

An Empirical Study of Learning Objects As Alternative Pedagogical Tool In Engineering Education

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Abstract. This study aims to analyze the effectiveness of learning objects as alternative pedagogical tool in laboratory engineering education. 160 undergraduate students who enrolled in a Digital Systems course were randomly assigned to either a control group or an experimental group. This study utilized pre-test, post-test and postponed-test as the basis of data collection to measure the effectiveness of learning objects. The results show that the experimental group performance betters especially the low-achiever and medium-achiever sub-groups benefited more in increase and retention of knowledge and concept compare to the same sub-groups in the control group.

Keywords: learning objects, engineering education, interactive learning environments, post-secondary education

1. Introduction

In recent years, with rapid development of information communication technologies, drastic changes in education in terms of instructional content and delivery medium to complement the traditional face-to-face teaching and learning have taken place [1]. One of the most important breakthrough in this field has come from the reusable object-based learning approach, referred to as "learning object" [2]. It is an idea to decompose existing course materials into smaller instructional components that can be reused in different learning contexts [3]. An exponential growth of learning objects available through the Internet is creating opportunities and offers the potential of cost and time savings for educators in course development and delivery [4]. Polsani [5] suggests that educators can effectively employ object-based learning approach to course design by using learning objects from a variety of repositories to produce a sound curriculum. They can be used as a single learning unit or combined to form larger educational interactions to allow teaching and learning to be centered on the needs and interests of the learners [6].

The Digital Systems course at our institution is a core subject for first year undergraduate students who come from a variety of backgrounds with different levels of learning experience. The students have very little conceptual understanding of logic circuit which led to hours of wasted time spent on understanding and applying the concepts incorrectly. In order to bring all students to a common understanding of the fundamental concepts in a short period of time, an effective learning approach is important to provide accurate, relevant, and just enough content at the right time to assist the students to gain the correct concepts and apply them well in the early stage. Based on some of the previous related studies [7-9], it was hoped that some of these issues could be addressed by using learning objects to facilitate the process of knowledge transfer between the educators and the students.

Although many assumptions have been made about the learning objects' contribution in the process of teaching and learning, few empirical study has been done to support this claim [10]. More independent study

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on the effectiveness of learning objects need to be conducted to provide new insights to the field [11]. The main objective of this study is to examine the impact of learning objects towards student's academic performance in engineering education. This study is designed to answer the following research questions:

- What are the differences in students' learning achievements of the two study groups?
- How do high-, medium- and low-achievers' learning achievements change over time?

2. Methodology

160 undergraduate students who enrolled in Digital Systems course were randomly assigned to either the control group or the experimental group, forming 80 students for each group. Three types of tests were used to measure and compare the learning achievements. The pre-test aimed to ensure that both groups of students had the equivalent basic digital electronic knowledge required for taking the course. The post-test was intended to compare the learning achievements of the two groups of students after taking the course. The postponed-test was used to measure the knowledge retention by the students after the post-test. In this study, relevant learning objects for this course were retrieved from various general repositories which provide higher education level learning objects. When students needed to use the learning objects, they used the browsers to login to the learning system via local area network or Internet.

The main design for this study was a quasi-experiment with an experimental group and a control group. Two types of teaching instruction were applied: (a) Using learning objects to teach four units of Digital Systems course to the experimental group. (b) Using traditional methods with PowerPoint slides to teach four units of Digital Systems course to the control group. Before the experiment began, both groups were given pre-test at the first week of the semester. During the 7 weeks of experiment, the students in the experimental group through the availability of learning objects in the intranet and internet, they could modify their cognition and develop digital systems concepts in accordance with individual conditions by adjusting the pace of their own learning progress. On week 9, after the experiment period, all students were given a post-test followed by the distribution of questionnaires to the experimental group. At the end of the semester (week 13), both groups were given postponed-tests.

3. Results and Discussions

In order to compare whether learners' achievements change and how do they change over time, we compared the mean scores pair-wise via a series of t-tests within and across the group.

A paired-samples t-test on the control group learners' achievements revealed a significant differences in the post-test and postponed-test, $t(71) = 2.74, p < .05$. The postponed-test mean score ($M = 28.02$) was significantly lower than the post-test mean score ($M = 28.55$). For the experimental group learners' achievements, the mean score of the postponed-test ($M = 30.64$) is slightly higher than that of the post-test mean score ($M = 30.32$). Pairwise t-test result in Table 1 shows there is no significant differences between post-test and postponed-test, $t(75) = -1.16, p > .05$. The outcome indicates that the effect of learning objects is significantly retained the knowledge much longer than the traditional class.

Tab.1: Comparison of Post-Test and Postponed-Test Mean Scores within Group

Group	Post-Test (PT)		Postponed-Test (PPT)		Diff (PT-PPT)		t-statistic	p-value
	Mean	S.D.	Mean	S.D.	Mean	S.D.		
Control	28.55	4.651	28.02	4.995	.535	1.654	2.744	.008
Experimental	30.32	4.132	30.64	3.942	-.322	2.426	-1.159	.250

Further analysis was conducted to compare the post-test and postponed-test scores across two groups. From Table 2, a paired-samples t-test revealed a significant differences in the post-test scores, $t(71) = 2.89, p < .05$. This indicates that the mean post-test score for experimental group ($M = 30.18$) was significantly higher than the control group ($M = 28.56$). The average postponed-test score of the experiment group ($M = 30.48$) is also better than that of the control group ($M = 28.02$). The pairwise t-test results show that the postponed-test score of the experiment group is significantly higher than the control group $t(71) = 4.76, p$

< .001. The outcome indicates that the effect of learning objects is significantly positive to the effect of the traditional class.

