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THE EFFECTS OF HANDS-ON ACTIVITIES INCORPORATING A COOPERATIVE LEARNING APPROACH ON EIGHT GRADE STUDENTS' SCIENCE PROCESS SKILLS AND ATTITUDES TOWARD SCIENCE

Ibrahim Bilgin

Abstract. *The purpose of this study was to investigate the effects of hands-on activities incorporating a cooperative learning approach on eighth grade students' science process skills and attitudes toward science. The sample of this study consisted of 55 students, from two different eighth grade classrooms in an elementary school, which were instructed by the same science teacher. The classrooms were assigned randomly as the control group and the experimental group. In the experimental group, hands-on activities were employed along with cooperative learning approach; whereas in the control group, the same activities were employed using teacher demonstration approach. In order to assess the treatment effects on eighth grade students, Science Process Skills Test (SPST) and Attitude Scale toward Science (ASTS) were administered as pre- and post- tests to the control and experimental groups. Pre-tests were used as covariates. The results of MANCOVA showed that students in the experimental group had better performance on Post-SPST scores and Post-ASTS.*

Key words: *science process skills, hands-on activities, cooperative learning approach, teacher demonstration approac*

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Introduction

The knowledge that has been accumulated since the first eras is collected systematically. The whole of this knowledge collection is called the knowledge content. In today's world, with the rapid advance in knowledge and technology, teaching different ways to attain knowledge has been emphasized rather than supplying pre-packaged knowledge to students. Several examples in the literature (Campbell, Campbell and Dickinson, 1999; Haar, Hall, Schoepp and Smith, 2002; McKeachie, 1994) point out the fact that in the classroom, some changes regarding the roles of the teachers should be conducted. These studies reached the following common results:

1. The teacher shouldn't see himself or herself as the center of all activities, as the basic source of knowledge, or as the licensed expert.
2. The teacher shouldn't convey the knowledge to his or her students, but rather he or she should reinforce research and motivate students to participate in classroom activities.
3. The teacher should prepare course contents and teaching methods by taking students' individual differences into consideration.

According to the constructivist theory, learning is the interpretation of what is happening in the world from the point of view of the individual in planned experiences (Jaworsky, 1994). With the word 'experience', it is meant that students take part in the learning-based activities, feel the activity by using all possible senses, and reach a conclusion

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after thinking in terms of cause-effect relations. Perceiving, organizing, and classifying the knowledge; interpreting experiences; and reaching a conclusion are important elements in developing concepts.

Science process skills are defined as an understanding of methods and procedures of scientific investigation. They are related to the proficiency in using various aspects of science and are associated with cognitive and investigative skills. Through these skills, scientists collect knowledge, put experiments together, analyze data, and formulate results. Science process skills are very important for meaningful learning; because learning continues throughout the life, and individuals need to find, interpret, and judge evidences under different conditions they encounter. Therefore, it is essential for students' future to be provided with science process skills at educational institutions (Harlen, 1999). If these skills are not developed sufficiently, students cannot interpret the knowledge. For example, if the related evidence is not collected, collected concepts won't help students to understand what takes place (Tobin., Kahle, and Fraser, 1990). For this reason, the basic target in science classes should be teaching students how to attain knowledge rather than passing the convenient knowledge.

Several studies in the literature show that the science classroom is the most appropriate environment for students to gain experience in hands-on activities. Hands-on activities help students to learn science and gain more experience by doing different instructional strategies such as inquiry (Flick, 1993), computer simulation (Huppert, Lomask and Lazarowitz, 2002), web-based learning (Mohd, 2004), and cooperative learning (Okebukola and Ogunniyi, 1984). Some of the researchers indicated that acquisition of science process skills requires continued instruction (Arena, 1996; Padilla, 2004; Padilla, Okey and Garrard, 1984). Through hands-on activities, students use different senses in science classes by touching, feeling, moving, observing, listening, smelling and sometimes testing materials in a controlled manner. This helps students to progress from concrete thinking levels to more complex thinking levels (Jones, et. al., 2003). Although effects of hands-on activities in teaching and learning have been accepted, why and how these are effective are still discussed. According to the constructivist theory, students are not passive recipients of knowledge; they construct knowledge by participating actively in learning activities and by using cognitive processes (Wheatley, 1991). Therefore, if hands-on activities are demonstrated by the teacher or by video, students take the role of passive learners and this isn't as effective as their actively participation in hands-on learning activities in group dynamics (Daniel, 1993; Shapley and Luttrell, 1993). Cooperative learning approach provides an instructional learning environment in which students discuss the material, share ideas, listen, consider other's ideas, and clarify their thinking throughout verbal interaction with each other (Lonning, 1993; Watson and Mashall, 1995; Webb, 1982).

