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Adopting Problem Based Learning in Third Level Computer Science

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Introduction

It has been recognised that the traditional teaching approach of the teacher being solely a transmitter and the student being a receiver is not sufficient. This is evident when a traditional style of teaching is compared to a more hands-on approach to learning. When discussing the traditional style of teaching, Earl and Ellington (1999, p.83) describe how in this approach to learning;

> (current) teaching methods are almost invariably of the 'face-to-face' type. The whole system is generally geared towards the smooth operation of the teaching institution, with little or no attempt being made to cater for the different learning styles and particular difficulties of individual students,

In comparison to this approach, Harden and Crosby (2000, p.4) describe what makes a good teacher, stating that "the teacher's role goes well beyond information giving, with the teacher having a range of key roles to play in the education process". They discuss how a teacher should be an information provider, a role-model, a facilitator, an assessor, a course planner and a resource material creator (2000).

Students graduating today may be required to solve problems with cross disciplinary boundaries and consequentially may be required to produce innovative approaches (Duch, Groh, & Allen, 2001). Using Problem Based Learning (PBL) techniques in the classroom may be a good way to help students prepare for this. The primary principle behind PBL is that the learner solves a problem or puzzle and in doing so learns (Boud & Feletti, 1991). In PBL the teacher acts as a facilitator of discussions rather than being the sole provider of information to the learner, where groups work together (Schwartz, 2013).

For this research, I implemented a PBL approach to my own teaching in order to determine if it is a more effective teaching style when compared to the traditional teaching approach. I outline the benefits and disadvantages on using PBL and establish how feasible it is to continue to use this approach in my everyday teaching. The research report is presented as follows;

Firstly, the background to PBL is outlined along with an overview of the need for PBL. The next section discusses PBL and outlines the approach needed to introduce PBL into teaching and learning. Following this, the research methodology is outlined and explained and finally, the research findings and conclusions are presented.

Background to Problem Based Learning

PBL originated in the 1960's at McMaster University in Canada. It was borne through the frustration amongst medical students and teachers at the traditional teaching approach i.e. teacher's role as transmitter with little consideration for students' learning needs. The teaching approach at McMaster University changed to using problems based on actual clinical cases as focal points (Barrows & Amblyn, 1980).

A number of different third level institutes have modified the PBL approach created at McMaster University to suit their own needs. For example, Harvard Medical School expanded the McMaster approach by integrating PBL problems with didactic, discussion and experimental sessions (Tosteson, Adelstein, & Carver, 1994). Schmidt (1983) explains that PBL provides an environment in which students can draw upon prior knowledge, learn within the real-world context and reinforce knowledge through independent and small group work. The use of PBL in domains other than the medical field has come from the identification that students retain very little information from traditional didactic teaching and based upon this have difficulty transferring knowledge to new experiences (Conley, Livingstone, & Meharg, 2006).

The need for Problem Based Learning

In traditional teaching methods students are taught to pass exams, however the information taught is often forgotten soon after the exam. Take for example the following quote (Thinktask qtd. in Li, 2013, p. 1):

> Three years ago, I could do trigonometric functions and simultaneous equations. I could recite periodic tables, I knew oxidation reduction reactions and Newton's three laws, I could draw atmospheric circulation map, and I knew that plant cells have walls and that animal cells do not, I could recite several ancient classical poems and essays…..Now I have forgotten all of them. I am completely illiterate

Throughout Dewey's book *Experience and Education* (1938), the author defines the term "continuity" in which he sets an important dimension of the educational experience. Based upon this quote, it can be determined that the learner's educational experience did not

contribute to the learner's current knowledge. Traditional teaching methods place an emphasis on the acquisition of knowledge, and identify the importance of knowledge retention. Freire (1970, p.80) analogises traditional teaching methods with a banking system. In this system, the students are equated with empty accounts, in which teachers place knowledge and the account is emptied when the student is assessed. However, this analogy can easily be used to explain the failing of traditional teaching methods, in that once the account is emptied, yes the exam may be passed, but the learner remains without the knowledge.

