

Problem based learning in science

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Problem based learning (PBL) is a recognised teaching and learning strategy used to engage students in deep rather than surface learning. It is also viewed as a successful strategy to align university courses with the real life professional work students are expected to undertake on graduation (Biggs, 2003). Problem based learning is practised internationally, for example, in Europe, Australia and the United States (Dolmans et al., 2005; Savin-Baden, 2000; Schwartz et al, 2001). In this paper I report on implementing PBL tasks to replace conventional tutorial and laboratory sessions in three first year units during 2007 and 2008. I also describe participant unit coordinators' understanding of the changes required to shift their focus from 'what the teacher is teaching' to 'what the students are learning' and include student perceptions of PBL in these units. Generally unit coordinators perceive the implementation as successful and valuable to enhance the student learning experience. Student feedback on PBL is varied and ranges from enjoyment to resentment.

Introduction

In this paper I describe an initiative begun in 2007, and continued in 2008, to implement Problem Based Learning (PBL) into a research intensive science faculty at a Western Australian university. Following a brief overview of PBL, I outline the scope of the implementation for the two years. Preliminary data presented describes participants' perception of the implementation of PBL into three entry level faculty units. Case study data were collected via semi-structured interviews with participant unit coordinators and student surveys. Semi-structured interviews capture participant understanding of the changes to shift their focus from 'what the teacher is teaching' to 'what the students are learning'. Student feedback offers insight about student likes and dislikes of PBL.

Why introduce PBL into the faculty

PBL is a recognised teaching and learning strategy popularised during the 1960s as a result of research (Barrows & Tamblyn, 1980) and used to engage students in deep rather than surface learning. It is also viewed as a successful strategy to align university courses with the real life professional work students are expected to undertake on graduation (Biggs, 2003; Biggs & Tang, 2007). PBL represents a major and widespread change in educational practice within higher education (Dolmans et al., 2005) and has been introduced into all of the health sciences, engineering, business, science and education (Boud & Feletti, 1991). Both 'pure' and 'hybrid' approaches have been adopted in tertiary institutions (Dahlgren & Oberg, 2001, Pawson et al, 2006). According to Savin-Baden (2001, p.4) PBL is 'an approach to learning that is characterised by flexibility and diversity in the sense that it can be implemented in a variety of ways in different subjects and disciplines in diverse contexts'.

Problem based learning is 'problem first learning' (Spencer & Jordan, 1999) because it is the problem which defines the learning. Instructors design problems to represent authentic, real world situations which small groups of students work to resolve. To emphasise fundamental sciences training in the context of real world problems in undergraduate degrees, PBL was implemented in the Faculty. Purported benefits of PBL include:

- students deciding on the information and skills they need to investigate issues while building on their current knowledge to synthesise then integrate new information
- students taking responsibility for the learning that occurs within their group while instructors monitor and facilitate student learning
- students engaging with the learning experience more fully.

According to Biggs (2003) and Biggs and Tang (2007) there is a greater likelihood of deep learning rather than surface learning due to the alignment of teaching and learning activities, curriculum objectives and assessment tasks when students engage with PBL.

To complete this research answers to the following questions were sought.

1. How did the unit coordinators perceive the implementation of PBL?
2. What did students like about PBL?
3. What did students dislike about PBL?
4. Did implementing PBL into these units enhance the student learning experience?

Unit structure and methodology

To study the implementation of PBL three first year units which included PBL tasks during Semester 1 in 2007 and 2008 were chosen. A hybrid version of PBL, involving part of the curriculum within faculty units, implemented into four entry level (Level 1) units in the four faculty schools during Semester 1 2007, was reported in Pepper (2008). Implementing the hybrid model of PBL continued during 2008 with three of the 2007 unit coordinators enthusiastic to remain involved. Thus PBL was used as a teaching and learning strategy for part of the curriculum with no attempt to redefine the entire curriculum. Such use of a single problem over several weeks is reported as effective by Hans (2001).