According to Newman (1990), social conditions in a class are constructed actively by the teacher and students. The learning environment constructed in the classroom should support interactive dialogue, discussion, and cooperation in activities. Science laboratories are the most important learning environments that provide the development of attitudes and cognitive levels in a positive manner and that lead students to discover scientific facts and concepts in small groups as well as providing development of social relations through activities. Due to these reasons, lab activities should be given more consideration in science teaching (Hofstein and Lunetta, 2004; Lazarowitz and Tamir, 1994).

With these basic principles, research showed that when science courses are enriched by cooperative learning approach, positive effects are found on achievement and higher level thinking skills, social development, and cognitive and emotional characteristics such as self-respect and attitude (Bilgin and Geban, 2004; Zacharia and Barton, 2004). Tobias (1992) reported that main reasons of students' negative attitudes towards science are the lack of interest and motivation, being passive recipients, competition with grades instead of cooperative learning, and rote learning based on problem solving instead of grasping concepts.

This study was conducted to investigate effects of hands-on activities incorporating a cooperative learning approach on eight grade students' achievement of science process skills and attitudes toward science.

The study was guided by the following research questions

1. Is there a significant difference between effects of hands-on activities incorporating a cooperative learning approach and teacher demonstration approach on eight grade students' science process skills when their pre-SPST scores were used as a covariate?
2. Is there a significant difference between effects of hands-on activities incorporating a cooperative learning approach and teacher demonstration approach on eight grade students' attitude toward science when their pre-ATSS scores were used as a covariate?

Methodology of research

The study included 55 students from two separate 8th grades instructed by the same science teacher in an Elementary School located in an urban area in Bolu.

The participants of this study were 55 8th grade students from two intact classes of an elementary school located in an urban area in Bolu, in Turkey. This study was conducted over a 15-week period in the spring term of 2004-2005 academic year. All participants attended three hour lecture per-week in a science course. One class was randomly assigned to the experimental group (n=28; 16 girls and 12 boys) while the other group formed the control group (n=27; 16 girls and 11 boys). The average age of the participants was 14 years.

In order to address research questions asked in this study, Science Process Skill Test and Attitude Scale toward Science were used.

Science Process Skill Test (SPST): This test included 30 items. In this test, 25 items were taken from Raming, Bailer & Ramsey (1995) and 5 items were taken from Gabel (1993). The test, which has 8 dimensions, includes 5 items related to observation, 3 items related to measurement and metric system, 4 items related to inferences, 3 items related to prediction, 4 items related to operational definition, 4 items related to controlling variables, 3 items related to interpreting data and 4 items related to testing hypotheses. Some examples of science process skills test were given in Appendix 1. All of the items in the test were adopted into Turkish by the researcher. Also, an English language teacher checked the translation and a science course instructor checked the content validity of the test. For pilot study, the test was applied to 861 7th Grade and 8th Grade students and the Cronbach's alpha reliability coefficient of the test was found to be .78.

Attitude Scale toward Science (ASTS): This scale, which was developed by Geban and Ertepinar (1994), measures the students' attitudes toward science as a school subject and contains 15 likert-type items (strongly agree, agree, undecided, disagree and strongly disagree). The reliability of this scale was found to be .83. ASTS was given in appendixe 2.

The researcher prepared teaching materials including theoretical knowledge related to the science process skills, open-ended questions, hands-on activities, and the comprehension test related to each activity from the literature (Gabel, 1993; Ramig, Bailer and Ramsey, 1995).

