Innovative Problem Based Learning Approach for Science and Engineering Education

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Abstract

Students' achievement in Biology is often looked up as a benchmark to evaluate the mode of teaching and learning in higher learning. Problem based learning (PBL) is an approach that focuses on students searching and gaining knowledge using teamwork. The educator's role is more towards a facilitator, thus it is expected that students play a proactive role in the PBL sessions. There were eighty samples involved in this study. The samples were divided into three groups namely: ICT integrated with PBL group, PBL group and lecture groups. All these groups went through four sessions of PBL. Before the beginning of session one and after the fourth session, the achievement test was given to all the students. Based on the analysis for MANOVA with repeated measure 3 x 2 x 2, the main effect for type of treatment, exam time and subscale were found to be significant. Other than that, the type of treatment interacts with exam time and subscale in contributing towards the achievement test scores. Overall the findings supported that the ICT integrated with PBL group was significant compared to the PBL group and control group. The ICT integrated with PBL group was also found to be significant for the subjective scale.

Keywords: Problem based learning (PBL)

1. Introduction

One of the main concerns in science education is about the need to improve students' academic achievement. This is not only because a higher achievement especially in the science is the foundation for technical skills which is in short supply but also because higher achievement is particularly valued in a society which sets high premium on academic success as the stepping stone for entrance into more prestigious occupation (Okoye & Okecha 2008). Heavy expectation on academic excellence forces the students to rely heavily on mugging as many concepts and formulas they can in the hope to stay ahead in the academic race.

Thus educators are often faced with a dilemma to deliver and perform to meet the stringent standards set by their faculty. Often than not, this educators are resorted to teach using the normal lecture method to cope with the syllabus. Wekesa et al. (2006) commented that incompatibility of regular teaching methods which are teacher centered will minimize the students' perception of learning experience and affect their academic performance. There is need to change from reading to 'doing' Biology the active way. This includes of implementing new ways of teaching for example using Problem Based Learning (PBL). Altogether PBL promotes engagement, inquiry, investigation and performance, all of which require a higher level of thinking and promotes a better level of long-term retention of material (Verhovsek & Striplin 2003). Dochy et al. (2003) reported that students in PBL are better in applying their knowledge. Other than that, students remembered more of the knowledge they learned because their knowledge has been elaborated during the PBL process. PBL alone as a method cannot meet the current education standards as it is lacking in terms of ICT. Thus the integration of ICT as an element in PBL is found important to enhance the teaching and learning process in Biology.

2. Aim of Study

The overall aim of this study is to investigate effectiveness of integrating Information and Communication Technology (ICT) into PBL in Biology towards students' achievement scores.

3. Research Question

1. Does PBL integrated with ICT improve the achievement scores of students in Biology?

4. Study Design

This study is designed using *quasi*-experimental to minimize biases in estimating differences between the lecture discussion (control group) and PBL (treatment) classes (Maxwell et al. 2005). The *quasi*-experimental design used in this study is specifically known as non-equivalent control group design. The non-equivalent control group design uses separate experimental and control groups, without using random assignment or matching to equate them and only the experimental group receives a particular experience or treatment (Cook & Campbell 1979). It also includes the pretest and posttest observation. The pretest and posttest scores are compared to assess if there are changes from the pretest to posttest significantly (Sarafino 2005). Figure 1 show the non-equivalent group control design used with pretest and posttest.

E1	O_1	X_1	O_2
E2	O_3	X_2	O_4
C	O_5		O_6

Figure 1 The Non-Equivalent Control Group Design with Pretest and Posttest

Representations of symbols:
E1   : First experimental treatment group
E2   : Second experimental treatment group
C   : Control group
X_1 : PBL integrated with ICT
X_2 : PBL
O_1, O_3, O_5 : Pretest
O_2, O_4, O_6 : Posttest

The samples were chosen from three 'intact groups' in a private university, situated in the state of Selangor, Malaysia. Thus the sampling method used for this study is purposive sampling. A total of eighty students from the Foundation course were involved.

