Effectiveness of hands-on and minds-on activities on students' achievement and attitudes towards physics*

Özlem ATEŞ[1] and Ali ERYILMAZ[2]

[1]Celal Bayar University, Faculty of Education, Demirci, Manisa, TURKEY

[2]Middle East Technical University, Faculty of Education, Odtü, Ankara, TURKEY

[1]Correspondence author E-mail: hozlem@gmail.com

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Contents

Abstract

This research aimed to investigate the effectiveness of hands-on and minds-on activities on ninth grade students' achievement in and attitudes towards simple electric circuits. The study was conducted with 130 students, 70 of which were

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assigned as experimental group and instructed by hands-on/minds-on activities, while the 60 were assigned as control group and instructed by the traditional method. For the study, three measuring tools were used; the Physics Achievement Test, Physics Attitude Scale, and observation checklist. When the data were analyzed by using multivariate analysis of covariance (MANCOVA), the results indicated that there was a significant difference between the means of the students' physics achievement in favor of the experimental group. However, the analyses failed to show any significant differences between the means of the students' attitudes towards simple electric circuits. The results of this study are important especially for developing countries that can not use expensive materials to make students physically active.

Keywords: Hands-on activities, minds-on activities, physics achievement, physics attitude, physics education

Introduction

Science begins for children when they realize that they can learn about the world and construct their own interpretations of events through their actions and experience. "A child best learns to swim by getting into water; likewise, a child best learns science by doing science" (Rillero, 1994, p.1). Doing science, as opposed to simply hearing or reading about it, engages students and allows them to test their own ideas and build their own understanding (Ewers, 2001). Therefore, it is difficult to imagine a science-teaching program without doing science experiences.

Hands-on science is defined mainly as any instructional approach involving activity and direct experience with natural phenomena or any educational experience that actively involve students in manipulating objects to gain knowledge or understanding (Haury & Rillero, 1994). Some terms such as materials-centered science and activity-centered science are used synonymous with hands-on science or terms such as materials-centered activities, manipulative activities and practical activities are used synonymous with hands-on activities (Doran, 1990; Hein, 1987). Unlike the laboratory works, hands-on activities do not necessarily need some special equipments and special medium. According to Jodl and Eckert (1998), hands-on activities are based on the use of everyday gadgets, simple set-ups or low-cost items that can be found and assembled very easily. McGervey (1995) states that "some hands-on activities can be done for less than a dollar per hand, a few have zero cost. Thus, it will be no disaster if a piece breaks or disappears" (p. 238).

Hands-on activities were perceived as an enjoyable and effective form of learning of almost all the major U.S science curriculum reforms of the late 1960s and early 1970s (Hodson, 1990). For example in physics, Physical Science Study Committee (PSSC) was formed and published its textbook and lab manual. In biology and chemistry, Biological Science Curriculum Study (BSCS) and Chemical Education Materials Study (CHEMS) were developed, respectively. For the elementary school level, particularly three major curriculum programs such as Science-A Process Approach (SAPA), Elementary Science Study (ESS), and Science Curriculum Improvement Study (SCIS) began to be used in classrooms during those times. Although these programs (ESS, SCIS, SAPA) differed in their organization and style, they were synonymous with the spirit of the elementary school curriculum innovations of 1960s and 1970s by their hands-on and activity-based strategies emphasizing problem solving, process skills, and creativity (Shymansky, 1989; Stohr-Hunt, 1996).

Several studies in the literature show that hands-on activities help students to outperform students who follow traditional, text-based programs (Bredderman, 1985; Freedman, 1997; Glasson, 1989; Shymansky, 1989; Staver & Small, 1990; Stohr-Hunt, 1996; Turpin, 2000), to enhance their understanding and replace their misconceptions with the scientific ones (Coştu, Ünal & Ayas 2007; Ünal, 2008), to develop attitudes toward science positively (Bilgin, 2006; Bredderman, 1983; Bristow, 2000; Jaus, 1977; Kyle, Bonnstetter, & Gadsten, 1988; Schibeci & Riley, 1986), and to encourage their creativity in problem solving, promote student independence, improves skills such as specifically reading, arithmetic computation, and communication (Haury & Rillero, 1994; Staver & Small, 1990). Lebuffe (1994) emphasizes that children learn better when they can touch, feel, measure, manipulate, draw, make charts, record data and when they find answers for themselves rather than being given the answer in a textbook or lecture.

For students to truly learn science concepts, they both need practical opportunities to apply knowledge and also need help in integrating or exchanging the knowledge they gain. According to the U.S. National Science Education Standards (1995), students should have minds-on and/or heads-on experiences during hands-on activities. While doing hands-on activity, the learner is learning by doing but while minds-on learning, the learner is thinking about what she or he is learning and doing. Hofstein and Lunetta (1982) state that a minds-on science activity includes the use of higher order thinking, such as problem solving compared to the hands-on activity. Therefore, students should be both physically and mentally engaged in activities that encourage learners to question and devise temporarily satisfactory answers to their questions (Victor & Kellough, 1997).