Each unit involved in the PBL implementation has equal value towards an undergraduate degree. The biology unit is a core component of all courses taught across the faculty with in excess of 300 students enrolled annually. Six contact hours are timetabled for students weekly. Both the ecology and economics units are core components of several applied science degrees and annual enrolment numbers range between 40 and 60 students. Six contact hours are timetabled weekly for the ecology students and three are timetabled weekly for the economics students. Prior to implementing PBL biology laboratory sessions involved group and individual exercises with students submitting an individual laboratory report weekly. Ecology students completed individual exercises during tutorials

and the economics students completed group work. A table summarising the presentation of PBL sessions to the students in the three units during 2007 appears as Table 1 below.

Table 1: Introduction of PBL into first year units in Semester 1, 2007

Unit (Generic)	Session style	Tutor training	No. of tutors	Student training	No. of students	No. feedback
Biology	Laboratory	Yes	13	No	300	14 (group)
<ul style="list-style-type: none"> • three, three hour laboratory sessions over three weeks • student groups of 6 or 7 • three triggers, (new sets of information), were progressively disclosed • assessment – group oral presentation 						
Ecology	Tutorial	Yes	6	No	80	26
<ul style="list-style-type: none"> • two, one hour tutorial sessions over two weeks • student groups of 4 or 5 • one problem was presented • assessment – group oral presentation 						
Economics	Tutorial	Yes	1	Yes	75	36
<ul style="list-style-type: none"> • four, one-hour tutorials over four weeks • student groups of 6 to 8 • three triggers progressively disclosed • assessment – group oral presentation 						

Table 2 summarises the presentation of PBL sessions to the students in the same three units during 2008.

Table 2: Introduction of PBL into first year units in Semester 1, 2008

Unit (Generic)	Session style	Tutor training	No. of tutors	Student training	No. of students	No. feedback
Biology	Laboratory	Yes	12	No	300	66
<ul style="list-style-type: none"> • four, three hour laboratory sessions over four weeks • student groups of 6 or 7 • five triggers progressively disclosed • assessment – group oral presentation, 2 page individual summary, lab notebook 						
Ecology	Tutorial	Yes	3	Yes	45	42
<ul style="list-style-type: none"> • two, two hour tutorial sessions over four weeks • student groups of 4 or 5 • two separate problems • assessment – group oral presentations 						
Economics	Tutorial	Yes	2	Yes	75	44
<ul style="list-style-type: none"> • six, one hour tutorials over six weeks • students in groups of 4 or 5 • five triggers were progressively disclosed • assessment – group oral presentation 						

Data were gathered via semi-structured interviews with the three unit coordinators and written feedback from all students at the completion of each task. During the semi-structured interviews I explored background information about the participants, their

understanding of the benefits and challenges of participating in the PBL initiative and their perspective on changes required to implement PBL. I allocated participants pseudonyms to ensure anonymity and crafted short narrative accounts from their interview data (Pepper & Wildy, 2008; Wildy & Pepper, 2005). Narratives are life like accounts which honour participants' stories and descriptions of experience and are aligned with qualitatively oriented educational research (Clandinin & Connelly, 2000; Conle, 2003). Prior to analysis each narrative was returned to the participant for approval of its use in the study.

All students in the three first year units were invited to complete a feedback sheet after completing each PBL task. However, due to the large number in the biology unit, three laboratory classes were randomly chosen to complete individual responses and the majority completed group responses. The first two questions required answers relating to the unit content while questions three and four asked students what they did and did not like about the task. It is possible that some students completed the three units so may have provided feedback for each unit. The majority, however, participated in only one or two of these units. To determine whether implementing PBL into these units enhanced the student learning experience data obtained from the unit coordinators and student feedback were considered.

Data and analysis

Initial data are presented in three narratives developed from semi-structured interviews with the three unit coordinators. The purpose of using narratives to present this data is to illustrate the every day, ordinary actions and beliefs of participants rather than the bizarre or exotic. Summaries of general student feedback for each unit follow the narratives.

How did the unit coordinators perceive PBL?

Pete is the pseudonym given to the biology unit coordinator. He has coordinated the unit for the past four years and delivers the majority of lectures. Pete is a mid career academic with an interest in pedagogy and has teaching and learning responsibilities within the faculty.

