The effectiveness of project-based learning and STAD learning on improving Web programming competency

Hary Suswanto†, Achmad Hamdan†, Rina R. Mariana†, Ahmad Dardiri†, Aji P. Wibawa†, Andrew Nafalski‡ & Ainun F. Vianiryzki*

State University of Malang, Malang, Indonesia†
University of South Australia, Adelaide, Australia‡
Institute of Technology Bandung, Bandung, Indonesia*

ABSTRACT: The aim of this research was to determine the effectiveness of project-based learning and student teams-achievement divisions (STAD) co-operative learning on Web programming competency. A quasi-experimental, non-equivalent control group design was adopted for the research. The data were collected using sampling techniques in the form of tests and documentation. A *t*-test was used to show the improvement of students' ability in project-based learning and STAD co-operative learning. The comparison of the average gain or improvement scores for students' knowledge and skills shows that project-based learning achieved better results than did the STAD co-operative learning in improving students' competency in Web programming.

INTRODUCTION

Success or failure of education depends upon the teaching and learning process [1][2]. It is, therefore, necessary to select and apply an appropriate learning model. This is important for engineering students, because as graduates they need to be *ready for work*.

In traditional Web programming, the teaching and learning process is centred on the teacher [3]. Students are not actively involved; they just listen to the teacher and work on a worksheet provided [4]. This leaves many students confused and with a poor understanding of the material.

Project-based learning is an alternative learning model [3]. This can increase a student's participation in the learning process by promoting active learning and self-learning. As well, communication and collaborative skills are developed, which are important in the student's future work [5]. The results of several studies indicate that the use of project-based learning can improve and facilitate the learning process by improving skills, the quality of learning and the learning outcomes [3].

Student teams-achievement divisions (STAD) is another potential learning model based on co-operative learning. Co-operative learning provides an opportunity for students to express thoughts, views and experiences during group learning, thereby developing a group view [6]. The results of some studies show that STAD-type learning is very effective in improving students' learning outcomes [7]. The STAD method is used as the co-operative learning model in this study.

This research examined the learning outcomes for Web programming students using project-based and STAD co-operative learning. The application of project-based learning and STAD is appropriate for Web programming lessons. Therefore, the application of both learning models was expected to improve the cognitive and psychomotor competence of students studying Web programming. The research aimed to measure the improvement using project-based and STAD co-operative learning separately, and then comparing the project-based with the STAD co-operative learning.

PROJECT-BASED LEARNING

Project-based learning is a collaborative teaching method, which can be affected by the nature of the project or the nature of the students [8]. Project-based learning directly involves students in the learning process through research activities leading to completion of a particular project [9][10].

Project-based learning is based on several principles, i.e. centrality, questioning, constructive involvement, autonomy and realism. The steps in project-based learning are:

1. The teacher describes the topics to be studied, the learning objectives, the motivation and the competencies to be achieved.
2. Working in groups, the learners identify problems or questions related to the topic. Questions may be asked by or of the teacher;
3. A group makes a project plan to resolve the problem.
4. The group creates a project based on an understanding of the concepts and principles related to the subject matter.
5. The results of the project are presented.

CO-OPERATIVE LEARNING: STAD

Co-operative learning focuses on the use of small groups of students to work together to maximise learning in achieving learning objectives. The STAD method is a co-operative model for students with heterogeneous abilities [11]. The STAD model is a learning tool, whereby groups of students use verbal or text presentations as part of group discussions to collaborate and elaborate with peers to solve a problem [12][13].

The general way STAD operates in class is as follows:

1. The class is divided into several groups.
2. Each group consists of 4 to 5 students who are heterogeneous in terms of ability, gender, culture, and so on.
3. Each group is given the necessary teaching materials and a set of tasks.
4. Tasks are undertaken by group discussion.
5. During the group discussion, the teacher will be a facilitator and a motivator.
6. Every one or two weeks, the teacher provides an evaluation of individuals and groups, to identify student improvement.
7. A reward will be given to the students and group who achieve the best outcome. If a number of groups achieve equivalent, *best* outcomes, then all those groups are rewarded [13].

RESEARCH METHOD

The non-equivalent control group design was adopted for this research, with the experimental groups decided randomly [14]. The research design is presented in Table 1.

Table 1: Research design.

