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Statistical Analysis of Cooperative Strategy Compared with Individualistic Strategy: An Application Study

Tawfik A. Saleh[1]
King Fahd University of Petroleum and Minerals, Kingdom of Saudi Arabia

Abstract

The study investigates the effect of cooperative and individualistic learning strategies on the academic performance of students in the general chemistry laboratory. The samples of the study were divided into experimental and control groups. The hypotheses were first generated and, after collecting data, analyzed by an analysis of t-test at an $\alpha = 0.05$ level of significance. The findings revealed that a cooperative learning strategy is more effective than an individualistic strategy; and, the students in the cooperative group performed significantly better. The mean difference of the final examination of 6.80, $t = 6.10$, $p = 0.001$ indicated that the difference of the results for control group and experimental group was significant at $p<0.05$. Students of cooperative groups, at the end of the course, were given a questionnaire to reflect their perception. Their response was positive toward the cooperative learning strategy. 90% of the students would like to help, get help and mutually discuss the labs with their partners. A majority of them were in agreement that working as a group to conduct an experiment could improve their teamwork skills as well. This study adds to the global discussion about the role of the University in preparing students toward teamwork.

Keywords: Cooperative learning, individualistic learning, general chemistry, laboratory, scholarship of teaching, effective teaching, teamwork.

In pedagogy, educators seek for a learning methodology to teach a specific subject properly so that students maximize learning. Learning appropriately occurs when students are actively involved in the construction of their knowledge (Mestre & Cocking, 2002). Generally, there are three major learning structures: competition learning, independent (individualistic) learning, and cooperative learning (Roon, et al., 1983). These three ways of learning lead to different interaction patterns and thus promote different learning outcomes. In competition learning, students perceive that they can achieve their goals if other students fail to do so. In independent learning, the achievement of each student is unrelated to others; there is no concern about competing for grades since there is an individualistic goal structure and student goal achievement is independent. In cooperative learning, students' goal achievements are positively correlated. Cooperative learning (CL) is defined as a technique for helping students to work together in small groups more

[1] Corresponding author's email: tawfik@kfupm.edu.sa

effectively to achieve shared goals with maximum learning (Johnson & Johnson, 1999). Johnson and Johnson (1989) have indicated that CL fosters creative thinking such that students in a group generated new ideas, strategies and solutions which are more powerful than those generated in individual learning. Also other studies have pointed out that CL helps to improve students' achievement and retention and develop more positive attitudes towards learning skills (Pressel, 1992; Nichols and Miller, 1994). It is more effective than competitive learning (Kolawole, 2008). Roon used CL groups in a biochemistry laboratory course for first year students and reported that the faculty were positive about CL impact (Roon et al., 1983). According to the educational literature related to CL methods, CL requires six principles. (1) Individual accountability: all students contribute to know and master the material, learn and share their knowledge and ideas with their teammates; (2) Positive interdependence: the success of all members in the group is linked through goals and materials so everybody should understands that his contribution is important in achieving the shared goals or tasks and others' understanding; (3) Cooperation as a value: students have to know that cooperation is not only a way to learn but it is a part of the content to be learned; (4) Equal participation: the structure of the goals to be learned should encourage and promote group members to fairly participate equally; (5) Simultaneous interaction: to ensure that more than one member is actively engaged at a time. At least one student gives the idea and the others receive the idea and mutually discuss it; and (6) Promotive interaction: students can have face to face interaction in at least part of the task (Johnson & Johnson, 1994; Johnson, Johnson, & Smith, 1998; Kagan, 1994; Jones & Jones, 2008; Jacobs, Power, & Loh, 2002; Jacobs, 2008). These six elements are used as a basis for implementing CL in this work due to its solid foundation in educational research.

This paper describes and statistically analyzes the application of CL as a strategy of introducing general chemistry laboratory to enhance students learning and satisfaction.

Objective of the Study

The purpose of the study includes the comparison of the academic performance of students taught with CL strategy and those taught with individualistic learning strategy in general chemistry laboratory.