Tab. 2: Comparison of Post-Test and Postponed-Test Mean Scores across Groups

Test	Experimental Group (EG)		Control Group (CG)		Diff (EG-CG)		t-statistic	p-value
	Mean	S.D.	Mean	S.D.	Mean	S.D.		
Post-test	30.18	4.139	28.56	4.651	1.63	4.772	2.889	.005
Postponed-test	30.48	3.982	28.02	4.995	2.46	4.382	4.760	.000

Besides the comparison of the overall learning achievements of the two groups, in order to gain more details about how each group students' learning achievements change, further analyses of learning achievements with three sub-categories for experimental and control groups were conducted. This study divided students of each group into three sub-categories, high-achiever (HA), medium-achiever (MA), and low-achiever (LA) based on their pre-test scores. Students who earned A grade were assigned to the high-achiever category. Students who earned D or F grades were assigned to the low-achiever category. The rest of the students who earned B and C grades were assigned to the medium-achiever category.

For the experimental group, a 2 (Test) x 3 (Sub-group) mixed-model ANOVA reveals that the main effect for the three sub-group of achievers (LA, MA and HA) were significant, $F(2, 73) = 72.10, p < .001$, Eta-squared = .66. Thus, there were overall differences in the mean test scores of the LA ($M_{LA} = 25.85$), MA ($M_{MA} = 31.38$) and HA ($M_{HA} = 33.79$). However, a not significant main effect for Test was obtained, $F(1, 73) = 1.44, p > .05$. The overall mean of the postponed-test score ($M = 30.51$) was not significantly higher than the post-test score ($M = 30.17$).

Further analysis, a not significant of the Test x Sub-group analysis was also obtained, $F(2, 73) = .11, p > .05$. Examination of the cell means indicated that each sub-group (LA, MA & HA) maintained the level of achievement after the post-test with slightly increase of postponed-test scores for high-achiever ($M_{HA} = 34.05$), medium-achiever ($M_{MA} = 31.47$) and low-achiever ($M_{LA} = 26.02$).

While for the control group, a 2 (Test) x 3 (Sub-group) mixed-model ANOVA also revealed that the main effect for the three sub-group of achievers (LA, MA and HA) were significant, $F(2, 69) = 75.79, p < .001$, Eta-squared = .69 (Table 6). Thus, there were overall significant differences in the mean test scores of the LA ($M_{LA} = 22.80$), MA ($M_{MA} = 28.60$) and HA ($M_{HA} = 33.28$). A significant main effect for Test was also obtained, $F(1, 69) = 5.86, p < .05$, Eta-squared = .08. The postponed-test scores ($M = 28.01$) were slightly lower than the post-test ($M = 28.45$).

A significant Test x Sub-group was also obtained, $F(2, 69) = 8.65, p > .001$, Eta-squared = .20. Examination of the cell means (Table 7) indicated that that although there were significant decrease in test scores for all LA and MA from post-test ($M_{LA} = 23.28, M_{MA} = 29.11$) to postponed-test ($M_{LA} = 22.33, M_{MA} = 28.09$), but the HA managed to retain the level of achievement with a significant increase of postponed-test score ($M_{HA} = 33.60$) compared to post-test score, $M = 32.95$.

The comparison of overall learning achievements of the two groups indicates that the effect of learning object is significantly superior to the traditional class. Further analysis to compare the post-test and postponed-test mean scores across two groups revealed significant differences. The outcome indicates that the use of learning objects significantly increase and retain the knowledge much longer than the traditional class.

In addition, significant differences are also observed between experimental group and control group when the students' post-test and postponed-test mean scores are compared within the sub-groups (LA, MA and HA). For experimental group, each sub-group managed to maintain the level of achievement after the post-test with slightly increase of postponed-test scores. However, for control group, the LA and MA sub-groups' postponed-test mean score significantly decrease compared to post-test mean score. But the HA managed to retain the level of achievement with a significant increase of postponed-test mean score.

The scores suggest that the all students who participated in object-based learning environment are benefiting more than students with conventional learning environment. The learning objects used by the experimental group did produce much of a change in terms of the students' learning achievements and retain the knowledge much longer compared to the control group, especially the LA and MA sub-groups.

4. Conclusions

Learning objects are opening up new potentials for learning in innovative ways in various contexts. This study compares the learning achievements within two groups. Statistical analyses outcomes reveal that the post-test and postponed-test mean scores of the experiment group students who utilised the learning objects for learning Digital Systems is better than that of control group students, who learned through the conventional classroom lecture. The low-achiever and medium-achiever categories tend to benefit more with the learning objects by obtaining in-depth information. High-achiever category is equally benefited in increased knowledge, as measured by differences in the pre-test and post-test scores. They also enjoy good retaining effect.

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