Group	Pre-test	Treatment/Learning method	Post-test	Analysis
Experimental class 1	O_1	Project-based learning	O_2	O_2P_2
Control class 1	P_1	Direct instruction	P_2	
Experimental class 2	Q_1	Co-operative STAD learning	Q_2	Q_2R_2
Control class 2	R_1	Direct instruction	R_2	

O_2P_2: The difference in competency gain between experimental class 1 and control class 1
Q_2R_2: The difference in competency gain between experimental class 2 and control class 2

In this research, the data were obtained using sampling of four Web programming classes [15]. The data were collected using tests and documentation. The pre-tests and post-tests measured students' cognitive and psychomotor competence. A pre-test was used to determine the basic skill of a student before the treatment, while the post-test was used to determine the final ability or competence of the student after the treatment.

Pre-requisite normality, validity, homogeneity and heterogeneity analyses were done before the hypothesis testing. In order to examine the level of efficiency of each experimental class, the means of pre-test and post-test and gain or improvement scores were compared between the experimental class 1 and control class 1, as well as between experimental class 2 and control class 2.

The effectiveness was determined both for the experimental class using project-based learning and the experimental class using STAD. The results for both experimental classes were analysed using a *t*-test on post-test and improvement scores.

RESULTS

The descriptive analysis of the pre-test and post-test scores on knowledge and skill competences in the experimental and control classes showed that the data were normally distributed. The results of the homogeneity of variance test (Lavene

statistic) showed that the data were homogeneous. Paired sample *t*-tests were used on the pre- and post-test data and gain scores to measure the efficiency level of the learning models for these experimental classes.

Efficiency of the Project-based Learning Model

Table 2 shows that project-based learning improved the knowledge and skills competency of the students in experimental class 1. Furthermore, the results for gain scores show that the level of students' knowledge and skills competence in the experimental class 1 is higher than the students in the control class 1, as shown in Table 3.

Table 2: Paired sample statistics for experimental class 1 for knowledge-skills competency.

Competency		Mean	N	Std. deviation	Std. error mean
Knowledge	Pre-test	4.7813	32	1.00753	0.17811
	Post-test	28.8125	32	1.30600	0.23087
Skills	Pre-test	51.2188	32	1.49697	0.26463
	Post-test	176.3125	32	3.26702	0.57753

Table 3: Result of gain scores for knowledge competency for experimental class 1 and control 1.

Class	Number of students	Knowledge gain scores	Skills gain
Experimental 1	32	24.03	125.09
Control 1	32	12.72	68.78

Efficiency of the STAD Learning Model

Table 4 shows that the STAD model improved the knowledge and skills competency of the students in the experimental class 2. Furthermore, the result of gain scores shows that the level of students' knowledge and skills competence in the experimental class 2 was higher than the students in control class 2, as shown in Table 5.

Table 4: Paired sample statistics for experimental class 2 for knowledge competency.

Competency		Mean	N	Std. deviation	Std. error mean
Knowledge	Pre-test	4.3750	32	1.40850	0.24899
	Post-test	24.4688	32	1.99975	0.35351
Skills	Pre-test	51.3125	32	1.89119	0.33432
	Post-test	160.5000	32	3.24286	0.57326

Table 5: Result of gain scores for knowledge competency in experimental class 2 and control 2.

Class	Number of students	Knowledge gain scores	Skills gain
Experimental 2	32	20.09	109.19
Control 2	32	13.19	70.16

Results of the Effectiveness Test

The effectiveness was obtained by comparing the post-test results for experimental class 1 with experimental class 2. In addition, the effectiveness result can be seen from the gain scores for experimental class 1 and experimental class 2.

Table 6 shows that the average knowledge and skills competency post-test for experimental class 1 was greater than for experimental class 2.

Table 6: Group statistics for knowledge competencies.

Competency		Mean	N	Std. deviation	Std. error mean
Knowledge	Post-test experimental 1	28.8125	32	1.30600	0.23087
	Post-test experimental 2	24.4688	32	1.99975	0.35351
Skills	Post-test experimental 1	176.3125	32	3.26702	0.57753
	Post-test experimental 2	160.5000	32	3.24286	0.57326

Table 7: Independent sample test for knowledge competencies.

