Student Perceptions Change in a Chemical Engineering Class Using Cooperative Problem-Based Learning (CPBL)

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Abstract

This paper reports a phenomenological study of a class of third year Chemical Engineering students at Universiti Teknologi Malaysia towards their first experience in undergoing a course using Cooperative Problem-Based Learning (CPBL). The main purpose of this study is to understand the students' perceptions on CPBL in two aspects; (1) the student perceptions and acceptance on the learning approach; and (2) what the students gained from the learning process. The paper illustrates the pattern of perception change among the students and how CPBL affects the students' mastery of the content knowledge (Process Control), problem-solving, team-working as well as self-esteem. At the same time, this study also investigates the role played by the lecturer in affecting the students' perception change. Through classroom observations and interviews for one whole semester, the results are reported in three stages: (1) the beginning; (2) the middle; and (3) the end of the semester. The findings have wider relevance for evaluating student assessments of CPBL in Engineering Education.

Keywords: Cooperative Problem-Based Learning, Chemical Engineering Education, Phenomenological Study, Psychological Changes;

1. Introduction

Cooperative Problem-Based Learning (CPBL) is a new learning approach that is gradually gaining interest among the engineering educators. It is a model that combines two learning methods; Cooperative Learning (CL) and Problem-Based Learning (PBL) that emphasizes learning and problem solving in small groups (consisting of 3-5 students). CPBL is designed for medium-sized classes of up 60 students for one floating academic staff or facilitator (Khairiyah et al., 2011).

The principle of Cooperative Learning (CL) model is based on that learning is best achieved interactively compared to one-way transmission process. It is a structured and systematic learning strategy to form appropriate and sustainable learning groups of interdependent members in determining specific learning goals, while slowly transforming the groups into functioning teams (Cueso, 1992). The values of cooperation between students in their groups are more prioritised rather than competitiveness (Felder & Brent, 2007). This functioning group is very important as an individual's learning success or failure is linked to the learning success or failure of other group members' performances. Cooperative Learning (CL) is proven to promote cooperation among students resulting in improved learning quality and skills of academic achievement, interpersonal skills and self-esteem. These student performances are described by Smith (2007) in four types of learning group performance in the classroom:

1. Pseudo learning group: Group members passive and reject to work together and compete with each other. The group performance level is lower than if members were to work individually.
2. Traditional classroom learning group: Members accept that they have to work together, but contribute for very little joint work because tasks given can be divided and done individually. There been free-riders in the group that cause responsible members feel burdened, and resulting in a very low performance. The group performance level is about the same as if members were to work individually.
3. Cooperative learning group: Members relieved they can work together in a group, and understand that success depends on the effort of each member. Group performance level is higher than individual members.
4. High-performing cooperative group: Members are committed to help each other and the group succeeds. Synergy is achieved resulting in a group performance level that is much higher than those the individual members.

As for Problem Based Learning (PBL), it is an inductive learning approach that uses a real problem as the starting point of learning. The problem becomes the 'trigger' that channel students toward self-directed and individualized learning as well as to motivate their own responsibility for learning (Khairiyah et al., 2011). Both elements of CL and PBL are combined in a course instruction, which facilitates students' achievement in three aspects (Felder & Brent, 2003):
1. Planning - identifying course contents and defining measurable learning objectives
2. Instruction - selecting and implementing the methods that will be used to deliver a specified content and facilitate student achievement of the objectives;
3. Assessment and evaluation - selecting and implementing the methods that will be used to determine how well the objectives have been achieved