The theoretical knowledge related to the science process skills include observation, measurement, inferences, prediction, operational definition, identifying and manipulating variables, organizing and interpreting data, and formulating hypotheses and experimenting. Following activities were used in this study: 1) Penny observations, 2) Candle activity, 3) Measurement of mass and volume, 4) Measurement of temperature, 5) Mysterious journeys in the life of a raisin, 6) Creating a scientific model, 7) Penny prediction, 8) Prediction about paper and plastic, 9) Helicopter happening, 10) Telephone technology made simple, 11) Thinking about combustion, 12) Kaibab deer story, 13) M&M color experiment, 14) Pendulum experiment. Since the project emphases were centered on the science process skills of students rather than the specific content knowledge, hands-on activities were chosen from different science content areas. The treatment was conducted in one of the three hours of the weekly science classes.

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Experimental and control groups were given SPST and ASTS as pre-tests before the treatment. The science teacher was trained with cooperative learning approach and teaching materials. Although a worksheet, which included theoretical knowledge of science process skills, is given to the both experimental and control groups, the difference between to groups is explained below.

In the control group, students were instructed with teacher demonstration approach. The teacher first asked open-ended questions to get students' attention and chose some students to answer these questions. After the answers were given, the theoretical knowledge of science process skills was explained during the lecture. After the lecture over, the teacher presented an activity related to the subject to the whole class, A comprehension test, which measures students' understanding of each hands-on activities with the help of questions that will be answered by the students, was administered at the completion of particular activities using a projector, with the teacher allocating fair time and opportunity for the students.

Prior to the beginning of the treatment in the experimental group, the students were assigned to four member-learning teams in a small group-learning environment. The groups were heterogeneous with respect to their achievement: one high, two average and one low achiever students for their previous science exam scores. Students in the experimental group were trained about cooperative learning approach and the worksheets of hands-on activities including a detailed description of the cooperative learning approach were distributed to all of the students before the treatment. The teacher asked open-ended questions to raise an interest of the students about the subject. This time, students were asked to answer the questions first in pairs and then in groups of 4. When groups completed their work for each question and reached a consensus, the teacher asked some of the groups to explain their answers. The teacher continued asking questions until one of the groups provided the expected answer. The students first read the given information sheets individually and then they talked about what they understood in their groups. After the contents of information sheets were grasped, hands-on activities were applied in pairs. The results were recorded in each pair's worksheets and compared with the results of the other pairs. If the results were not matching, pairs repeated their activity within their groups or discussed the outcome by sharing their ideas. Only after reaching a consensus, they shared their findings with the whole class. After each hands-on activity, a comprehension test including questions that will be answered by each group was presented using a projector. After each pair discussed and shared their ideas with other pairs in the group, the group reached a consensus and wrote their explanations with the teacher allocating fair time and opportunity. A speaker is assigned for each group to report their explanations and the speakers within a group are changed for each answer.

The teacher got answers selectively from each student in the control group and the groups of 4 in the experimental group. However, in order to keep the learning environment fair, the teacher gave equal chances to the students to report their explanations. For this purpose, the teacher used a check list. If the answers were correct, positive feedback was given, if not, clues were provided or the activity was redone in order to reach the right answer. If the correct answer was still not found, the teacher explained the right answer with reasons. Only after the successful completion of these steps, another activity was used. At the end of the treatment, both the experimental and the control groups were administered SPST and ASTS as post-tests.

Students' grade levels (8^{th} grade), the number of hands-on activities, content knowledge related to the science process skills, and the instructional time were held constant. Dependent variables of the study were the students' achievement scores of SPST and ASTS. Independent variables of the study were the different types of instructions employed. The data obtained from pre- and post-tests were analyzed by using SPSS (Statistical Package for Social Sciences) (Norusis, 1991). When students' pre-SPST scores and pre-ASTS scores were used as a covariate, MANCOVA was used to test the research questions and to determine the treatment effects on students' post-SPST scores and post-ASTS scores.