Dewey (1916) identified two forms of educational thought, retrospective education and prospective education. Retrospective education tends to see education as a constantly reproducing tradition. This approach is heavily dependent upon tradition and encourages the reproduction of tradition. This retrospective education approach is the system used in most third level institutes currently. Prospective education on the other hand informs students and engages in learning them by promoting inquiry. This is where PBL comes into being.

What is Problem Based Learning?

Barell (2006, p.3) defines PBL as "an inquiry process that resolves questions, curiosities, doubts and uncertainties about complex phenomena in life". He highlights the importance of student inquiry as an integral part of the process of problem resolution. When implementing PBL in the classroom, it may consist of the following seven steps (van Berkel, 2010):

1. Terms which are new or not understood by the learner are explained;
2. The problem is identified by the group;
3. A brainstorming session is conducted;
4. A list of possible explanations to the problem is produced;
5. Students formulate learning issues;
6. Students work independently researching literature sources to determine which issues are to be pursued;
7. The students meet and report the findings of their independent research.

In PBL, the teacher directs the students to the answers however, does not lead them all of the way there. This process not only teaches students about the problem which they are trying to solve, but they also learn whilst on their journey to the solution.

Implementing Problem Based Learning

Research Methodology

In order to determine if PBL is more effective than the traditional teaching method, I introduced PBL into my first year DT211 group in my module "Introduction to Algorithms". This module involves teaching students the concepts behind key searching and sorting algorithms within computer programming. The lectures were previously delivered using traditional lecturing methods i.e. lecturer = transmitter and students = receivers. In order to determine which method was more successful, I taught two similar concepts across two lessons. The first lesson was taught in the traditional teaching style and the following lesson was based on a PBL approach.

The two topics I taught for this research were "Bubble Sort" and "Selection Sort". These concepts are similar in that they are both algorithmic methods for searching through arrays. The concept of "Bubble Sort" was taught using a traditional lecturing technique involving lecture notes and a PowerPoint presentation, and when teaching the concept of "Selection Sort", I incorporated a PBL approach where I acted as a facilitator and helped to direct the students' learning. The PBL lecture was set out as follows:

1. Without any prior knowledge, students worked together in small groups to demonstrate how a Selection Sort Algorithm would sort a given list of numbers.

2. Individually, students then wrote a pseudo code to implement a Selection Sort Algorithm.

3. Back in their groups, students then compared their findings to the original group activity.

At the end of both sessions, students were asked to complete a short survey to observe what they had learned in each lecture and the surveys were then analysed to determine which teaching approach was most effective.

Findings

After both lectures the surveys were analysed. Fifty students completed the survey in lecture one and 48 students completed the survey in lecture two. At the end of the first lecture which

was based on a traditional lecturing approach, all of the students were able to state that "Bubble Sort" was the concept being discussed during the lecture. Whilst 76 percent of students claimed to understand the concept, only 34 percent stated that they would be comfortable if they were asked to explain it to another someone else. These findings relate to the previously discussed argument of John Dewey (1998, p.13) where he claims that the educational experience does not always contribute to a learner's current knowledge. In this instance, it is to be expected that many of the students, particularly those who are not confident in explaining the concept will not retain this information that they have learned or be able to apply it in other circumstances. In comparison, after the second lecture, in which a PBL approach was taken, 96 percent of students specified that they understood the concept

Percentage of Students who Understand Topic
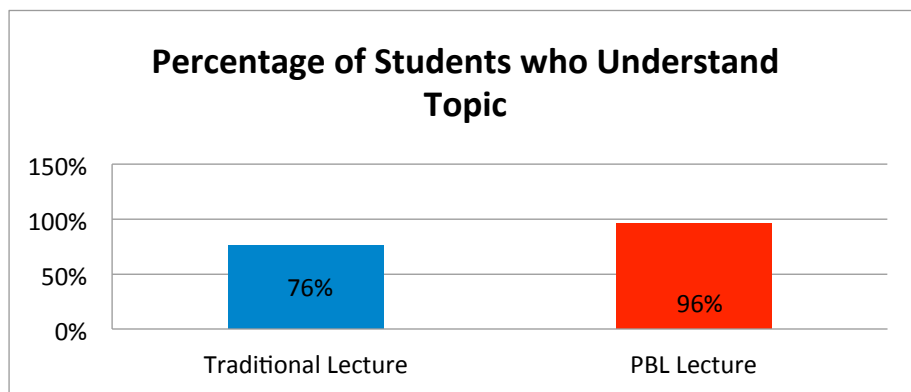
with 85 percent of students being confident to explain the topic to someone else.