CPBL is the instruction used in the traditional classes to achieve and promote for transforming learning groups into functioning teams. CPBL is conduced in three phases: (1) Problem Restatement and Identification (PR&PI); (2) Peer Teaching, Synthesis of Information & Solution Formulation; and (3) Generalization, Closure and Reflection (refer Figure 1).
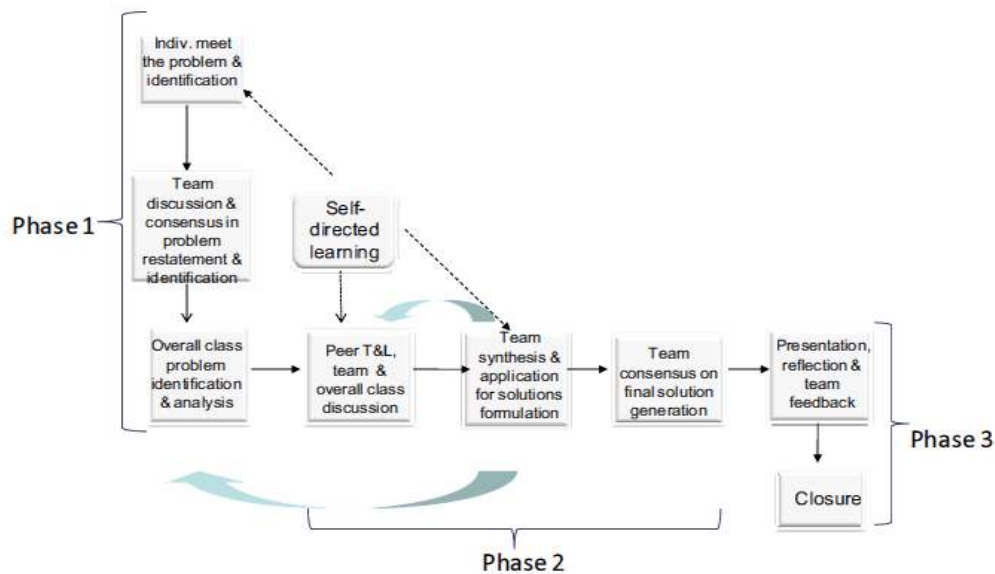

Figure 1: The CPBL Framework (Khairiyah, 2010)

1.1. Student Perceptions in Learning

The nature of the human perceptions in a learning process changes due to the influences and values of the environment. These learning conceptions has conceptualized into 6 hierarchical levels: (a) increasing one's knowledge; (b) memorizing and reproducing of knowledge; (c) applying; (d) understanding; (e) seeing of something in a different way; and (f) changing as a person in nature (Marton et al., 1993; Tynjala, 1997). In the first three categories, the learning is described as reproduction of information, while the next three categories of learning as knowledge transforming.

Although there are many studies on the conceptions of learning, it is still difficult to predict the changes on students' perception and its development. Some claims that the development trend of a student changes drastically in the later stage of the learning process than in the earlier stage (Marton et al., 1993). However, there are also others who believe that there are no changes in knowledge perceptions (Boulton-Lewis, 1994). Thus, it is crucial to understand how the learning environment affects the students' perception change.

In a study conducted by Vermunt & Van Rijswijk (1988), the learning environment is an important factor that influents students' learning conceptions and their perceptions. As shows in Figure 2, this quality of learning environment could normally be examined in the earlier stage and the present stage of the learning process. The early stage is normally deals with development of understanding on the learning procedures while the present stage highlights the responses of students after undergoing the process.

> **EARLY STAGE OF LEARNING**
> - Describes students' conceptions & perceptions on *what learning is all about* and *their definition of learning.*

> **PRESENT STAGE OF LEARNING**
> - Concerns with students' conceptions & perceptions of: (i) *how learning takes place* (what the learning all about); (ii) *process is real-like*; and (iii) the *changes* of the perceptions as results of the teaching and learning.
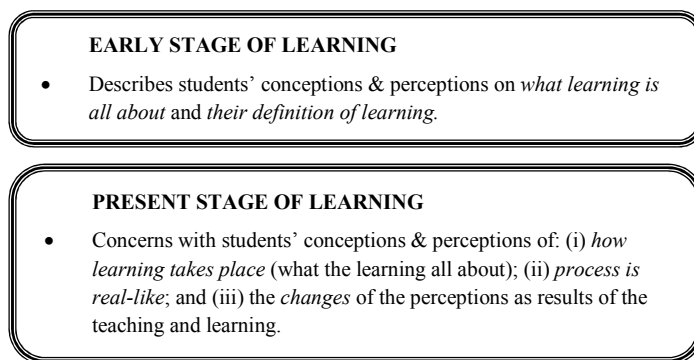
Figure 2: Framework of learning conceptions and perceptions

As for the intermediate period of learning, it is easily described as emotional progressive tenses. These tenses are mostly developed due to shock or upset of the learning process or because of over-positive reactions during the process. Vermunt & Van Rijswijk (1988) did not report this stage in their further discussion as they claimed that the students' pressures and tenses will decline as the students going through the learning process. In contrast, this paper will highlight this intermediate stage as it present how students transformed from negative to positive perspective towards the learning process and vice versa. Through the understanding of changes in student perceptions, the operation of CPBL as an instructional approach can be further improved.

