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Evaluating Biology Achievement Scores in an ICT integrated PBL Environment

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Students' achievement in Biology is often looked up as a benchmark to evaluate the mode of teaching and learning in higher education. Problem-based learning (PBL) is an approach that focuses on students' solving a problem through collaborative groups. There were eighty samples involved in this study. The samples were divided into three groups: ICT integrated with PBL group: a PBL group, and a lecture group. The PBL with Information and Communication Technology (ICT) group used a PBL module integrated with the following ICT elements: Microsoft Word template; Microsoft PowerPoint; electronic discussion group, and blog. Meanwhile the PBL group used the PBL module alongside log books and posters. The control group utilized the lecture method. All these groups went through four sessions of Biology. Before the beginning of session one and after the fourth session, an achievement test was given to all the students. Based on the analysis for MANOVA with repeated measure 3x2x2, the main effect for type of treatment, exam time and subscale was found significantly different. Additionally, the type of treatment interacts with exam time and subscale in contributing towards the achievement test scores. Overall, the findings suggested that the ICT integrated with PBL group was significant compared to the PBL group and control group. The ICT integrated with PBL group also performed significantly higher for the subjective scale.

Keywords: achievement, PBL, ICT, biology teaching, higher institution

INTRODUCTION

One of the main concerns in science education is the need to improve students' academic achievement. This is not only because a higher achievement especially in 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 a high premium on academic success as the stepping stone for entrance into more prestigious occupations (Okoye & Okecha 2008). Heavy expectation on academic excellence forces the students to rely heavily on "swotting" as many concepts and formulas they can in the hope to stay ahead in the academic race.

Malaysian Qualifications Framework, which was established by the Malaysian Qualification Agency, emphasizes the importance of higher learning to develop attitude, content knowledge and generic skills amongst its graduates (Ministry of Higher Education Malaysia 2004). Currently, Malaysian higher education focuses on the development of knowledge and inculcation of generic skills such as problem-solving, communication skills and team work skills using student-centered teaching methods. There are many

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State of the literature

- There are many student-centered teaching methods that could be used in the higher learning such as projects, group discussion, field trips and Problem-based learning (PBL).
- PBL was selected in this study as students remembered more of the knowledge they learned as their knowledge had been gained during the PBL processes. PBL process begins with reading of the problem and ends with the presentation and discussion of the findings.
- However, analysis of literature reveals that PBL lacks the ICT element. The effectiveness of PBL enriched with ICT is seen to improve not only the students' acquisition of knowledge, but also the inculcation of generic skills such as communication skills and team work skills.

Contribution of this paper to the literature

- This study investigates the achievement of students in respiration, photosynthesis, ecology and environmental issues using PBL, PBL with ICT and a lecture group.
- Both the PBL groups conducted PBL sessions using modules. The PBL group documented the process in a log book and presented using a poster. Whilst the PBL with ICT group documented their processes using Microsoft Word templates and uploaded it in the blog and posted the last phase in the blog. Presentation was done via Microsoft PowerPoint.
- Students from the PBL with ICT group fared higher compared to the other groups in the achievement test. The ICT element helped in improving the PBL process and students' retention of knowledge.

student-centered learning approaches that could be applied in higher learning, such as project-based learning, group discussion, cooperative learning, service learning, field trips and Problem-based Learning (PBL). PBL was used in this study as it is argued that students remembered more of the knowledge they learned as their knowledge had been gained during the PBL processes. To say the least, PBL focuses towards learning that takes place as a result of the process of working towards and resolving a problem (Verhovsek & Striplin 2003). As indicated in the literature of higher learning, the shift from traditional lecture to a more learner centered approach such as PBL has created significant impact on higher education system, covering wide spectrum of academic disciplines (Candela & Edmunds 2008; Ruiz-Gallardo et al. 2011; Steele, Medder & Turner 2000).

