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The Effects of Problem-Based Learning on Self-Directed Learning Skills among Physics Undergraduates

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Abstract
The aim of this study is to compare the effects of three methods: problem-based learning (PBL), PBL with lecture method, and conventional teaching on self-directed learning skills among physics undergraduates. The actual sample size comprises of 122 students, who were selected randomly from the Physics Department, College of Education in Iraq. In this study, the pre- and post-test were done and the instruments were administered to the students for data collection. The data was analyzed and statistical results rejected null hypothesis of this study. This study revealed that there are no signifigant differences between PBL and PBL with lecture method, thus the PBL without or with lecture method enhances the self-directed learning skills better than the conventional teaching method.
Keywords: Self-Directed Learning Skills, Problem-Based Learning, PBL With Lecture Method, Conventional Teaching

Introduction

The science and its applications are part of daily life to make our life better and therefore the development of an individual's understanding of science and its applications is one of the objectives of science instruction (Adiguzel, 2006). Rapidly changing recent science applications require science students to gain self-directed learning skills for lifelong education, where skills

are part of the efficiency to react to development in knowledge. Moreover, the teaching of science has become important now more than ever (Montero & Gonzalez, 2009; Sahin, 2010b). One of the most effective approaches is problem-based learning (PBL), which is a scientifically accurate model (Bouwma-Gearhart et al., 2009; Olgun, 2008; Miller et al., 2009).

PBL enhances a set of pedagogical results such as skills of self-directed learning (Neild, 2004). According to Hmelo-Silver (2004), PBL as a teaching method, is based on students-centered learning, where students learn through simplified problem solving and where problems should be complex, ill-structured, and real. Students participate in self-directed learning for solving problems. PBL is a student-centred teaching approach that enables students to become active participants in solving problems, answering questions, cooperating in learning, working in teams on problems or projects, and taking on more of the responsibility for learning (Ates & Eryilmaz, 2011). In PBL method, learners are encouraged to take the initiative for their own knowledge (Lee, Mann, & Frank, 2010). There are evidences in support of PBL which seemingly have a superior effect on self-directed learning skills for fostering it, compared with conventional curricula (Evans, 2009; Khoo et al., 2008).

Under skills of self-directed learning, students can run the planning, conceptualization, conduct and evaluation of learning (Brookfield, 2009). Self-directed learning is present in education statuses, and variety of actions including reading, cooperation, debate, accessing resources, research, and development. Using the time to prepare their course and studying in-depth are expected from students in self-directed learning (Deepwell & Malik, 2008). Consequently, self-directed learning means an ability to sub-edit education objectives, name resource, select and carry out proper education strategy, and evaluate instruction outcome as well as learning experiences. In addition, under self-directed learning, a person takes the primary responsibility and initiative for planning and diagnosing his/her learning requirements (Deepwell & Malikb, 2008).

In the current study, the PBL alone or with lecture method compared with conventional teaching method were used to investigate their effectiveness on the self-directed learning skills among physics undergraduates.

Problem Statement

There is the weakness of the traditional science teaching method, under it that teacher-centred learning assumes that all learners take in recent material in a like speed and have like degree of knowledge in the topic being taught. A teacher guides the students and offers them new information. The focus of teaching is on the transmission of knowledge from the expert teacher to the novice learner (Cheong, 2008). The role of students, in the conventional manner, is passive rather than an active, thus hindering learning among bachelor's degree physics students. Under the conventional manner, students listen and watch, and most teaching time is spent with the instructor lecturing. In the traditional method, a teacher is required to have or to learn effective writing and speaking skills. Mostly, under traditional experiments of science, students have conceptions on what the findings will be, or what they anticipate it to be, and the student tries to emphasize on this (Azu & Osinubi, 2011).

