PRINT: ISSN 0975-1122 ONLINE: 2456-6322
Int J Edu Sci, 15(3): 377-381 (2016)
DOI: 10.31901/24566322.2016/15.03.08

Effect of Jigsaw Method on Students' Chemistry Laboratory Achievement

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KEYWORDS Assessment. Chemistry. Instruction. Laboratory. Jigsaw

ABSTRACT This paper analyzed the effect of jigsaw method on prospective elementary science teachers' chemistry laboratory achievement. The sample consisted of (n=63) students who were studying at elementary science education program. Students were divided into two groups using the true experimental design. Universe of the research of the research consists of all the students studying at the same program. A pre-test whose reliability score was 0.689 and a post-test whose reliability is 0.720 were given to students to assess students' academic and whose reliability score was 0.720 were given to students to assess students' academic and experimental knowledge. Students in the groups took two quizzes each week, one before the experiment and another after the experiment. The research was completed in seven weeks. Data analysis was carried out through independent samples t-test analysis. Further analyses were carried out to investigate gender factor in the paper. Research revealed that jigsaw method increases students' academic achievement. The research also revealed that gender has no effect on academic achievement.

INTRODUCTION

Education is shaped with respect to the demands of the changing world; a knowledge-based economy has shaped educational approaches, pedagogy and curriculum. Individuals and societies are being shaped spontaneously with respect to changing demands. Countries are beginning to start educational reforms to reach or keep pace with increasing knowledge (Tang et al. 2012; Dogan et al. 2015). This could be achieved through education by raising the individuals who have analytical thinking strategies. In this aspect, it is important that the individuals in the society have science literacy, understanding of science and ability of using scientific process. Active learning is one of the methods which can be used to reach the desired goals (Gardner and Belland 2012). Active learning may trigger the situational interest of students in topics; thus, this may help students to understand conceptual facts (by using deeper processing strategies). Cooperative learning methods are also one of the active learning methods and it is based on simple psychological needs for competence which promotes learning (Rotgans and Schmidt 2011; Uyanik 2016). Active learning is a good way to facilitate learning because it enhances thinking strategies which in fact develops cognitive skills of students (Buckley et al. 2011; Byrd 2012). However, to improve the students' thinking strategies, it is also necessary to ask them appropriate questions. This means teachers should also be prepared for unexpected questions and answers from students. Moreover, it is also important to give students hands-on activities or homework since it is an essential tool of visualizing the lecture topics for the students (Shieh et al. 2010). Studies point out that students, when become teachers, tend to teach in the way they learned through their education life. This means pedagogy or core concepts taught at school about teaching and information is not embraced by the future teachers but instead they tend to act with respect to facts based on their experiences. In that case, it is important to give information to students (future teachers) in a constructivist approach which may help the students to experience meaningful learning, and help their future students to achieve better meaningful learning (Tang et al. 2012). Jigsaw technique is one of the active learning techniques used for educational purposes. This technique relies on sharing materials, purpose and time between students within a group. By doing this, it is assumed that students will benefit from each other, socialize, gain responsibility and regulate their learning (Doymus 2007; Yoonkyung and Yongseob 2015). Bonestroo and Jong (2012)

pointed out that self-learning activities are one of the key factors increasing students' critical thinking levels. However, it is also important to incorporate proper planning into learning activities since studies also indicated that planning has the biggest effect among the factors affecting students' achievement. Cetin and Akkus (2016) also implied similar points of view. In their paper, they implemented jigsaw technique in the chemistry laboratory and they argued that if course content is not related with proper assessment then positive learning outcomes would not be achieved. Implementing cooperative learning in the right way not only increases academic success but also have positive effects on long term retention of knowledge (Dat 2016). Warfa (2016) in his paper showed that there is a positive relationship between cooperative learning and chemistry achievement. Similar findings were reached by Joel et al. (2016), pointing out that cooperative learning groups have better academic achievement than traditional groups and these findings are statistically significant. Yoruk (2016) used Jigsaw technique in Chemistry laboratory, and pointed out in his paper that using Jigsaw technique in chemistry laboratory increases students' awareness towards chemistry, chemistry laboratory, and their surroundings along with increasing positive social skills.

Objective

The purpose of this paper is to determine the effect of Jigsaw technique on prospective elementary science teachers'academic achievement for chemistry laboratory course.