There are three groups present in the study. The first two groups are the experimental groups followed by the control group. The three main groups were further categorized into ICT integrated with PBL classroom, PBL classroom and control classroom. Students were divided into groups of four and five in each classroom.

The first treatment group uses the PBL integrated with ICT method of teaching. In this method, samples are required to fill the PBL phases using a Microsoft Word template. The presentation is then done using Microsoft PowerPoint. At the end of the session, phase two till phase four is uploaded into the electronic discussion group whilst phase six is posted on the blog. Meanwhile the second group on the other hand utilizes PBL method solely. Samples are required to record the PBL phases in a log book. The presentation is then done using a poster. By using this second group as a comparison, the researcher receives input on the effectiveness of the new method proposed that is integration of ICT into PBL. Lastly, the control group uses the conventional method of teaching that is the lecture method. The Biology lecturer uses lecture method following the syllabus. Samples employ the normal ways of learning such as using text books and reference books. Assignments that are similar to the other two groups are given to the samples without any additional aid. The control group is used as it helps to rule out possible confounding effects of history, developmental maturation and regression to the mean (Sarafino 2005).

5. Instrument

To measure the achievement scores, there were three types of instruments used in this study. They are as the following: PBL integrated with ICT module, PBL module, four PBL cases and achievement test.

Both the modules consisted of six phases. The first to the fourth phase required groups to understand the problem, collect relevant data and choose the best solution for the problem. At the fifth phase, both the groups were required to do presentation on the solution of each PBL case given to them. The PBL group used a poster as a mode of presentation, whilst the ICT group presented using Microsoft Power Point. To further complement the modules, four PBL cases were used. These cases were based on the following chapters: respiration, photosynthesis, ecology and environmental issues.

The content validation of the PBL module was conducted by a group of academicians to improve the modules in the study. Content validation is evaluation about the objectives of the instrument and the content area which is assessed by a panel of judges (Creswell 2008). Two Biology lecturers who have been teaching the Foundation program were asked to give feedback based on the contents of the problem and its relationship with the students' syllabus. An English lecturer was asked to look at the problems and offer comments on the grammar and structure of sentence. A science education expert was also asked to provide feedback. Lastly a PBL international expert, Dr Ann Lambros was consulted on the PBL module regarding the contents, the flow of the process and recommendation on improving the module. A feedback form was provided for both the science education lecturer and the PBL international expert.

In order to measure the achievement scores, an achievement test was used. The achievement test was divided into two parts: multiple choice

questions and short essay questions. Both the parts covered all the topics intended for this study. The achievement test went through a series of assessment. The first stage included the inspection of the test by two Biology subject experts. The next stage involved two science education lecturers.

Lastly the test was administered on forty students. A pilot test was carried out to determine the reliability of the achievement test. Forty samples were used for this test. The data were analyzed using SPPS version 15.0. The reliability for the achievement test was determined using KR 20. It was found that multiple choice questions had a reading of .76 and the short essay questions .660. For the multiple choice questions, .70 onwards is an accepted reading. Meanwhile for the short essay questions .65 is acceptable (Nitko 2004). Both the types of questions fitted the range recommended by Nitko (2004). Other than that, the discrimination index for all the items was determined. Results showed that the discrimination index for all items in the multiple choice segment ranged from .165 to .588. According to Varma (2008), items which displayed discrimination index values below .15 should be removed from the test. Thus the following items 17, 21, 23 and 24 were removed in administering the test during the main study. While the discrimination index for the short essay questions ranged from .528 to .777.

6. Findings

The achievement was assessed during before the treatment and after the treatment. The analysis of main effect for (i) type of treatment, (ii) time of treatment (pretest and posttest) and (iii) two subscales in the achievement test. To measure the interaction between (i), (ii) and (iii), mixed between-within subject MANOVA with repeated measure 3 x 2 x 2 will be used. The hypothesis measured is as stated below:

H_{01}: There is no significant difference in the mean score for the pretest and posttest for the subscales in achievement test for students who participated in the ICT integrated with PBL group, PBL group and conventional group.