As collection of the most popular methods, interactive engagement methods also give emphasis to hands-on activities (usually) as well as minds-on activities (always), which provide immediate feedback through discussion with peers and/or instructors (Hake, 1998). He suggest that students in physics courses that make use of interactive engagement or active learning methods retain knowledge of physics concepts better than students in traditional lecture and lab courses (Hake, 1998).

This study claims that hands-on and minds-on activities without requiring specific expensive materials can be one of the interactive engagement methods. Therefore, the main purpose of this study is to develop hands-on/minds-on activities and to investigate the relative effectiveness of instruction with those activities and traditional method on ninth grade students' achievement in and attitudes towards simple electric circuits. The results of this study are very important especially for developing countries that can not use expensive materials to make students mentally and physically active.

Method

Sample

A public high school was chosen for its convenience for the researcher from the schools in Ankara, Turkey. Within 11 ninth grade classes of this school, four classes of two teachers, consisting of 130 ninth grade students were involved in this study. One of the physics teachers volunteered to use the suggested hands-on activities in her physics classes. Therefore, her two classes with 70 students were assigned as experimental group and instructed by hands-on/minds-on activities, while the two classes of the other teacher with 60 students were assigned as control group and instructed by traditional method.

Instruments

Three measuring tools were used in the study: Physics Achievement Test (PACT), and Physics Attitude Scale (PATS) about simple electric circuits and an observation checklist.

Physics Achievement Test (PACT): The purpose of the PACT was to assess students' achievement in simple electric circuits. This test consists of 25 questions and covers the physics contents taught in ninth grade curriculum (old one that had been implemented before 2008) about simple electric circuits: circuit elements, electric current, electric resistance, electric potential, voltage source, Ohm's law, series circuits, parallel circuits, compound circuits and short circuit. Before developing this test, a list of learning objectives for simple electric circuits was prepared. Then, questions prepared by the previous researchers (Chambers & Andre, 1997; Heller & Finley, 1992; Sencar, 2001) were investigated and physics books and Turkish University Entrance Exam questions were examined. From the pool of the questions, the researcher chose more than 30 questions by taking the list of learning objectives into consideration. After that, a table of test specification was prepared in which the objectives and questions were categorized according to the cognitive domain of Bloom's Taxonomy. Some questions were discarded by taking the table of test specification into consideration, and the researcher prepared 13 questions by this way. Moreover, 12 multiple choice questions were taken from the study of Sencar (2001) which were prepared in order to assess the students' misconceptions about simple electric circuits. Figure 1 shows a misconception question and Figure 2 shows a multiple choice question from the PACT.

Figure 1: *A sample misconception question from the PACT*

Will the identical bulbs light in figure at the right side?

a) Yes, because passing through the bulbs, current can flow from one side of the battery to the other side.

b) Yes, but the brightness of bulb C is higher than the brightness of bulb A and bulb B since current is used up by the bulbs.

c) Yes, but the brightness of bulb A is higher than the brightness of bulb B and bulb C since current is used up by the bulbs.

d) Yes, but since bulb A is the closest to the battery, the brightness of it is higher than brightness of bulb B and bulb C.

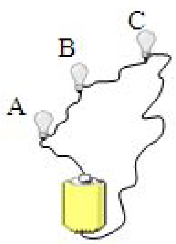
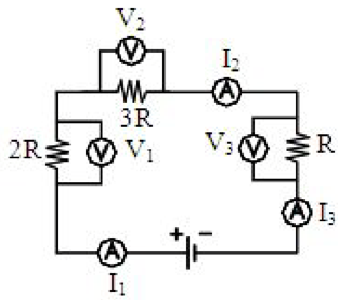


Figure 2: *A sample series circuit problem from the PACT*

Three resistors (R, 2R, 3R) are connected as shown in figure at the right side. Which one of the following comparisons is true for the values of voltmeter (V_1, V_2, V_3) and ammeter (I_1, I_2, I_3)?

a) V1 > V2 > V3 and I1 = I2 = I3
b) V3 > V1 > V2 and I1 > I2 > I3
c) V2 > V3 > V1 and I3 > I1 > I2
d) V2 > V3 > V1 and I1 = I2 = I3
e) V2 > V1 > V3 and I1 = I2 = I3



The test was administered to 349 ninth grade high school students as a pilot study. As a result of item analysis, four questions were completely discarded and 21 items were left in the PACT. Three of these items were true-false type, three were matching type and the rest of the items were multiple-choice type. For content validity, the test was checked by an instructor, three research assistants, and two preservice teachers from Middle East Technical University, Secondary Science and Mathematics Education Department in major of Physics Education. The internal reliability of the test was calculated by using Cronbach Alpha and the coefficient was obtained as 0.74. Possible PACT scores ranged from 0 to 21, with higher scores indicating higher achievement in simple electric circuits.