MATERIAL AND METHODS

Research Design and Sample

The study population consisted of all the students studying Elementary Science Education. Of these, 63 were chosen; hence, the study sample consisted of 63 students studying Elementary Science Education in their first grades. The study was implemented using true experimental design. Students studying chemistry laboratory course were given a pre-test to determine students' academic knowledge level. Reliability analysis of pre-test was conducted using Cronbach Alpha's reliability and questions which scored below the expectation of the reliability test were exempted. Pre-test consisted of 20 questions and Cronbach's Alpha of reliability for pre-test was determined as 0.689.After obtaining the required data related with students' academic level, students were divided into two groups through the s-shaped distribution method. By this method, it was ensured that both groups were at equal levels of academic knowledge. Consequently, one of the groups was randomly selected as the experimental (Jigsaw) class while the other group was selected as the control (traditional) class. For internal validity, the same instructor worked with both groups. Six experimental (E) topics were selected for the laboratory course and both groups did the same experiments. Experiment topics are shown in Table 2. The only difference between the two classes is their study method. The control class conducted the experiments with respect to the traditional laboratory instruction as advised by the curriculum while the experiment class conducted the experiments using the jigsaw method.

Jigsaw Appliance in the Laboratory

Students in the experiment class were informed about the jigsaw technique and then randomly divided into five groups. Each group consisted of five or six students. Each group was named alphabetically (Group A, Group B, Group C, Group D and Group E) and students in the groups were tagged with respect to their group name. For example, first student in group A was tagged as A1, and last student was tagged A5. This step was applied for all the class. All students in each of the classes were informed that they will take two quizzes, before and after the experiment.

First Phase: After creating groups; each third tagged student in each group was selected as the group leader who would be responsible of regulating the group work. Later, students with the same numbers came together and created a different group which was named the specialized groups. Each specialized group studied only one specific experiment in one week. Students studied both the theoretical and experimental elements of experiments and prepared questions related to the experiment, and then they passed into second phase.

Second Phase: Students carried out the experiments and outlined problems or obstacles

they encountered during experiments. Those obstacles might be related to carrying out the experiments or understanding the experiments. Studying experiment both theoretically and experimentally, each student in the specialized groups are titled as teacher of the experiment. Teacher of the experiments were asked to teach and carry out the experiments with their original groups next week.

Third Phase: Each week, an experiment was carried out by the specialized students (teacher of the experiment) and specialized students prepared their groups for quizzes. For that purpose, groups came together before the experiment. The teacher of the group studied with the whole group and prepared his/her group for the theoretical knowledge (TK) quizzes. TK consisted of five questions; thus, the maximum number of points that can be obtained by a student is five points. After carrying out the experiment, the teacher of the group prepared his/her group for the experimental knowledge (EK) quizzes. EK consisted of five questions; thus, the maximum number of points that can be obtained by a student is five points. The third phase was carried out by the experimental class for six weeks and each week, the teacher of the experimental group studied with his/her group. Every week teacher of the experiment changed with respect to experiments. Thus each student had the chance to become teacher of the experiment for one week. After finishing all the experiments, all the students who worked in both classes took the achievement test (post-test).

RESULTS

Pre-study Data Analysis

To determine the difference between the control and experiment classes and the effect of gender, t-test for independent groups run.

Table 1: Independent t-test for groups and gender

Pre-test	*n*	*X*	*sd*	*t*	*P*
Traditional	29	5.52	3.680	1.731	0.90
Experiment	29	4.10	2.410		
Boys	22	5.59	3.157	-1.484	0.143
Girls	36	4.33	3.117		

The data in Table 1 implies that there is no significant difference between the groups: Groups' academic levels are similar to each other. Experiment group's mean is lower than Traditional group mean and that difference is 1.42 points. t-test's result also shows that this difference is not significant statistically ($p=0.90 > 0.05$). It is also shown that academic levels of gender are similar to each other as well. Only difference for gender occurs at their mean value and boys' mean point is higher than girls', which is 1.26 point. t-test's result also shows that this difference is not significant statistically ($p=0.143 > 0.05$). That case supports the idea that students' distribution to groups is random and groups are homogenous with respect to each other in terms of academic knowledge. It should be also noted that after pre-test some students were enrolled in the course, thus to keep internal consistency of the paper, the researcher distributed the extra students randomly to both experiment and control groups.

Jigsaw Appliance in the Laboratory and Quiz Test Results

Every week, each student in the groups was given a quiz before and after experiment. Quizzes done before experiment are related to academic knowledge of the topics covered in the experiment. Five questions were asked to assess students' theoretical knowledge. Quizzes done after experiments were related to experiment academic knowledge. Five questions were asked to assess students' experimental knowledge. By this way, it was aimed to show differences between the groups in terms of academic and experimental knowledge. Table 2 shows information about topics carried out in the laboratory. Table 3 shows the weekly quiz data with respect to experiment topics.

