Exploring Problem-Based Learning (PBL) and Case-Based Learning (CBL) in Stimulating Cognitive Skills among Medical Students: Analysis of Verbal Interaction

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ABSTRACT

INTRODUCTION: Problem based learning (PBL) has many benefits; however, research on PBL indicates that students are not quite good at integrating knowledge in basic sciences and clinical aspects. Case-based learning (CBL) might be an alternative method to enhance the integration of this knowledge. No research explored the way these two methods stimulate cognitive skills. This study aimed to explore the differences between PBL and CBL in stimulating cognitive skill by analyzing verbal interaction. **MATERIALS AND METHODS***:* This descriptive research was performed at the Faculty of Medicine, Universitas Islam Indonesia (FM UII). Twenty-one undergraduate students contributed voluntarily to this study. The students were then split up randomly into a PBL Group (n=10) and a CBL group (n=11). Each group performed twice discussion meetings facilitated by an experienced tutor. The discussion processes were video recorded and analyzed using a coding scheme categorizing the verbal interaction into five types: cumulative reasoning, exploratory questioning, procedural interaction, handling conflict about knowledge, off-task/ irrelevant interactions. **RESULTS:** Students in both PBL and CBL groups spent most of their time-sharing cumulative reasoning and then asking exploratory question. Students in the PBL group were more frequently asking exploratory questions. Students in both groups rarely handled conflict about knowledge since it was a high order thinking skill. Students in the CBL group were more frequent than the PBL group in performing procedural interaction. **CONCLUSIONS:** Students performed various cognitive skills in both PBL and CBL. Each method has its own strengths in stimulating reasoning skills of students.

INTRODUCTION

Problem based learning (PBL) as one of student-centred learning method was developed firstly in the preclinical setting for preparing students to enter clerkship. Students were expected to have sufficient capabilities to integrate knowledge in basic sciences and clinical aspects. PBL also has some objectives such as 1) increasing the achievement of adaptable knowledge 2) developing clinical reasoning 3) supporting self-directed learning 4) developing teamwork skills and 5) improving student motivation.[1,2] Small group discussions as the main learning activities of PBL has been conducted based on some characteristics including collaborative, constructive, contextual and self-directed learning.[3] Students work in a group to achieve learning goals. They construct their knowledge stimulated by a case that has similarity with the case found in their future profession. In tutorials, students activate their prior knowledge and then connect it with their new knowledge. They are facilitated to develop their self-directed learning skills since they determine their own learning goals, apply various learning strategies to achieve these goals collaboratively.[4]

Tutorial PBL is conducted in 3 phases: problem analysing, self-directed learning and the reporting phase.[5-8] Students perform the problem analysing phase in the first tutorial meeting, where they discussed a case and made a

hypothesis based on their prior knowledge. Through this process, students could identify their learning gap, and their learning objectives.[4] Students then conduct independent learning to search for information guided by the learning objective. The independent learning leads to the self-directed learning phase after which students report their learning finding in the tutorial meeting. [5,7] In this reporting phase, students apply the knowledge gained in self-study by connecting it with their prior knowledge and evaluating the hypothesis constructed in the first phase.[6]

Some of the research evaluating the PBL outcomes provide evidence that PBL students have better clinical reasoning skills compared to conventional students.[9,10] However, PBL students do not have basic science skills that are as good as conventional students. Case-based learning (CBL) is believed as an alternative learning method that can stimulate the integration of basic and clinical science knowledge. This method was developed firstly from PBL.[11] Case-based learning is a guided inquiry process. Students discuss based on their response to the provided question related to the case.[12] Compared to PBL, CBL's case is simpler and more focused.[12,13] The role of the facilitator / tutor in CBL is reinforcing the important concept by asking a question or giving information relevant to the case. All of this condition is arranged to enhance students' high order thinking skill by which they are supported to have more curiosity and ability to integrate knowledge.[14]

There are several models of the CBL process. Firstly, CBL could be conducted in two phases, namely preparation, and reporting. During the first phase, student analysis a case using their prior and new knowledge obtained from the case. This process is supposed to stimulate students for further independent learning. Students then share their knowledge in groups during the second phase.[11] Secondly, CBL could also be performed in one session. As a preparation, students are given a task that has been completed before the discussion session. The objective of the task is to direct students in reviewing relevant knowledge.[15]

