PROBLEM BASED LEARNING IN SPATIAL INFORMATION SCIENCES – A CASE STUDY

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ABSTRACT:

This paper describes the introduction, implementation and evaluation of a Problem Based Learning component in the Geodetic Surveying syllabus of the fourth / final year of the honours degree programme in Geomatics at the Department of Spatial Information Sciences, Dublin Institute of Technology, Ireland. The reasons behind adopting this constructivist educational approach as opposed to traditional instructivist methods more commonly employed are addressed, together with an evaluation of the process from both the educator (academic) and student (learners) perspective. The results of this case study are considered in the context of a number of interconnected pedagogical issues including (a) enhancement of student learning, (b) effective teaching, learning and assessment methodologies and (c) effective evaluation strategies. It was found that the adoption of PBL as a learning mechanism in Spatial Information Sciences represented a cultural change for both facilitators and learners, resulting in significantly increased time commitments from both parties. However, it was also found that student technacy abilities and reporting skills were greatly enhanced with WebCT used as a communication tool. Furthermore, learners covered a significant breadth of topics in an integrated way while identifying the inter-relationship between classroom material and real-world issues thus helping to equip them with the professional skills required in the modern commercial environment.

1. INTRODUCTION

In recent years it has become apparent that the traditional 'bottom-up' teaching methodologies (Shortis et al., 2004) ill serve modern engineering and geomatics graduates and that industry favours graduates with more problem solving and team based skills (Fink, 2001). These changes are partially due to rapid technological developments in the Spatial Information Sciences and, also, an increased requirement for cognitive flexibility in graduates.

The instructivist methodology for teaching, as traditionally applied in the tertiary educational sector is generally based on the traditional, passive approach to education, whereby the learner is provided with all necessary course information. Thus, it is possible for a student to excel in an examination situation through strategic learning but without having gained any deep understanding of the subject area. This approach is, therefore, not considered ideal for advanced students expected to become productive members of the commercial sector. In addition, graduates from a degree course in the Spatial Information Sciences area will, most likely, work in a team environment where they will be expected to bring their particular expertise and knowledge to solving problems in conjunction with other experts. To succeed in their profession they will require, *inter alia*, advanced communication skills and an ability to apply the team approach to problem solving.

The constructivist approach to education, as used in Problem Based Learning (PBL), emphasises the importance of social interaction between the students (learner to learner) and establishes more mature learner to lecturer (learner to facilitator) interaction. Furthermore, by placing the emphasis on the individual (self directed learning) a vigorous interaction with the content material is established thus reducing the passive approach to learning that has become prevalent amongst students (Smerdon et al., 1999).

With this in mind a pedagogical change in the teaching methodology has been introduced in the Dublin Institute of Technology (DIT) and in the last two academic years students of the honours degree in Geomatics undertook PBL in one module of their fourth year syllabus during the first semester. Initially, in 2004-05, the syllabus module chosen to implement PBL was Geodetic Surveying. This subject was chosen for a number of reasons including the number of disparate module components being delivered by different academics resulting in granularity of the module content and leading to a lack of subject coherency for the student group.

2. METHODOLOGY

At the inception of this pedagogical approach (PBL) it was recognised that a cultural shift for both academics (facilitators) and students (learners) would ensue and, therefore, in advance of implementing the PBL process the facilitators needed to become familiar with the PBL process. This was achieved through attendance at many of the specifically designed in-house PBL workshops and School training seminars provided by the DITs' Teaching and Learning Centre. The following sections describe delivery of the PBL module from induction to final evaluation.

2.1 Introduction to PBL

Induction seminars were arranged for the learner group to ensure that they were familiar with the concept of PBL and could actively engage in the learning process. These seminars included:

(a) A seminar aimed specifically at the learner group to introduce the concepts of PBL and brainstorming, and to provide the cohort with a geodetic surveying-related problem to solve. Bearing in mind that PBL problems should be loosely

defined and relate to current real-world issues, the problem assigned to the learner group was:

"It is post-war Iraq and peace has returned. The national survey control framework infrastructure is largely destroyed. As part of the international aid programme for the redevelopment of Iraq you have been commissioned to advise on the design of a replacement framework. Prepare your report."