Physics Attitude Scale (PATS): Developed by Taşlıdere (2002), the PATS with 24 items were used to determine students' attitudes towards simple electric circuits. The items were designed to be rated on a 5-point Likert type response format (absolutely disagree, disagree, neutral, agree, absolutely agree). The scale covered five subcategories: enjoyment, importance of physics, interest related behavior, achievement-motivation, and self-efficacy. Examples of an item for each subcategory are given in Table 1. The internal reliability of the scale for each subcategory was calculated by using Cronbach Alpha as 0.86, 0.84, 0.80, 0.87, 0.87 respectively and 0.93 for overall scale. Possible PATS scores ranged from 24 to 120, with higher scores indicating positive attitudes towards simple electric circuits.

Table 1: *Examples of an Item for Each Physics Attitude Scale Subcategory*

Subcategory	Item
Enjoyment	I enjoy studying subjects related with simple electric circuits.
Self-Efficacy	I am sure that I can be successful about simple electric circuits.
Importance of Physics	I believe that simple electric circuits will help me in my future studies.
Achievement-Motivation	I do my level best for being successful about simple electric circuits.
Interest Related Behavior	I enjoy talking with my friends about simple electric circuits.

Observation Checklist: The observation checklist (see Appendix I) was developed for treatment verification. The first 10 items show how frequently some actions were done during the lessons. Items 8 and 9 are negative items for the hands-on activity criteria. Item 11 indicates whether the activities are done alone, in pairs or in groups of three and the last item shows how much time the students spent on doing hands-on activities in a class hour. All the items include “no activity” choice in order to detect whether the control group performed any activity or not. During the study, all the lessons of the experimental and control groups were observed by the researcher. However, four of 14 observations were done by two observers. The inter-rater reliability coefficient value was 0.91 for the observations of control group and 0.87 for that of experimental group, which indicated high consistency through scorers.

Teaching/Learning Materials

Various tables and materials were developed and used in this study: a list of learning objectives, a table of test specification, hands-on/minds-on activities, an objective-activity table, a criteria-activity table, a misconception-activity table, and a handout. While preparing activities, the list of learning objectives, activity criteria and misconceptions of the students about simple electric circuits were taken into consideration. Therefore, nine hands-on activities including minds-on experiences were developed to engage students actively in simple electric circuits by making use of a wide range of sources (Cunningham & Herr, 1994; Laws, 1997; McDermott, 1996). The titles of the activities were; a simple electric circuit, a circuit with switch, measuring electric current, measuring electric potential, Ohm's law, factors affecting resistors, series connected circuits, parallel connected circuits, and short circuit. All the activities were done with simple materials such as: bulbs, bulb sockets, batteries, switches, connection wires, ammeters, and voltmeters. As a sample of an activity, "a simple electric circuit" activity is given in Appendix II.

In order to examine how the objectives match with the activities, objective-activity table was prepared. Next, both activity criteria (activity sheet attract students' interests with its format, activity have clear directions and illustrations etc.) and hands-on/minds-on activity criteria (students are both physically and mentally engaged in activity, activity contains easy to obtain materials etc.) were developed. Then, criteria-activity table was prepared to make sure that every activity has these criteria. Finally, misconception-activity table was prepared. This table helped us to show that all the misconceptions about simple electric circuits specified in literature were aimed to be eliminated by the hands-on/minds-on activities. As a result, the activities were revised with the help of those tables. Moreover, one page handout was prepared to give some of the necessary definitions, symbolic representations and units of the circuit elements. This handout was delivered to the experimental group students as well as the control group students.

Treatment

A quasi-experimental study design was used in this study since it was not possible to randomly assign subjects to both the experimental and control groups. Two weeks before the study, the activity sheets, sets of materials, and all equipments were provided to the teacher who volunteered to implement hands-on activities. It took two hours to introduce the students' role, the teachers' role, the hands-on activity sheets, and their implementation process to the teacher.

The teachers administered the PACT and PATS to both groups as pretests one week before the treatment started. All pretests of the control and experimental groups were administered on the same day. Within 130 ninth grade students, 70 students were assigned as experimental group and instructed with hands-on and minds-on activities, while the 60 were assigned as control group and instructed by the traditional method. In this study, traditional method is defined as conventional lecturing method supplemented by textbook where teacher has the primary role in delivering the content and students are mainly taught accompanied by reading, assignment, note taking, and a few demonstrations. On the other hand, hands-on instruction is defined as devoting minimum time to lecturing and maximum time to hands-on and minds-on activities through discovery method.

During the treatment period, the topics related to simple electric circuits were covered as part of the regular curriculum in the physics course. Students in both groups were exposed to the same content for the same length of time. The duration of the lessons was two 40-minute sessions per week. Throughout the study, the researcher observed the control and experimental classes for the verification of the treatment. The students in the control group were generally taught with the note taking strategy. The teacher explained important concepts and solved problems related to these concepts. The students wrote down the teacher's explanations and from time to time, they asked questions about unclear points during the instruction. The instruction via lecture was not accompanied with demonstrations, lab-based experiments or any activities. Therefore, for the control group, the observations verified the absence of hands-on activities.

