What Student Attributes Affect Experience of PBL in Virtual Space?

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***Abstract**: Some Engineering Faculties are turning to the problem-based learning (PBL) paradigm to engender necessary skills and competence in their graduates. Since, at the same time, some Faculties are moving towards distance education, questions are being asked about the effectiveness of PBL for technical fields such as Engineering when delivered in virtual space. This paper outlines an investigation of how student attributes affect their learning experience in PBL courses offered in virtual space. A frequency distribution was superimposed on the outcome space of a phenomenographical study on a suitable PBL course to investigate the effect of different student attributes on the learning experience. It was discovered that the quality, quantity, and style of facilitator interaction had the greatest impact on the student learning experience. This highlights the need to establish consistent student interaction plans and to set, and ensure compliance with, minimum standards with respect to facilitation and student interactions.*

Introduction

Questions have recently been posed about the ability of engineering graduates to meet new world challenges such as: ability to transfer basic knowledge to real-life engineering situations; ability to work in virtual global multi-disciplinary teams; ability to adapt to changes and solve problems in unusual situations; and a commitment to continuous life-long learning and self-improvement (Ribeiro & Mizukami, 2005; Thoben & Schwesig, 2002). As a consequence, a new era is emerging in professional engineering education largely driven by a recognition that university graduates need to be better prepared for today's rapidly changing professional environment. This has led to recent changes to both curriculum and pedagogy in some Engineering Faculties in Australia.

One of the changes made at the Faculty of Engineering and Surveying (FoES) at the University of Southern Queensland (USQ) to help address these emerging needs was to adopt the problem-based learning (PBL) educational approach (Brodie & Porter, 2004a, 2004b; Gibbings, 2008). One example is the course, ENG1101 (Engineering Problem Solving 1), which is the first of a strand of four consecutive PBL courses; it is compulsory for all students in FoES.

Conducting PBL at FoES is challenging due to the exceptional diversity of the student cohort. Approximately 80 percent of FoES' 2,500 students study in the external (off-campus/distance) mode. Students studying ENG1101 in this mode do not meet face-to-face and conduct their studies entirely in virtual space. Because of the student diversity in the undergraduate population, and the fact that individual students have different skill and competence levels and take different career paths, their 'learner context' (Haggis, 2002; Savin-Baden, 2004, p. 224) is quite different.

Research Questions

This has prompted administrators of academic programs at FoES to ask the following questions:

- How effective is PBL in virtual space in technical fields such as Engineering and Surveying when there is such a diverse student cohort in the teams?

- What are the practical implications and what lessons can be learnt from conducting ENG1101?
- How do student attributes such as final course grade, age, academic study major, and team facilitator affect the student learning experience in this course?

Theoretical Framework, Background and Context

In 2008 a qualitative study was undertaken by the authors of this paper in the context of ENG1101 concentrating on the external mode where students study entirely in virtual space (Gibbings, 2008; Gibbings, Lidstone, & Bruce, 2008, (submitted manuscript)). The well accepted and documented interpretative qualitative research approach of phenomenography was used for this investigation. The basic premise of that approach was that analysing students' responses to appropriate questions will reveal a *'limited number of qualitatively different ways'* (Marton, 1984, p. 31; Marton & Booth, 1997) of experiencing PBL in virtual space, and that this will be possible even if the differences are grounded in reflective thought and not necessarily in immediate physical experience (Marton & Booth, 1997; Marton & Pang, 1999; Pang, 2002). The phenomenographical approach used in that project concentrated on developing a representation of the variation in students' interpretations of how they went about PBL in virtual space in the context of the ENG1101 course offered in the external mode. Total enrolment in ENG1101 in semester one 2007 was 308 of which responses from 138 external students were analysed. The responses were from both males and females (87% males and 13% females), each of the nine study majors was represented, and responses were received from students of various age groups. Ages ranged from 17 to 58 with an average age of 28 years.