(b) An inter-school seminar conducted by an academic from outside the Department but within the Faculty aimed at both Spatial Information Sciences students and Property Economics students. The rationale for joint attendance of the different student groups at this seminar was to increase their awareness of PBL as a cross-discipline means of learning and assessment and to learn from the experiences of others within the Faculty.

(c) A seminar led by a senior academic from the DIT Learning and Teaching Centre outlining the constructivist teaching methodology and providing mock PBL exercises.

At the induction stage of the PBL a personality testing study using the Belbin Test (Belbin, 2000) was undertaken by a member of the DIT Faculty Careers Department. The objective of this test was to establish effective PBL teams based on personality strengths and weaknesses. It had the added advantage of providing the learners with an insight to differing personality traits and how these might be most effectively utilized to further the team experience. This method of team selection was a major departure from previous selection criteria whereby groups were formed on a random basis or relative to previous academic performance. It also distinguished between group project work, with which the learners had become familiar during the first three years of their studies, and team roles within a self centred study environment. In reflective analyses of PBL, individuals were expected to critically examine their role within the team.

2.2 The PBL Process

The PBL module progressed with bi-weekly team meetings. PBL is primarily a learner-driven teaching process wherein the most effective teaching methodologies are through self study and peer teaching (learner to learner) and therefore, for the team to progress, each team member had to amass a certain knowledge base and disseminate this information to his/her peers. To facilitate the peer teaching process each team was allocated a private space on a web-based educational course management system known as WebCT for discussion and information dissemination. The adoption of WebCT promoted and increased demand in the level of technical literacy (technacy) by the learners and further permitted remote ("Big Brother") monitoring of the weekly process of individual teams by the facilitators. Furthermore, WebCT served as a project documentation service whereby all the minutes from team meetings were presented. Thus, monitoring of the range and quality of reference materials used by each team and the effectiveness of this teaching process could be discretely undertaken.

In addition to the self and peer teaching methods, group moderation of each PBL team by the facilitators took place on a weekly basis. This enabled the facilitators to directly monitor the level of self study and peer teaching that had occurred, and also to assess the group dynamics in terms of their internal communications.

2.3 Assessment of PBL

To ensure effective assessment of each aspect of the process, formative assessment methodologies were applied. The assessment techniques applied included:

1. Formative staff assessment of students:
   This was on a team basis and was assessed weekly under the criteria of critical thinking, quality of research, and effective group methods. Feedback allowed the learners to make beneficial changes in their solutions.
2. Peer assessment:
   The team members twice assessed performance of their peers, once during the interim presentation and once during the final group presentation where the assessment criteria were mainly focused on the group dynamics rather than academic quality.
3. Self assessment:
   During the peer review process each team member assessed his/her own contribution to the process under the same criteria as in 2 above.

Comparability of formative assessment results was ensured through double reading of all technical submissions by the facilitators and grades were subsequently analysed for anomalies in the results.

2.4 PBL Evaluation

Effective evaluation of the PBL process was through the strategies of a final meeting of staff involved, student individual feedback through the DIT quality assurance procedures, student group feedback through informal round-table meetings and both interim and final monitoring reports from the Teaching and Learning Centre. Reflection on the process took place in the months following the completion of the module and was summarized in a lunchtime presentation to Faculty staff.

3. RESULTS

The results of this case study focus on a number of interconnected pedagogical issues including: Enhancement of student learning; Effective teaching, learning and assessment methodologies, and; Effective evaluation strategies, each of which is outlined in the following sections.

3.1 Enhancement of student learning

Effective learning was achieved for the team through a problem-solving approach, whereby an understanding of the solution came through an appreciation of the relevance of individual topics culminating in a final written report. As the individual problem statements allow for multiple possible solutions, technical solutions proposed by individual teams could vary significantly in their emphasis.

The enhancement of student learning was evident from an examination of (i) the team final written reports, (ii) the team oral presentations and (iii) the individual reflective writing reports. By placing the emphasis on the individual (self directed or 'learner-centric' learning) a vigorous interaction with the content material was established thus reducing the passive approach to learning that has become so prevalent. The learning evident from these reports shows a wealth of knowledge in both breadth and depth gained by each team and is a real example internally driven learning. The reflective

writing report, in particular, demonstrated the development within individual students of thoughtful review and self-appraisal skills, and an understanding of the group dynamic.