Pete: New tricks

Early last year I was invited to introduce problem based learning into the first year biology unit I coordinate. I had no prior knowledge or experience of PBL but welcome innovative ways to engage my students with core unit material. I listened to the advantages reputedly offered by PBL and recognised taking up this invitation as valuable first hand exposure to a new initiative in the faculty. Before making any commitment I sought agreement from the co-coordinator responsible for the practical component of the unit and spoke with colleagues knowledgeable about PBL. I then met with the PBL lecturer to discuss implementing PBL into the final three practical sessions for the semester.

With assistance from the PBL lecturer I modified two genetics practicals, to represent a problem, by reducing the content covered and allowing student groups time to present their findings to their class in the third session. I retained the practical elements of the sessions while allowing students flexibility to complete them. I knew it was important for the first year students to be clear about the aims of the task so provided them with learning outcomes as a guide and several useful references.

I resisted the PBL lecturer's requests to address the students about PBL in case students viewed the initiative as a novelty. The week before the PBL exercise was introduced I invited the PBL lecturer to address the ten demonstrators responsible for the practical sessions to inform them about the process, their responsibilities and how the task should be facilitated and assessed. While our demonstrators are competent and experienced I suspect some heard different sections of the training information by choice. Some embraced the concept of PBL by listening carefully, asking pertinent questions and completing the additional reading. I suspect others made a strategic choice not to ask questions and were less committed to the initiative. Nevertheless, I found implementing PBL more successful than I expected.

After refining the task I repeated the PBL exercise this year. I included a fourth practical session, increased the number of activities disclosed as PBL triggers and allocated the topics students presented orally. Demonstrators again attended a training session with the PBL lecturer. Once more, I found some demonstrators more committed to PBL than others, though all undertook their responsibilities seriously. Several still believed they should provide answers rather than guide students to them. Student feedback to the PBL tasks varied. While most students were happy to work in groups to complete the group assessment they were less comfortable identifying learning issues and addressing audience questions after delivering oral presentations. For both years, unit satisfaction feedback from the students indicates they want to be taught rather than learn themselves and they did not welcome the change of laboratory format towards the end of semester. Average student exam performance has not altered over the years.

Despite requests from the PBL lecturer to address my students about PBL in future, I prefer that their attention is not drawn to teaching and learning strategies. I am happy including PBL in the biology unit again next year though I may trial introducing the task at the beginning of the semester.

With no previous experience of PBL Pete was prepared to participate in this faculty initiative after consultation with the unit co-coordinator. He describes the commitment and understanding displayed by the ten demonstrators also involved in implementing PBL as varied. In refining the original task he extended the exercise over four sessions and structured the group assessment. Pete resists requests that his students receive training prior to participating in PBL tasks.

Clare is the pseudonym I gave to the ecology unit coordinator. She is also a mid career academic with an international research reputation and has coordinated the unit for the past five years.

Clare: Clarifying concepts

When the problem based learning lecturer asked me to introduce PBL into my ecology unit I agreed because I have been using problem solving with my students for many years. Initially I thought agreeing involved continuing as I had in the past. After meeting with the PBL lecturer a few times, to learn more about PBL, I was less certain, though still prepared to go ahead. I agreed when she asked to meet with me and the five tutors I had ready to assist in the unit for training. We each received a variety of information including explanations about the advantages of PBL and tutoring hints. I modified the practical task used in previous years and believed student groups would work well to complete the task. Two weeks later I was surprised when the PBL lecturer expressed her distress about the implementation after visiting the tutorial classes during their PBL sessions. "They are not practising problem based learning at all," she complained. We clearly had different ideas about PBL. Later in the year I attended a Faculty Teaching and Learning Forum and listened to more information about PBL. I now understood both the rationale behind PBL and the PBL lecturer's earlier dismay better.