Five categories of description were identified that represent five qualitatively different ways students experience PBL in virtual space. The categories were: 1: 'A necessary evil for program progression'; 2: 'Developing skills to understand, evaluate, and solve technical Engineering and Surveying problems'; 3: 'Developing skills to work effectively in teams in virtual space'; 4: 'A unique approach to learning how to learn'; 5: 'Enhancing personal growth'. With respect to the referential aspects for each category of description: in category 1 PBL in virtual space was experienced as completing assessment items to a suitable standard in order to successfully complete the course and progress in academic programs; in category 2 PBL in virtual space was experienced as gaining knowledge and practical skills of a technical nature that may be useful in students' future professional endeavours; in category 3 PBL in virtual space was experienced as developing skills and knowledge of how to work effectively in virtual teams; in category 4 PBL in virtual space was experienced as learning about, and gaining understanding of, the process of how to learn; and in category 5 PBL in virtual space was experienced as providing an opportunity for personal satisfaction, self improvement, and to grow as a person. In Gibbings (2008) the outcome space was symbolised as a series of terraces with the higher levels representing higher level awareness.

Methodology

In order to achieve the research aims, these results were extended by superimposing a response frequency analysis onto the referential aspects of the outcome space. To do this, individual student responses to the questions were ranked into the highest possible category from the data collected. This provided total numbers of responses falling into each conception. A comparison between each category was then made by totalling responses from before the course and those made after the course.

The metaphor of ascending terraces (Gibbings, 2008; Gibbings et al., 2008, (submitted manuscript)) is now extended to include the notion that some students may ultimately stand on different levels and that this level may change as a result of participating in the course (refer to Figure 1).

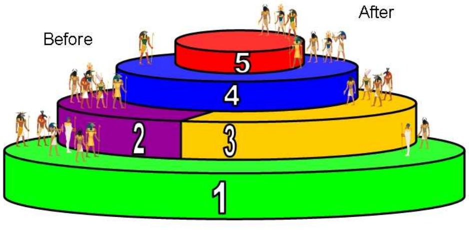

Figure 1: Pre and Post Course Priority Rule

In the phenomenographical study (Gibbings, 2008; Gibbings et al., 2008, (submitted manuscript)), data analysis was treated as a type of horizontalisation where parts of responses were coded to discover categories of description. This paper now changes this context by going back to look at the data as individual responses once again and relating individual students back to the categories. Individual responses were ranked into the highest possible level of conception from the data provided: a process described by Marton, Dall'Alba, and Beaty, as ‘priority rule’ (1993, p. 295). This provides total numbers of responses falling into each category. A comparison was then made between responses from before the course and those made after the course by dividing the data into two groups and reforming the numbers of responses falling into each conception. For example, in Figure 1 a change may be seen as those responses from before the course on the left hand side and those from after the course on the right hand side – some will have changed levels as a result of the course. Finally, an investigation is carried out to see if there is any obvious relationship between students’ attributes of academic grade, age, study major and facilitator, and how they experience PBL in virtual space in the course. The results help to interpret the outcome space from the earlier phenomenographical study with respect to its application in education and team-based curriculum. The phenomenographical study provided evidence of what students were experiencing in a range of categories. This response frequency analysis now provides some insights into why this might be the case so informed recommendations can be made with respect to the practical aspects of teaching in similar courses.

Findings and Conclusions

I. Before and After

Due to the design of the data collection, of the total 276 responses, 138 were from before the course and 138 were from after the course. Before and after responses were from the same students and this provides some justification for comparing results from the two subsets of data. The inference is drawn that any difference in results from before and after the course was grounded in the learning experience in ENG1101, although it is acknowledged that other life experiences during the same period may also be influential. It is also acknowledged that students after the course may be better able to express themselves and describe their experiences compared to before the course however, this difference in language and jargon usage is accounted for by attention to meaning and context during the data analysis process.

Figure 2 presents a graphical summary of the response frequency and compares the before (pre-course) and after (post-course) groups. Category ‘2+3’ in the figure represents responses that indicate a simultaneous awareness of core meaning from both categories two and three. These are considered in this way since, as represented in the metaphor of terraces in Figure 1, categories two and three are considered at the same hierarchical level. Students may experience aspects of awareness from category two only, or from category three only, or simultaneously from both categories two and three.