Results of Research

Mean and standard deviation for pre- and post-test scores for the experimental and the control groups on SPST and ASTS are given in Table 1 and 2, respectively.

Table 1. Descriptive statistic for pre-and post-SPST scores.

		Pre-SPST		Post-SPST	
Group	n	Mean	SD	Mean	SD
Experimental group	28	13.54	2.22	22.14	3.35
Control group	27	12.85	2.29	16.52	3.46

Table 2. Descriptive statistic for pre-and post-ASTS scores.

		Pre-ASTS		Post-ASTS	
Group	n	Mean	SD	Mean	SD
Experimental group	28	52.75	3.68	57.64	5.82
Control group	27	52.41	3.92	53.00	6.89

It is seen from the tables that students' mean scores of pre-SPST and pre-ASTS were similar for the experimental and the control groups. Prior to the treatment, an independent t-test was employed to determine whether there was a statistically significant mean difference between control and experimental groups with respect to the pre-SPST and pre-ASTS scores. No statistically significant mean differences between the two groups were found with respect to the pre-SPST scores ($t=1.123$, $df=53$, $p>0.05$) and pre-ASTS scores ($t=0.334$, $df=53$, $p>0.05$). These results indicated that students in the experimental and the control groups have similar attitudes towards science and science process skills.

In order to investigate the effects of hands-on activities incorporating a cooperative learning approach on students' science process skills and attitudes toward science, MANCOVA was run on independent variables and pre-tests scores were used as a covariate to control the initial group differences. Before conducting the analysis of MANCOVA, the covariates were examined. According to Weinfurt (1995), a covariate should be used only if there is a statistically significant linear relationship between the covariate and dependent variables. Therefore, the condition has been tested with Pearson correlation between pre- and post-SPST scores and pre- and post-ASTS scores. Pre-SPST scores have significant correlation with post-SPST scores ($r=+0.397$, $N=55$, $p<0.01$) and pre-ASTS scores have significant correlation with post-ASTS scores ($r=+0.359$, $N=55$, $p<0.05$). Hence, pre-tests scores were used as a covariate.

One of the assumptions of MANCOVA is the homogeneity of covariance matrices. In order to test this assumption, Bax's Test was used. This analysis revealed that observed covariance matrices of dependent variables are equal across the experimental and the control groups ($F=0.373$, $p>0.05$). Therefore, this assumption was not violated. Levene's Test was used to check the assumption that error variance of dependent variables is equal across the experimental and control groups. All significant values for dependent variables, post-SPST scores ($F(1, 53)=0.003$; $p>0.05$) and post-ASTS scores ($F(1, 87)=0.253$; $p>0.05$), were greater than 0.05, meaning the equality of variances assumption was not violated.

After checking whether assumptions were violated, Hotelling's T was used to test the effects of hands-on activities incorporating a cooperative learning approach and teacher demonstration approach on students' science process skills and attitudes toward science. The results showed that there were significant differences between the dependent variables in the teaching methods

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used (Hotelling's T=0.991, F (2, 50) =24.775, p<0.05). Following up, ANCOVA was needed to decide which dependent variables were responsible for the significant effects on students' performance.

Table 3 and 4 contain the summary of ANCOVA comparing the mean scores of students' performances in both the experimental and the control groups with respect to the post-SPST and post-ASTS scores, respectively.

Table 3. Summary of ANCOVA comparing the mean post-SPST scores of the students in the experimental and the control groups.

Sources	df	Mean square	F	P
Treatment	1	361.197	37.566	0.000*
Pre-SPST	1	77.005	8.009	0.007*
Error	51	9.615		

*Significant at p<0.05

The analysis showed that students' pre-SPST scores have significant effects on their post-SPST scores (F (1, 51) =8.009, p<0.05). The results also indicated significant treatment effects F (1, 51) =37.566, p<0.05. The students in the experimental group who were instructed with hands-on activities incorporating a cooperative learning approach demonstrated better performances (adjusted mean=21.929) on SPST scores than the control group students who were instructed with hands-on activities incorporating a teacher's demonstration approach (adjusted mean=16.741).