Problem-based learning

Problem-based learning is defined by Finkle and Torp in Savery & Duffy (1995) as "a curriculum development and instructional system that simultaneously develops both problem solving strategies and disciplinary knowledge bases and skills by placing students in the active role of problem solvers confronted with an ill-structured problem that mirrors real-world problems". Problem solving skills is needed in the real world of complexity. Learners need to be able to analyze problems, form tentative hypotheses, collect and interpret data, and develop some types of logical approach to solve problem. An important point of PBL is that the learning resulting from a resolution of the problem is often more important than the solution (Hirca, 2011). Thus, PBL allows students become active learners and make students responsible for their learning, develops more positive attitudes to lesson (Akinoglu & Tandogan, 2007), and allow higher conceptual learning gains (Alper, 2008). In the problem solving method, learners use previously learned content and skills to resolve a challenging problem.

Generally, PBL process begins with reading of the problems that are chosen of the real world which attract students' attention, and ends with the presentation and discussion of the findings. Students must be given necessary time to think or gather information and to set their strategies in problem solving, and their creative thoughts must be encouraged in this process. The model points toward the organization of the structure of the students' knowledge in respect to problems, in such a way that allows the student to find the feasibility of a technique in order to solve a problem and a much clearer relation between theory and practice in order to face the necessary interdisciplinary method demanded by any solution of a real problem (Polanco et al. 2001). Even though some differences are observed in practice, the PBL is performed in sessions within which there are small working groups comprised of 6 or 8 persons guiding by an education mentor (Akinoglu & Tandogan, 2007). The most important role of the mentor in the PBL being operated in a student-centered manner is to facilitate learning activities by guiding students. Teaching mentors fulfill this role by monitoring discussions, asking questions, helping the resolution of occasional conflicts, enabling the participation of each group member to classroom discussions, giving examples when required, preventing scatter of discussions and making evaluations (Yuzhi, 2003)

Problem solving is based on the scientific method of inquiry; i) define the problem and all major components, ii) formulate hypotheses, iii) collect and analyze data, iv) formulate conclusions and or/ solutions, and verify conclusions and /or solutions. Through this process, learners are expected to arrive at a higher level of

understanding of the content under study (Newby et al. 2006). Some principles for using problem solving are as follows

1. *Clarify the problem when necessary, especially with less mature students. It is often the facilitators that help learners to clarify and identify the specific problem. However, facilitators are aware of overdoing clarification. Explaining too thoroughly make learners will not work for the answer by themselves.*
2. *Use additional resources and materials when necessary. It is important that students have access to additional resources, as well as instruction on how to use those resources most effectively.*
3. *Keep groups small. Because of the uniqueness of potential solution paths the problems and the time required to complete the various step, a smaller number of students is often essential*
4. *Help learners the need for generalization. Learners must recognize that problem solutions are generally unique and that no single answer works for all problems (Newby et al. 2006)*

PBL has been integrated in the higher education either totally or partially with the existing curriculum in the Malaysian context of education (Khairiyah et al. 2007; Lai 2007). Malaysian lecturers are beginning to meaningfully integrate PBL in their teaching. In many medical schools, full PBL method is inculcated to teach a subject. For the meantime, many institutions are using PBL to teach certain topics in a subject. The usage of PBL is growing extensively in higher education due to its flexibility and more importantly its emphasis on learner centeredness. PBL employs more interaction, as the students tend to communicate with their peers to reach a solution to the problem. It directs students to be more self-confident, independent and to master more generic skills while acquiring scientific knowledge. Moreover, problem solving has advantages of increasing comprehension and retention, involves higher- level learning, provides learners the opportunity to learn from their mistakes, and develops responsibility as students learn to think independently. Besides, it also provide a valuable learning experience, assitance in applying new knowledge and proven to succesfully achieve provided assesment criteria (Swart 2014). However, problem solving also has disadvantages such as; i) Limit the amount of content covered, ii) Selecting, modifying, and/or designing effective instructional problems can be time consuming, and iii) Requires teachers to have good management skills to coach learners without giving them the answer.