In the experimental group, each student was given related activity sheet and necessary materials. Students followed the procedure and answered the questions given in the activity sheets. The teacher helped the students when they had difficulty to connect the circuits. She never told what is expected to be found during activities. The students performed some of the activities individually, some in pairs. They completed all parts of the activities including their predictions, measurements, and comments. After completing each activity, they discussed their results with each other and the teacher. Therefore, the observations showed that the students were actively engaged in hands-on/minds-on activities and discovered both facts and concepts individually or independently while the teacher mostly acted as a guide and gave little direct instruction to summarize the results at the end of some activities.

Finally, after three weeks of the treatment period, the PACT and PATS were administered as posttests to the control and experimental groups again. All the data gathered were analyzed by the computer.

Results

The data obtained from the pretest and posttest achievement and attitude scores of all students were analyzed both descriptively and inferentially. Descriptive results related to the pretest and posttest achievement and attitude scores of all students are given in Table 2. The experimental group gained a mean increase of 2.16 points while the control group gained 1.09 points from pretest to posttest on the PACT. The mean increase on the PATS was 5.47 points for the experimental group while the mean increase was 2.59 points for the control group from pretest to posttest. Furthermore, the standard deviation values were relatively stable from pretest to posttest on the physics achievement and physics attitude scores.

Table 2: *Basic descriptive statistics related to PACT and PATS scores*

	Experimental Group		**Control Group**	
	Pretest	**Posttest**	**Pretest**	**Posttest**
Scores on Physics Achievement Test *				
N	70	70	60	60
Mean	10.64	12.80	8.99	10.08
Standard Deviation	2.84	3.31	2.04	3.13
Scores on Physics Attitude Scale **				
Mean	80.79	86.26	78.51	81.10
Standard Deviation	13.05	14.25	12.66	15.60

***** Possible minimum and maximum PACT scores are 0 and 21, respectively
****** Possible minimum and maximum PATS scores are 24 and 210, respectively

To statistically equalize the differences among the experimental and control groups, six independent variables; students' age, gender, pre achievement and pre attitude scores, previous physics course grades, and previous cumulative grade point averages were planned to be used as covariates. All pre-determined independent variables have been correlated with the two dependent variables. All independent variables -except students' age- had significant correlations with at least one of the dependent variables so were determined as covariates for the following inferential analyses.

Before using the statistical model of multivariate analysis of covariance (MANCOVA), normality, homogeneity of regression, multicollinearity, equality of variances, and independency of observations assumptions were checked. After validation of these assumptions, the MANCOVA model was conducted. Significant differences were found among hands-on/minds-on instruction and traditional methods on the collective dependent variables of the post achievement (PSTACH) and post attitude scores (PSTATT), $F(2,120) = 3.396$; $p < .05$. In order to test the effect of the methods of teaching on each dependent variable, a univariate analysis of covariance (ANCOVA) was conducted as follow-up test to the MANCOVA. The effect of those activities on the PSTACH, $F(1,121) = 5.781$; $p = .018$ was significant. Therefore, the results suggest that students instructed by hands-on/minds-on activities had a higher achievement in physics than the students taught by traditional method. However, the results on the PSTATT, $F(1,121) = 1.368$; $p = .244$ were not significant. Moreover, the statistical analyses failed to show any significant differences between the means of the students' attitude subcategories (enjoyment, self efficacy, importance of physics, achievement-motivation, and interest related behavior) towards simple electric circuits.

A step-down analysis was also used as a follow-up analysis subsequent to the MANCOVA. This analysis was used to investigate the unique importance of dependent variable, the PSTACH, which was found as significant in the ANCOVA. When the students' physics achievement scores were analyzed with physics attitude scores acting as an additional covariate, the effect of those activities was still significant, $F(1,120) = 5.375$; $p = .022$. This indicates that the effect of the hands-on/minds-on activities on students' physics achievement after accounting its effect on physics attitude was also significant. That is, physics achievement was also significantly and uniquely affected by the hands-on/minds-on activities after their effects on physics attitude.

Throughout the study, both the experimental and control groups have been observed for the purpose of the treatment verification. Mann-Whitney U test and independent t-test were conducted for those observation results. Results of these tests were significant which indicate that the treatments in the experimental and control groups were significantly different. Moreover, the means and the standard deviations of each item for both groups were presented in Table 3. It indicates that for the experimental group, means of positive items (hands-on activity criteria) for the experimental group were drastically greater than the means of the control group while the means of negative items (8 and 9) for the experimental group were drastically lower than the means of the control group. These results verified that lessons in the experimental group were implemented according to the hands-on activity criteria and those in the traditional group were implemented according to the traditional method. Therefore, treatment verification was supported.