This year, when the PBL lecturer offered to co-coordinate the Ecology unit with me I accepted her offer of assistance. I knew this was her strategy to gain greater input into the implementation of PBL in the unit. Course restructuring meant our student numbers were lower so two tutors and I met the PBL lecturer for a training session. Once more we received information about the process, tutor responsibilities and demonstrations of how we should conduct our PBL tutorials from her. With her assistance I crafted two PBL tasks as the first student assessments. I agreed to her request that she deliver a lecture to the students on group work and the PBL strategy before they embarked on the first task.

Before each PBL session the tutors and the PBL lecturer met to discuss student progress and reflect on our own skills to facilitate rather than teach the group. We ensured our students also spent time reflecting on their group progress and commitment to their group protocols. For both assessments students delivered a brief oral presentation to their tutorial group. I knew they were not comfortable with this form of assessment initially and encouraged them in their efforts. Student feedback indicates they enjoyed working in groups to meet new people in their early days at university. They also enjoyed the flexibility of the PBL tasks - a marked contrast from their secondary schooling.

I appreciate the assistance given by the PBL lecturer and know the PBL tasks were successful due to her close involvement. Students took responsibility for this portion of their learning and strong bonds are forming among them. I intend to continue using PBL in the ecology unit next year and I am comfortable shifting the focus from what I do in class to what the students do.

While Clare initially believed she understood PBL she was unclear about the distinction between PBL and problem solving. After attending a Faculty Teaching and Learning Forum and hearing various explanations of PBL her understanding deepened. Her

willingness to continue using PBL and agree to the PBL lecturer sharing the unit coordination provided Clare the support she needed to experience PBL successfully.

The third narrative is from the economics unit coordinator whom I call Jane. Jane has coordinated the unit for the past eight years and delivers all lectures and tutorials to the students enrolled in this unit. Jane is a mid career academic with an interest in pedagogy and has prior experience engaging with PBL.

Jane: Revisiting PBL

Last year, I introduced problem based learning into the natural resource economics unit I coordinate. While I viewed the strategy as worthwhile and of benefit to students' learning, I found it difficult to engage in group work without funding for additional tutors when I taught in other units that have a PBL element in them. I valued PBL because my students were working in groups to problem solve, reflecting on their own learning and becoming creative. With the appointment of a PBL academic to provide support to the faculty at the beginning of last year, I was keen to engage students in natural resource economics with PBL. While I was enthusiastic about the potential of PBL some reservations remained. I consider PBL as one strategy to assist students accept responsibility for their own learning, take on challenging material and move on from rote learning alone, although I understand the apprehension students often experience. I also worried about fair and effective group assessment for my students.

Together with the PBL lecturer I developed an economic problem with multi-discipline elements to run over four weeks of semester 1. I included some guiding questions and session plans for the progressive disclosure of the problem. I also knew it was important for the first year students to be clear about the aims of the task so included the learning outcomes and several references as a guide for them. Just prior to introducing the PBL exercise I invited the PBL lecturer to address my students to inform them about the process, her involvement, their group responsibilities and how the task would be facilitated and assessed. I knew how motivated students are by marks yet couldn't risk allocating more to PBL because tutorial attendance marks were already published. On completing the PBL exercise student feedback was generally positive and I was relieved that marks were shared equally within each group. I know several student groups met out of class time to share information and the task helped them engage in believable and real world economic issues.

This year I crafted a new task and refined the PBL exercise in the natural resource economics unit. Once more the PBL lecturer addressed my students and participated in all PBL sessions with us. Over seven weeks I progressively disclosed elements of the task while also monitoring group dynamics and progress. Rather than assess students on their attendance (and final presentation), I assessed them on their group knowledge, communication, collaboration, self direction and critical thinking using a rubric designed by the PBL lecturer. Student feedback indicates they enjoyed the flexibility, independence and different interpretations the task stimulated in their groups. In addition, they enjoyed 'thinking in depth' and 'outside the square' rather than simply following my instructions.

Some students described the task as vague and constantly reassessed the task to be sure they were on the right track.