Based on numerous researches done on PBL, there are many reports on the positive contributions of PBL in the science education. PBL has been reported to improve the attitudes of students, academic achievement, leadership skills, communication skills, teamwork skills, information searching and management skills, self directed learning skills and critical thinking skills (Kink 2002; Polanco et al. 2001; Riberio 2008; Hirca 2011). Besides, Hirca (2011) revealed that PBL is designed to help students to construct an extensive and flexible knowledge, develops individuals that apply their knowledge in a variety of problem situations, develop effective problem-solving skills includes the ability to apply appropriate meta-cognitive and reasoning strategies and it develops self-directed, lifelong learning skills; becomes effective collaborator who knows how to function well as part of a team. Overall the students benefited in terms of development of knowledge and generic skills. In the conventional curriculum, the development of generic skills was not emphasized thoroughly. The graduates that were produced were sound in knowledge but lacking in skills which were required in the workforce. Thus a change in curriculum was required to overcome this problem. PBL was found to be an ideal solution as it had contributed significantly to the science curriculum. Walton and Mathews (1989) suggested several benefits of PBL that have been inculcated into curriculum: a) Activation of prior knowledge, facilitating the learning of new information, b) development of better reasoning skills, c) motivation to learn, d) development of life long self-directed learning skills, e) learning how to obtain and analyze information and f) learning in a context they will encounter in the future, which will enable better recall of information.

However, PBL alone as a method cannot meet the current education standards as it is lacking in terms of Information and Communication Technology (ICT). PBL and ICT can no longer be separated in the current trend of higher education. There is a need to change the current mindset that PBL alone is sufficient. Lecturers should take the PBL approach and make the best of technology to facilitate the collaborative and problem solving learning processes (Tan 2003). Additionally as argued by Fallows and Bhanot (2005), teaching must 'fit for the purpose' of meeting the expectations of the twenty-first century student and this involves the use of appropriate information and communication technologies. Thus the integration of ICT as an element in PBL is found important to enhance the teaching and learning process in Biology. Moreover the effectiveness of PBL enriched with technology is seen to improve the students' application of knowledge (Pedersen & Liu 2003) by providing an environment in which students are immersed in a practical, ongoing activity that builds upon their previous knowledge and experiences (Massaro et al. 2006). During the beginning of the PBL process where the PBL case is given, activation of prior knowledge takes place. The students would probably not be able to answer the question at that point in their education, but the question may engage and interest them (Baram-Tsabari et al. 2010). It provides the opportunity to seek and apply newly acquired knowledge. This leads to reconstructing what they know and the emergence of a new, problem-oriented,

knowledge structure (Schmidt & Moust 1998). The overall aim of this study is therefore to consider the effectiveness of integrating ICT into PBL in Biology towards students' achievement scores.

METHODOLOGY

Research Design

This study is designed using a quasi-experimental approach in order 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. It includes a pre-test and post-test observation. The pre-test and post-test scores are compared to assess if there are significant changes from pre-test to post-test (Sarafino 2005).

Samples

The samples were chosen from three 'intact groups' in one of the private universities in Malaysia. Thus the sampling method used for this study is purposive sampling. A total of eighty students from the Foundation for pre-medical students were involved in the study. 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). Prior to the treatment the achievement test was given to all the groups to measure their understanding on four topics in Biology. Upon completion of treatment, the achievement test was once again administered for post-test purposes.

Within the group, students were characterized in terms of gender and race. For the ICT group the samples consisted of 48% male and 52% female. Meanwhile the distribution for the sample's race is as the following: 48% Malay, 12% Chinese, 32% Indian and 8% others. Whilst for the PBL group, the percentage of males was 38.7% and females were 61.3%. There were 41.9% Malay, 22.6% Chinese, 32.3% Indian and 3.2% others in the PBL group. Lastly in the control group, the samples were 29.2% male and 70.8% female. The races of the samples were recorded as such: 41.7 % Malay, 16.7% Chinese, 33.3% Indian and others 8.3%.

Instruments

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 an achievement test.