Table 3: *Basic descriptive statistics related to items of the observation checklist*

Item Number	Experimental Group		Control Group	
	Mean	Std. Dev.	Mean	Std. Dev.
1	3.00	-	0.00	-
2	3.00	0.58	0.00	-
3	2.71	0.49	1.86	0.69
4	2.71	0.75	0.00	-
5	2.57	0.53	1.43	0.53
6	3.29	0.49	1.43	0.53
7	3.00	0.82	1.43	0.53
8	**1.00**	-	**3.57**	0.53
9	**1.14**	0.38	**3.71**	0.49
10	3.57	0.53	0.00	-
11	2.14	0.38	0.00	-
12	2.57	0.53	0.00	-

Conclusion and Discussion

It was found that hands-on/minds-on activities were an effective means of increasing physics achievement about simple electric circuits. Students instructed by those activities gained a higher achievement in physics. However, the hands-on/minds-on activities did not increase the students' attitude towards simple electric circuits significantly more than the traditional method did. In comparing the results of this research with those of previous ones, this research supports the findings of previous studies (Freedman, 1997; Stohr-Hunt, 1996; Turpin, 2000) reporting that learning via hands-on activities are more effective than learning in traditional method in the area of science achievement. Stohr-Hunt (1996) investigated the effect of frequency of hands-on activities (daily, once a week, once a month, never) on eight grade students' science achievement. Results of his study indicated that students who experienced hands-on activities frequently (every day or once a week) had significantly higher scores of science achievement than those students who experienced hands-on science infrequently (once a month, less than once a month, or never). The findings of this study support the findings of Stohr-Hunt (1996). Similarly, in this study, the experimental group studied all the lessons with hands-on activities including minds-on experiences twice a week and students in the experimental group had significantly higher scores compared to students in the control group. The findings of this study are also in agreement with those of Freedman (1997) and Turpin's (2000) study in terms of the effects of hands-on instruction on science achievement and attitude towards science. They also concluded that the students in hands-on laboratory instruction or activity-based science curriculum had significantly higher scores compared to students using a traditional science curriculum. However, no significant differences to students' attitude towards science were found in their study.

This study also supports the findings of meta-analysis studies of activity-based science programs in the area of achievement. Bredderman (1983) conducted 57 studies of activity-based programs and found a positive effect of these programs on student achievement as compared with traditional science programs. Similar results were found in analysis of 105 studies by Shymansky et al. (1983). The mean effect sizes of these studies were 0.35 and 0.29, respectively, which are small. In the other studies, the effect sizes were not reported. However we calculated the mean effect size as 0.32 for Freedman's (1997) study, which is also small. In our study, results also yielded approximately small effect size for the PSTACH.

The findings of this study are not in agreement with that of Bristow (2000). He examined whether sixth grade children learn science concepts better when taught using hands-on teaching methods versus a traditional approach. As a result of her study, there was no significant difference between the performances of the groups but students receiving hands-on instruction had a more positive attitude towards science instruction than those students receiving a traditional textbook instruction. It is interesting why the data in our study showed no significant difference in the attitude of the students although some of the literature supported the superiority of the hands-on teaching method (Bilgin, 2006; Bredderman, 1983; Bristow, 2000; Jaus, 1977; Kyle, Bonnstetter, & Gadsten, 1988; Schibeci & Riley, 1986). In trying to reach a view about this reason, some explanations might be put forth in order to clarify this reason. Firstly the treatment lasted for three weeks, which may not have been a long enough period to show a difference in the attitude of students between the two teaching methods. In the study of Bristow (2000), the treatment lasted 12 weeks or it lasted 15 weeks in the study of Bilgin (2006). A longer treatment time may be needed to elicit a change in the students' attitude.

Moreover, some researchers (Simpson & Oliver, 1985; Yager & Yager, 1985) claim that students' attitudes towards science are declining from elementary to high school. Simpson and Oliver (1985) also found that attitudes towards science declined from the beginning to the middle of the school year for each grade level studied. Our study was conducted on ninth grade high school students in the last weeks of the semester, which may also have caused students not to increase their attitude towards simple electric circuits significantly more than they did in the traditional method.

During observations, it has been noticed in this study that students were not used to perform hands-on/minds-on activities, so they had some difficulties following the manuals and doing the activities. The reason might be the fact that in their regular lessons, they were used to listening to their teachers and taking notes during lectures without performing experiments on their own. Studies have shown that the lecture approach associated with most textbooks leaves students as passive learners of facts and is an ineffective way to teach. Students become accustomed to receiving knowledge rather than helping to generate it by this way (McDermott, 1990; Weaver, 1998). Renner et al. (1985) claim that students who are taught physics in that fashion are not experiencing physics; they are being informed about the products physics has produced.

Ayas, Çepni and Akdeniz (1993) states that as developments in science education around the world had been continuing during the late 1960s and early 1970s, some attempts (organizing in-service training for teachers, producing the curricular materials and establishing moving laboratories for schools where there was no laboratory) were also taken place in Turkey. Some of the well-known curricula (PSSC, BSCS, CHEMS) were adapted into Turkish and implemented in the schools. At those times, the economic conditions in Turkey were not sufficient to implement such curricula and the social background was significantly different than the country of origin. Therefore, the programs were never fully implemented all over the country and policy makers decided to finish this application in secondary schools (Ayas, Çepni, & Akdeniz, 1993). In fact, the traditional patterns of Science and Physics curriculums did not change fundamentally until the new Turkish Science and Technology curriculum in elementary education has been announced by the Ministry of National Education in 2004 and the new Physics Curriculums (through grade one to four) have been started to be implemented in 2008, 2009, 2010, and 2011 respectively. Hands-on and minds-on experiences are frequently emphasized in those curriculums in which principles of constructivist philosophy have been integrated. Therefore, students attending science and physics lessons are expected to be both physically and mentally engaged in activities and tutors are expected to replace teaching methods that rely on rote memorization with authentic experiences, guide and facilitate students' learning, and encourage their students to perform hands-on/minds-on activities in order to construct their own knowledge.

