AN ACCOUNT OF STUDENTS' LEARNING EXPERIENCE IN AN ENGINEERING PROBLEM-BASED LEARNING SUBJECT: IMPLICATIONS FOR IMPLEMENTATION

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Problem-based Learning (PBL), as an educational innovation, has generated a surge of interest and resulted in a series of initiatives among academics. However, it is important for schools to note that taking on an educational initiative in PBL is not only about understanding how PBL works, but also about how the advantages it brings to learning can be conferred upon students.

It is thus necessary for any PBL practitioner to understand how students perceive their learning in a PBL context, and how implementation could affect the way that students learn. In particular, the author is interested in researching Engineering students, as currently most PBL-related papers involve research in non-Engineering faculties.

This paper is based on research conducted to investigate the learning experiences of Engineering students who are encountering PBL for the first time. Data sources include online questionnaire surveys, class observations and group and individual interviews. While analysis of the findings indicates that the response of these students towards certain activities was not markedly different from what was discovered in some earlier research studies in the non-engineering disciplines, an interesting point that emerged was that quite a significant number of students were able to cope well with the PBL process despite the fact that this was their first exposure and they did not go through intensive formal PBL preparatory training. They were able to find strategies to cope with their learning even though facilitators did not provide direct assistance. Implications of many other findings for instructional practice are also discussed.

INTRODUCTION

Many research articles on PBL discuss the numerous benefits the pedagogy brings to learners. Schools, in the hope of reaping these benefits, go to great lengths in brainstorming, planning

and implementing their plans. In fact, judging from several studies conducted in the 1990s, there has been a growing realisation that facilitators have little real understanding about how students see themselves as learners and what learning means to them in a given learning process. While it is undeniably important to get the faculty to provide financial support in resources and facilitator training, what we may have failed to realise is that there is a likelihood that we have conveniently assumed that the journey from problem to learning outcome is uncomplicated. The question is: when students are put through a PBL process, do they naturally work together to solve a given problem that is imposed by the curriculum so that they become better problem-solvers at the end? If they do not, what should be considered in the implementation process to enhance the learning outcome?

The PBL process is one that involves many aspects of learning through activities such as discussion, research, peer teaching, application and reflection. Students work on situations in a way that fosters reasoning, reflective thinking, knowledge and skill application congruent with their level of learning. PBL advocates believe that PBL allows students to acquire an essential body of retrievable and usable knowledge and skills in their profession and to develop continuous learning skills to extend the knowledge base in order to remain professionally competent. Researchers in cognition science believe that for all these to happen, knowledge must be meaningful to the learner and that the level of acceptance of new knowledge varies with the learner's prior knowledge of that subject. Nevertheless, how meaningful a PBL activity is to learners depends very much on the meaning which learners themselves place on their learning.

Hence, PBL is a complex design that requires a considerable amount of attention from learners and teachers, both to content and to context (Evensen & Hmelo, 2000). When PBL is misapplied through highly simplistic methods, it is likely to run the risk of becoming just a passing fad, as in the case of many educational reforms. While there have been several studies conducted to gather student learning experience with PBL, many of these studies were done on students from non-engineering background. Therefore, it is with this interest that this paper was written.

METHODOLOGY

A student is a learner with multifaceted needs and diverse experience. The experience comes from the various components of the learning process, interacting actively and affecting each other. It is misleading to capture the essence of experiences by quantitative means alone as "dependence on purely quantitative methods may neglect the social and cultural construction of the 'variables' which quantitative researcher seeks to correlate" (Silverman, 2000, p.5). Qualitative research methods are appropriate if social processes, such as behaviour, are to be observed. Thus, in this study, a combination of quantitative and qualitative research methods was used through the process of method triangulation. The study aims to achieve a broad perspective of experiences of those students involved in the study so that the findings could be taken into consideration and used as a reference for educators who are planning a PBL curriculum. Patterns of convergence from the quantitative and qualitative data will be identified to corroborate the overall interpretation of the results.

The following research methods were used:

- An online questionnaire survey for a cohort of 323 second-year Engineering students
- Class observations, followed by group interviews, of three groups of students
- Randomly selected from the above cohort
- Individual interviews of three students pre-selected from the above cohort

The reasons for using different research methods are as follows:

- The online questionnaire survey is one of the cheapest and quickest means of collecting mass data that can be sufficiently representative of students' learning experiences.
- Classroom observations and interviews provide a deeper understanding of group learning behaviour that is not immediately discernible in the questionnaire survey.

