listed six "New Competencies" in leaders, of which the second competency is that leaders should have the ability to understand the variability of work planning and problem solving. The fourth competency is that the leaders should understand people and why they behave, i.e. the interpersonal skill. With regards to this, one of the students said, "perhaps I would love to master the art of saying the not so good things in a good way", which reflected the tendency of the student to acquire one of the characteristics of effective leadership skills.

The next category interdependence, where three themes emerged: shared value, tolerance and commitment. All these are considered as important since all are saturated, with commitment mentioned the most, followed by shared value and then tolerance. Interdependence is about learning how to work together, producing better results in solving team-based problems. A very important element in interdependence is commitment. This theme emerged several times in the reflections and interviews. An example of commitment is as stated by one of the students, "*In my team, everyone cover up every weakness in others to make our team complete*." Clearly, all students in the team are very committed in helping each other to ensure they achieve high performance team, and together produce good results. The following statement is proclaimed by one of the students that emphasized the shared value among her team, *"Overall, I am satisfied with myself and my team performance and I feel that my team is a Cooperative Learning Group. All my team members willingly spend their weekend to finish the report of Case Study 2 and they are full of commitment. We work as a team and I can say that 'if you jump, I jump and we jump together'."*

The last statement in the vignette illustrated the form of sharing and unity among team members. The last theme that is also important in this category is tolerance. Differences are routine aspects in almost every situation. To be interdependent, one needs to understand and tolerate each other. In problem solving, an ill-structured, open-ended problem solved by smart and motivated students routinely cause disagreement about the best way to accomplish the tasks and about how to deal with trade-offs among priorities. In this heated discussion, tolerance is highly required to solve the problem constructively. With this regards, one of the students reported, "*At first, we were just like a traditional group, but doing a little more than a traditional group. But as time goes by, we improved and performed better, and were more like a cooperative team. We shared with each other and worked with each other. From there, we learnt from each other. Though we are all of different backgrounds, we still worked together very well. I hope this can be a preparation of what I am going to face when I am working*." In CPBL students learned to have tolerance of others. But, this will take some time and progressively improve. With scaffolding and correct facilitation, students can perform well working in a team.

In face-to-face category, theme that emerged in the analysis is discussion. In the analysis, there are several vignettes that belong in this theme. One student remarked: "I assumed that actually I can determine the control configuration of the loop by looking at the P&I Diagram. If it measured the variables before entered the valve, I assumed it was feed-forward and if it measured the variables at the exit of valve, it was feedback. After discussion in our meeting, I was exactly wrong."

Discussion is very important as it enables the verbalization of thought, forcing ideas to be organized logically. Verbalization also makes thinking visible, enabling critical examination. This exercise in thinking process often results in better solutions to problems. At the same time a lot of problems happened because of communication breakdown. In CPBL, discussion is the essence of cooperative learning. Students were trained to have positive and deep discussions at every phase and every cycle of CPBL process, from problem identifications, peer teachings, overall class discussions until result presentations. Face- to-face interaction is not only among the students, but also with facilitators and invited experts form industries.

Another category of theme is individual accountability. There are two themes identified as important in the analysis: learning and time management. With regards to learning, one of the students reflected, *"After discussing in team, standard block diagram was used instead of following the process in the diagram. I do my study on block diagram after meeting with teammates again. It make stronger concept to me after revision was done*." CPBL is student-centered learning, where students are responsible on their own learning. With peer support and probe by a facilitator, students were trained to be self-directed learners. In peer teaching, students not only have to learn, but also to teach one

another. Learning to teach will definitely enhance individual accountability. Time management is another theme that is classified in this category. As one of the students explained how she managed her time, "*Then, our first case study came out. I cannot manage my time because of too many things to do. To prevent the time management problem, I included our discussion in the time table. I fixed the time. So that, I will prepared well before attend the meeting and class."* CPBL trains and requires students to manage their time well. Be it in class or outside of class. Students realize that procrastination will definitely jeopardize not only the CPBL course but also others. It is not that CPBL consumes a lot of work, but it is about how someone managed their time.

The last category of effective team working is regular self-assessment. The themes that emerged in this category are peer reviews and reflections. However, though peer review is considered as an important factor in assessment, it is very seldom mentioned by the students. Since it is not saturated, the researcher has to omit this from the finding. Formal reflections usually are done at the final stage of CPBL cycle. However, along the way students are encouraged to reflect upon and be cautious of their decisions at every stage of CPBL process. During reflections students will reflect on their problem solving process and their performance as a team player (Tan, 2003). This is in line with what one of the students mentioned in her reflection, "*We started our serious discussion about shower control system. I gave my opinion but I'm still afraid to deny their opinion although I didn't agree with their opinion. That was my weakness. I still thought they are better than me. Then, they always right. Totally, I am wrong.*" With regular self assessment, for example, through reflections, students will evaluate themselves, and improve upon whatever weaknesses that they have. They might also do the comparison between themselves and their team member, so as to gauge their ability, performance or attitude for self-evaluation and improvement.