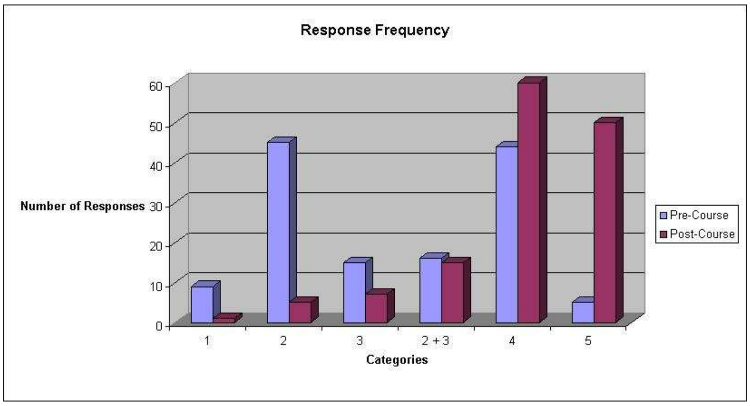

Figure 2: Pre and Post Course Response Frequency

An obvious trend can be seen. Responses from before the course indicate a strong awareness that students expect to learn some technical skills, and also that they expect to be exposed to a learning experience that should provide opportunities for them to discover information about how they learn. This is suggested by the large number of responses in category two (Developing skills to understand, evaluate, and solve technical Engineering and Surveying problems) and category four (A unique approach to learning how to learn). In contrast, responses from the after group indicate a significant shift in awareness towards categories four (A unique approach to learning how to learn) and five (Enhancing personal growth). This may be viewed as evidence that the design, delivery, and general approach of the course has ushered students into deeper ways of experiencing PBL in virtual space.

II. Other Attributes

Final academic grades were recorded for students at the end of the course. The grade point average in categories four and five are higher than the lower level categories, indicating students in these categories may achieve more highly in the course objectives.

The mathematical mean age was calculated for students whose responses ranked into each category. It was expected that age may be used as some surrogate for past life experience since all students are studying externally and most do so because they are working in some professional capacity. No obvious link was observed between age and category. This is perhaps a little surprising since it could have been expected that those with greater life experience may better realise the importance of life long learning, ethical considerations, and social and community issues that are characteristic of categories four and five.

Data was sorted into study major and the responses in each of the categories were totalled for each of the study majors. These counts were then expressed as a percentage of the total responses in each study major so that they could be compared across study majors. Results are presented in Figure 3.

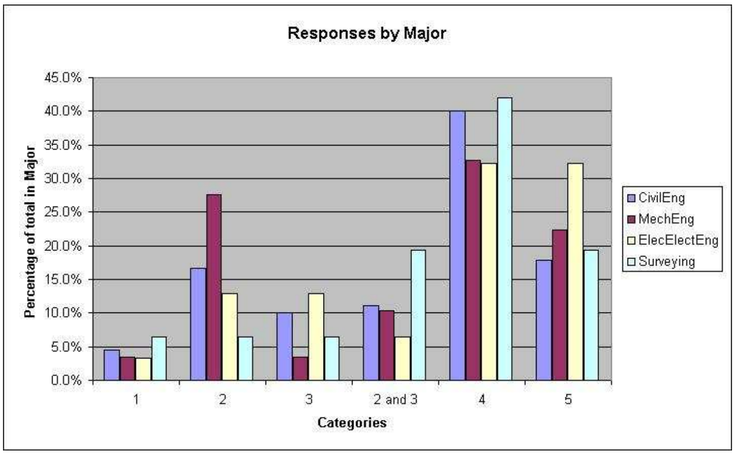

Figure 3: Percentage of Total Responses in Each Category per Study Major

The Mechanical Engineering study major seems to have a disproportionately high representation in category two. This may be explained by the bias towards practical instruction in this discipline at FoES, which may contribute to students over-emphasising the technical skills to the detriment of other soft skills and graduate attributes. The Electrical and Electronics Engineering major seems to enjoy high representation in category five. Another trend can be seen that the Surveying discipline seems to be more biased towards combined categories two and three, and category four than other study majors. One explanation for this may be because at USQ this discipline places great emphasis on team work in most practical activities and tutorials.

III. Facilitator

Responses in each category were attributed to an individual student by virtue of a unique identifying number. This allowed the student PBL team, and consequently the team's facilitator, to be associated with the responses as an attribute attached to the original data. Although all team facilitators are encouraged to make contact with their teams as early in the course as possible, and this is done in a coordinated approach so there is equity for teams with different facilitators, there may still be some question about whether responses from before the course could provide any useful indication about the facilitator's role since their interaction with the team would be minimal at this stage of the course. Accordingly, only responses from after the course were analysed. Using the facilitator as an attribute, the number of responses in each category was tallied for each facilitator and expressed as a percentage of total responses for that particular facilitator (see Figure 4).

