Process study of verbal interactions in problem based learning

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The goal of this study was to increase our understanding of the learning-oriented verbal interactions taking place between students during the entire problem-based learning (PBL) process, and to identify the relationships between what students say with their learning outcomes. The verbal interactions of one PBL group of five students throughout an entire PBL process were recorded in this data-intensive case study consisting of more than 1000 utterances. Our results show that a large proportion of students' learning-oriented verbal interaction focused on stating or recalling facts with a much lower percentage involving constructive statements, arguments, evaluation, proposals and critical questions. Simple correlation analysis indicated that percentages of questions, verification questions and requests correlated negatively with student achievement while critical questions, arguments and evaluations positively. At the practical level, suggestions that are relevant to educational practice can be derived from our observations. Furthermore, this study gives insight to the different types of group interactions during the entire PBL process, including those during the self-directed study time, to help us better understand the learning processes involved in PBL.

Keywords: Problem-based learning, verbal interactions, group processes

Introduction

Problem-based learning (PBL), as its name implies, starts with a problem. This refers to an academically or professionally relevant issue that students are to find out more about. Here students work in small collaborative groups with guidance from a facilitator. Descriptions of PBL usually emphasise its benefits such as enabling students to develop collaborative and self-directed learning skills. Research also suggests that small group discussions enhance critical thinking and encourage students towards a deep learning approach (Hmelo-Silver, 2004). In addition, studies by De Grave, Schmidt, and Boshuizen (2001) and Schmidt, De Volder, De Grave, and Moust (1989) demonstrated that elaboration during problem analysis in a small group leads to increased knowledge acquisition and recall. While there has been considerable research in various aspects of PBL over the past twenty years, the answers to the questions of how the actual activities of PBL produce these positive outcomes as well as how do students learn during group discussions and self-directed study are still unclear (Dolmans and Schmidt, 2006; Hak and Maguire, 2000).

Research up to now also has been limited to specific phases of the PBL process and no observational study has been carried out to better understand the self-directed study phases (Visschers-Pleijers et al., 2006; Visschers-Pleijers, Dolmans, Wolfhagen, and Van der Vleuten, 2004). The goal of this study then, is to describe and analyse the verbal interactions of students in a complete PBL process (including self-directed learning time) so as to increase our understanding of the how students learn in all the relevant phases of PBL. We also aimed to identify relationships between verbal interactions of students with their learning outcomes.

Method

Participants were five first-year students from a polytechnic in Singapore. In this polytechnic, all first-year students undergo a common curriculum regardless of their subject discipline. The five students (making up one team) were from the same Basic Science class and were being recorded on the fifth week of Semester Two. Students were not new to PBL as they had already completed more than 16 weeks of PBL classes. Both students and facilitator gave informed consent.

The PBL process in this polytechnic is a unique One-day-one-problem approach where students work on one problem in a day. It takes place in a class setting consisting of 25 students and one facilitator. The students are grouped into teams of five. The daily routine consists of three meetings with facilitator interaction and two self-directed learning (SDL) periods which are periods of individual study and team work without facilitator involvement. A brief description of the day's process is shown below:

- First meeting (~ 1 h): Facilitator presents problem for the day. Students work in teams of 5 to identify their prior knowledge and learning issues.
- First SDL period (~ 1 h): Students do individual research or work with their teams on worksheets and other resources provided. Time is spent teaching one another within the team. Most of the individual research is done by reading up on online resources from the internet.
- Second meeting (~ 1.5 h): Students meet with the facilitator to share their progress and strategy of solving the problem. The facilitator usually spends about 10-15 minutes with each team, while the other teams continue with their research and/or discussion.
- Second SDL period (~ 2 h): Extended time where teams consolidate their research and formulate a response to the problem.
- Third meeting (~ 2 h): Each team presents their response to the problem, defending and elaborating based on questions raised by peers and the facilitator.

Verbal interaction was recorded using a digital audio recorder placed at the team's table. The students were audio-recorded twice beforehand to allow them to be familiar with the procedure on the actual day. The voice recording device was started at the beginning of the day when the problem was first shown to the students till the end of the day (a total of about 7 hours). To ensure an authentic recording that was representative of what usually happens during the self-directed study times, no facilitator or observer was present during the SDL periods. The room in which the recordings were carried out was the students' regular classroom.