Figure 1: Percentage of Students that Understood Concept Taught

Figure 2: Percentage of Students Confident to Explain Concept to another Member of their Group

The survey results demonstrate that when teaching a concept, the approach taken during the lecture can dramatically affect the level of knowledge and understanding gained by students.

When asked if they felt that working as part of a group makes it easier to understand a concept, after the PBL lecture 96 percent of students felt that it made the learning easier. When asked why, some of the reasons stated were:

Percentage of Students Confident to Explain Concept
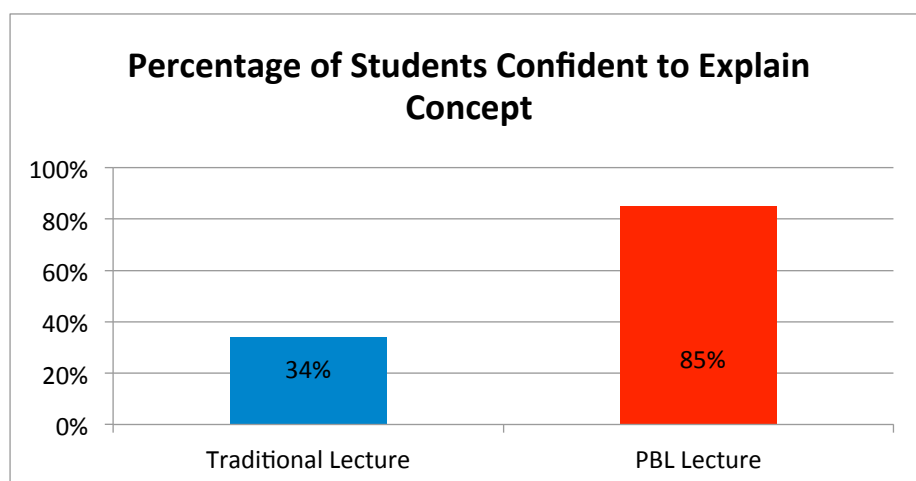
- That the students feel more involved;

- That they enjoy the lesson more and it is less boring;

- They are able to ask each other questions if they are struggling;

- They prefer completing tasks than listening all of the time.

One particular student stated that;

> This lecture was a lot easier to understand than other lectures that we had. It was a lot less boring. It was good working in a group because we could chat to each other and work together to solve the problem rather than just listen to you explain it. It would be good if we could do things like this more. Working in a group makes it easier.

The results here clearly highlight that along with gaining a better understanding of the concept taught, students prefer this approach as they are more in control of the learning. When students were asked what they would change about each of the lectures, the first set of results found that students wanted more activities where they could put in to practice what is being taught. They found that the experience was an "information overload" and as a result, some found that they became lost or confused. Some students suggested using animated video clips or exercises to highlight the most important information. The findings from the second survey found that 100 percent of students would have liked more time to complete the final group exercise. A small number of students (6 percent) suggested that the lecturer choose the working groups in order to avoid conflict. The results highlight that traditional lecture techniques are not sufficient and more interaction is needed in the classroom to promote a positive learning outcome. Whilst the findings from the second survey revealed no negative responses in terms of learning it the exercise in implementing PBL did highlight that when taking a PBL approach, more organisation and planning is needed, in this case in terms of task set-up i.e. allocation of groups and time management i.e. ensuring that students have enough time to complete the task.