Introducing PBL into natural resource economics was not a difficult task for me. I found the challenge was thinking of a relevant problem for students enrolled in a diverse range of degrees. Students welcomed the opportunity to address the problem and incorporate their own interests. I know they grew to appreciate the benefits of simplifying an issue then addressing it within their capabilities to reach a logical solution. I believe that empowering students to take control of their learning is an important generic skill and is useful for their future workplaces. PBL enables students to show initiative and illustrates to students that teachers are a resource whom they can work with rather than work for.

Jane welcomed PBL exercises as opportunities for her students to take responsibility for their own learning and to help shift them from rote learning all material. After reflection she refined both the task and her delivery of the PBL sessions. During the implementation Jane viewed her PBL tasks as successful learning experiences for her students.

How did the students perceive PBL?

Students were invited to complete a four question feedback sheet after completing each PBL task. For the economics unit and the ecology unit all students were asked to participate. Due to the large number of students in the biology unit, students in three of the fourteen laboratory classes were randomly invited to complete the feedback forms individually.

The first two questions asked students "What was the most important thing you learned in today's session?" and "What questions do you have from today's session that remain unanswered?" Students answered these questions differently depending on the unit they were completing. However, the majority of responses related to content matter in the respective unit. These responses were consistent with the majority received from students who completed the feedback survey during 2007.

What did students enjoy about PBL?

Question 3 asked "What are two aspects you enjoyed about the PBL process?" As the student responses varied, the information was categorised into themes (Ryan & Bernard, 2003). Not all students described two aspects they liked. Student responses appear in Table 3.

Many similarities are evident among the student responses from the three classes. Students enjoyed *working in groups* to complete PBL tasks. *Working in groups* appears most frequently in the list of 'enjoyed about PBL' across the three units (62% total responses). The *flexibility (time, presentations, focus and pace)* offered through PBL is identified as enjoyable by students across all the units (29% total responses). Interestingly, students in the ecology and economics units enjoyed *the presentations*, though biology students made no mention of

presentations. Across the three units students indicate they enjoyed *sharing opinions and perspectives* (16% total responses). Student 'likes' are consistent with those described by students in the economics unit during 2007 (Pepper, 2008).

Table 3: Thematic responses to PBL feedback question 3 (2008)

Theme identified in responses	Number of student responses (Biology – 66)
Working in groups	42
Flexibility to complete tasks (time, presentation)	14
Hearing different perspectives	14
Content related	11
Solving research problems	9
Recognising objectives to consolidate concepts	5

Theme identified in responses	Number of student responses (Ecology – 42)
Working in groups	28
Flexibility to focus on personal interest	12
Independent learning about a new topic	11
Presenting to others	7
Hearing different perspectives	6

Theme identified in responses	Number of student responses (Economics – 44)
Working in groups	24
Gathering information of group interest	13
Solving a problem	9
Sharing opinions and information	5
Flexibility to complete tasks	5
Learning from presentations	5
Different approach	4

What didn't students enjoy about PBL?

Question 4 asked 'What are two aspects you didn't enjoy about the PBL process?' Many students did not answer this question and several did not offer two aspects. Nevertheless, these responses were diverse and were also categorised into themes (Ryan & Bernard, 2003). The themes identified appear in Table 4.

Across the units the most common theme which students identify they did not enjoy is the *lack of direction and uncertainty* in the PBL tasks (24% total responses). Interestingly, while *working in groups* was rated most frequently as enjoyable (62%), some students did not enjoy *group work* or commented on *group issues* (14% total responses). Similarly, some students in all units did not enjoy being assessed on their *oral presentation* (14% total responses) despite students in the Ecology and Economics units indicating they did enjoy the presentations. Eleven students (7%) did not enjoy the *progressive disclosure of information* and thirty one students (20%) did not like the *time allocated* to complete the tasks. Students

across all groups indicate *difficulty in meeting out of class time*. Responses are similar to those received from student feedback in 2007 (Pepper, 2008).