Therefore, there is a need to adopt problem-based learning (PBL) for solving the problem of the traditional science teaching method, which is one of the most successful approaches (Prince,

2004; Sahin, 2009a; van Berkel & Schmidt, 2005). In recent years, educational institutions have evidenced the requirement of utilizing substitutional teaching methods to develop learners' abilities (Azu & Osinubi, 2011). PBL, as a teaching method, was primarily developed to address the attendant difficulties in conventional methods and respond to the conventional methods which failed to enable students to solve problems of to solve problems of various topics in physics material (Hung, Jonassen, & Liu, 2008). Instructors in PBL are more creative with their teaching while old methods, which are based on boring lectures and memorization of material, are challenged with this delivery method (Ates & Eryilmaz, 2011; Sulaiman, 2011).

Based on previous literature, the PBL allows the development of the self-directed learning skills to enable students assume individual responsibility for their learning. The PBL allows learners to pursue information from any subject, and this allows them to deeply understand Physics concepts (Ates & Eryilmaz, 2011; Ball & Pelco, 2006; Cheong, 2008). Lycke, Grottum and Stromso (2006) demonstrated that PBL students showed "significantly more self-regulated learning and they perceived themselves as more active contributors to group learning process and used a broader range of resources than students in the traditional programme" (p. 113). Consequently, PBL environment can provide opportunities for students to develop their skills of self-directed learning which will help them to manage in designing, solve problems, performance, and evaluating learning outcomes (Bell, 2012; Downing et al., 2011; Thornton, 2010; Whitcombe, 2013).

It is worth mentioning that using the PBL approach alone and adopting it only as a teaching method, is considered risky because it entails complete shift from a teacher-centred learning in conventional manner to another student-centred learning in the PBL. PBL, as an instruction process, centers on the precept of using problem, which should be complex and ill-structured, that will lead to drastic change in learning approach. Under the PBL method, students are encouraged to be active rather than passive and cooperate rather than compete (Cheong, 2008). Incorporating PBL into traditional method could be a useful tool to reinforce material covered in traditional lecture, which will leave a positive influence on the learning process (Liceaga et al., 2011). According to Saalu et al (2010), "there should be an intelligent combination of using both the traditional and PBL approaches for teaching anatomy which may provide the most effective training for undergraduate medical student" (p. 197).

Objective of the Study

To compare the effects of using pbl, the pbl with lecture method, and the conventional teaching on self-directed learning skills among physics undergraduates.

Research Question

Are there significant differences on the linear combination of posttest mean scores of self-directed learning skills among physics undergraduates who followed pbl, the pbl with lecture method, and the conventional teaching after the effect of mean scores of pretest is controlled?

Research Hypothesis

There are no significant differences on the linear combination of posttest mean scores of self-directed learning skills among physics undergraduates who followed pbl, the pbl with lecture method, and the conventional teaching after the effect of pretest mean scores is controlled.

Methodology

Research Design

This study's design can be represented schematically as O_1 the pretest on the self-directed learning skills; O_2 the posttest on the self-directed learning skills; X_a represents PBL treatment; X_b represents PBL with lecture method treatment; X_c represents the conventional teaching method, as shown in Table 1.

Table 1: *Nonequivalent Control Group Design*

No	Group	Pretest	Treatment	Posttest
1	Experimental	O_1	X_a	O_2
2	Experimental	O_1	X_b	O_2
3	Control	O_1	X_c	O_2

The sample consisted of three groups of the bachelor's degree physics students. The first experimental group used PBL treatment, and the second experimental group used the PBL with lecture method treatment, while the third group was a control group and it used conventional teaching.

Distribution of Groups

Table 2 shows distribution of groups based on the teaching methods. There were 42 subjects for the PBL method, 39 subjects for the PBL with lecture method, and 41 subjects for the conventional teaching method. The all groups consist of 122 subjects involved in the study.