Competency	*t*-test for equality of means			
	t	Sig. (2-tailed)	Mean difference	Std. error difference
Knowledge	10.288	0.000	4.34375	0.42222
Skills	19.432	0.000	15.81250	0.81374

In Table 7, the value of *t* and the value of the mean difference is positive, which indicates that the average for experimental class 1 was higher than that of experimental class 2. So, it can be concluded that the application of project-based learning was more effective than was STAD in improving the competence of students' Web programming knowledge.

Furthermore, Table 8 shows that the score for experimental class 1 was higher than that for experimental class 2.

Tabel 8: Gain scores for knowledge competencies for experimental class 1 and experimental class 2.

Class	Number of students	Knowledge	Skills gain
Experimental 1	32	24.03	125.09
Experimental 2	32	20.09	109.19

DISCUSSION

Differences in the competence of students' knowledge and skills using project-based and STAD learning models can be seen from the effectiveness of the post-test results for experimental class 1 and experimental class 2.

Differences in Knowledge Competency

Based on Table 6, it can be seen that the post-test result for experimental class 1 for knowledge competency was higher than the result for experimental class 2. So, it can be concluded that the application of project-based learning was more effective than STAD in improving the competency of students in Web programming.

The superior in students' knowledge competency from using project-based learning compared with STAD co-operative learning was caused by differences in the way students gain conceptual understanding of Web programming materials. Students in the project-based learning class gained knowledge through the process of identifying the problem, designing and producing the solution, hence leading to a better understanding and improved competency.

Project-based learning requires students to learn independently. Thus, students learn to identify what they understand and identify what they do not. This provides an opportunity for students to work autonomously. This is in accordance with one of the basic principles of cognitive learning theory that the activeness of students in finding information to solve problems will help their understanding. This is a consequence of the critical thinking skills required to solve cognitive problems.

Students in the class using STAD co-operative learning gained an understanding of the concepts of Web programming through the teacher's explanation. The understanding gained through teacher explanation will vary because not all of the students will have the same skills and abilities. In addition, students who are taught by the STAD method will tend to use only the information or subject matter that has been delivered by the teacher. Although the result of the students' knowledge competency in the class taught by STAD is high, it is still lower than is that for the class taught with project-based learning.

Differences in Skills Competency

Based on Table 9, the value of post-test competency of experimental class 1 was higher than the post-test result for experimental class 2. It can be concluded that the project-based learning model is more effective than the STAD learning model in improving students' skills in Web programming.

The difference in students' skills outcomes in classes taught by project-based learning and by STAD co-operative learning are due to different cognitive processes. These differences of cognitive processes in learning are shown in Table 9.

Referring to Table 9: students who learn to use project-based learning conduct learning activities, from the beginning to the end, independently. However, students who use STAD co-operative learning conduct independent learning activities only on completion of a task through group discussion and at the time of presenting the results.

Table 9: The differences of cognitive processes in project-based and STAD learning.

Cognitive process		
Project-based learning		STAD learning
1	Identify problems and construct basic concepts to complete project tasks using information sources from the Internet, direct observation and question and answer sessions.	Construct the basic concepts through information sources and explanations from the teacher accompanied by questions and answers to understand the teacher's explanation.
2	Carry out a problem-solving process by independently designing a project tailored to the topic under study, followed by prototyping and project creation.	Complete assigned tasks with information, instructional materials and directions provided by the teacher, as well as through group discussion.
3	Analyse the project based on basic concepts, information obtained and input, as well as suggestions from the teacher.	Analyse the results of tasks with inputs and suggestions from the teacher, and other groups, then present the results.
4	Strengthen understanding and knowledge through practice and application.	Strengthen understanding through practice and application.

Scientific learning, such as project-based or STAD, can develop students' skills in problem solving. Students are able to analyse a problem, develop hypotheses or questions, design experiments, make observations, engage in question and answer (QA) activities and finally draw conclusions.

Student learning activities, ranging from identifying issues about the topic under review and then designing, creating and evaluating a project, will require them to think critically about complex issues and concepts. The competency of students is higher after project-based learning than after STAD co-operative learning.

CONCLUSIONS

Based upon research, it was concluded that project-based learning and STAD co-operative learning can increase students' knowledge and skills in Web programming. However, project-based learning was more effective in improving knowledge and skills of Web programming than was STAD co-operative learning.

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