It was also evident that, in comparison to the traditional, instructivist approach to the teaching of fourth-year Geodetic Surveying, the students have covered a significant breadth of topics in an integrated way while identifying the inter-relationship between classroom material and real-world issues. Furthermore, while developing written and oral presentation skills and learning to work effectively in group situations they are, by addressing the particular PBL problem, gaining an appreciation of the international value of their third-level qualification.

3.2 Effective teaching, learning and assessment methodologies

Overall it was found that learners extended their knowledge base and incorporated cross-subject disciplines. The ability of learners to interact on different levels with both their peers and their mentors was improved, and promoted deep learning by forcing the learners out of their 'comfort zone'. In terms of assessment the learners, on average, increased their grades by approximately 10 – 15 % from previous examination results, this was considered appropriate relative to the increased self-learning time required for the module. Table 1 shows the grades awarded in each of the aforementioned assessment techniques. From this table it can be seen that, in general, the grades awarded at each stage were high. Furthermore, a fundamental change in approach by team members to the importance of peer and self-assessment techniques was evident on comparison of the interim presentation grades (column 3) and the final Group Presentation grades (column 6). In the first peer assessment no grade distinction was made by individual team members however, as the process progressed the importance of peer assessment became more apparent, there is a significant difference between the lowest (59) and highest (73) marks awarded.

3.3 Effective evaluation strategies

Quality assurance procedures adopted enabled objective learner group feedback through informal round-table meetings with both module facilitators and specialized PBL coaches from within the institution but external to the Department of Spatial Information Sciences. In addition, reflective analyses of the PBL process and outcomes from both the learners and facilitators perspective were achieved through interim and final monitoring reports.

4. CONCLUSIONS

The main findings of this case study indicate that the adoption of PBL as a learning mechanism in Spatial Information Sciences represents a cultural change for both facilitators and learners. Learners covered a significant breadth of topics in an integrated way while identifying the inter-relationship between classroom material and real-world issues thus, equipping them with the professional skills required in industry today. The adoption of PBL as a learning mechanism has improved the ability of learners to interact on different levels with both their peers and their mentors, and promoted deep learning by forcing the learners out of their 'comfort zone'. However, it is also recognised that the development of any new and innovative teaching and learning methodology is an iterative process. The initial PBL case study in Geodetic Surveying module from the academic year 2004/2005 resulted in significantly increased time commitments from both parties and, as a remedy, has been extended in 2006 to encompass additional, related course components. Generally, the introduction of PBL has been seen as a positive development by learners, academic staff and external moderators alike and, going forward, it is expected that PBL will be adopted in other course components.

08/10/2004	15/10/2004	22/10/2004	29/10/2004	05/11/2004	03/12/2004	03/12/2004	10/12/2004	Final Mark
WM1	WM2	Int. Pres. + P.Rvw.	WM3	WM4	Gr. Pres. + P.Rvw.	Gr. Rpt.	Refl. Rpt.	
8	9.5	69	9.5	9	81	83	78	81
8	9.5	69	9.5	9	81	83	70	78
8	9.5	69	9.5	9	81	83	65	76
8	9.5	69	9.5	9	81	83	67	76
8	9.5	69	9.5	9	81	83	58	73
6	7	59	6	8	73	70	90	77
6	7	59	6	8	73	70	75	71
6	7	59	6	8	61	70	60	64
6	7	59	6	8	64	70	65	66
6	7	59	6	8	59	70	60	63
7	9	68	8	9.5	79	70	70	73
7	9	68	8	9.5	79	70	58	69
7	9	68	8	9.5	79	70	80	77
7	9	68	8	9.5	79	70	64	71
7	9	68	8	9.5	79	70	60	69
7	9.5	71	8.5	9.5	67	70	50	65
7	9.5	71	8.5	9.5	75	70	62	71
7	9.5	71	8.5	9.5	72	70	50	66
7	9.5	71	8.5	9.5	75	70	65	72
7	9.5	71	8.5	9.5	75	70	80	78
7	9.5	71	8.5	9.5	75	70	68	73
Contribution =								
5%	**5%**	**10%**	**5%**	**5%**	**10%**	**20%**	**40%**	

WM = Weekly Meeting; Int. Pres. = Interim Presentation; P. Rvw. = Peer Review; Gr. Pres. = Group Presentation; Gr. Rpt. = Group Report; Refl. Rpt. = Reflective Report.

Table 1: PBL Assessment Results

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