Background of participants

323 full-time students from a second-year Engineering course were invited to participate in various activities of this research study. These students were encountering an Engineering PBL subject for the first time. They did not undergo any formal training on PBL process skills. However, they were given a briefing on the stages of a reiterative PBL method (Barrows, 1986) during their first two days in the course. The median age of the participants was 18.

At least 20% of those who participated in the online survey were international students, and the rest were local students. Their academic abilities also differed widely. Owing to a streaming exercise done at the end of their first year of study, the students entered this course because they had indicated their interest in it or had been admitted because they failed to meet the minimum entry criteria for other courses. Since only one out of six subjects offered in the semester was PBL-based, no emphasis was placed on PBL initiation before the students joined the course.

The PBL subject that these students took was technical in nature. They did not have any prior knowledge of the subject fundamentals. In this subject, they were required to develop a piece of hardware and write a programme to demonstrate the function of the hardware. The students were also required to attend a one-hour lecture and three-hour laboratory session per week throughout a 15-week semester. During the lectures, briefings on important concepts required in the project were conducted. Fairly detailed lecture notes, online subject resources and guided laboratory exercises were provided to help the students understand the content better. The tutor-facilitated laboratory sessions were conducted in laboratories equipped with the necessary development tools for their project. Students were allowed to conduct discussions, complete their guided laboratory exercises and develop their product during this period. Each class, comprising a maximum of 24 students, was further divided into groups of four to five students.

During the period when the study was conducted, the participants were already in the eleventh to thirteenth week of a 15-week semester. By then, the students had obtained the results of a written test held in Week 8 and were developing their product.

Online questionnaire survey

A total of 323 second-year Engineering students from a diploma course were invited to participate in the online questionnaire survey during the eleventh and twelfth weeks of a 15-week semester. 312 students responded.

The questionnaire consisted of a list of 34 closed-ended questions and two open-ended questions. The closed-ended questions were related to students' readiness to respond to PBL, their experience working on their group project, their interaction with their facilitators as well as the resources available to help them complete their project. A four-option scale was used to indicate the varying degrees of agreement and disagreement on a given item. The responses to these closed-ended questions were summarised and represented in percentages of the total number of respondents. The open-ended questions were included to elicit responses that probably could not have been obtained from the closed-ended items.

Class observations and group interviews

Class observation was chosen as the instrument to judge how group learning behaviour closely matches the questionnaire answers. It was not meant to replace what was revealed in the surveys, but rather to emphasise the virtue of group characteristics. After each class, a group interview was conducted with the group under observation**.**

Three groups of between four and five students participated in the class observations and group interviews. These groups were randomly selected from three different classes belonging to the same cohort that participated in the survey. No particular criterion was used for the selection.

The class observation was intentionally carried out in the middle of the period allocated to the lesson. This was to ensure that adequate time was given for the students to settle down and to get work done. The one-hour observation schedule used in the class observation involved simple counting of certain behavioural events. The observed period was broken into 20 three-minute blocks to provide a useful summary of the level of activity that occurred during the observation period.

The items recorded during the observational period were:

- the number of three-minute blocks containing verbal contributions and hands-on contributions relevant to project made by each member of the group within an observed period of one hour. The author's experience of having taught a similar subject gave her the ability to judge the relevance and appropriateness of student contribution to the project.
- the types of strategies adopted by the members when they encountered difficulty in working on the project.

Individual interviews

Interviews can provide an in-depth understanding of a respondent's motives, pattern of reasoning and emotional reactions which is not possible with online surveys. Furthermore, the interview setting enables the author to clarify questions that respondents may find confusing.

A combination of the response-guided approach and the converging technique was used in the individual interviews. At the start, a broad open-ended question was posed to discover what seemed uppermost in the interviewees' minds in relation to the topic at hand. Depending on their responses, this was followed by questions that were aligned to the categories of data found in the survey questionnaire.

FINDINGS

The data from the research was compiled and analysed. The results of the online questionnaire survey were collated and used as inputs to the design of the schedules for class observations and interviews.

Online questionnaire survey – closed-ended questions

A total of 312 students participated in the online questionnaire survey. The findings from the survey were tabulated using spreadsheet software (Appendix). The item number on the questionnaire and the percentage of respondents in agreement with that item are presented as two numbers within [ ] brackets respectively.