One point to note is that all students in the polytechnic where the study was conducted have a personal laptop that can be connected to the internet. First-year students generally rely mainly on internet resources for their research, and remain in class instead of going to the library for their self-directed study. Thus it was possible to continue recording students' verbal interactions even during the SDL periods.

The problem statement for the day was entitled "Code of Life" and it introduced students to the concept of heredity and genes. Students' learning was measured using both free recall essay questions and a concept recognition test. These were given to the students immediately at the end of the day.

Table 1: Definition of different categories of utterances

Type of utterance	Defined as
Statement	Provides factual information containing no indication of reasoning or analysis e.g. "They are talking about genes."
Constructive statement	Here a concept is related to another concept e.g. "DNA is nucleic acid but it's comprised of nucleotides."
Argument	Indicates reasoning and builds on logically to a previous utterance e.g. "So you see since they have the same allele - they are both dominant Bs -so that means they are homozygous…"
Counter argument	Indicates reasoning and contradicts previous utterance
Evaluation	Contains a judgment or opinion regarding the individual's or someone else's knowledge and understanding of the problem e.g. "I don't know if two different dominant alleles can coexist or not, but I know two similar ones can exist together."
Open question	Elicits new information and explanations e.g. "What is a gene?"
Critical question	Casts doubt or indicates the need to reevaluate a previous utterance e.g. "Are you sure RNA is related to genes?"
Verification question	Shows the intent of checking one's own ideas or reasoning e.g. "DNA makes up genes right?"
Request	Asks for help or favour e.g. "Can you show me how to draw a genetic diagram?"
Proposal	Indicates a plan or a strategy towards problem-solving e.g. "We are going to research on how genes mutate."
Confirmation	Agreement with previous utterance, with no indication of reasoning or analysis (usually 'Yes')
Negation	Disagreement to previous utterance, with no indication of reasoning or analysis (usually 'No')
Repeat	Repetition of previous utterance
Procedural	Focuses on organising the duties of each team member in terms of delivering what the facilitator requires at various time points of the day e.g. "What shall we tell the tutor?"
Others	Off-task or irrelevant response that does not obviously contribute to the discussion

A verbatim transcript of the verbal interactions of the team was produced. The transcript was examined and coded using an adaptation of the utterance coding scheme of Van Boxtel, Van der Linden, and Kanselaar (2000). An utterance was defined as one message unit distinguished from other utterance by a pause, comma or period (Van Boxtel et al., 2000). The utterances in this study were coded as defined in Table 1.

Results

Table 2 shows the mean percentage of each type of utterance for the 5 students. The total number of utterances produced during the day was 1075.

Table 2: Mean percentages and standard errors of the number of utterances in each category during the learning-oriented interaction of the PBL process (N = 5)

Utterance	Mean ± S. E. (%)	Utterance	Mean ± S. E. (%)	Utterance	Mean ± S. E. (%)
Statement	46.9 ± 11.3	Open question	6.3 ± 2.0	Confirmation	9.2 ± 2.8
Constructive statement	3.8 ± 1.1	Critical question	0.5 ± 0.2	Negation	3.1 ± 0.5
Argument	6.6 ± 1.6	Verification question	3.3 ± 1.5	Repeat	3.4 ± 0.9
Counter argument	1.1 ± 0.3	Request	0.4 ± 0.3	Procedural	10.1 ± 2.9
Evaluation	2.2 ± 1.4	Proposal	1.2 ± 0.4	Others	1.7 ± 0.7

The results of the utterance analysis indicate that a large proportion of students' learning-oriented verbal interaction focuses on stating or recalling facts (*M* = 46.9%, *S.E.* = 11.3%), with a lesser percentage involving constructive statements (*M* = 3.8%, *S. E.* = 1.1%) and arguments (*M* = 6.6%, *S. E.* = 1.6%). Utterances related to collaborative learning such as arguments, questions, confirmations etc constituted 27.3% of the groups' interaction while those related to procedural processes made up 10.1 %. A smaller percentage of utterances involved evaluation (2.2%) and proposals (1.2%) while critical questions (0.4%) took up an even lesser percentage.

