

Effects of Guided and Semi - Guided Laboratory Investigations on Sixth Grade Students' Conceptualization Levels

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Abstract

The present study is an attempt to enlighten the effects of two different types of investigation techniques on sixth graders' conceptualization levels related to the concepts of physical and chemical changes. The study was carried out with the six graders in a public primary school located in an economically disadvantaged district of İstanbul. Eighty students were selected as the sample of the study and two homogeneous groups (n=40) were formed by matching subjects with their science grades and science attitude scores. However, only 27 of the students in the first subgroup and 23 of the students in the second subgroup completed all the treatments. Science Attitude Scale (Toğrol, 2000) was used in order to determine students' attitudes towards science. Science Concept Scale-Physical and Chemical Changes is the second instrument used to measure students' conceptualization levels related to the selected science concepts-physical and chemical changes. Two groups treated with guided investigations, and two groups treated with semi-guided investigations. During guided investigations, the procedure of the tasks were given to the students explicitly by the teacher, during semi-guided investigations students find out the procedures by themselves and continue their investigations according to their own procedures. Results of the study indicates that both types of investigations cause positive developments on six graders' conceptualization levels (guided $df=26$, $t=-7.13$, $p=.000$; semi-guided $df=22$, $t=-6.17$, $p=.000$). In addition, Analysis of Covariance (ANCOVA) was conducted in order to find out whether there is a difference between the conceptualization levels of students who were treated with different investigation techniques. Although the result of this analysis did not indicate a statistically significant difference between the effects of these laboratory investigations on students' conceptualizations, it is found that the number of incorrect answers or answers which include alternative conceptions for the students who were treated with guided investigations are more comparing with the other group. Also, the number of completely correct answers given by the students who were treated with semi-guided investigations is more than the ones who were treated with guided investigations.

Keywords: Guided and semi-guided laboratory investigations, physical and chemical changes, conceptualizations

Introduction

There is a large amount of literature on understandings of learners the everyday phenomena, and these studies evidenced that learners' ideas often have conflicted with scientifically accepted ones (Driver, et al., 1998; Eryılmaz, 2002; Gazi, 1995; Haidar, 1997; Kikas, 2004; Noh and Scharmann, 1997; Osborne and Freyberg, 1990; Özmen, 2004; Schmidt, et al., 2003; Schoon and Boone, 1998; Taber, 2001; Valanides, 2000; Yontar, 1989; Zafer, 2004). Furthermore, these types of ideas prevent formation of meaningful and permanent learning (Sönmez, et al., 2001). One reason for studying alternative conceptions depends on the fact that science is an area which includes many abstract concepts which are difficult to learn. In addition to this, these abstract science concepts are related to each other. Thus, if an individual is not able to internalize the

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basic concepts of science, probably there may be some problems in understanding the concepts which are built upon these basic concepts (Abraham, et al., 1994). It can be concluded that difficulties or confusions in basic science concepts will cause difficulties or confusions in further learning. In order to prevent students' from such kind of difficulties, teachers should be aware of the characteristics of these difficulties and confusions. The most important aim in determining learners' alternative conceptions is to inform teachers about them before teaching any particular topic. In this way, they will be aware of the alternative conceptions which learners may bring to class and plan their teaching learning activities by keeping that probability in mind and it will be possible for them to deal with the alternative conceptions. In addition to being a barrier to further learning, alternative conceptions also causes some difficulties in building connections between the knowledge acquired in the class and the experiences in everyday life. Some of the students think that the subjects that they have learned in science classes and the observations or experiences that they come across in their real life are completely different. One of the criteria of scientific literacy is to make people who have science process skills which allow them to function in work, in daily life, and in society (Collette and Chiapetta, 1989).

Table 1. Common alternative conceptions about dissolution in the literature.