More than 83% of the respondents were aware of what PBL was, what they were expected to do and how to contribute as members of a working group at the start of the course [Q1, 83].

The respondents enjoyed group work [Q26, 96.4]. Most respondents agreed that the group interactions enhanced their input for the project and stimulated ideas [Q27, 95.8]. However, at least 22% respondents felt that their groups were not well prepared for meetings [Q29, 77.9]. This could have contributed to respondents not knowing what to follow up on after every group meeting [Q30, 70.8]. Close to half the respondents felt that they were not learning much from one another within their groups [Q28, 50.7].

There is reasonably strong indication that the students knew what to do whenever they faced difficulties in PBL [Q27, 95.8] though the nature of difficulties was not captured in this survey. Facilitators were also seen to be making constant checks on students' learning progress [Q22, 90.7]. Most respondents perceived that their facilitators were guiding them in their thinking rather than telling them what to do [Q21, 89.7]. While facilitators were encouraged to give more autonomy to students for their learning in PBL, a significant number of students felt that the facilitators were still in control of their learning [Q23, 82.3]. The facilitators were perceived to be less tolerant of mistakes made by students and more likely to intervene when the students were not seen to be doing well [Q24, 78.5].

Most of the respondents agreed that they were informed of their facilitators' expectations of their work [Q20, 89.7]. However, they often wondered if their facilitators actually kept track

of how well they had contributed to the project or whether their performance met with their facilitators' expectations [Q25, 89.1].

It was encouraging to note that respondents were giving feedback to one another on individual performance in a group [Q11, 91.1]. However, the validity of their feedback seems to be questionable, as only 71.1% [Q9, 71.1] indicated that their feedback was genuine. There could be reasons that were not captured in the survey, such as students' fear of peer rejection should they say something that could hurt their relationship.

Generally, the respondents perceived that they were spending a large amount of time on a single PBL subject even though there were five other non-PBL subjects to cope with [Q32, 90.1]. Despite this, 74% felt that they had time for research [Q5, 74.1].

The findings reveal that the respondents understood the subject better through hands-on practice [Q19, 88.8] than peer-teach meetings [Q18, 74.7]. From the results, more than 25% did not benefit from the peer-teaching meetings. Surprisingly, they preferred to clarify their doubts on the content acquired with their peers rather than with their facilitator [Q17, 69.5].

Clearly, half of the respondents felt that the resource sessions were not useful in reinforcing their understanding of the subject [Q16, 87.8]. This is definitely an area of concern as resource sessions were originally planned to help students validate content learnt. Close to 20% of the respondents were not too confident about what they learned and expressed some concerns if they were challenged [Q15, 81.1]. About the same number felt that their groups might not be able to complete the project on time [Q31, 80.4].

The project seemed to challenge their thinking [Q7, 88.7] although initially, the respondents were anxious when they had to come up with their own project specifications [Q8, 85]. Most of the respondents indicated that they had little difficulty working on the project as the subject syllabus was given [Q2, 86.3]. Part of the reason could be the fact that relevant information was readily available in books [Q4, 85.6] as well as on the Internet [Q3, 85.6]. However, a contradiction arose. Half of those surveyed had difficulty in relating to and applying what they had researched to the project [Q6, 46.5].

In summary, slightly more than 75% of the students appreciated what PBL was [Q34, 77.5] although comparatively fewer respondents were coping well with it [Q33, 68.6].

Open-ended questions

Key issues raised by the responses to the open-ended questions are summarised under the following sub-headings:

Things which students like about PBL [Q35]:
- Interacting with group, getting to know members better
- Learning at own pace
- Learning independently
- Thinking critically
- Learning more study skills
- Learning problem-solving skills

- Reinforcing knowledge through hands-on activities
- Seeking alternative ways to solve problem
- Deeper understanding of subject content through reinforcing the basics
- Peer teaching

Things which students feel could enhance their learning [Q36]:
- Knowing the fundamentals before embarking on a problem
- Doing individual projects instead of group projects
- Being provided with more reference sources
- Learning from someone who is knowledgeable
- More notes and guides
- More tips
- More guidance from facilitators with regards to the relevance of learning issues
- More approachable facilitators
- More time to work on the project
- More hands-on practice

Class observations

Table 1 summarises what was observed for groups G1, G2 and G3. Members in each group are labelled as A, B, C, and D.