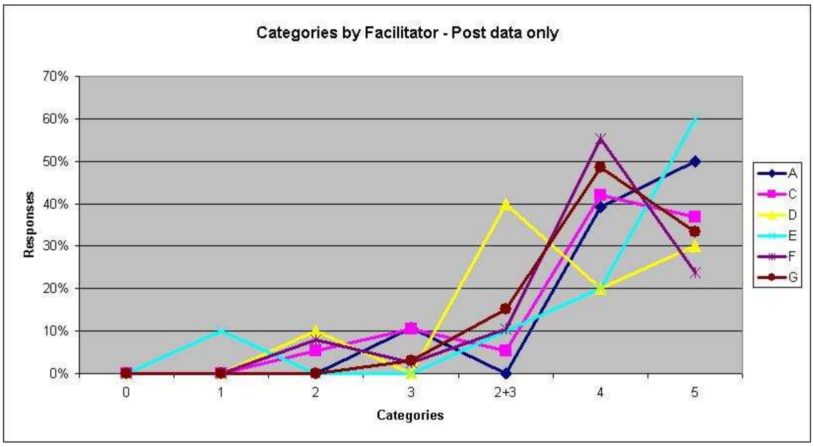

Figure 4: Percentage of Total Responses in Each Category for Facilitators

When analysing this graph, consideration was taken of the profile for each facilitator. Figure 4 shows that students under the guidance of facilitator E may not be as aware of the teamwork aspects of the course. This may be explained by the possible lack of full understanding of the PBL concept due to this facilitator being from another faculty and not being involved in the course on a regular basis. It may also be suggested that students under the guidance of facilitator D may not be as aware of the critical aspects of learning by PBL. This may be explained by this facilitator's background being in the engineering profession and not academia or education. In both cases further evidence is required to draw any definitive conclusions however the results are of interest and indicate potential areas for further study.

Consideration was also taken of the results of a student experience questionnaire. An interesting point is now revealed: facilitators A and E achieved the third lowest, and lowest, student evaluation scores respectively, however they also achieved the highest in category five in Figure 4. This further highlights the need for more research into what impact the PBL facilitator has on student learning.

Recommendations and Further Research

This paper builds on the results of an earlier phenomenographical study. It presents an analysis of the frequency of student responses ranked into the highest possible level of conception, which formed the outcome space from the earlier study. This highest level of conception was determined only from the data provided. It is acknowledged that students may actually experience higher levels of conception, but if they did not reveal this in their responses, then this aspect was ignored and they were ranked on their responses alone. The frequency analysis was more concerned with the discovery of obvious trends that might aid discussions about the results of the phenomenographical study, and consequently results were presented in a graphical manner.

A foundation has now been provided to begin developing answers to the three questions posed in the introduction to this paper:

- *How effective is PBL in virtual space in technical fields such as Engineering and Surveying when there is such a diverse student cohort in the teams?*

Results suggest that the students' perceptions have been changed at least partly as a result of ENG1101. The diversity of the student cohort was effectively used as a resource to aid student learning. It is concluded that PBL courses can be effectively delivered in virtual space in technical fields provided the courses are appropriately developed, facilitated, and managed. Comparison of results against traditional face-to-face delivery is recommended, but is beyond the scope of this paper.

- *What are the practical implications and what lessons can be learnt from conducting this course?*

Information provided by all of the course facilitators must be consistent. Each PBL team must be provided with the same information at the same time. Even when this is managed properly, individual differences between facilitator styles may still be noticed due to factors such as personality traits, attitude, and professional background. This difference between facilitators is an aspect that warrants further investigation.

- *How do student attributes such as final course grade, age, academic study major, and team facilitator affect the student learning experience in this course?*

Perhaps the greatest surprise is that student age, even if viewed as a surrogate for experience, does not have a major impact on students' learning experience in this course. It seems that only interaction with the team facilitator does. Although all team facilitators in the course undergo the same training, receive the same direction throughout the semester, and provide the same resources and support to their teams, indications are that the quality and quantity of interaction with the facilitator may still have a significant impact on the student experience in virtual PBL courses. This implies that minimum standards should be set and monitored for facilitators with respect to quantity, quality, and timeliness of student interaction including responses to student enquiries. Future staff facilitator training should address this issue and ensure a consistent high-quality approach to team facilitation. It is recommended that the area of facilitation in these types of courses be further investigated.

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