2. Methodology

This study involved a class of third year chemical engineering students who enrolled in a course to study Process Control at Universiti Teknologi Malaysia. Of 35 students, 10 (29%) are male students while 25 (71%) are female students. The purpose of the study is to understand how the learning environment of CPBL affects the students' learning experiences especially their perceptions. For this purpose, a phenomenological research design was carried out through non-participant observations and unstructured interviews. The phenomenology studies itself aimed for exploration and description of the essential nature of things and experience as they are in their own terms. This

allow the studies to provide descriptive answers grounded in evidence arise from and verifiable through human experience (Ekebled, 1995).

The students were divided into nine groups (about four students in a group). The data were collected qualitatively which focused on the three phases of CPBL, namely (a) Problem Restatement and Problem Identification (PR-PI); (b) Peer Teaching and Class Discussion; and (c) Closure Session and Reflection Responses. The results are presented in three stages: (i) initial learning stage in the beginning of the semester; (ii) middle stage in the middle of the semester; and (iii) final stage at the end of the semester. The analysis of the results are coded and organized based on the emerging themes found in the data (Strauss & Corbin, 1998).

During and after each cycle or case study, the students were asked with a set of questions centred on students' initial thought as they approach the CPBL system in initial stage (refer Table 1). The questions aimed to investigate the students' expectation on CPBL after attending classes in the first few weeks of the semester; what differences they felt compared to their former teaching and learning experience, and what concerns that they had regarding the new approach. In the middle stage, the focus shifted towards their emotional pressure, anxiety and tenses of the learning process. In the final stage, they were asked to compare their present perception with their initial expectations of CPBL and what have they gained from the new learning approach. The students were selected for interviews based on their convenience. Some students were interviewed more than once in each stage.

Table 1: Interview questions

Initial stage
1.   How do you see the class of CPBL today?
2.   Is there any difference to other engineering classes? Are other engineering classes like this?
3.   Do you have any difficulty in following your lecturer?
4.   What do you think your friends' comments about this class?
5.   What do you expect in this class for this semester?

Middle stage
1.   What is you perceptions now about CPBL conducted in the classroom? (i.e., from aspect of motivation, problem solving, knowledge mastery, team working or other issues?)
2.   Are you comfortable with the cycles and tasks given to your group?
3.   How is the involvement of students in classroom or in your group?
4.   Do you feel disappointed with your group member or the lecturer?
5.   Do you think you can cope with the CPBL learning approach?
6.   Any other comments?

Final stage
1.   What is your overall expectation of the CPBL experience after one semester?
2.   What are the most important things that you have learned from this class?
3.   What is the highest self-improvement you have gained through this class?
4.   Do you think that CPBL is a waste of your time?
5.   Do you think CPBL should be used in other engineering classes?
6.   Are there any issues you want to raise? Positive issue or negative issue?
7.   Are there any initiatives that you/your group have taken to improve your learning in this CPBL class?
8.   Your comment on the present peer-teaching class discussion?

At the final stage, the students were categorized into four groups:
(a) those who held positive perception about CPBL from the beginning until the end of the semester;
(b) those who held negative perception from the beginning until the end;
(c) those who changed from positive perception in the beginning to negative perception at the end; and
(d) those who changed from negative perception in the beginning to positive perception at the end.

For the purpose of this paper, the quotes of the students in English were not edited but some parts that were mixed with Malay were translated for appropriate comprehension of the international readers.

3. Results and Discussions

3.1. Student's Perceptions on CPBL: From negative to positive

From the interviews at the initial stage, there was a mixed of feeling among the students ranging from excitement to anxiety. The students compared their study performance between CPBL and other more traditional approaches such as lecture and classroom discussion. As the course of "Process Control" is one of the most difficult courses in chemical engineering, as advised by their seniors, the students worried that CPBL would cause them to fail the course. They also worried that the time required for group discussions would be too much of a waste of their study time and the works assigned for their groups might be too difficult for them to accomplish. This pressure contributed to the negative perceptions in the initial stage. Overall, the negative perception could be categorized in Table 2.