H_{A1}: There is a significant difference in the mean score for the pretest and posttest for the subscales in achievement test for students who participated in the ICT integrated with PBL group, PBL group and conventional group

Preliminary assumption testing was conducted for Mixed Between-Within Subject MANOVA. The significant value for Box's Test of Equality of Covariance Matrices was checked. It was found

that the homogeneity was violated. The plot that showed the relationship between the mean score for pretest and posttest was examined. It was found that it portrayed a linear relationship. For the Levene's test, it was found that ($p>0.05$) for all the scales except for pre subjective scale. The analysis was carried out with an assumption that all the variance is homogenous for the two subscales in pretest and posttest.

The analysis showed that the main effect for time was significant, Wilks'=.078, $F (1, 77)=915.698$, $p=.000$, partial eta squared=.922; interaction effect for time and method was significant, Wilks'=.230, $F (2, 77)=128.535$, $p=.000$, partial eta squared =.770; main effect for subscale was significant, Wilks'=.527, $F (1, 77)=69.215$, $p=.000$, partial eta squared=.473; interaction effect for subscale and method was significant, Wilks'=.514, $F (2, 77)=36.394$, $p=.000$, partial eta squared=.486; interaction effect for time and subscale was significant, Wilks'=.193, $F (1, 77)=322.552$, $p=.000$, partial eta squared =.807; interaction effect for time, subscale and method was significant, Wilks'=.240, $F (2, 77) =121.804$, $p=.000$, partial eta squared =.760. Table 1 displays the results.

Table 1 MANOVA Results for Achievement Test

Effect		Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
TIME	Pillai's Trace	.922	915.698	1.000	77.000	.000	.922
	Wilks' Lambda	.078	915.698	1.000	77.000	.000	.922
	Hotelling's Trace	11.892	915.698	1.000	77.000	.000	.922
	Roy's Largest Root	11.892	915.698	1.000	77.000	.000	.922
TIME * METHOD	Pillai's Trace	.770	128.535	2.000	77.000	.000	.770
	Wilks' Lambda	.230	128.535	2.000	77.000	.000	.770
	Hotelling's Trace	3.339	128.535	2.000	77.000	.000	.770
	Roy's Largest Root	3.339	128.535	2.000	77.000	.000	.770
SUBSCALE	Pillai's Trace	.473	69.215	1.000	77.000	.000	.473
	Wilks' Lambda	.527	69.215	1.000	77.000	.000	.473
	Hotelling's Trace	.899	69.215	1.000	77.000	.000	.473
	Roy's Largest Root	.899	69.215	1.000	77.000	.000	.473
SUBSCALE * METHOD	Pillai's Trace	.486	36.394	2.000	77.000	.000	.486
	Wilks' Lambda	.514	36.394	2.000	77.000	.000	.486
	Hotelling's Trace	.945	36.394	2.000	77.000	.000	.486
	Roy's Largest Root	.945	36.394	2.000	77.000	.000	.486
TIME * SUBSCALE	Pillai's Trace	.807	322.552	1.000	77.000	.000	.807
	Wilks' Lambda	.193	322.552	1.000	77.000	.000	.807
	Hotelling's Trace	4.189	322.552	1.000	77.000	.000	.807
	Roy's Largest Root	4.189	322.552	1.000	77.000	.000	.807
TIME * SUBSCALE * METHOD	Pillai's Trace	.760	121.804	2.000	77.000	.000	.760
	Wilks' Lambda	.240	121.804	2.000	77.000	.000	.760
	Hotelling's Trace	3.164	121.804	2.000	77.000	.000	.760
	Roy's Largest Root	3.164	121.804	2.000	77.000	.000	.760

After that, an analysis was carried out for between-subjects effects. The main effect for method was significant at F=36.140, p=.000, partial eta squared = .484. Table 2 shows the results.