Table 4: Thematic responses to PBL feedback question 4 (2008)

Theme identified in responses	Number of student responses (Biology – 66)
Lack of direction/uncertainty	16
Working in groups	15
Presentation to peers and demonstrators	14
Timing of task (too long/short/late in semester)	7
Page limit for written task	5
Progressive disclosure of triggers	4
Difficulty meeting out of class time	1

Theme identified in responses	Number of student responses (Ecology – 42)
Time limit on presentation	18
Lack of direction/uncertainty	11
Finding own information	7
Difficulty meeting out of class time	6
Presentation issues (no ppt, repetitive)	3
Group issues	2

Theme identified in responses	Number of student responses (Economics – 44)
Lack of direction/uncertainty	9
Difficulty meeting out of class time	9
Progressive disclosure of triggers	7
Timing of task (too long/short)	6
Working in groups	5
Presentation to peers	4

Discussion

The unit coordinators who agreed to participate in this implementation of PBL did so with differing levels of understanding about PBL. While the economics coordinator was experienced in PBL neither the biology nor the ecology coordinators were familiar with the strategy. Both coordinators acknowledged their position prior to taking up PBL. For this reason implementing PBL into the economics unit, though complex, was less challenging than implementing the strategy into the other units (Pepper, 2008). Nevertheless, both coordinators, and the economics coordinator, continued working to refine then repeat implementing PBL into their unit. With continued reflection and exposure to additional PBL coaching the coordinators are likely to sustain their interest in PBL. Indeed, each makes mention of their intention to continue including PBL with Level 1 students into the next academic year.

Implementing change is challenging because teaching practice, pedagogical beliefs, collegial ways of working and curricular materials may be questioned (Biggs, 2003). Such concerns are evident in the narratives, when for example, misunderstandings between the concepts of PBL and problem solving are mentioned in *Clarifying concerns*, laboratory practical sessions are modified rather than new problems written and some students are denied access to explanatory information about PBL in *New tricks*. Nevertheless, the coordinators each refer in some fashion, to their interest in assisting students become more responsible for, and better engage in, their own learning.

Similarly, it is not unusual for participants to experience a range of emotions, including confusion, anxiety, frustration and anger when implementing change (King, 2006). Strategies in place to reduce such emotions are described in the narratives. Consistently, the unit coordinators acknowledge the importance of receiving assistance and training in PBL. Adopting a collaborative approach and shared ownership with the PBL lecturer, so that new materials and approaches were jointly prepared, also impact positively on the coordinators involved. Persistent collaboration with the PBL lecturer is described in each of the narratives. For example, in *New tricks* regular discussion is indicated throughout the task between the PBL lecturer and the demonstrators assisting in the unit; in *Clarifying concepts*, coordination of the unit is shared to ensure smooth implementation of PBL and; in *Revisiting PBL*, facilitation during PBL sessions is shared.

Several differences exist in the implementation of PBL into the three units. Most importantly, while all coordinators welcomed training for themselves and their tutors and demonstrators, only students in the ecology and the economics units received training in PBL. It is equally common for students to experience a range of emotions, including confusion, anxiety, frustration and anger when subject to change and particularly unexplained change (Pawson et al, 2006). According to these authors it is vital that students receive guidance about how and why they are expected to work in new ways. It is also reassuring for students to learn in advance that while using PBL strategies they may find working on the 'messy', 'unstructured' problem frustrating in the early stages (Biggs, 2003; Pawson et al, 2006). In *New tricks*, the unit coordinator describes his resistance to requests that students receive training in PBL so they do not perceive PBL as a novelty. Due to the timing of the PBL initiative, many students in the unit were introduced to PBL in the earlier timetabled units. However, there is a strong likelihood that student perception and understanding of PBL was diminished due to this absence of training.

Tutors and demonstrators assisted unit coordinators in the ecology and biology units. In *Clarifying concepts* two tutors and the unit coordinator received training, additional materials and ongoing support. Similarly, in *Revisiting PBL*, the unit coordinator and PBL lecturer collaborated closely to facilitate all PBL sessions together. However, in *New tricks*, the situation is complicated with ten demonstrators, who receive training, responsible for conducting PBL laboratory sessions without discussing PBL with their students. Despite weekly preparation and reflection the unit coordinator implies a variety of approaches to PBL were employed by these demonstrators. He suggests some demonstrators were more committed to PBL than others and that this is reflected in student feedback.