Table 2: Negative perceptions among students at the initial stage

Aspect	Example quotes from the students at the initial stage
The learning cycle is too fast	"...the number of case studies was too much and many things need to do in one cycle. The time distance between case studies also too close and this compact my learning schedule. This makes life horrible for me, difficult to absorb knowledge and to have deep understanding in each case studies as well as tension on the non-stop case studies"
Longer time to engage in the CPBL process	"The biggest problem is time consuming. This makes me into trouble as CPBL required all team members come together and discuss each of case studies whenever the new cycle started. I cannot deny the benefits offered, however an excessive use of time affects the pattern of my personal learning style."
Confusion, anxiety and feeling of giving up	"... We are now at the stage of CS2 [Case Study 2] part 1. However, the main concept of CS1 I still do not even fully understand yet, and now had entered into a new chapter. It made me confuse, lost and I think I no longer can follow. That's the reason why many students and even myself is a bit lost and blur in the classroom.... "
Different sources of references	"...it's not that I do not understand. It just when others start debating with a different method from different textbook, that's difficult. As for me, I do not refer so much on Seaborg textbook as its explanation was too difficult and complex. I did refer to other books. However, this causes us do not have mutual understanding..."
Focus on self-efforts and fewer of lecture notes, feeling of lack of guidance and insecure learning environment	"Lecturers only leave it to the students to independently search for the truth as he himself did not teach in the classroom. Although the students have presented the PR-PI, the lecturer did not intervene in correcting things. This caused for more confuses as we just want a justification on which one is right or wrong ... "
Different understanding and ideas among group members	"Sometimes the simple things become so complicated. I think the issue is simple and I already understand. But when come for class discussions, they debate over the issue and sometimes jump into beyond the expectations. That thing causes confuses to others"
Worries on examination and the uncertainty of CPBL in achieving a good grade for the course	"…although I learned through CPBL in the classroom, but there always missed topics lots more that uncertain. For example, in class discussion there not covered up the topic but yet the questions appear in the exam. The lecturer also not covered in the syllabus and input gained also very little, so it's very dangerous!"

However, after underwent the learning process in one semester, most of the students found that the workloads given in each case study have actually increased their skills in time management and forced them to make wide readings. This caused them to enjoy the following case studies as it produced deeper and clearer understanding of concepts due to longer time engagement. The aspects are summarized in Table 3.

The issues on CPBL were raised as the students are burdened with the workloads, challenging real projects and problem-solving, huge commitment, self efforts and longer time spent. In the beginning, almost all the students were having difficulty to accept CPBL learning approach. At the middle stage, a majority of students reported that they experienced new learning approach that emphasizes students' efforts and minimize lecturer's. They reported that with open discussions in the classroom, these help to create better understanding while their mistakes had been corrected. CPBL foster the students' willingness to learn more, move away from the spoon-feeding culture and work with group members.

Table 3: Student perceptions at the middle stage

Aspect	Example quotes from the students at the final stage
Exposure to workplace problems	"I admitted that at first, it's very hard & tough. But now I feel ok with CPBL. CPBL help me to expose the real problems in the reality of plant / workplace later on. Secondly, CPBL approach on forcing students to learn and read has lead for greater deal and understanding. Thirdly, during case-study not much that I know. However, at the end of each case-study, I learnt to know more and specifically on the issues or problems"
Learning time management skills	"Time consuming really a big problem for me! At the beginning, it's very difficult to adapt into the system and all need to be done by ourselves. But now, these difficulties make me learnt a lots about process control. It also trained me in managing time more practical. I cannot deny that there are a lot that I learnt through CPBL even though it consumed most of our time"
Training of self-learning and lifelong learning	"It's truly different! This class acquired no spoon-feeding and less guidance from the lecture. It cannot be denied, before, I totally blur, but later it become better and understandable"
More reading	"…that presented notes are results from reviews on peer-teaching notes from other friends. I have reviews on others' models several times and study the differences and its similarities in different textbooks. It causes me lots of reading, rewrite and reread in which this act I never done before…"
Promote self effort	"At the first time I am very curious on the subject as it seem so challenging and difficult to learn. I also curious on the topics and the awkward learning system than usual. But, after series of discussion with group members, I began to understand the flow of the learning system, the probe by lecturer and its hidden agenda. But, it tends to urge us confusing first and have own efforts on suggested textbooks"
More confident with the knowledge learnt	"For the test preparation, I have no longer need to struggle to study. I also no longer touching the textbooks. I just need to refer peer teaching notes and case studies report as the concept just apply back to the exam questions. From there I can simply answer questions and I am more confident."
Spend less time to revise for the final exam	"That's the different between this class with other classes. When finished the semester, I realize it really works! I have no longer need to study harder, read a lot and make past year questions. Over discussions, I can directly remember what have been learnt and discussed because we are always applied during case studies and self-learning through peer teaching..."