Conclusions

In order to evaluate the effectiveness of PBL compared to traditional teaching methodologies in my own teaching, two similar concepts were taught to students using the 2 different methods. Students were asked to complete a short survey at the end of each lesson and the results were analysed. The survey found that the students preferred the PBL approach to

learning. They were able to take more control over their learning as they were more involved in various activities. When the traditional methods were used, students explained that they become bored during the lecture. The survey results from the PBL lecture demonstrated that students had a better understanding of the concept being taught and were more confident when it came to explaining that concept. The main issue that was found when it came to PBL, was the need for the lesson to be well structured and organised in order for students to effectively complete the activities i.e. ensure that there is enough time for students to complete tasks.

Based on these findings and the benefits that I have seen, I have decided to incorporate a more PBL approach to my overall teaching in order to ensure that I am continuously delivering a high quality of education to my students. In order to achieve this, I will need to spend more time when planning my lessons to ensure that I include a variety of inquiry-based learning tasks when teaching various concepts. Whilst it will be easier to make the transition to PBL in some modules compared to others, through reflection on the benefits that I have seen from this research and reading of the literature, it is worth investing time and planning to make the transition to a PBL approach.

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Appendices

Survey Questions and Results

1. Name the concept that was discussed in today's lecture.

After both lectures, all students were able to name the concept.

2. Do you understand this concept?

After the first lecture (traditional style), 38 students out of 50 indicated that they understood the topic. In comparison, after the PBL lecture, 46 students out of 48 understood the topic

Percentage of Students who Understand Topic

Traditional Lecture	76%
PBL Lecture	96%
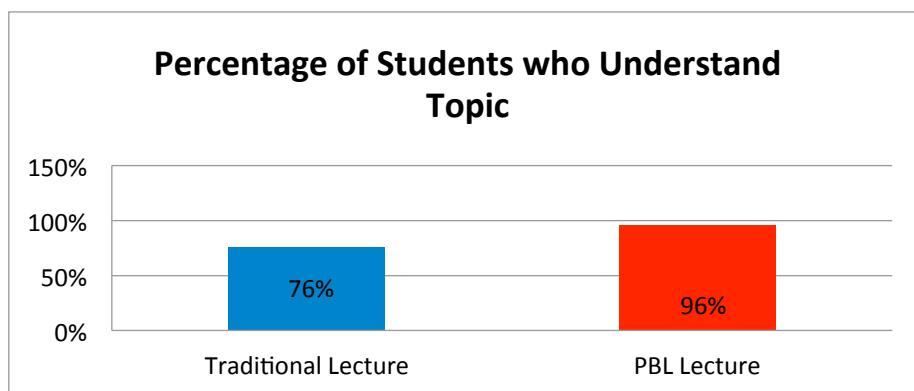
being taught.

3. Did you work alone during this lecture or as part of a group?

In the first survey (traditional lecture style), all of the students stated that they worked on their own. A couple of students even marked on the survey that they had nothing to do during

the lecture, they only sat and listened. In the second survey, the majority of students ticked both of the boxes, indicating that they worked both individually and as part of a group during the lecture.