A simple descriptive correlation analysis between percentage of utterance types and students' post-test scores was conducted. The largest correlations are displayed in Table 3.

Table 3 Correlation analysis between percentages of utterances and post-test scores

Tests	Free recall essay post-test	Recognition post-test
Argument	.83	.35
Evaluation	.51	-.10
Question	-.25	-.65
Critical question	.56	.60
Verification question	-.53	-.93*
Request	-.48	-.96**
Procedural	-.17	-.70
Others	-.40	-.93*

*p < .05, **p < .01

Discussion

The purpose of the present study was to make clearer our understanding of what students do in all the phases of PBL by providing a detailed description of their actual activities (through their verbal interactions) in the PBL process, and how the different types of utterances were correlated with students' learning.

First we observe that throughout the PBL process, almost half of the learning-oriented verbal interactions consisted of factual statements. Students tended to verbalise their prior knowledge or what they had found out during SDL as a means of sharing information or to enhance clarity for themselves. Although such verbal interactions are not classified as higher order learning process, they can be considered a relevant part of learning where students choose to repeat and remember some facts. One point to note is that the verbal interactions generally stem from students' own choice of their learning approach and direction, as the SDL component took up more than half of the time in which the discussions were recorded. Even

during SDL times, students were exchanging ideas and questions while they did their online research, thus blurring the line between individual study and collaborative learning. We also observe that students did not naturally make linkages between the concepts they have learned, as seen from the low percentage of constructive statements. Similarly there seems to be a lack of critical questioning and the resolution of conflicting ideas by means of discussion and elaboration. These are important components of the learning process and it is disturbing to note the low frequencies in which they appear.

An interesting result from the descriptive correlation analysis is the high negative correlations between the percentage of verification questions and requests asked with student learning outcomes. Although verification questions and requests are legitimate and important aspects of the collaborative learning process, over-dependence on them could be an indication of a lack of self-directed learning and effort to construct one's own ideas. Also, this seems to suggest that those who had a lot of questions and requests in fact showed their ignorance and lack of learning during the day. Utterances classified as 'others' also correlated negatively with student achievement, suggesting that those who made comments which did not contribute much to the discussion eventually learned less than those who were more involved in the learning task. The negative correlation between procedural utterances and student learning outcomes also indicate that being too focused on fulfilling the task of the day or in meeting facilitator expectations was not beneficial to student learning.

We also found positive correlations between the percentages of arguments (statements indicating reasoning) made by students with their learning outcomes. In a study by Van Boxtel et al. (2000), they found a positive correlation between collaborative elaboration and individual learning outcomes, indicating the value of both elaborative and collaborative student interaction. Our results similarly suggest the importance of collaborative reasoning but also imply that excessive dependence on group members may have a negative effect on learning outcomes.

This is a preliminary study focusing on a large amount of data with a small group of students. Despite the small size of our sample, we found statistically significant effects on learning. Given the fact that the power of the statistical tests used was extremely small due to sample size, the significant results are the more telling. They strongly suggest that our findings are meaningful and likely to be valid. However, it will be useful to replicate the study with a larger sample size which would enable more detailed analyses using multiple linear regression and possibly more subtle information regarding the relationships between students' verbal interactions, individual study, facilitator contributions, and student learning would be uncovered.

In conclusion, by analysing the verbal interactions of students in the PBL process, we intended to contribute to current understanding of how all the relevant phases of PBL are carried out in practice. At the practical level, suggestions that are relevant to educational practice can be derived from our observations. Students tend to pick up cues from the facilitator during the limited interaction time. Thus, one way to encourage students to formulate more critical questions, and seek clearer explanations and reasoning during their group interaction is for facilitators to actively model such questions when interacting with students. Students should also be guided to understand that collaborative learning does not only consist of cooperative teamwork, but also requires mutual questioning and challenging in order to stimulate effective learning.

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