Various studies show that although hands-on science programs are more effective, teachers indicate use of textbook rather than activity-based programs. Moreover, they often prefer to demonstrate an experiment rather than to have students perform it themselves (Morey, 1990; Glasson, 1989). When the researches investigated in Turkey about the new Science and Technology Curriculum were analyzed, tutors similarly complain a lot about lack of resources and emphasize the need for in-service training about new teaching/learning methodologies and assessment/evaluation techniques (Ateş & Akdağ, 2006; Erdoğan, 2007; Kırıkkaya, 2009; Yangın & Dindar, 2007). Yangın and Dindar (2007) state that if tutors do not have enough resources, they tend to lecture in a traditional way. Teachers mostly tend to teach in the same way as they have been taught. According to McDermott (1996), even very competent teachers, who eventually might be able to adopt content learned through lecture to activity-based instruction, cannot be expected to do this so quickly. In fact, teacher's uncertainty, discomfort, lack of resources, lack of time, material management problems, limited backgrounds with experiential approaches to science teaching, and dependency on textbooks cause to conduct hands-on/minds-on activities less frequently than lecture and discussion (Lebuffe, 1994; Morey, 1990; Tilgner, 1990).

In this study, the teachers told that they were used to teacher-centered learning environments and complained that preparing and guiding such activities takes too much time and effort. Therefore, having adequate preparation and gaining authentic experiences are also very important while implementing these curriculums. Based on the findings presented, the practical significance of this study is low. Therefore, we cannot claim that drastic changes should be done in the programs. However, we may give some recommendations. For example, some courses including hands-on/minds-on activities might be developed in universities to familiarize prospective teachers with linking physics with daily life phenomena. Moreover, in-service trainings, workshops or projects may be organized for the teachers allowing them to gain practical experience and proficiency with hands-on/minds-on activities. Lastly, materials consisting simple set-ups or low-cost items that can be found and assembled very easily should be developed and provided to the schools in order to implement the curriculum efficiently and effectively, especially for the certain topics in which low-cost activities are easily available, e.g. simple electric circuits. Thus, students better realize that they do not need a special laboratory environment or complicated apparatus to perform hands-on and minds-on activities and learn physics better.

References

Ateş Ö. H. & Akdağ, Z. A. (2006) *Fen ve teknoloji dersinde öğretmenlerin karşılaştıkları sorunlar ve bu sorunların nedenleri*. VII. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi, Özetler Kitabı, p. 33, Ankara: Gazi Üniversitesi.

Ayaş, A., Çepni, S., & Akdeniz, A. R. (1993). *Development of the Turkish secondary science curriculum. Science Education*, *77*(4), 433-440.

Bilgin, İ. (2006). The effects of hands-on activities incorporating a cooperative learning approach on eight grade students' science process skills and attitudes towards science. *Journal of Baltic Science Education*, *1*(9), 27-37.

Bredderman, T. (1983). Effects of activity-based elementary science on students' outcomes: A qualitative synthesis. *Review of Educational Research*, *53*(4), 499-518.

Bredderman, T. (1985). Laboratory programs for elementary school science: A meta analysis of effects of learning. *Science Education*, *69*(4), 577-591.

Bristow, B. R. (2000). The effects of hands-on instruction on 6th grade students' understanding of electricity and magnetism. *Dissertation Abstracts International, 39*(01), 30A (UMI No. AAT 1400301).

Chambers, S. K., & Andre, T. (1997). Gender, prior knowledge, interest and experience in electricity and conceptual change text manipulations in learning about direct current. *Journal of Research in Science Teaching, 34*(2), 107-123.

Coştu, B., Ünal, S., & Ayaş A. (2007). A hands-on activity to promote conceptual change about mixtures and chemical compunds. *Journal of Baltic Science Education, 6*(1), 35-46.

Cunningham, J. & Herr N. (1994). Hands-on physics activities with real life applications. West Nyack, New York: The Center for Applied Research in Education

Doran, R. L. (1990). What research says … about assessment? *Science and Children, 27*(8), 26-27.

Erdoğan, M. (2007). Yeni geliştirilen dördüncü ve beşinci sınıf fen ve teknoloji dersi öğretim programının analizi; Nitel bir çalışma. *Türk Eğitim Bilimleri Dergisi, 5*(2), 221-254.

Ewers, T. G. (2001). Teacher-directed versus learning cycles methods: effects on science process skills mastery and teacher efficacy among elementary education students. *Dissertation Abstracts International*, 62(07), 2387A (UMI No. AAT3022333).

Freedman, M. P. (1997). Relationships among laboratory instruction, attitude toward science, and achievement in science knowledge. *Journal of Research in Science Teaching, 34*(4), 343-357.