The PBL Modules

The construction of the PBL modules was based on three learning theories, namely: Vygotsky's social constructivism theory; information processing theory, and self-directed learning theory. Vygotsky specified that students need to learn task-specific skills and knowledge is not exploration and discovery but instead is guided participation (O'Donnell et al. 2007). In the predevelopment stage, students often face difficulties in trying to resolve the problem. The zone of proximal development is where students can solve the problem if they receive help while trying to solve the problem. The last stage is where the student is able to solve the problem independently without any aid. Scaffolding method is used by teachers in the zone of proximal development. Apart from the social constructivism theory, processes of PBL involve the information processing theory. In the information processing theory, there are four important elements, namely: metacognition; sensory register; short-term and working memory, and long-term memory (Jordan & Porath 2006). The first element (metacognition) refers to the monitoring of the cognitive processes that occurs during the learning process. Meanwhile, the sensory register receives information from the senses in the body. Information is then passed on to the short term memory. The information is kept for a short duration and then passed on to the long term memory. The long

term memory stores memory for a long time till is needed for further use. The self-directed learning model coupled with PBL process was adapted from Schmidt and Moust (1998). Self-directed learning is seen in all four steps of the PBL. The learning process starts of with the teacher giving a problem, a small group tutorial, self-directed learning, a small group tutorial and, lastly, reflection on the solutions of the problem.

The PBL modules used in this study were adapted and modified from Torp and Sage (2002). 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 a 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. A PBL international expert was consulted on the PBL module regarding the contents, the flow of the process and asked to make a recommendation on improving the module. The researcher observed the usage of the PBL module in the classes and noted the weaknesses of the module. The PBL sessions were conducted during normal class sessions. After that, an interview was carried out on the lecturers and the students to get their feedback on the module. The modules were assessed using the action research method (Simranjeet et al. 2009). To evaluate the module, the research was conducted by the researcher and assisted by peer review. The module is tested against four PBL cases which are relevant to the Biology for Foundation syllabus. PBL module was tested four times hand-in-hand with these cases. Peer reflection, interview feedback and researcher reflection were incorporated to improve the modules.

The Achievement Test

In order to measure the achievement scores, an achievement test was used. The achievement test was divided into two sections: multiple choice questions and short essay questions. Four topics were assessed in the achievement test: respiration; photosynthesis; ecology, and environmental issues. Both the sections 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. These experts were asked to go through the questions and circle questions that were not clear and had some grammatical error. After that, the experts were asked to categorize the questions based on the four topics assessed in this test. Prior to that, the syllabus, alongside with brief outline of each topic, was given to the experts to give them some insight on the contents of each topic. The next stage involved two science education lecturers. The achievement tests were sent to them along with a feedback form and notes on the topics assessed in the tests. They were asked to group the questions based on the levels of Bloom's taxonomy.

Lastly the test was administered to 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. Reliability for the achievement test was determined using KR 20. It was found that multiple choice questions had a reading of 0.76 and the short essay questions 0.66. For the multiple choice questions, 0.70 onwards is an accepted reading (Nitko 2004). However, for the short essay questions 0.65 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 0.165 to 0.588. According to Varma (2008), items which displayed discrimination index values below 0.15 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 0.528 to 0.777.

RESULT

The samples for this study were eighty students from a private university in the state of Selangor, Malaysia. The overall pre-test description is given in Table 1. It shows the mean, standard deviation, minimum and maximum value for the pre-test. Whilst in Table 2, the mean and standard deviation value is displayed for all three treatments. It was found that the PBL with ICT group had the highest mean followed by the control and PBL group.

The overall post-test description is given in Table 3. It shows the mean, standard deviation, minimum and maximum value for the post-test. Meanwhile in Table 4, the mean and standard deviation value is displayed for all three treatments. It was found that the PBL with ICT group had the highest mean followed by the PBL group. The lowest mean was obtained by the control group.

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 (pre-test and post-test) 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 was used.

Table 1. Overall Pre-test of Achievement Test for Mean, Standard Deviation, Minimum and Maximum Values

	Pretest
N	80
Mean	16.550
Standard Deviation	5.024
Minimum	7.000
Maximum	33.000

Table 2. Overall Pre-test Mean Score in Achievement Test Based on Type of Treatment

Group	N	Mean	Standard Deviation
PBL with ICT	25	16.680	4.289
PBL	31	16.452	4.288
Control	24	16.541	6.594

Table 3. Overall Post-test of Achievement Test for Mean, Standard Deviation, Minimum and Maximum Values

	Posttest
N	80
Mean	33.000
Standard Deviation	9.834
Minimum	11.000
Maximum	50.000

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 pre-test and post-test was examined, and 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 pre-test and post-test.