Table 1
Class Observation Data

	Group G1	Group G2	Group G3
Average rate of occurrence of verbal contribution for whole group	36%	25%	63.8%
Average rate of occurrence of hands-on activity for whole group	5.6%	11%	32.5%

Group G1:
Generally, G1 did not optimise the use of the time spent in these group meetings. Little hands-on activity was observed (5.6%) in the group meetings as only one participant was working on the hardware most of the time. One participant, B, did not contribute to meetings at all.

G1 employed two strategies when things were not going well. On one occasion, D prompted A, B and C to check if they were following the discussions after noticing that they were not sharing anything for the 10 minutes. On the second occasion, E sought help from D when he/she had difficulty with the soldering.

Group G2:
Among the three groups observed, G2 had the lowest average rates in both verbal contribution and hands-on activity. A had a lower occurrence of verbal contribution and hands-on activity (30 % and 25% respectively) than B (50% and 30% respectively) even though he/she was the group leader. C and D did not contribute to the meeting. When A was 'stuck', he/she sought help first from classmates outside his/her group. When this did not help, he/she approached the facilitator.

Group G3:
A comparatively high occurrence of verbal interaction (63.8%) and practical activity (32.5%) could be observed in this group. All participants shared verbally and contributed to the development of the hardware. When D had a problem, he/she was able to solve it quite quickly with the assistance provided within the group.

Semi-structured group interviews

All the above three groups of students were interviewed on the observation day so that they were able to provide a more vivid recollection of what transpired in the observation.

The following highlights some of the key findings.

- The grouping of students varied from group to group; two groups selected their own members (G2 and G3), while the other members were selected by the facilitator (G1).
- Two groups (G2 and G3) knew what to do before the meeting; one did not (G1).
- For G2 and G3, the method of task allocation was different. G2 did it by means of drawing lots while members in G3 volunteered for the tasks. G1 started assigning tasks only at the start of the meeting.
- Only one group perceived that they were doing well (G2); the other two were not satisfied with their performance. G1 said that the problem was due to the difficulty in finding a common time-slot for all members to meet. G3 mentioned that it could have been better if the tasks were further broken down so that each member had something specific to do.

Semi-structured individual interviews

Three second-year students were interviewed. These students also participated in the questionnaire survey. All three interviewees did not consent to having their conversation recorded on tape. Hence, notes were made of the interview.

The following highlights some of the key points raised by the interviewees:

- They valued the importance of groups. The success of their learning seemed to be dependent on who their group members were and how they interacted and cooperated.
- They seemed to be concerned about their individual grades.
- They were unsure if they had progressed well.
- They spent much time completing journals, possibly due to lack of skills and guidance.
- They needed more references and samples to start their project.
- They needed more time to complete the project.
- Facilitators needed to provide more guidance.
- Facilitators needed to give prompt feedback on performance.
- They picked up cues from lectures, notes and facilitators as well as from seniors.
- The solution to the given problem was different from that of previous years.

- They needed to have a clearer idea of facilitators' expectations of the quality of work.
- They did not seem to know what was expected of them in PBL.
- Some felt that their research and work delegation skills had improved.

DISCUSSION

The findings in this study raise issues that can be broadly categorized into the following sub-headings: those related to learner-readiness, project, facilitation and facilitator, working in a group, the learning process and finally, assessment.

Issues related to learner-readiness

It was noted that 31.4% of the students did not seem to cope well with PBL [Q33]. Having been educated in a traditional curriculum for the past 10 years or more, students could sometimes find the reality of having to "fend for oneself" too much in conflict with their habits and expectations of learning that may result in initial resistance. Woods (1994) attributes this to a form of "grief" (for the old curriculum) and suggested that the grieving process needs to be undertaken and completed before coping positively with change (the new curriculum). Perhaps, a comprehensive orientation programme could be included at the start of the semester to facilitate students' induction into PBL. Topics such as the facilitator's expectations of self-directed learning, the role of the facilitator, the role of the students in group learning, interpersonal skills and time management could be included as part of the programme's agenda. Curriculum planners could also consider the process of phasing the students in by appropriately moderating their schedules and activities so that the "jump" from traditional teaching to PBL learning is more gradual. Students also found that cues and assurance from the facilitators helped make the transition to PBL more bearable. No further attempt was made to investigate the type of coping strategies students used to adapt to PBL.