Statement of the Problem

Despite its efforts to prepare students for the practice of chemistry, Chemistry departments confront challenges related to increasing diversity of students' backgrounds in basic science and the failure of many students to appreciate the important role of chemistry in the practice. In addition, many students are impatient with studying basic science because they are primarily motivated to enter their major of interest and do not perceive the direct relevance of the science of chemistry to their majors. To make chemistry interesting and to contribute to greater efficiency and effectiveness, a number of innovative approaches have been used in teaching including cooperative learning and individualistic learning. Thus, the main problem this study investigates is to determine which of these

learning strategies leads to better achievements of the students in the chemistry laboratory and to what extent do these learning strategies affect the learning outcomes.

Based on this, the author postulated the following question: Will those taught with a co-operative learning strategy and those taught with an individualistic learning strategy perform equally in chemistry laboratory?

Hypotheses

Based on the statement of the problem, the following hypotheses are generated and tested at an $\alpha = 0.05$ level of significance:

> **Hypothesis 1:** There is no significant difference between the academic performance of students in experimental and control groups taught with individualistic learning strategy in the first three experiments.
>
> **Hypothesis 2:** There is no significant difference between the mean academic performance of students taught with an individualistic learning strategy and those taught with a cooperative learning strategy during the other 8 experiments.

Methodology

Research Design and Implementation

Both an experimental group and a control group were established for this study. To determine whether there were any statistical differences between the control and experimental groups, an individualized learning strategy was used during the first three experiments for both groups. Then, starting with experiment four, the study was performed by using CL to teach some sections of students (experimental group) and using individualized learning to teach the other sections (control group). All students are taught the same experiments using the same materials, have the same facilities, and the same form of quizzes, assignments and exams. Specifically, the principles of CL were explained to the students of experimental group and they were instructed and encouraged to function as units in conducting the experiments, related laboratory concepts, calculations and the reporting of the data. On the other hand, the students in th control group were instructed and encouraged to work individually. Each student had to turn in individual report.

Students' performance in the laboratory was assessed in three ways: laboratory reports, quizzes, and a final examination. The laboratory reports included laboratory data and calculations. Uniformity of grading was encouraged by the use of detailed scoring keys. In laboratory quizzes, only laboratory-related material was included and questions required single word, sentence, or paragraph answers. At the end of the course, students were examined practically and theoretically.

Variables and Instruments

The independent variable in this study is the learning approach (cooperative learning vs. individualized learning), and the dependent variables are the students' achievements as measured by their report, quizzes and final semester examination scores, and their attitudes and perceptions.

The measuring instruments used in this study consisted of the experiments' reports, quizzes and final semester examination. The quizzes were designed to measure the performance of the students. The statistical tools used to analyze the experiments' reports, quizzes, and final exam scores in the study were the mean, the standard deviation, and the student t-test. Students also were asked to fill out a questionnaire to reflect their opinions and perceptions.

Validity and Reliability of the Instruments

The instruments were validated by content and face-to-face validity methods. For validity, the instruments were revised with the suggestions of the experts in the field. During the final week of the semester, some students in the experimental group were randomly chosen for face-to-face interviews.

Administration of the Instrument

A purposive sampling technique was used to divide the sample into two groups; experimental group taught using comparative learning and the control group taught using individualistic learning. In order to ascertain the homogeneity of the treatment groups, the same work scheme was used in explaining the experiments and introducing the quizzes and final exam. After treatment, the scores of both groups were collected and subjected to appropriate statistical analysis. The hypotheses were analyzed by analysis of the t-test at an $\alpha = 0.05$ level of significance.

Results and Discussion

Qualitative Findings

The attitudes of students were assessed in two ways: 1) by observation and discussion with students (face-to-face interviews) and 2) by administration of a written questionnaire. From the students' responses in the interviews and laboratory observation, most of them showed a very positive response and expressed that they like the CL method instead of the individualistic learning method. They welcomed the CL strategy and enjoyed learning and hoped that the teacher would continue implementing this strategy. It was observed that the students were motivated to perform better than their previous performance since they had a chance to mutually discuss the experiment with their partners. In the students' opinion questionnaire, administrated at the end of the course, students in the experimental group were asked to respond to statements about the laboratory taught by cooperative learning. The results of this questionnaire are presented in Table 1.