Table 2: Experiment topics carried out in chemistry laboratory

Experiment 1	Properties of matter
Experiment 2	Density of matter
Experiment 3	Melting and freezing point of matter
Experiment 4	Solubility of matter
Experiment 5	Separating mixtures by using density and melting of matter
Experiment 6	Separating mixtures by using solubility of matter

Post-study Data Analysis

After all the experiments were carried out in the laboratory, an achievement test was pre-

Table 3: Weekly quiz data

	E1		*E2*		*E3*		*E4*		*E5*		*E6*	
	TK	*EK*	*TK*	*EK*	*TK*	*EK*	*TK*	*EK*	*TK*	*EK*	*TK*	*EK*
Jigsaw	2.23	3.60	1.58	2.77	2.15	3.79	3.80	3.00	1.41	2.62	1.89	3.63
Traditional	1.78	2.81	1.63	2.42	1.97	3.86	3.10	3.39	1.14	2.58	2.07	3.29

pared. All the questions asked were related to experiments done in the laboratory and it aimed to determine experimental knowledgelevel of the students related to the experiments done. After doing reliability analysis through Cronbach's Alpha method, questions below the reliability score were omitted from the achievement test, leaving the test with 30 questions with a reliability value of 0.720. To determine the difference between control and experiment group, and effect of gender, t-test for independent groups was run for each factor and results are shown in tables:

Table 4: Independent t-test for groups and gender

Post-test	*n*	*X*	*sd*	*t*	*P*
Traditional	31	21.39	4.447	-2.441	0.018
Experiment	32	23.78	3.220		
Boys	24	23.00	4.263	-0.611	0.544
Girls	39	22.36	3.910		

Analyses of data in Table 4 outputs that experiment group's mean value is 2.39 point above the control group. t-test results show that this difference is significant statistically and in favor of the experiment group ($p=0.018 < 0.05$). That result shows that the new method (jigsaw) introduced to classroom has positive impact on students' level of understanding related to experiment topics. A further analysis was done to investigate the gender factor. To determine gender effectiveness on academic success, independent t-test was run and result is also shown in Table 5. It is clear that boys' academic achievement test's mean is higher, 0.64 point than girls; however, this difference is not significant statistically ($p=0.544 > 0.05$). To investigate the effect of gender factor further, statistical tests are run for the experiment group. A Shapiro-Wilk test was run for normality and it was found that data was normally distributed ($p =0.064 > 0.05$). Thus an independent t-test was run and results are shown in Table 5.

Table 5: Independent t-test for gender within experiment group

Post-test	*n*	*X*	*sd*	*t*	*P*
Girls	19	23.79	3.190	0.017	0.986
Boys	13	23.77	3.395		

Data analyses shown in Table 5 implies that there is no gender difference in terms of academic achievement within the experiment group ($p=0.986 > 0.05$). In that case, it may be assumed that new educational method introduced to education environment has nearly the same effect on both genders.

DISCUSSION

Weekly experiment tables show that experiment group has better theoretical knowledge when compared to control group (Experiment 1, 3, 4, 5). This implies that experiment group acquired more knowledge on the topics; however, the method did not work for experiment 2 and 6. When analyzing the experiment knowledge statistics, it is clear that experiment group has better understanding when compared to control group for the experiment 1, 2, 5 and 6. However for experiment 3 and 4, the method did not work as desired and hence control group has better experiment understanding and thus knowledge. That result might be due to questions asked in quizzes which might not properly assess students' knowledge. Cetin and Akkus (2016) also implemented Jigsaw technique into the chemistry laboratory course and they used weekly quizzes. Yet they did not give any details on quizzes. However, it is also noteworthy that they emphasized the importance of the questions students are asked. They pointed out that if questions asked do not correlate with experiment experiences then students would be unable to comprehend the relationship between course and questions asked which eventually result in poor success or no success at all which are based on assessment.

For further discussion, pre and post-test analyses were done. It is clear from Table 1 that

students in both groups have similar academic knowledge and this case is also valid for gender. However, post-test results showed that experiment group did better on achievement test and this difference is significant in terms of statistics. In that case, it is safe to assume that experiment group did better than traditionalon post-achievement test. Another point shown by Table 5 is that group's success is not based on gender but on the group's instruction method itself. Uyanik (2016) stated that if jigsaw technique is implemented correctly then it is highly possible for the students to increase their academic success. Akcay (2016) also reported similar findings in her/his paper: there is no statistically significant difference for the gender factor; however, the researcher indicated academic success in favor of jigsaw implemented group, and also stated the importance of right implementation of the jigsaw technique results for academic success.

CONCLUSION

The paper itself showed that when jigsaw technique is applied correctly, it has positive effects on learning, however observing some lower statistics in terms of weekly experiment quizzes, it may also be assumed that students either/both need further guidance from the instructor for better learning, or/and questions asked for assessment should be relevant to students' learning experiences.

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Paper received for publication on April 2016
Paper accepted for publication on November 2016