Apart from what was noted in the classroom observations where students sought help from their peers and facilitators, some responses gathered at the individual interviews seem to indicate that the adequate provision of books and Internet resources, together with the availability of reference lists, could help students manage PBL better. This result was also congruent with the questionnaire responses gathered for Q3 and Q4.

An interesting finding surfaced during the class observation which could contribute to students' perception that they were coping well. The author observed strong similarities between the technical specifications of this year's student project with those of previous years. During the laboratory sessions, sample prototypes were available for students to refer to. The data obtained from the class observations showed that at least two groups relied heavily on the sample to design their project; one of them being G2. The over-reliance on the prototype could have given G2 the perception that they were doing well. If this is true, then it strongly suggests that problem designers would have to review the problem scenarios given so that students would not have the tendency to "copy" and take short-cuts in their learning.

Issues related to the Project

The lack of time to complete their projects was a commonly cited reason amongst students when responding to the open-ended question and during the interviews. This could be a result of overly-ambitious project scope. When students had difficulty managing their time, they chose to do selective reading, resulting in some underlying knowledge about the subject not being well covered. The lack of time could also be aggravated as a result of other non-PBL subjects' increased demands on the students' time. Although this factor is not unique to PBL courses, its impact on the latter is more disastrous as it means that important core concepts were either overlooked, or received only cursory attention. This would pose a danger in PBL when the overt aim is to assume responsibility for learning. This finding is also noted in Albanese and Mitchell's (1993) research. As PBL consumes more time and the workload for students and teachers is heavy (Cawley, 1989), there is a need for curriculum planners of all subjects, whether in PBL mode or not, to coordinate deadlines among themselves such that students are given ample time to complete their learning tasks well.

The other approach would be to prepare a problem package that comprises guidelines, or a suggested approach that provide cues about what to do. As evident throughout the research, the students, who were novice problem-solvers, tended to seek cues to help them progress and pass assessments (Miller and Parlett, 1974). Such students can benefit from this type of support and direction (Albanese and Mitchell, 1993). However, caution must be exercised as such approaches can limit the development of more open inquiry skills. They may encourage surface approaches to learning, as found in a study reported by Marton and Saljo (1984).

Issues related to facilitation and facilitator

Throughout the research, students strongly indicated that they needed feedback and guidance from the facilitators in order to gauge their learning progress. Albanese and Mitchell (1993) suggest that teacher directiveness in tutorials can be gradually adjusted according to the independence level of the students. For novice problem-solvers, facilitators could perhaps be more directive initially and then become increasingly less directive as the time proceeds. On the other hand, care must be taken to ensure that even though facilitators are meaningfully involved in student learning, the facilitators must constantly take note that they have to suspend judgment when eliciting the opinions and reactions of students. Such an environment minimises pressure and control while encouraging a high level of performance (Albanese, 2000).

The individual interviews suggested that our students valued different positive aspects of the facilitators' performances. While there were students who preferred content-expert facilitators as they could provide expert advice on their content knowledge, there were students who felt that the facilitator's personal qualities and commitment were more important because the latter is likely to be more sensitive to the students' needs and styles of learning. This seems to indicate that there is no single best definition of a good facilitator as different students value different styles of facilitation (Schmidt and Moust, 1995; Dolmans and Schmidt, 1994).

Issues related to working in a group

Students were strongly supportive of the interaction generated by group work as revealed during the group interviews. They liked the idea of learning from each other to reinforce concepts and to self-reflect.

There were, however, some concerns about working in groups. Some members were seen as "withholding" information from their groups; some were seen to be overly reliant on the other members to do the work. Group conflicts were common in at least two groups (G1 and G3). If such conflicts are not managed well, group learning suffers. As Thorley and Gregory (1994) pointed out, group learning requires special skills and students must have the ability to deal with complex interpersonal situations. Therefore, the curriculum planners should consider providing time and opportunities for students to learn and practise these skills. When students are happy working with their group, their learning can improve (Savin-Baden, 2000; Barnett, 1994; Colditz, 1980).

Data from class observations revealed that some students were observed to be more proactive than the others. This behaviour is congruent with what was discovered by Biggs (1999). Academically weaker students tend to adopt passive, convergent approaches and often work towards a single solution quite quickly in the early stages of their development. The solution tends to be limited in scope. On the contrary, academically stronger students tend to adopt active, divergent thinking approaches that extend beyond the set scope to multiple possible solutions. They usually take a longer time before starting to converge and work towards their preferred solutions (Cowdroy and Crick, 1997). This suggests that student groupings could incorporate a mixture of students with different academic abilities. In this way, the academically weaker students could learn the multiple or strategic approaches to solving a problem from the academically stronger students.