Figure 2 shows the open, axial and selective coding of the analysis. The five elements mentioned above are grouped into an axial coding named the CL principles. Interpersonal skills and face-to-face interaction are grouped into an axial coding called potency; while regular self-assessment and individual accountability are grouped into an axial coding named goal setting.

The potency and goal setting axial coding plus element of interdependency formed a new axial coding which is team effectiveness. The selective coding is named as high performance team working which is the integration of the CL principals and team effectiveness. This concept is illustrated in Figure 3. This sub-model shows all the related elements and the processes involved in how students could achieve high performance team working which leads to the enhancement of students' team-based problem solving skills.

Conclusion & Implications

This research shows that students were able to develop and enhance their team working skills as they go through several cycles of CPBL throughout the semester in a typical engineering course. The study also revealed that students actually experienced the effect of all the cooperative learning principles, which guided them to develop the necessary skills. Therefore, this shows that the CPBL model designed is constructively aligned to the desired outcome of developing team based problem solving skills. Since CPBL can be used in a typical class, the model has the potential for others to use, especially when institutional support is lacking for the implementation of PBL, since it can be applied in a stand-alone manner. In addition, it is essential for engineering educators implementing CPBL to emphasize the support that students need to provide to one another that is built in to the CPBL framework.

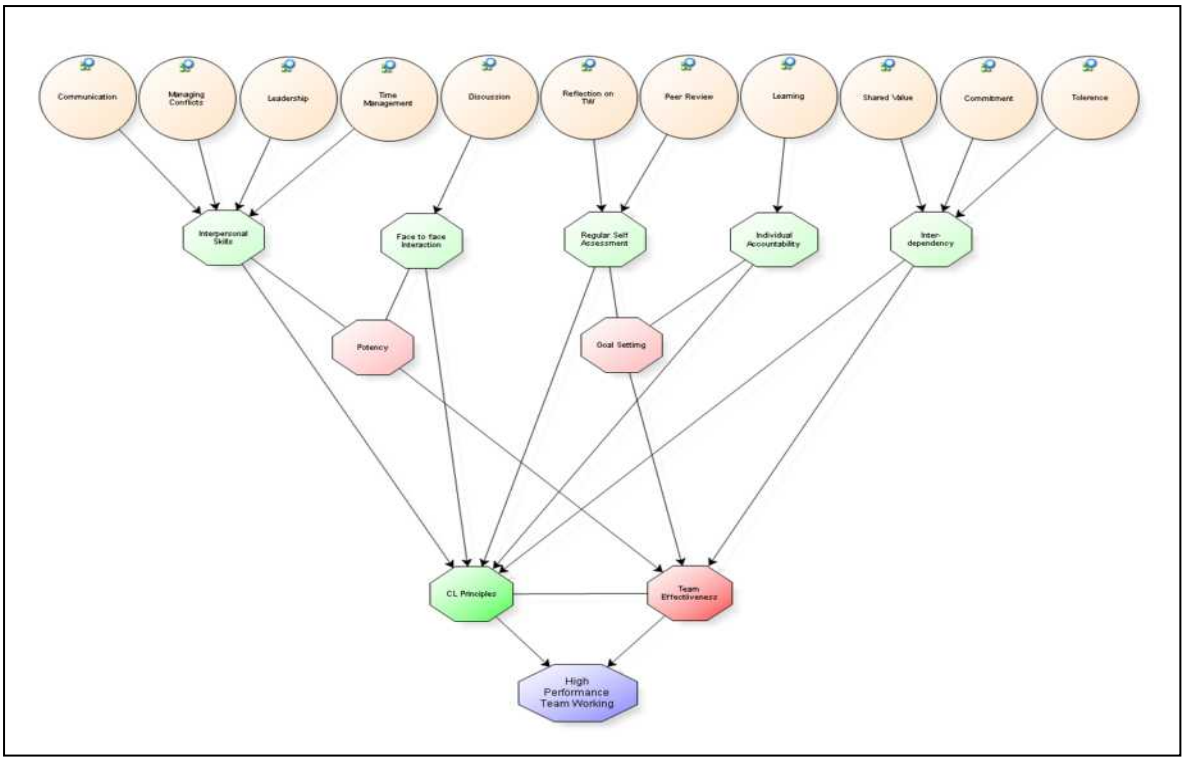

Figure 2. Open, axial and selective coding for sub-model enhancement of team-based problem solving

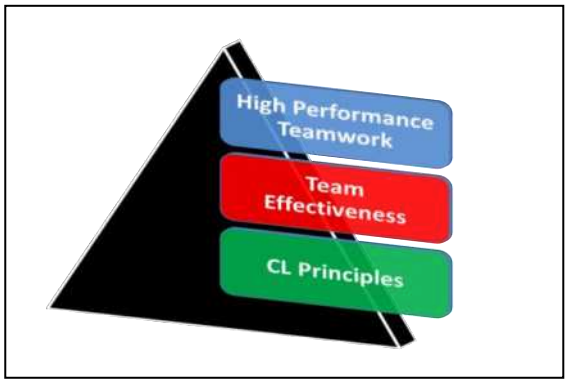

Figure 3. High performance teamwork

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