Previous research showed that CBL was more effective to stimulate problem-solving and communication skills than conventional methods.[16,17] Research exploring the PBL and CBL process also showed the same results. Students perceived that CBL was better to enhance problem-solving and communication skills. However, it was less effective in stimulating self-directed learning skills than PBL.[18,19] These reviewed research were conducted based on students and tutor perception. Another research was conducted by observing students' behaviour in PBL and CBL tutorials. The finding indicated that there was no difference of knowledge achievement, which was measured using students' examination score between PBL and CBL groups.[20]

To the best of the our knowledge, no research comparing PBL and CBL especially in stimulating cognitive skills through observational method has been conducted. The aim of this research is to explore the differences of PBL and CBL tutorial in stimulating cognitive skills through verbal analysis.

MATERIALS AND METHODS

This research was conducted at the Faculty of Medicine, Universitas Islam Indonesia (FM UII), which has applied PBL as the learning method in preclinical stage since 2001. The primary learning activity in PBL is small group discussion (tutorial). Each group consists of 8-11 students, and a tutor facilitates it. The curriculum in FM UII is based on a body system and lifecycle that is divided into 5 phases; introduction on biomedical science, pathology of human disease, management of human disease, comprehensive health care, and professional health care. Phases 1-4 are the preclinical phases (year 1-year 4) while the fifth phase is clinical education. Since 2011, CBL has been applied in course comprehensive clinics as an alternative learning method at FM UII.

The participants of this research were fourth-year students who joined the Tropical and infectious disease course since students who have learned about diagnosis and disease management is the requirement of this CBL tutorial. Tutor facilitated tutorial in this research were

tutors who have at least five years of experience in the PBL and CBL methods. The researchers sent invitation letters to all students who took the Tropical and infectious disease course.

Twenty-one students stated their agreement to join in this research. They were then divided randomly into two groups, i.e., PBL (n=10) and CBL groups (n=11). The clinical case used in these two groups was similar, being related to hepatitis. The differences were the case format and the deepness of the information provided in each case. Each group was facilitated by one tutor. Each tutorial method was conducted in two sessions. Students performed tutorial PBL using the seven jump methods [21]: 1) Identifying and clarifying unfamiliar terms/concepts, 2) Defining the problem, 3) Analysing the problem using prior knowledge, 4) Organising and making inferences from the explanation in step 3, 5) Defining the learning objective, 6) Self-study, 7) Synthesising and applying the acquired knowledge. Students completed step 1-5 at the first meeting, and performed step 7 at the second meeting.

In CBL tutorial, students conducted discussion guided by a set of inquiry. In the first meeting, students discuss a case guided by questions focusing on pathogenesis, clinical manifestation, and differential diagnosis. At the second meeting, students discussed disease management related to the case. All of the tutorial processes in PBL and CBL were recorded using videotape; however, the self-study process was not recorded since as the focus of this research is on the tutorial process.

Data was analysed using specific software to verbal analysis interaction (Behavioural Observation Research Interactive software/BORIS) without a transcript as conducted in previous research.[22] The analysis was focused on the verbal interaction among subjects in the PBL or CBL tutorial. The unit analysis is every verbal action from each subject called utterance. The data was coded using coding scheme [22], which is modified from the previous research conducted by Van Boxtel [23]. These coding scheme including five categories that are exploratory questioning, cumulative reasoning, handling conflict about knowledge, procedural interaction and off-

task/irrelevant interactions. The first three interactions are part of the learning-oriented interaction.

The definitions and components for each category are in Appendix 1. To obtain similar perception in analysing the data, both of the authors watched several sections of the video and then coded together. When the difference codes were found, the discussion was conducted. After achieving the same perception, each author then analysed all the of video independently. The data from the two authors were collected together and was then calculated for the standard mean of each category or subcategory.

RESULTS

The comparison of verbal interaction in PBL and CBL are in Table 1. The data of each tutorial type derived from the average of session 1 and session 2 of PBL and CBL.