One possible factor which contributed to students spending more time on the PBL subject compared to non-PBL subjects could be the quality of peer-teaching sessions. If the teaching was not done well, it is likely that these students tutored by peers might work harder to compensate for the peer tutors' lack of experience (Moust and Schmidt, 1993). This was evident in Q28 when slightly more than 50% indicated that they actually did not learn much from their peers. A lack of confidence in their learning could also be a contributing factor. On the other hand, the time spent on finding resources, whether from library or Internet, or as a result of informal discussions with peers, could be a sign of increased self-directedness (Blumberg, 2000).

Issues related to learning process

Responses to the open-ended questions in the questionnaire revealed that students had trouble deciding what the relevant learning issues were. Unlike in traditional programmes where teachers indicate upfront what should be learned, students in a PBL curriculum have to make such decisions on their own. As mentioned earlier, guidance is necessary to help students gain confidence in the learning process.

As mentioned earlier, analysis of the survey results raised some concerns. Almost half of the respondents indicated that they had difficulty in relating what they learned to the project [Q6,

46.5]. This is extremely disturbing yet important. Although we understand that PBL places value on prior experience and encourages learners to learn from past experiences by making connections between theory and practice, formulating concepts and making deductions from observations to build new knowledge, this is apparently lacking in the findings derived from class observations. The groups seemed to experience difficulties in relating what they have learned to complete the project. To support the need for the learners to be constantly aware of where they are in their learning, and how they can relate the knowledge they have acquired to the project progressively during the learning process, PBL facilitators must be prepared to set aside time, regularly, to listen to their students and guide them to apply what they have learned progressively and to provide feedback for the students to reflect on the work they have put in. Through reflection, students learn to develop awareness of their own thinking and their learning progress (Brookfield, 1986) and this is a key process for learning in a PBL tutorial (Engel, 1998). Together with the integrated application of knowledge, skills and attitudes to professional situations, reflection has the capacity to encourage "deep" rather than "surface" approaches to learning (Ramsden, 1992).

When students encountered difficulty in their learning and needed to clarify doubts, they preferred to approach their peers rather than their facilitators [Q17, 69.5]. They also perceived that they understood the subject better through peer teaching [Q18, 74.7]. This could possibly be due to their peer tutors' ability to understand them and pitch their explanations at a level comfortable to the tutees. De Grave *et al*., (1990) referred to this ability as "cognitive congruence". In hindsight, about half of those surveyed indicated that they did not seem to be learning a lot from their peers [Q28, 50.7]. There seems to be a contradiction between both scenarios. One possible reason could lie in the attitude that students adopt in their teaching. When their facilitators were observing their teaching, students tended to be more prepared (or at least attempted) to put in their best. However, when their teaching was not monitored (e.g., outside formal class hours), the quality of teaching or assistance given to their peers dropped. Possibly, peer tutors saw no compelling reasons to help the members of their group or have an interest in their learning. They could have had a motive for not trying to understand the nature of their peers' difficulties. It may, therefore, be good for the curriculum planners to reflect on the mode of assessment that was being used to assess the students' performance.

Issues related to assessment

The best curricular intentions can sometimes be foiled by incongruent assessments. It could be asked why students should be grappling with group collaboration when the performance is determined by traditional individual written tests. This could possibly provide the answer to the problem stated in the previous paragraph.

There is also evidence to suggest that students were missing the point that skill development is as important to them as their acquisition of academic content. For example, all three groups of students used the project to assess how well they had fared in the meeting. Rarely did they mention how well they had overcome certain learning obstacles. During the individual interviews, all three students were concerned about their grades. If the main emphasis of the curriculum and the facilitator is on assessing students on content rather than process, then students would tend to focus on acquiring content without putting much thought into how it should be done, and how it is to be reused subsequently in other situations. Hence, some

substantial credit, in the form of marks, is needed to reward students for their efforts in all other aspects of learning besides content-learning.

CONCLUSION

Many factors contribute to the successful implementation of PBL, such as the faculty's financial support in the form of resources, appropriate training programmes for facilitators and well-designed curriculum for students. However, the findings in this paper suggest that while recognizing that the above considerations are important, other factors such as the learners themselves and the meaning which they bring to the learning context play an important role in enhancing the success of such implementation.