Table 4. Summary of ANCOVA comparing the mean post-ASTS scores of the students in the experimental and the control groups.

Sources	df	Mean square	F	P
Treatment	1	224.347	6.400	0.015*
Pre-test	1	235.531	6.719	0.012*
Error	51	35.055		

*Significant at p<0.05

The analysis showed that students' pre-ASTS scores have significant effects on their post-ASTS scores (F (1, 51) =6.400, p<0.05). The results also indicated significant treatment effects (F (1, 51) =6.719, p<0.05). The students in the experimental group who were instructed with hands-on activities incorporating a cooperative learning approach demonstrated better performances (adjusted mean=57.371) on ASTS scores than the control group students who were instructed with hands-on activities incorporating a teacher's demonstration approach (adjusted mean=53.282).

Discussion

The main purpose of this study was to compare the effects of hands-on activities incorporating a cooperative learning approach and a teacher demonstration approach on the development of eight grade students' science process skills and attitudes toward science. The main differences between the two instructional approaches were as follows: students in the experimental group discussed open-ended questions, reading content knowledge related to science process skills and doing hands-on activities cooperatively in small groups, while in the control group the science teacher directed the open-ended questions, explained content knowledge related to science process skills, and did the hands-on activities.

According to the findings of the collected data for the first research question of the study, it's been determined that when hands-on activities are used along with a cooperative learning approach compared to teacher demonstration approach, the science process skills of 8th graders have developed in a positive manner. This result supports the findings that when hands-on learning activities are undertaken along with student-centered teaching approaches, the science process skills of students develop better (Hofstein and Lunetta, 2004; Lazarowitz and Huppert, 1993; Walters and Soyibo, 2001; Westbrook and Rogers, 1994).

The findings of the collected data for the second research question show that when hands-on learning activities are used with a cooperative learning approach, it enables the development of positive attitudes in 8th grade students compared to teacher demonstration approach. This result supports the findings in the literature. That is, when hands-on learning activities are used in groups, the students' attitudes toward science develop positively (Bilgin and Geban, 2004; Hofstein and Lunetta, 2004; Lazarowitz and Huppert, 1993).

In traditional teaching approaches, students are passive recipients, but in the cooperative learning approach students are in an active position. This approach allows students to work in groups and enables them to develop social interactions. According to Johnson and Johnson (1986), students who talk through course materials with peers will learn more effectively. The tasks requiring social interactions will stimulate learning and will enable students to recognize that an action should be taken with reference to others. In cooperative learning, students are provided with concrete experiences at the first hand. According to Fleming and Levie (1979), the higher the number of senses used in a learning situation, the better the learning will take place and the more difficult forgetting will be. Jones et. al. (2003) found that hands-on learning activities used along with student-centered teaching approaches provide students with positive attitudes towards science.

Most of the research studies in the literature showed that there were positive relationships between the students' science process skills and their achievements in science (Bybee, 2000; Padilla, 2004; Wolters and Soyibo, 2001) and also between the students' positive attitudes toward science and their achievements in science (Kesamang and Taiwo, 2002; Schibeci and Riley, 1986). Therefore, science teachers should be aware of the importance of improving the students' science process skills and positive attitudes toward science, because they are strong predictors of the students' achievement in science.

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Appendix 1: Some examples from Science Process Skills Test

1) Which of the following is an observation only?
A) The piece of metal is red, so it must be hot
B) The street is wet, so it must have rained
C) The table looks like it made of wood.
D) The child's block is orange

2). Which of the following represent prediction about a snowman in front of the school?
A) The snowman is made of three large balls.
B) The students at the school made the snowman
C) The snowman will be melt within five days
D) The snowman has a red scraf aroun its neck

3). Select the definition that is not an operational definition.
A) An acid is a substance that changes the color of litmus paper to pink
B) Ice is frozen water
C) An araser is a material that when rubbed on a pencil mark makes it disappear
D) A telephone is a device that is esed to talk to someone who is not physically present