Table 1. Analysis of verbal interaction in PBL and CBL

Behaviour	Total number		Total duration (s)		Duration mean (s)		Percentage	
	PBL	CBL	PBL	CBL	PBL	CBL	PBL	CBL
Exploratory questioning	80	40	813.26	507.11	41.38	58.34	14.43%	8.77%
Open question	22	2	167.45	26.13	7.61	13.06	2.97%	0.45%
Critical question	18	3	159.48	80.98	8.86	26.99	2.83%	1.40%
Verification question	15	1	204.76	6.72	13.65	6.72	3.63%	0.12%
Alternative argument	25	34	281.57	393.28	11.26	11.57	5.00%	6.80%
Cumulative reasoning	145	105	3285.8	3196.10	66.31	86.29	58.29%	55.27%
Statement	23	20	591.26	427.50	25.71	21.37	10.49%	7.39%
Other argument	88	73	2594.3	2628.23	29.48	36.00	46.02%	45.45%
Other question	5	2	27.77	37.20	5.55	18.60	0.49%	0.64%
Judgement, acceptance or confirmation	13	10	72.403	103.17	5.57	10.32	1.28%	1.78%
Handling conflict about knowledge	11	13	146.16	299.47	39.49	122.54	2.59%	5.18%
Counter argument	5	1	69.23	31.44	13.85	31.44	1.23%	0.54%
JudgementTa / disagreement	3	10	11.95	107.28	3.98	10.73	0.21%	1.86%
Evaluation	3	2	64.98	160.75	21.66	80.38	1.15%	2.78%
Procedural interaction	85	104	1337.4	1686.61	15.73	16.28	23.72%	29.17%
Off-task/ irrelevant interactions	6	10	54.42	92.97	9.07	14.83	0.97%	1.61%
Total	327	272	5637	5782.25	17.24	20.72	100%	100%

Table 1 indicates that in both of PBL and CBL tutorials, students spent most of the discussion time on learning-oriented interaction (cumulative reasoning, exploratory reasoning and handling conflict about knowledge). In PBL, the spent time for this interaction was around 75%, while in CBL was around 68%. This occurred since students were using longer times on procedural interaction (about 30% of total discussion time) than in PBL, which was only 23%.

The most frequent learning oriented interaction performed by students was cumulative reasoning. They spent 63.4% and 58.3% of the total discussion time in PBL and CBL respectively. The most applied sub-categories were providing other arguments followed by the statement. Students shared other arguments approximately 45% of discussion time in PBL or CBL tutorials and explained through statement 23 times (10.4%) for PBL and 20 times (7.39%) for CBL. They rarely used the time to provide acceptance or to ask other question.

Students in PBL group were more frequently asking exploratory questioning rather than in CBL group. They asked this question 22 times in PBL and only two times in CBL. They also spent more time asking verification and critical question in PBL rather than in CBL. On the other hand, students in the CBL group shared alternative argument more frequently than PBL groups. The interaction categorised as handling conflict about knowledge both in PBL and CBL group were very rare. Students conducted this interaction less than 15 times in each group. They spent only around 2.5% and 5% of the total discussion time in PBL and CBL respectively. In CBL, the longest interaction in this category was evaluating the opinion of others while in PBL; it was providing the counter argument. Negation and disagreement more commonly occurred in CBL groups (10 times) rather than in PBL group (3 times). Conversely, the irrelevant interaction was found more frequent in CBL groups than in PBL. Although this interaction accounted for the shortest time of all the interaction types, students more conducted this task in CBL groups (around 1.6% of the total discussion times).

Table 2. Comparison of the number of tutor intervention in PBL and CBL tutorials

Tutor intervention	Total number	Total duration (s)	Duration mean (s)
PBL Part 1	9	226.40	25.16
PBL Part 2	9	196.14	21.79
PBL All	18	422.54	23.47
CBL Part 1	56	649.11	11.59
CBL Part 2	48	515.05	10.73
CBL All	104	1164.16	11.19

The tutor intervened more often in the CBL group (Part 1 and part 2) rather than in PBL groups (Table 2). In PBL, the tutor gave comments only 18 times, lasting around a quarter of minute for each comment. On the other hand, tutors in CBL groups intervened much more, which was 104 times, 56 and 48 interventions in session 1 and session 2 respectively. However, the duration of each comment was shorter than in PBL, where it was only around 11 seconds for each comment.