This paper has attempted to understand how the complexities of learning can influence the outcomes of the teaching and learning approaches that facilitators adopt. In summary, the author suggests the following five points which educators could consider when planning to adopt PBL in their curricula.

- A problem is used as stimulus for learning the technical competency of subjects; the choice of the problem is important.
- Deep and reflective learning through iterative practices is needed; opportunities should be created to allow students to learn to reflect on their learning (e.g., facilitators providing feedback, or students given ample chance to reiterate the problem-solving process)
- Facilitators should guide, not dictate learning: the level of guidance and directiveness can gradually taper off as students slowly gain independence in their learning.
- Student-directed and student-accountable learning is important. Students should be taught skills to manage their learning.
- Group "deliverable" through group learning – group learning needs special skills which students should be taught prior to working together.

Curriculum planners aware of these complexities would then not only be concerned about implementing PBL methods in their curriculum for the sake of reaping the advantages of PBL, but also about understanding how the students could truly benefit from such methods.

REFERENCES

Albanese, M. & Mitchell, S. (1993). Problem-based Learning: A Review of Literature on Its Outcomes and Implementation Issues. *Academic Medicine*, *68*, 52-81.

Albanese, M. (2000). Problem-based Learning: Why Curricula are Likely to Show Little Effect on Knowledge and Clinical Skills. *Medical Education*, *34*, 729-738.

Barnett, R. (1994). *The Limits of Competence*. Buckingham: Open University Press/SRHE.

Barrows, H. (1986). A Taxonomy of Problem-Based Learning Methods. *Medical Education*, *20*, 481-486.

Biggs, J. (1999). What the Student Does: Teaching for Enhanced Learning. *Higher Education Research and Developmen*t, *18*(1)*,* 57-75.

Blumberg, P. (2000). Evaluating The Evidence That Problem-based Learners Are Self-directed Learners: A Review of the Literature. In D.H. Evensen, & C.E. Hmelo, (Eds.), *Problem-based Learning: A Research Perspective on Learning Interactions*. London: Lawrence Erlbaum Associates.

Brookfield, S. D. (1986). *Understanding and Facilitating Adult Learning: A Comprehensive Analysis of Principles and Effective Practices*. San Francisco, CA: Jossey-Bass.

Cawley, P. (1989). The Introduction of a Problem-Based Option into a Conventional Engineering Degree Course. *Studies in Higher Education*, 1*4*(1)*,* pages 83-95.

Colditz, G. A. (1980). The Students' View of An Innovative Undergraduate Medical Course: The First Year At The University Of Newcastle, New South Wales. *Medical Education, 14*, 320-325.

Cowdroy, R. & Crick, M. (1997). *Inspired Creative Design Thinking*. Broadbeach: Design Teachers Association Congress.

De Grave, W., De Volder, M., Gijselaers, W. and Damoiseaux, V. (1990). Peer Teaching and Problem-based Learning: Tutor Characteristics, Tutor Functioning, Group Functioning, and Student Achievement. In Z. Nooman, H. Schmidt, and E. Ezzat, (eds.) *Innovation in Medical Education: An Evaluation of its Present State.* New York, Spring Publishing.

Dolmans, D. H. J. M. & Schmidt, H. G. (1994). What Drives the Student in Problem-Based Learning. *Medical Education*, *28*(5)*,* 372-380.

Engel, C. E. (1998). What Is Problem-Based Learning? In D. Boud, & G. Feletti, (Eds.), *The Challenge of Problem-based Learning, 2nd Ed.* London: Kogan Page.

Evensen, D. H. & Hmelo, C. E. (Eds.) (2000). *Problem-based Learning: A Reserarch Perspective on Learning Interactions*. London: Lawrence Erlbaum Associates.

Marton, F. & Saljo, R. (1984). Approaches To Learning. In F. Marton, D. Houndell, & N. Entwistle, (Eds.), *The Experience of Learning*. Edinburgh: Scottish Academic Press.

Miller, C. M. L. & Parlett, M. (1974). *Up to the Mark: A Study of the Examination Game.* London: Society for Research into Higher Education.

Moust, J. & Schmidt, H. (1993). Comparing Students and Faculty as Tutors: How Effective Are They? In P. Bouhuis, (Ed.), *PBL as an Educational Strategy.* Maastricht: Network Publications.