The analysis showed that the main effect for time was significant, Wilks'=0.078, F (1, 77)=915.698, p=0.000, partial eta squared=0.922; interaction effect for time and method was significant, Wilks'=0.230, F (2, 77)=128.535, p=0.000, partial eta squared =0.770; main effect for subscale was significant, Wilks'=0.527, F (1, 77)=69.215, p=0.000, partial eta squared=0.473; interaction effect for subscale and method was significant, Wilks'=0.514, F (2, 77)=36.394, p=0.000, partial eta squared=0.486; interaction effect for time and subscale was significant, Wilks'=0.193, F (1, 77) =322.552, p=0.000, partial eta squared =0.807; interaction effect for time, subscale and method was significant, Wilks'=0.240, F (2, 77) =121.804, p=0.000, partial eta squared =0.760. Table 5 displays the MANOVA results.

After that, an analysis was carried out for between-subjects effects. This was done to measure the effect of the methods used in the three groups that contributed towards the achievement test. The main effect for method was significant at F=36.140, p=0.000, partial eta squared = 0.484 (see Table 6).

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 pre-test and post-test. 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 (see Table 7).

DISCUSSION

Based on the results analysis, the main effect for time was significant. This shows that there was a difference in the sample score for achievement test in the pre-test and post-test based on the treatment given. Other than that, the main effect for subscale was also significant. This implies 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 post-test scores are influenced by the treatment used in this study. Furthermore the interaction effect for subscale and method was also significant. The post-test scores for both the subscales were influenced by the treatment. The interaction effect for time and subscale was significant. This shows that the duration of tests had an impact on the performance of samples on the subscales of the achievement test. Subsequently the interaction effect for time, subscale and method was also significant. Overall it could be concluded that the achievement test scores were influenced by a combination of three factors, namely: time; sub-scale, and method.

A subsequent comparison of post-test mean was made between all the groups for the post-test 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

Table 4. Overall Post-test Mean Score in Achievement Test Based on Type of Treatment

Group	*N*	*M*	*SD*
PBL with ICT	25	40.920	3.685
PBL	31	36.355	4.378
Control	24	20.420	6.665

Table 5. MANOVA Results

Effect	λ	*F*	df_1	*Error df*
Time	0.078	915.698	1.000	77.000
Time x Method	0.230	128.535	2.000	77.000
Subscale	0.527	69.215	1.000	77.000
Subscale x method	0.514	36.394	2.000	77.000
Time x subscale	0.193	322.552	1.000	77.000
Time x subscale x method	0.240	121.804	2.000	77.000

Table 6. Tests of Between-Subjects Effects

Source	*F*	*Sig.*	*Partial Eta Squared*
METHOD	36.140	0.000	0.484

Table 7. Multiple Comparisons

(I) METHOD	(J) METHOD	Mean Difference (I-J)	Std. Error
ICT	PBL	1.198(*)	0.4574
	CONTROL	5.160(*)	0.7337
PBL	ICT	-1.198(*)	0.4574
	CONTROL	3.962(*)	0.7080
CONTROL	ICT	-5.160(*)	0.7337
	PBL	-3.962(*)	0.7080

integrated with ICT group and control group; PBL group and the control group. On the whole, the findings supported the idea that the PBL integrated with ICT group was significant compared to the PBL group and control group in the subjective scale and overall achievement score.

As previously mentioned, the achievement test consisted of two sections: multiple choice questions and short essay questions. Both the sections measured the sample's achievement in respiration, photosynthesis, ecology and environmental issues. The multiple choice questions were centered on the first three levels of Bloom's taxonomy namely: knowledge, comprehension and application. Meanwhile the short essay questions were focused on the comprehension level and application level based on the Bloom's Taxonomy. This study showed that when compared to their counterparts, PBL with ICT significantly enhanced students' performance on the short essay section, in which the focus of the section was on comprehension and application of the concepts rather than recall of factual knowledge. Overall the PBL with ICT group score was the highest.