While no explicit statement is offered in any narrative, coordinators demonstrate different levels of support for PBL implementation into their unit. For example, in *New tricks*, little of the content covered in traditional practical sessions is reduced to accommodate PBL in either iteration. The coordinator comments that students indicate they want to be taught rather than learn themselves and they did not welcome the alternative laboratory format. In addition, while encouraging students to take responsibility for their learning he allocates their topics for presentation. In *Clarifying concepts*, there is little understanding of PBL during the first iteration. However, in the second, the coordinator speaks of her comfort in shifting the focus from her own actions to those of her students. *Revisiting PBL* involves a coordinator already familiar with PBL and open to opportunities to her assist students take responsibility for their own learning.

Generally coordinators describe students as happy to work in groups (a situation not unique to PBL) though less comfortable about delivering oral presentations for group assessment. Student feedback supports this view with *working in groups* ranked first among student 'likes' for each unit. Interestingly, *working in groups* was also ranked highly in the 'dislikes of PBL' in the biology unit. Perhaps this is a result of varied interpretations of PBL among biology demonstrators and an absence of background training about PBL for the students. Student feedback indicates they enjoyed listening to and sharing different perspectives which implies they were working collaboratively and constructing new knowledge. According to Allen et al, (n.d.) the power of working collaboratively fosters strong communication and interpersonal skills while harnessing the power of different thinking and learning styles. Many students however, were less enamoured with presenting their solutions orally to an audience.

Students enjoyed the flexibility and independence offered by PBL. Responses indicate that students appreciate the freedom to allocate their time, aspects of the tasks and their presentation focus to complete the exercise. Such responses are similar to those reported in an earlier study which found that first year students enjoyed PBL based practicals (Shelton & Smith, 1998). However, such freedom also caused some angst because students lacked confidence in making decisions about the direction to take to complete tasks. Some students found the progressive disclosure of information frustrating and students in the biology unit questioned the relevance of demonstrators allocating student presentation topics.

Did implementing PBL into units enhance the student learning experience?

Each unit coordinator expresses a willingness to continue using PBL, in the unit they are responsible for into the next year, which implies some satisfaction with the implementation. However, little real change is evident in the organisation of the biology unit before and after PBL implementation, despite positive reflection from the unit coordinator. Student exam performance is unchanged from previous years. Perhaps because of the large cohort, and many demonstrators, student feedback in the unit varied from enjoyment of the approach to strong resentment. Thus for some students the learning experience was enhanced but perhaps less so for others.

Strong facilitation in tutorial groups and positive student feedback suggests implementing PBL into the ecology and economics units did enhance student learning experiences. Such a perspective is clearly the view of the ecology unit coordinator who describes the implementation as successful. With her prior experience of PBL the economics coordinator indicates strong support for the benefits PBL offers to students. She describes empowering students to take control of their own learning as her goal and her pleasure that students enjoyed thinking for themselves rather than simply following her instructions. Some students recognised the alignment between learning activities, learning outcomes and assessment, while others did not. Student exam performance across the years has not been compared in these units though anecdotally group assignment results are higher than previously.

Conclusion

In summary, there is a generally positive perception towards PBL from unit coordinators and students involved in this implementation. Unit coordinators express their readiness to step back from directing all aspects of student learning and instead to support or facilitate student learning. Despite such readiness, coordinators demonstrate different understandings of the changes necessary to implement PBL into the units they are responsible for, to allow students the flexibility in process and content required. Coordinators recognise PBL as a student centred approach to learning and understand the need to shift from the teacher centred approach of the past. The challenge is finding the right balance between being supportive of students while stepping back from the instruction process.

Student feedback is, in the main positive, though varied from acceptance through to resentment across the three units analysed. Responses over the two years are consistent. A range of emotions, including enjoyment, confusion, anxiety and frustration surfaced in student responses. Positive comments from the majority of students indicate they relished working in groups to share new knowledge, the flexibility in approach and the workload. While some students are certain their learning experience was enhanced through PBL others disagree and prefer greater direction.

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