At the end of the semester or the final stage, many students realized that the CPBL learning process has slowly optimize their learning skills. However, it still undeniable the process have burdened students with a lot of works and longer learning hours as well as dissatisfaction towards irresponsible group members. Through the interview, the students' perception can be categorized as in Table 4.

Table 4: Student perceptions at the final stage

Aspect	Example quotes from the students at the final stage
Self-directed and independent learning	"…I love this class! I love the self-making notes, group activities and open-minded class discussions. All these hardworking efforts make me more appreciate myself..."
Improve the reading and learning skills	"…that presented notes are results from reviews on peer-teaching notes from other friends. I have reviews on others' models several times and study the differences and its similarities in textbooks. It causes me lots of reading, rewrite and reread in which this act I never done before…"
Address own efforts and less on lectures	"It's very different! This learning style causes no lecture-based and lecturer notes as well as no direct spoon-feeding. It all about self-learning that acquires students to talk and discuss among each others."
Open discussion promotes better understanding and identifying own mistakes	"It's truly different! If we have misconceptions, these concepts will well-discussed together again and again in the classroom. It differs from previous learning method where it's only on the paper, no body care to ask and most students just pretend to understand…"
Promote future industry problems and applications	"Since study using CPBL approach, my understanding on specific problems is better. As compare to previous classes, students are only describes the theoretical situations and concepts in industry. But, through CPBL the problems are more practical, reliance on what may happen and how to solve the problems in the real-world."
Improve interpersonal skills	"Before, I am very passive. I am shy in interactions with friends and to come forward in front of audience. But now, I slowly feel relax, enjoy my communications and close talking to my friends. Now I can freely express my jokes!"
Improve time management and sense of professionalism	"... After went through series of case studies, I have learnt many new things. The most importantly, I learned to manage time as no longer last minute work and better understanding on what will occur, what are the problems and ways to overcome the problem in the industry. I learned to understand the ethical work of an engineer and its profession"

Most of the students claimed that at the final stage, they could follow and enjoy the learning process which offers them the following long-term benefits:

(a) contribution of long-term memory and makes them more hardworking;
(b) increase level of understanding, capabilities and self-performance;
(c) increase level of confidence and trained to be self-independent;
(d) increase passion and interest in discussion and learning intention;
(e) improvement on weakness from the Peer-writing Assessment and Feedback; and
(f) shorter time needed for exam preparation in term of notes, defined models and sample of calculations.

As in the end of the semester, a majority of students agreed that they have improved in the following areas: (a) critical thinking; (b) team-working; (c) mastery of knowledge; (d) communication skills; and (e) interpersonal skills. The enhancement of soft skills has raised their confident to face different learning and working environments in the future.

3.2. Student's Acceptances on CPBL System in the Learning Process

The study also explored further on student's acceptance on CPBL learning process. At the final stage, the students were asked if CPBL should be used in other engineering classes in the future. The responses were categorized into three groups: a) strongly agree; b) moderately agree and c) strongly disagree. Only a few students agreed that CPBL should be implemented in other engineering classes. This is because of the longer time spent and commitment to one course may jeopardize their performance in other courses. One student said:

"No! Every weekend is always packed with CPBL. I did not have time for others subject as well as for my excitement in life. I cannot do anything else at all! This is so problematic."

However, for those who strongly agree with CPBL, one of them said:

"Compared with the conventional learning system which highlights on individually learning, I prefer to learn with PBL. PBL emphasize self-learning with a functioning group. It is much easier!"

At the same time, a larger number of students held a moderate opinion on this issue. They believed that the number of credit allocated for a course that uses CPBL should be higher. Table 5 summarizes the level of acceptance of CPBL of the students.

Table 5: Student's Acceptances on CPBL Framework

Level of Acceptance	Reasons
Strongly accept	• Enhance time management skill
	• Increase reading skills
	• Increases personal efforts & patience
Moderately accept	• If the number of case-studies can be reduced
	• If the time for one case study can be extended
	• Less time engagement in group or class discussions
Strongly reject	• Wasting quality time
	• Uncertain results and increase worries
	• Difficulties in learning due to lack of lecture notes and guidance

4. Conclusion

This paper has attempted an initial assessment by exploring students' opinions and perceptions about the CPBL framework and its implementation in a Chemical Engineering class. By addressing challenges, stresses and tenses as well as discovering the student's abilities, it is become very important for the survival of CPBL implementation in the educational curriculum of chemical engineering.

Acknowledgement

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