Pre-test and post-test was used to analyze the achievement of samples in the PBL with ICT group, the PBL group and the control group. During the pre-test the knowledge level for all the samples in the three groups was quite similar. A post-test was conducted three months after the pre-test. Surprisingly enough, during the post-test it was found that the PBL with ICT group achieved the highest score followed by the PBL group and the control group. The PBL group findings were found to be not consistent with Riberio's (2008) 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. This shows that the PBL with ICT group outperformed the other two groups on long term

retention assessments. The PBL with ICT group were able to apply knowledge and remember theories better compared to their counterparts in the other groups. The PBL process coupled with ICT initiates deeper processing of information which leads to better retention of knowledge over a longer period of time.

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.

In comparison with Oldenburg and Hung (2010) research, a group of undergraduate nursing students enrolled at a single university in an online section of pathophysiology course that used online PBL approach. These students were divided into groups and were given six cases to solve in a semester using online PBL. Findings showed that students were able to define the problem in the case, using their previous experiences. The students demonstrated the use of problem-solving skills to solve the cases systematically. They also shared and applied their previous experiences to solve the problem. Information gathering process was utilized by seeking information using textbooks, journals and online resources. Generally the findings were similar with this research as students who were exposed to PBL with ICT scored better than their counterparts. The integration of the ICT element helped to produce a systematic PBL process and at the end of the day improve the retention of knowledge.

PBL sessions are normally carried out based on the following procedures: (1) encountering the problem; (2) identifying the learning needs in an interactive group process; (3) engaging in self study; (4) applying newly gained knowledge to the problem, and (5) summarizing what was learned (Barrows 1985). However in this study, the PBL process was carried out in a systematic manner as a module had been prepared to guide students step by step to solve the PBL cases. The modules guided students to identify the problem statement, collect and sort information systematically and selecting the best solution to solve the problem. By having a module, students were more focused and found it easy to delegate duties and solve the problem in a collaborative manner (Bednall & Kehoe 2011).

The ICT element improved the PBL sessions considerably. During the PBL sessions, students recorded each phase using Microsoft Word templates and uploaded it on their electronic discussion groups. In the modules, the use of ICT was seen in searching for reliable information. Students used World Wide Web to search for relevant information to solve the problems compared to their counterparts who used books to solve the problem. Interestingly enough, there was a huge difference in the presentation of the solutions to each case. The PBL integrated with ICT group came up with creative and concrete solutions to solve the cases. Their solutions were very much up to date with the current global situation. Meanwhile the PBL group's presentation was good but it was limited to the contents of reference books. By integrating ICT with PBL, the retention of Biology topics increased, and this was proven in the higher overall scores between groups for the post-test. These results are similar with this study in terms of the highest post tests score for PBL with ICT group in the achievement test (Baturay & Bay 2010). It was found that using ICT alone to teach a course is not sufficient to produce high achievers. However by coupling ICT with PBL, the students showed a higher performance compared to the PBL and control group.

CONCLUSION

Overall the findings showed that the ICT integrated with PBL group scored the highest compared to the PBL group and control group. Both the PBL and ICT integrated with PBL group used modules in this study. The major difference between these two groups is the integration of ICT elements such as Microsoft Word, Microsoft Power Point, blog and electronic discussion group in the ICT integrated with PBL group; the PBL group on the other hand employed the log book and poster in the PBL process. The ICT element enhanced the PBL process by allowing students to document the phases in the module using Microsoft Word and uploading it on the electronic discussion group to compare and sort ideas. Meanwhile the presentation was greatly enhanced by the usage of Microsoft PowerPoint. Based on the blog reviews, it was found that the ICT integrated with PBL group did not face many problems in understanding the four topics that they had been given after undergoing the PBL with ICT process. This proves that the ICT element helped to enhance the retention of knowledge in the PBL process. For higher learning, it is recommended to integrate the PBL process with ICT elements such as Microsoft Word, Microsoft Power Point, blog and electronic discussion group as it is a commonly available and easy to use. By integrating the ICT elements, the PBL process becomes

more systematic, structured and enhances the achievement of students in Biology.

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