Table 1: Students' perception about the application of the strategy.

Statement	%				
	SA	**A**	**N**	**D**	**SD**
I prefer to work individually to perform the whole experiment.	10	15	0	35	40
I prefer to work cooperatively with teammates to perform the experiment.	70	20	0	10	0
I like helping others understanding the content of the experiment.	70	20	10	0	0
I would like to get help from others understanding the content of the experiment.	30	40	10	10	10
Working cooperatively increases mutual discussion of contents of the experiment with teammates	70	20	10	0	0
Working cooperatively improves understanding the experiment	30	50	10	10	0
Working as a group to conduct an experiment increase positive interdependence	45	45	10	0	0
Working as a group to conduct an experiment improve the teamwork skills	70	20	0	10	0
Working as a group to conduct an experiment improve my laboratory skills	30	30	20	10	10
Working as a group to conduct an experiment make the lab more enjoyable and interesting	60	20	20	0	0
Ease and speed of the lab improve when we work as a group	35	35	10	10	10

SA: strongly agree; A: agree; N: neutral; D: disagree; SD: strongly disagree.

In general, the students were positive about the cooperative learning strategy. A majority of them preferred to work cooperatively, rather than individually, to conduct the experiments. 90% of them did like to help, get help, and mutually discuss the experiments with their partners. This led to positive interdependence. A majority of them were in agreement that working as a group to conduct an experiment could improve their teamwork skills.

Quantitative Findings

Hypothesis 1: As illustrated in Table 2, the results show that the control group obtained 80.67 mean score compared to the experimental group which obtained an 80.33 mean score. The mean difference of 0.34, $t = -0.277$, $P = 0.808$ indicated that the difference of the results between the control group and the experimental group was not significant ($p > 0.05$). Hence the null hypothesis is accepted at an $\alpha = 0.05$ level of significance. Thus, there was no significant difference between both groups when individualistic learning was used for both groups in the first three experiments (Table 2 & Figure 1). Therefore,

Table 2: Statistical analysis of reports' scores of pre-application of strategy.

Source of variation	Mean	SD	t_c	t_t	*P*	Result
Experimental group	80.67	7.30	0.277	1.96	0.808	NSS
Control group	80.33	7.40				

SD: standard deviation; t_c : student t-test calculated; t_t : student t-test tabulated; P-value; NSS: not statistically significant.