Glasson, G. E. (1989). The effects of hands-on teacher demonstration laboratory methods on science achievement in relation to reasoning ability and prior knowledge. *Journal of Research in Science Teaching, 26*(2), 121-131.

Hake, R. R. (1998). Interactive-engagement vs. traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses. *American Journal of Physics, 66*, 64-74.

Haury, D. L. & Rillero, P. (1994). *Perspectives of hands-on science teaching*. Retrieved January 2, 2003 from http://www.ncrel.org/sdrs/areas/issues/content/cntareas/science/eric/eric-toc.htm

Hein, G. E. (1987). The right test for hands-on learning. *Science and Children, 25(*2), 8-12.

Heller, P. M. & Finley, F. N. (1992). Variable uses of alternative conceptions: A case study in current electricity. *Journal of Research in Science Teaching, 29*(3), 259-276.

Hodson, D. (1990). A critical look at practical work in school science. *School Science Review, 71*(256), 33-40.

Hofstein, A. & Lunetta, V. N. (1982). The role of the laboratory in science teaching: Neglected aspects of research. *Review of Educational Research, 52*(2), 201-217.

Jaus, H. H. (1977). Activity-oriented science: Is it really that good? *Science and Children,14*(7), 26-27.

Jodl, H., & Eckert, B. (1998). Low-cost, high-tech experiments for educational physics. *Physics Education, 33*(4), 226-235.

Kırıkkaya, E. B. (2009). Opinions of science teachers in primary schools related to Science and Technology Program. *Journal of Turkish Science Education, 6*(1), 149-155.

Kyle, W. C., Bonnstetter, R. J., & Gadsten, T. (1988). An implementation study: an analysis of elementary students' and teachers' attitudes toward science in process-approach vs. traditional science classes. *Journal of Research in Science Teaching, 25*(2), 103-120.

Laws, P. W. (1997). *Workshop physics activity guide*. New York: John Wiley & Sons, Inc.

Lebuffe, J. R. (1994). *Hands-on science in the elementary school*. East Lansing, MI: National Center for Research on Teacher Learning (ERIC Document Reproduction Service No. ED 375003).

McDermott, L. C. (1996). *Physics by Inquiry*. New York: John Wiley.

McGervey, J. D. (1995). Hands-on physics for less than a dollar per hand. *Physics Teacher, 33*(4), 238-241.

Morey, M. K. (1990). Status of science education in Illinois elementary schools. *Journal of Research in Science Teaching, 27*(4), 387-398.

U.S. National Science Education Standards (1995). *National science education standards: An overview*. Washington, D. C.: National Academy Press. Retrieved January 8, 2006 from http://books.nap.edu/html/nses/html/overview.html#organization

Renner, J. W., Abraham, M. R., & Birnie, H. H. (1985). Secondary school students' beliefs about the physics laboratory. *Science Education*, *69*(5), 649-663.

Rillero, P. (1994). *Doing science with your children*. East Lansing, MI: National Center for Research on Teacher Learning (ERIC Document Reproduction Service No. ED 372 952).

Schibeci, R. A., & Riley, J. P., Jr. (1986). Influence of students' background and perceptions on science attitude and achievement. *Journal of Research in Science Teaching, 23*(3), 177-187.

Sencar, S. (2001). *The effect of gender on different categories of ninth grade students' misconceptions concerning simple electric circuit*s. Unpublished master thesis, Middle East Technical University, Ankara, Turkey.

Shymansky, J. A. (1989). What research says about ESS, SCIS, and SAPA. *Science and Children, 26*(7), 33-35.

Shymansky J. A., Kyle, W. C., & Alport, J. M. (1983). The effects of new science curricula on student performance. *Journal of Research in Science Teaching, 20*(5), 387-404.

Simpson, R. D. & Oliver, J. S. (1985). Attitude toward science and achievement motivation profiles of male and female science students in grades six through ten. *Science Education*, *69*(4), 511-26.

Staver, J. R., & Small, L. (1990). Toward a clearer representation of the crisis in science education. *Journal of Research in Science Teaching, 27*(1), 79-89.

Stohr-Hunt, P. M. (1996). An analysis of frequency of hands-on experience and science achievement. *Journal of Research in Science Teaching, 33*(1), 101-109.

Taşlıdere, E. (2002). *The effect of conceptual approach on students' achievement and attitudes toward physics.* Unpublished master thesis, Middle East Technical University, Ankara, Turkey.

Tilgner, P. J. (1990). Avoiding science in the elementary school. *Science Education*, *74*(4), 421-431.

Turpin, T. J. (2000). A study of the effects of an integrated, activity-based science curriculum on student achievement, science process skills, and science attitudes. *Dissertation Abstracts International*, 61(11), 4329A (UMI No. AAT 9993727).

Ünal, S. (2008). Changing students' misconceptions of floating and sinking using hands-on activities. *Journal of Baltic Science Education, 7*(3), 134-146.

Victor, E. & Kellough, R. D. (1997). *Science for the elementary and middle school* (8th ed.). Upper Saddle River, New Jersey: Prantice Hall.