DISCUSSIONS

Learning-oriented interaction is a type of interaction stimulating cognitive skills consisting of cumulative reasoning, giving exploratory questioning and handling conflict about knowledge. The findings indicated that in both the PBL and CBL tutorial, students spent most of the discussion time on this interaction. Also, students shared cumulative reasoning more frequently than asking the question and managing knowledge conflict.

The results showed that in both the PBL and CBL tutorials, most of the cumulative reasoning interaction conducted by students was sharing other arguments, which was conducted based on a reasoning process. This condition indicated that these two learning methods can stimulate critical thinking through a collaboration process in students. Our finding is similar to previous research, which showed that PBL and CBL were quite effective in enhancing critical thinking.[24] The results described in Table 1 indicate that students not only shared other argument but also shared factual information without a reasoning process, which is called statement. However, students were more frequently stating in PBL rather than in the CBL process. One of the possible explanations for this condition is that in CBL tutorial students had been

guided by specific questions to solve the problem/case. For this reason, students applied cognitive skills that were relevant to the question.[13] On the other hand, In the PBL tutorial, the discussion process was characterised by an open inquiry approach in which the case /problem was only used as a trigger.[4,7] The type of f cognitive skills applied by students depended on the group dynamic and tutor stimulation.

The second type of learning-oriented interaction is giving the exploratory question. The results showed that in the PBL tutorial students spent more time to ask open, critical and verification question. Students were also quite frequently giving arguments such hypothesis or explanations based on logical thinking. This occurred since PBL is an open inquiry learning approach, stimulating students to formulate their own learning objective based on a case.[7,25] On the first session of the PBL tutorials, students are expected to analysis the problem based on their prior knowledge to determine the learning objective.[8] Conversely, in the CBL tutorial students had sufficient knowledge related to the case. They had conducted enough preparation using the question guide provided in the case. This condition affected the discussion process. They did not spend much time asking questions or formulating the hypothesis underlying the case.[13]

The findings indicated that students' ability to handle conflict about knowledge was very restricted in both the PBL and CBL tutorial. Students very rarely evaluated the argument of others or had different idea to others. As discussed before, this condition might have occurred because this interaction needs high order thinking and not all students could perform this. Moreover, cultural factors influenced students' interaction with each other. They avoided conflict since they preferred group harmony, and this is one of the characteristics of culture in Eastern countries.[26]

Besides the learning oriented interactions, students also performed other interactions categorised as procedural interaction and irrelevant tasks in both the PBL and CBL tutorial sessions. Procedural interaction needed more time than students' activity to ask questions and handle knowledge conflict. They spent a quarter of the total discussion time in each type of tutorials, which was 23.7% and 29.1% in PBL and CBL respectively. Most of this interaction was performed by the group leader. This occurred because the leader had the responsibility to manage the discussion process to meet the learning objectives. In the CBL tutorial, the leader was more frequently directing the discussion process than in PBL, since there were more questions that need to be answered.

Students' interaction that was not relevant to the task was very limited. It occupied the shortest time compared with other verbal interactions (1% of the discussion time in PBL and 1.5% in CBL). This finding indicated that students remained aware of their task during the discussion. They made an effort to focus on the collaborative learning process to achieve the learning objective. Students in CBL spent more time showing irrelevant task than PBL since they conducted this tutorial for the first time. They had not enough experience about how the CBL should be conducted. The findings showed that they spent less time for this interaction in CBL 2 than in CBL 1 (Table 2). This indicated that familiarisation of the CBL procedure reduced the irrelevant task and blocking during the discussion.

The role of tutors in PBL and CBL are different. Our findings indicated that CBL tutors intervened in the discussion process quite frequently in both session 1 and 2. This was almost five times compared to the frequency of tutor intervention in PBL (Table 2.). The results indicate that in PBL tutorial, the role of the tutors is facilitating and directing the discussion process to achieve the learning objective. On the other hand, the CBL tutor was not only directing the discussion process but would intervene and provide questions or information guiding students to finish the task.[14,19] This condition might hinder students in applying self-directed learning skills[18,19]. In conclusion, it is recommended that PBL is applied in the early year of students' learning in medical faculties, while CBL in a later years, during which time self-directed learning has been formed in students.