4. Do you think working as part of a group makes it easier to learn a concept? Why?

In the first survey, 20 out of 50 students left this question unanswered. 21 of the 50 students responded with "yes" but did not explain their reason. 6 of the fifty students responded "no" but did not give reasons. The final 13 students responded "yes" and left the following reasons for thinking this:
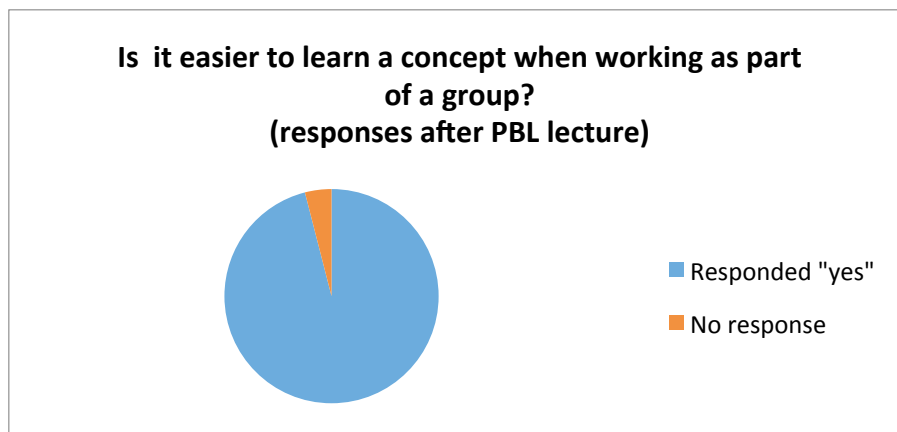
1. It is more fun
2. You get to talk to others in your group and can explain things in different ways
3. Working on your own is boring
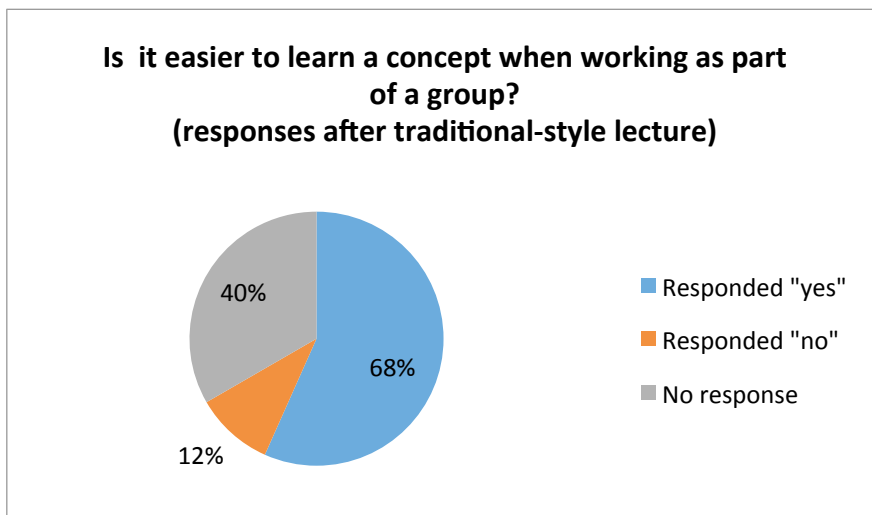
4. You are able to talk to others and hear their opinions

In the second survey (after PBL lecture) all of the students responded. 46 out of 48 students responded "yes". 33 of the 46 students that responded yes included reasons such as:

1. We like being more involved because it makes it easier
2. It is goof because we can ask each other questions if we don't know what to do or do not understand something
3. It is better to be going something rather than just sitting listening all of the time because that is just boring
4. It's more fun and less boring
5. You are able to concentrate better
6. You can listen to others ideas and learn from time

Is it easier to learn a concept when working as part of a group?
(responses after PBL lecture)

- Responded "yes"
- No response

The final two students left this question unanswered.

5. **How would you change today's lecture?**

   In the first survey, 21 out of the 50 students left this question unanswered. Some of the responses given by the remaining 29 students included:

   1. It would be better to have some task to do so we can practice what is being said
   2. Less talking because it is too much information to take in at one time
   3. Anything to make it less boring, maybe watch a video to help explain
   4. Some of the information is really confusing so if we could actually use what we are learning in some way it would be helpful
   5. Break the class up into different sections so it is not just listening all of the time because it gets boring and confusing

In the second survey, all of the students stated that they would have liked more time to complete the activity. 3 of the students suggested that I should have allocated the groups instead of asking the students to divide into their own groups as this would result in fewer arguments.

6. **Would you feel confident if you were asked to explain this concept to someone else in your group?**

In the first survey (traditional-style lecture), only 17 out of 50 students indicated that they would feel confident if they were asked to explain the concept of "Bubble Sort" to another student in their group. In comparison, after the PBL lecture, 41 out of the 48 students stated that they would feel confident explaining the concept of "Selection Sort".

Percentage of Students Confident to Explain Concept