Weaver, G. C. (1998). Strategies in K-12 science instruction to promote conceptual change. *Science Education, 82*(4), 455-72.

Yager, R. E. & Yager, S. O. (1985). Changes in perceptions of science for third, seventh, and eleventh grade students. *Journal of Research in Science Teaching*, *22*(4), 347-358.

Yangın, S. & Dindar, H. (2007). İlköğretim fen ve teknoloji programındaki değişimin öğretmenlere yansımaları. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 33*, 240-252. http://www.fao.org/docs/eims/upload/233069/energy-use-oa.pdf

Appendix I

Appendix I: *Observation checklist for the lessons of experimental and control groups*

<table>
<tr><th></th><th></th><th>always</th><th>frequently</th><th>sometimes</th><th>never</th><th>no activity</th></tr>
<tr><td>1.</td><td>Students obey the procedure</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2.</td><td>Students can follow the activities easily</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>3.</td><td>Students seem to enjoy the lesson</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>4.</td><td>Students get the information by doing the activities</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>5.</td><td>There is a student-student interaction during the lesson</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>6.</td><td>Teacher acts as a guide</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>7.</td><td>Teacher answers questions with short explanations</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>8.</td><td>Teacher has the primary role in delivering the content</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>9.</td><td>Information is given based on textbook</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>10.</td><td>Activity consist easy to obtain, inexpensive materials</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td></td><td>individually</td><td colspan="2">in pairs</td><td>in groups of three</td><td>no activity</td></tr>
<tr><td>11.</td><td>Students do the activity…….</td><td></td><td colspan="2"></td><td></td><td></td></tr>
<tr><td></td><td></td><td>0-15 minutes</td><td colspan="2">15-30 minutes</td><td>30-40 minutes</td><td>no activity</td></tr>
<tr><td>12.</td><td>Students are actively engaged in activity during……in a class hour</td><td></td><td colspan="2"></td><td></td><td></td></tr>
</table>

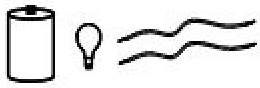
Appendix II

Appendix II: *Simple Electric Circuit Activity*

Purpose: The students should be able to build simple electric circuits and draw the corresponding diagrams.
Materials: a battery, bulb and connecting wires

Procedure:

1. Try to light the bulb by using a battery, bulb and connecting wires as shown in below.

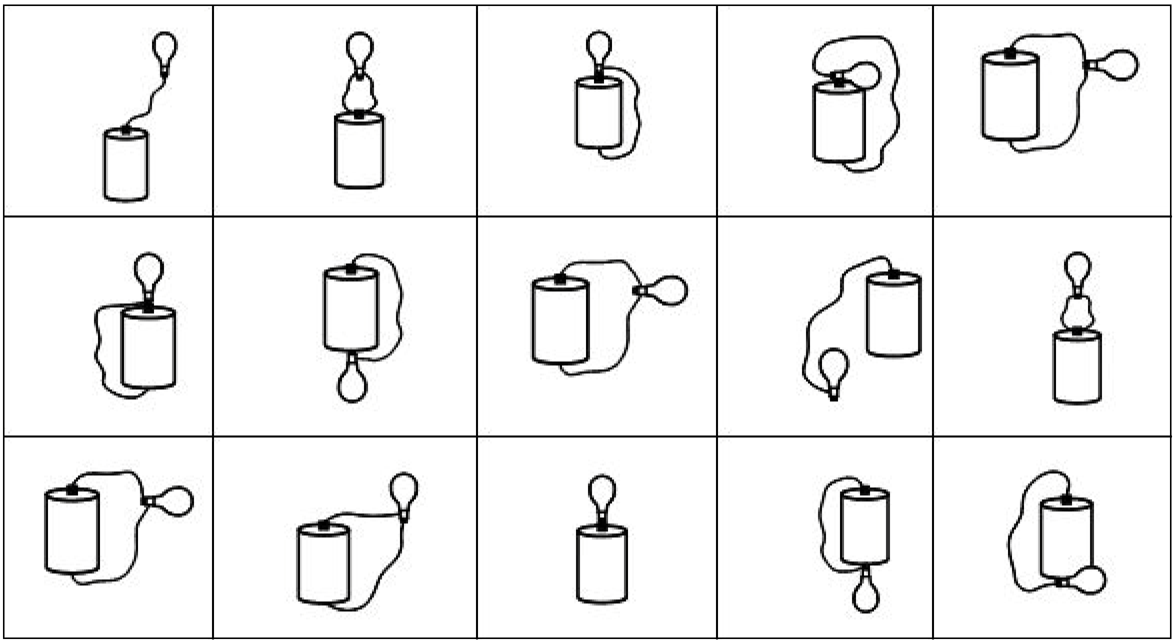


2. Draw the diagrams of your circuits to the related boxes given below.

Diagrams that the bulb lights:

Diagrams that the bulb does not light:

3. According to you, which bulbs light in the diagrams given below?



4. Try to build each circuit above and explain which conditions are necessary to light a bulb.

……………………………………………………………………………………

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