Table 2: *Distribution of Groups Based on the Teaching Methods*

Group	Teaching Method	Subjects	Percent
1	PBL	42	34.400
2	PBLwith lecture	39	32.000
3	conventional teaching	41	33.600
Total		122	100.000

In the current study, the five problems were developed in the field of thermodynamics in physics for problem-based learning (PBL) as the teaching method alone or with the lecture method (PBL with lecture method) to investigate their effects on self-directed learning skills among bachelor's degree physics students, compared with the conventional teaching method.

Population and Sample

The population for this study comprised of male and female (176) students enrolled in the Physics Department, College of Education in Iraq, for academic year 2011-2012. They were randomly selected from the college. Five subjects dropped from the sample, so the actual sample size was 122 students.

Instrument of the Study

Questionnaire on self-directed learning skills was adapted based on some resources (e.g., Fisher, King, & Tague, 2001; Lee, Mann, & Frank, 2010; Stewart, 2007) to collect data for the present study. Aforementioned questionnaire consists of of 25 items measuring student's self-directed learning skills. The self-directed learning skills questionnaires were administered to the physics undergraduates, before and after the treatment to measure the effectiveness of PBL alone or with lecture method, on the self-directed learning skills, compared with conventional teaching method. The difference between pretest and posttest results on student's skills of the self-directed learning determined the effectiveness of three teaching methods, on students' self-directed learning skills.

Findings

The results revealed that univariate test of statistical significance on the differences observed in the scores of posttest across the various groups, as shown in table 3.

Table 3: *Univariate Analysis of Subjects' Posttest Scores on Self-directed Learning Skills in Various Groups*

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Posttest of self-directed learning	16600.44[c]	5	3320.09	28.19	.00
Intercept	Posttest of self-directed learning	2297.49	1	2297.49	19.51	.00
Pretest of self-directed learning skills	Posttest of self-directed learning	11570.34	1	11570.34	98.23	.00
Group	Posttest of self-directed learning	3831.55	2	1915.77	16.27	.00
Error	Posttest of self-directed learning	13663.46	116	117.79		
Total	Posttest of self-directed learning	1015586.0	122			
Corrected Total	Posttest of self-directed learning	30263.90	121			

The scores of posttest questionnaire on self-directed learning skills across the various groups with F (2, 116) = 16.27, Mean Square = 1915.77 and P = .00. Therefore, these differences in the scores of posttest questionnaire on self-directed learning skills among the three groups were significant. So, the statistical results rejected the null hypothesis. Thus, there were significant differences on the linear combination of posttest mean scores of self-directed learning skills among physics undergraduates who followed PBL, the PBL with lecture method, and the conventional teaching. Overall, the results of comparison among the groups which were the PBL, the PBL with lecture method, and the conventional teaching, indicated that there were statistical significant differences. Thus, the results of univariate statistics were further investigated by performing a post hoc pairwise multiple comparison using LSD command for self-directed learning skills in order to identify significantly where the differences in the means resided.

Table 4 shows a summary of post hoc pairwise multiple comparisons across the groups of the PBL method, the PBL with lecture method, and the conventional teaching method, to study superior effects on students' self-directed learning skills.

Table 4: *Summary of Post Hoc Pairwise Multiple Comparisons Observed Means Scores of Posttest of Self-directed Learning Skills*

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.
Posttest of self-directed learning	(1) PBL	PBL with lecture	2.47	3.24	.45
		conventional	14.55*	3.20	.00
	(2) PBL with lecture	PBL	-2.47	3.24	.45
		conventional	12.08*	3.26	.00
	(3) conventional	PBL	-14.55*	3.20	.00
		PBL with lecture	-12.08*	3.26	.00

* The mean difference is significant at the .02 level.

Statistical results showed there were significant differences, with $P < .02$ on posttest mean scores of the self-directed learning skills between the PBL method of first group and the conventional teaching method of third group, with Mean Difference = 14.55*, in favor of the PBL method which was superior and better than methods of other groups. Likewise, there were statistically significant differences, with $P < .02$ on mean scores of posttest of the self-directed learning skills between the PBL with lecture method and the conventional teaching method, with Mean Difference = 12.08*, in favor of the PBL with lecture method which was better than the conventional teaching method.