4). Recently, Beth heard sirens roaring on a nearby street. The next day when she went to school she saw a house covared with wide black spots and smoke. The most reasonable inferences that she could make when describing what she saw was:
A) The house was destroyed by a tornado
B) The house was destroyed by a wild animal
C) The house was destroyed by a fire
D) The house was destroyed by a hurricane

5). A written statement of a hypothesis must contain or strongly imply which of the following variable?
A) Only the independent or responding variable
B) Only the dependent or manipulatated variable
C) Both the manipulated and responding variable
D) Both the manipulated and responding variable, as well as all the controlled variables

6). A students wants to know the effect of acid rain upon a fish population. She takes two jars and fills each of the jars with tha same amount of water. She adds fifty drops of vinegar (acid) to ona jar and adds nothing extra to the other. She then puts 10 similar fish in each jar. Both groups of fish are cared for (oxygen, food, etc.) in identical fashion. After observing the behavior of the fish for a week, she makes her conclusions. What would you suggest to improve this experiment?
A) Prepare more jars with different amounts of vinegar
B) Add more fish to the two jars already used
C) Add more jars with different kinds of fish and different amounts of vinegar in each jar
D) Add more vinegar to the jars already in use

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7) When converting from one unit to another in the metric system:
A) A series of prefixes are used to indicate the new unit
B) A series of suffixes are used to indicate the new unit
C) Conversion formulas must be used
D) There are twelve centimeters in each meter

8) Students created a data table showing the kinds of candy in a grocery store. They wanted to make a graph, so they could show the data in a second way. What kind of graph is most appropriate for the data?
A) Line graph
B) Bar graph
C) Both kinds of graphs
D) Another kind of graph

Appendix 2: Attitudes toward science scale.

Name and Surname:
Explanation: In this scale, there are 15 Likert-type statements to determine the students' attitudes towards science. There are five possible responses for each statement namely strongly agree, agree, undecided, disagree and strongly disagree. Please select the most appropriate response describing yourself after reading each statement carefully.

		Strongly agree	Agree	Undecided	Disagree	Strongly disagree
1	I like Science courses very much.					
2	I like reading Science books.					
3	Science has a vital role in our daily life.					
4	I enjoy solving Science problems.					
5	I would like to learn more about Science.					
6	I get bored at Scince Courses.					
7	I enjoy following Science Courses.					
8	I would like Science courses to be allocated more time.					
9	I get bored at studying Scince Courses.					
10	I would like to get more information about real life events related to Science subjects.					
11	Learning Science is important in developing our thought system.					
12	Science is important in understanding better the natural events around us.					
13	Science courses are the most unattractive courses.					
14	I do not like participating in discussions related to the Science.					
15	I would like to allocate the most of my study time to Science courses.					

Резюме

НАУЧНЫЕ НАВЫКИ И ОТНОШЕНИЯ К НАУКЕ УЧЕНИКОВ ВОСЬМЫХ КЛАССОВ В РЕЗУЛЬТАТЕ ПРОВЕДЕНИЯ ПРАКТИЧЕСКИХ РАБОТ С ПРИМЕНЕНИЕМ ПОДХОДА КООПЕРАТИВНОГО ОБУЧЕНИЯ

Ибрагим Билгин

Целью исследования было выяснение результативности развития научных навыков и отношений к науке учеников восьмых классов путём проведения практических работ с применением подхода кооперативного обучения. Исследовалась группа, состоящая из 55 учеников двух восьмих классов основной школы, обучаемых одним и тем же учителем. Путём случайного выбора были определены контрольный и экспериментальный классы. В экспериментальном классе обучение проводилось ввиде практических работ с применением подхода кооперативного обучения, в то время как в контрольном классе обучение осуществлялось путём показа демонстрационных опытов учителем. Для оценивания результативности работы в обоих классах до и после проведения соответствующего обучения применялись тесты определения научных навыков (SPST) и отношений к науке (ASTS). Предварительное тестирование являлось основой отсчёта для оценки прогресса в процессе обучения. Результаты итогового тестирования подтверждают лучший прогресс учащихся экспериментального класса.

Ключевые слова: научные навыки, практическая работа, кооперативное обучение, демонстрационные опыты учителя.

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