Ramsden, P. (1992). *Learning To Teach In Higher Education*. London: Routledge.

Savin-Baden, M. (2000). *Problem-Based Learning in Higher Education: Untold Stories.* Open University Press.

Schmidt, H. G. & Moust, J. H. (1995). What Makes A Tutor Effective? A Structural-Equations Modelling Approach to Learning in Problem-Based Curricula. *Academic Medicine*, *70*, 708.

Silverman, D. (2000). *Doing Qualitative Research: A Practical Handbook*. London: Sage.

Thorley, L. & Gregory, R. (Eds.) (1994). *Using Group-Based Learning in Higher Education*. London: Kogan Page.

Woods, D. R. (1994). *Problem-Based Learning: How to Gain the Most from PBL*. Ontario. Waterdown, Ontario.

Appendix
Online Questionnaire Survey Data

No.	*Expectations*	Agree	Tend Agree	Tend to Disagree	Disagree
1	I am aware of the nature of learning in PBL and the expectation of group participation.	27.9	55.1	10.6	6.4
	Resources				
2	I find it easier to work on the problem as the subject syllabus is given.	36.9	49.4	9.9	3.8
3	I am able to find the information which is relevant to my project on the Internet easily.	34.6	51	11.9	2.6
4	I am able to find relevant information from books easily.	35.9	49.7	9.6	4.8
5	I have time for research.	27.9	46.2	18.3	7.7
6	I find it difficult to relate my research findings to the project.	11.9	34.6	29.8	23.7
	Project				
7	The project is exciting and it challenges me to think.	41.3	47.4	10.3	1
8	I become anxious when we have to think of our own project specifications.	32.4	52.6	13.5	1.6
	Feedback				
9	I make efforts to give genuine feedback about my peers.	31.4	39.7	23.4	5.4
10	I am consciously aware that my peers are assessing me.	29.2	46.2	15.1	9.6
11	My peers give me feedback about my performance as a group member.	38.5	52.6	5.1	3.8
12	My facilitator gives me useful feedback on my performance.	29.2	50	15.4	5.4
	Self				
13	I seem to know how well I progress for non-PBL subjects than PBL subjects.	37.2	38.5	17.3	7.1
14	Whenever I face difficulties in PBL, I know what I need to do to overcome	53.8	42	3.5	0.6
15	I am prepared to answer any question on what I have been tasked to learn should someone challenges my knowledge.	29.8	51.3	11.9	7.1
	Reinforcement of knowledge				
16	I find resource sessions useful to reinforce my understanding of subject	47.1	40.7	8	4.2
17	When in doubt, I prefer to clarify with my peers than my facilitators.	33	36.5	21.2	9.3
18	I understand the subject better through peer teaching sessions.	40.1	41.7	10.9	7.4
19	I find hands-on practice more useful than lectures.	54.2	34.6	9	2.2
	Facilitator				
20	My facilitator conveys his/her expectations of the work to be done clearly.	50.3	39.4	8	2.2
21	My facilitator guides me in my thinking than telling me the answer to my question.	35.9	53.8	8.7	1.6
22	My facilitator constantly checks if my group is making good progress.	55.4	35.3	7.7	1.6
23	My facilitator allows my group to work out for ourselves what we need to learn.	42.6	39.7	12.2	5.4
24	My facilitator allows my group to make mistakes until we realise the problem ourselves.	22.1	56.4	15.1	6.4
25	I often wonder if my facilitator knows how much I have contributed to the project.	49	40.1	9.3	1.6
	Group				
26	I enjoy group work.	70.8	25.6	2.6	1
27	Group interaction stimulates my inputs to the project.	61.2	32.4	4.8	1.6
28	Within the group, we learn a lot from each other.	12.2	38.5	31.1	18.3
29	My group is well-prepared for group meetings.	31.4	46.5	17.9	4.2
30	I have no problem identifying what I need to do for the project after every group meeting.	28.2	42.6	22.8	6.4
31	I am confident that my group can complete the project on time.	39.1	41.3	13.5	6.1
	Overview				
32	I spend more time on PBL subject as compared to non-PBL subjects.	35.6	54.5	6.4	3.5
33	I am coping well with PBL.	27.6	41	20.2	11.2
34	In short, I appreciate PBL.	28.8	48.7	13.5	9