Strengths and limitations

This research adds evidence about the learning process in small groups. This research was conducted through direct observation to compare the verbal interaction applied in PBL and CBL tutorials. The comparison process was conducted not only by analysing each session of PBL and CBL but also by examining all the discussion processed in these two teaching methods. The analysis process was also performed with both students and tutors verbal interactions.

The limitation of this research is that the observation of each method was only conducted with one group. Such observation may not have been represented the real processes in the PBL and CBL tutorials since there are many other factors that may influence the group dynamics. The research was also conducted only in one institution, at FM UII. The findings may not be able to be generalised to other contexts with the different tutorial method being applied.

It is recommended for future research to increase the number of PBL and CBL groups. In addition, a more comprehensive research method using mixed methods is needed to capture a more extensive picture of students' learning process in both PBL and CBL groups.

CONCLUSIONS

PBL and CBL tutorial stimulate students to apply various cognitive skills. Students were supported to share their knowledge based on a reasoning process referred to as cumulative reasoning, which is the most common verbal interaction applied by students. Students were more stimulated to ask the question as part of exploratory questioning interaction in PBL tutorial (especially in session 1) than in CBL. However, the findings in both of these tutorial methods were not sufficient in supporting students to apply high order thinking, such as evaluation. This was indicated by the research findings showing that students were very restrictive in discussing handling conflict about knowledge in both the PBL and CBL tutorial group.

Procedural interaction and irrelevant task were also performed by students in these two tutorial groups. However, the frequency of student-conducted irrelevant task was very little. This condition indicated that in both the PBL and CBL tutorial students focused on the discussion process to achieve learning objective. On the other hand, the time spent for procedural interaction was considerably more, especially in CBL. This occurred since CBL is a guided inquiry approach. The group leader had to direct the discussion to solve the problem or enable students to finish the task.

ETHICAL CLEARANCE
This study has been approved by the Ethics committee of FM UII. Written informed consent was obtained from student and tutors participated in this study.

CONTRIBUTION

Both of the authors conceived the study and the design. The data collection and analysis was also conducted by both of the authors. UK drafted and finalised the manuscript. Both of the authors read and approved the final manuscript.

DECLARATION OF INTEREST
The authors declare that they have no competing of interests.

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APPENDICES

Appendix 1

No	Categories/ sub categories	Definition
1	Exploratory questioning	Group members' participation to criticize or to complete utterance from other members by asking critical question or providing alternative explanation.
	Open question	Question that is aimed to gather information or to draw conclusion from various explanations
	Critical question	Question to criticise other utterance
	Verification question	Question to clarify others' utterance
	Alternative argument	Additional explanation based on logical thinking to previous explanation from others.
2	Cumulative reasoning	Critical attempts to arrange and to collaborate utterance during discussion to build collective knowledge.
	Statement	Utterance about factual information that it is not created based on reasoning process. It is only based on reading loud a literatures
	Other argument	Utterance based on reasoning process to complete previous explanation. It is aimed to formulate group knowledge. Alternative and counter argument do not include in this sub category.
	Other question	Question to select 2 alternatives or more. It can also utterance aimed to evaluate and gain short answer.
	Judgement acceptance/ confirmation	Confirmation or acceptance to others' utterance
3	Handling conflict about knowledge	Group members discuss contradictive information by expressing disagreement and different argument to previous utterance
	Counter argument	Logical utterance based on reasoning process to counter contradictive utterance
	Judgement negation/ disagreement	Negation or dis agreement to previous utterance by saying "no" or negative answer to short question.
	Evaluation	Argument or utterance to evaluate previous utterance based on own knowledge or explanation from others
4	Procedural interaction	Utterance related to collaboration process including organisation, problem solving in the group such as task distribution and the order of discussion process.
5	Off-task/ irrelevant interaction	Utterance that is not relevant to the task or topic under discussion or a condition in which all of group members are silent /not participating.