In addition, there were no statistically significant differences, with $P > .02$ on mean scores of posttest of the self-directed learning skills between the PBL method and the PBL with lecture method. Thereby, the PBL method was superior and better than the conventional teaching method, also the PBL with lecture method was better than the conventional teaching method. Overall, the PBL without /with lecture method was better than the conventional teaching method. Therefore, using the PBL method or the PBL with lecture method promotes the self-directed learning skills among physics undergraduates better than the conventional teaching method.

Discussion

The posttest questionnaires of the self-directed learning skills were administered under supervision immediately after the subjects completed their materials on thermodynamics. Overall the finding revealed that experimental treatment of the PBL without /with lecture

method was able to promote skills of the self-directed learning greater and better than the conventional teaching method among physics undergraduates. This is evident by the significantly higher mean scores on posttest questionnaires of the self-directed learning skills of students who followed the PBL without /with lecture method compared to those who followed the conventional teaching method. In other words, students of the PBL without /with lecture method demonstrated a greater ability to get higher mean scores of response on posttest questionnaire items of the self-directed learning skills than their peers of the conventional teaching group. Thus, the finding of this study found that the the PBL without /with lecture method enhances skills of the self-directed learning. This result concurs with the findings of numerous studies which assured the efficiency of the PBL without /with lecture method to allow the expansion of the self-directed learning skills, thus making learners progress in taking responsibility for their own learning (Ates & Eryilmaz, 2011; Ball & Pelco, 2006; Cheong, 2008).

This finding also replicated the results obtained by Prince et al (2005) who had earlier demonstrated the superiority of the PBL over the conventional teaching in bringing about students' skills of self-directed learning. This study provides evidences that students under the PBL without /with lecture method are preferable prepared in skills than their peers who were not taught under the same method (Prince et al., 2005). the PBL without /with lecture method allows students to take responsibility and control of their own learning, to foster, enhance, as well as to develop self-directed learning skills (Barrows, 1986; Bereiter & Scardamalia, 1989; MacKinnon, 1999; McParland et al., 2004; Norman & Schmidt, 1992; Rahimi, 1995; Suh, 2005; Sundbladi et al., 2002).

Under skills of self-directed learning, students can run the planning, conceptualization, conduct and evaluate their learning (Brookfield, 2009). Self-directed learning is present in education statuses, and variety actions cover reading, cooperation, debate, accessing resources, research, and development. Students spending their time to prepare their course and to study in depth employ self-directed learning (Deepwell & Malik, 2008). PBL without /with lecture method provides students to implement self-directed learning as they have to be more autonomous in defining the problem, deciding what should be learnt, collect information and determine the best approach to solve the problem.

The improvement of effective self-directed learning skills is an educational objective that learners would attain during the PBL method (Barrows, 1986). Current approach can aid learners in improving skills of self-directed learning, which are a crucial part of continual regular knowledge (Williams, 2001). The information processing theory is based on the perspective that the individual mind processes are responsible for analyzing information (Gray, 2010). Under PBL, the current study showed the development of self-directed learning skills which are based on the information processing theory, that skills enable students to take the initiative and responsibility of diagnosing their learning. So, students need of information and knowledge, like the input of data in computer. The mind will process that through planning, carrying out, and evaluating their own learning, and finally assessing the value of the outcomes (Deepwell & Malikb, 2008; Tsay et al., 2000). Thus, this study supports the information processing theory. That stated the mind possesses attention mechanisms, working memory and long-term memory. It addresses growth development in the ability of individual's brains to process and react to the received information (Gray, 2010).

Current approach can aid learners in improving skills of self-directed learning, which is a crucial part of continual regular learning (Williams, 2001).

Conclusion

Based on the aforementioned findings of this study, using the PBL without /with lecture method enhance and develop the self-directed learning skills, among physics undergraduates, better than using the conventional teaching method.

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