Table 2   Tests of Between-Subjects Effects

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Intercept	47655.104	1	47655.104	2394.496	.000	.969
METHOD	1438.501	2	719.250	36.140	.000	.484
Error	1532.449	77	19.902			

Upon analysis, the main effect for method was found significant. Thus the treatment had a significant effect on the achievement test. Post hoc Bonferroni was used to identify which combination of groups had a significant effect. It was found that the following pairs had a significant effect: ICT integrated with PBL group and control group; PBL and control group. The variance was not all homogenous for the pretest and posttest. Post hoc Dunnett C was further used to identify the groups that were significant. The following groups are significant: ICT integrated with PBL group and PBL group; ICT integrated with PBL group and control group; PBL group and control group.

6. Discussion

The main effect for time was significant. This shows that there was a difference in the sample score for achievement test in the pretest and posttest based on the treatment given. Other than that, the main effect for subscale was also significant. This implements that the score for achievement test was influenced by the two subscales: objective and subjective.

Next the interaction effect for time and method was significant. This shows that the posttest scores are influenced by the treatment used in this study. Furthermore the interaction effect for subscale and method was also significant. The posttest scores for both the subscales were influenced by the treatment. The interaction effect for time and subscale was significant. This showed that the duration of tests had an impact the performance of samples on the subscales of the achievement test. Subsequently the interaction effect for time, subscale and method was significant. Overall the achievement test scores were influenced by a combination of three factors namely: time, subscale and method.

A comparison of posttest mean was made between all the groups for posttest achievement test. It was found that the PBL integrated with ICT group had the highest mean compared to the other two groups. PBL was second in row followed by the control group. After that, an analysis was done for the two scales in the achievement test. For the objective scale, a non significant result was shown

for all the groups. However for the subjective scale, it was found that there was a significant difference between PBL integrated with ICT group and PBL group; PBL integrated with ICT group and control group; PBL group and the control group. On the whole, the findings supported that the PBL integrated with ICT group was significant compared to the PBL group and control group in the subjective scale and overall score.

PBL was implemented in an administration theory module of an electrical engineering program at a public university in Brazil (Riberio 2008). The PBL procedures are as the following: the problem was presented to the students and the students were assessed based on their oral and written presentation. At the end of the session, the facilitator would provide a summary on the concepts relevant to the problem. A complete PBL cycle would take place approximately two weeks. Students commented that the main objectives of the module: content knowledge was achieved. They had also shown an improvement in their overall achievement. In comparison to this study, two PBL modules were used to facilitate the ICT session and PBL sessions. One PBL cycle took one week to complete. The PBL with ICT group had achieved higher posttest scores in the achievement test compared to their counterpart. The PBL group findings were found not consistent with Riberio's study. One major difference noticed was the influence of ICT in the PBL process. Students' knowledge was enhanced greatly as they had the opportunity to surf the WWW to gain relevant information. Other than that, they also felt it easier to communicate with their peers online to discuss the solutions used to solve the problem. This difference largely affected their retention of the material learnt through the PBL with ICT process.

In a high school in Izmir, students were divided into two groups that are the PBL group and control group (Tarhan et al. 2008). The chemistry class was involved in this study. A pretest was carried out to evaluate the students understanding in the intermolecular forces. Upon completion, a posttest was administered to measure the students understanding in intermolecular forces. The findings showed that the PBL group had higher scores compared to the control group. They also were more thorough in using scientific and critical ideas. Overall there was an improvement in the intermolecular force and attitude. Compared to this study, the PBL group did not fare as well as the PBL with ICT group. Thus it was assumed that the ICT group had an edge because of the ICT tools used compared to the PBL group which used log books and posters. Nevertheless the PBL group score was inevitably higher than the control group.

A research conducted by Liu (2005) was compared to the PBL with ICT research. Liu's research focused on the integration of CD based hypermedia PBL. The program was Alien Rescue

and the samples were sixth grade students. It was found that there was an increase in knowledge from pretest to posttest. These results were similar with the PBL with ICT group's achievement scores. There was an increase in achievement scores from pretest to posttest. This shows that the ICT group had an edge compared to the PBL group in this matter. The ICT factor helped in contributing towards the achievement scores compared to the PBL group which achieved scores lower compared to the ICT group.

7. Conclussion

Overall the findings supported that the ICT integrated with PBL group was significant compared to the PBL group and control group. The ICT integrated with PBL group was also found significant for the subjective scale.

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