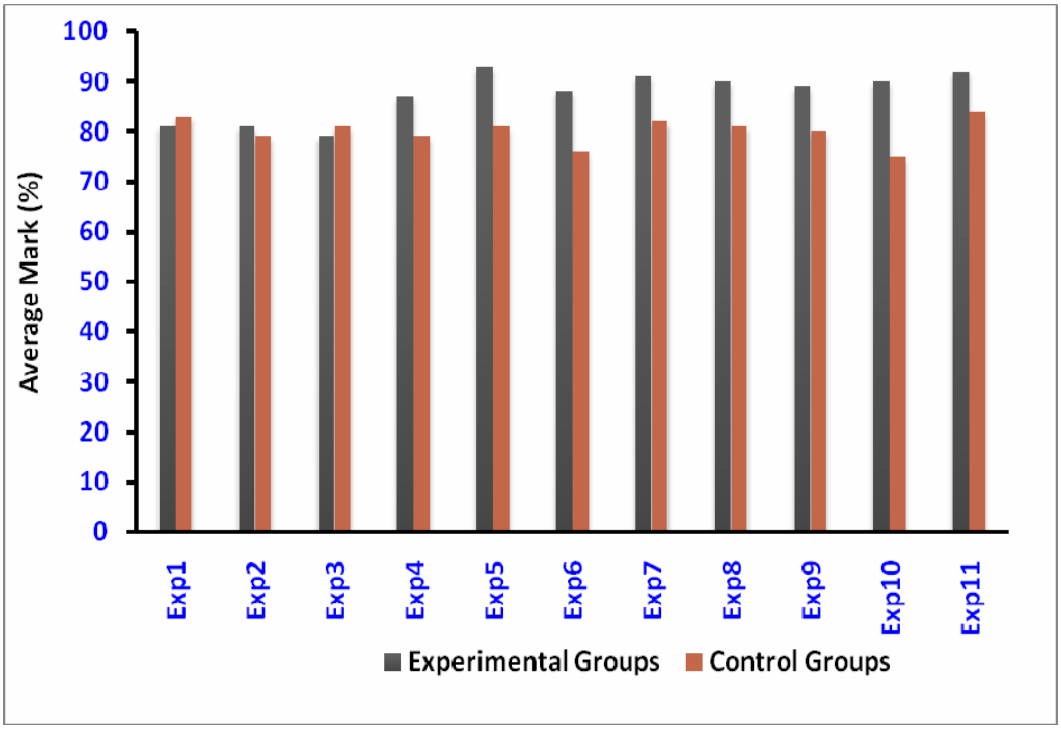

Figure 1: Mean experimental grades of students of both experimental and control groups.

before the study started, both the control and experimental group were not statistically different. Although the experimental group's mean score is 0.34 higher than the control group, the difference is not significant at $p < 0.05$ level.

Hypothesis 2: Table 3 shows that t-calculated vaue is greater than t-tabulated vaue; hence, the null hypothesis is rejected at an $\alpha = 0.05$ level of significance. This means there is a significant difference between the academic performance of students taught with cooperative and individualistic learning strategies in favor of cooperative learning strategy. After the application of the cooperative strategy, the analysis of the results in

Table 3: Statistical analysis of reports' scores of those taught with cooperative and individualized learning strategy (post-application).

Source of variation	Mean	SD	t_c	t_t	*P*	Result
Cooperative group	89.91	4.90	11.63	1.96	7.8×10^{-6}	SS
Individulistic group	79.75	7.70				

SD: standard deviation; t_c : student t-test calculated; t_t : student t-test tabulated; P-value; SS: statistically significant.

Table 3 showed that the students taught with cooperative learning strategy performed better than those taught with th individualistic learning strategy. The experimental group obtained a higher mean score of 89.91 as compared with the mean of 79.75 for the control group. The difference between the means scores of both groups is significant. The mean difference is only 0.34 during th pre-application of the strategy, and it increased to 10.16 after the application of the cooperative strategy (Table 3 & Figure 1).

The statistical analysis of the final semester examination mean scores for both groups was carried out. The results, as illustrated on Table 4, show that the control group obtained a 78.10 mean score as compared to the experimental group, which obtained an 84.90 mean score. The mean difference of 6.80 with $t = 6.10$ and $P = 0.001$ indicates that the difference between the control group and the experimental group was significant at $p<0.05$. The experimental group had higher mean scores than those of the control group, and the results were statistically significant. Therefore, the learning through a cooperative strategy had produced positive effects.

Table 4: Statistical analysis of final examination scores.

Source of variation	Mean	SD	t_c	t_t	*P*	Result
Cooperative group	84.90	3.5	6.1	1.96	0.001	SS
Individulistic group	78.10	6.9				

SD: standard deviation; t_c : student t-test calculated; t_t : student t-test tabulated; P-value; SS: statistically significant

Conclusion

This study has proven that a cooperative learning strategy is more effective than an individualistic learning strategy in teaching the general chemistry laboratory. The advantage

of a cooperative learning strategy is not only to teach but also to create and enhance students' motivation, interest, and achievement. This definitely can bring about more effective learning. The study adds to the global discussion on the effect of the CL to enhance practical performance and understanding, and thus motivates the interest in the learning of practical subjects.

Recommendations

Based on the findings, it is hereby recommended that: cooperative learning strategy should be adopted as an effective learning strategy in order to improve student's performance, social interaction skills and foster meta-cognition in students. In addition, the results of this study provide guidelines for further research and are used to create innovative knowledge creation in other fields. The effectiveness of the cooperative learning strategy is recommended to be studied in other subjects.

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