<p>Sugar melts and distributes through water homogenously. Sugar melts and becomes invisible to the naked eye. Sugar disappears physically, i. e., it dissolves. Hot water melts sugar and provides dispersion of acid in sugar. Either sugar melts in water or mixes with air by evaporating. Sugar melts and flavors water. Sugar absorbs water and then melts. As a result of dissolution, a new matter formed. Ionization of Na_2CO_3 in water is a chemical change. Salt is not resistant to dissolving, because it is not hard enough. The reason for not dissolving chalk in water is the chalk's hardness or heaviness. Melting and dissolving are the same processes. When one dissolves sugar in water, water takes the properties of sugar on it. Weight is lost in dissolving.</p>
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As mentioned before many researchers have studied on several basic science concepts and related alternative conceptions, but in the current study, only the research studies which are related to physical and chemical changes concepts were analyzed. Related literature indicated that some of the learners have difficulties in conceptualization of physical and chemical changes concepts (Abraham, et al., 1992; Abraham, et al., 1994; Ayas and Demirbaş, 1997; Bar and Travis, 1991; Çalık, 2005; Ebenezer and Erickson, 1996; Goodwin, 2002; Hesse and Anderson, 1992; Johnson, 2000; Johnson, 2002; Kabapınar, 2004; Watson, et al., 1995). Among these studies, some of them stated that dissolution, which is a physical change, is one of the concepts which learners have difficulties in the conceptualizing (Çalık, 2005; Ebenezer and

Erickson, 1996; Goodwin, 2002; Kabapınar, 2004). Some of the learners consider it as a chemical change, while some others conceptualize it as melting, absorbing, disappearing or transformation. Examples from these studies are shown in the above table.

Combustion, which is a chemical change, is another widely used concept by the researchers (Bou Jaoude, 1991; Watson, et al., 1995). Alternative conceptions of students' related to the concept are summarized in Table 2. Moreover, there are some other research studies on students' views about differentiating some events as physical and chemical changes (Hesse and Anderson, 1992; Johnson, 2000; Johnson, 2002). It is stated in one of these studies that while students can define a chemical change and able to balance the chemical reactions, they have difficulties in determining the changes occurred in real life situations like rusting of an iron. Melting ice, heating mercury oxide, burning food, heating sugar, electrolysis of water, vaporization and boiling are examples for the most common changes that students' cannot differentiate as a physical or a chemical change (Çepni, et al., 2001; Ayas and Coştu, 2001; Özmen, et al., 2001).

Table 2. Common alternative conceptions about combustion in the literature

<p>Combustion of a metal is not a chemical reaction.</p> <p>Combustion is a reduction to ashes.</p> <p>Much of the combustible material disappears.</p> <p>Burning of a candle is chemical because it's not changing into a solid; it's changing into a gaseous state.</p> <p>Burning of a candle is chemical. Because neither the rod or the candle changed physically, therefore it is a chemical change</p> <p>Burning of a candle is physical. You're burning matter not chemicals. The black film forming on the rod is physical. Residue from the flame.</p> <p>Burning of a candle is physical. Because you can physically see it.</p> <p>Burning of a candle is physical. It gives off heat and light. The film is smoke film from the flame.</p> <p>While alcohol is burning, it would weigh less due to the fact that it evaporates.</p> <p>During the burning of an alcohol, the decrease in the weight of an alcohol is due to the fact that some of the alcohol changes into gas, alcohol gas</p>
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Many researchers (Kikas, 2004; Hesse and Anderson, 1992; Limon, 2001; Santos and Mortimer, 2003; Shiland, 1997; Guzetti, et al., 1997; Gibson, 1996; Johnson and Lawson, 1998) studied the factors affecting the conceptualizations of learners. For example Limon (2001) analyzed the cognitive conflict process model, identified the variables that might contribute to cognitive conflict and classified the factors affecting conceptualization into three categories which includes the factors related to the learner as first category. It is believed that students' *prior knowledge* has an important effect in their ability to obtain new concepts (Johnson and Lawson, 1998; Limon, 2001). Furthermore, previous concepts that are related to the newly acquired concepts play a crucial role in students' lives (Novak, 1990 as cited in Johnson and Lawson, 1998).

Novak stated that students acquire knowledge in a hierarchical order. Thus, if one of the levels is missing in this hierarchy, new concepts cannot be acquired properly. In addition to prior knowledge, motivation and interest of the learners have also an effect on students' conceptualization (Limon, 2001). Pintrich, et al. (1993) stated that *motivational constructs* such as goals and values have an effect on concept formation. According to Pintrich, Marx and Boyle (1993), there is an interaction between the cognitive, motivational, classroom factors and the four necessities of conceptual change model-dissatisfaction, understanding, plausibility, and fruitfulness. In other words, some motivational beliefs such as values, goals, self-efficacy, and control beliefs affect the concept acquisition in students. Limon identified the second category of the factors affecting students' conceptualizations as to the social context in which learning takes place (Limon, 2001). *Common (non-scientific) word usage* is among the reasons that may cause alternative conceptions (Hesse and Anderson, 1992). In addition, *textbooks* used in the science lessons causes many alternative conceptions (Gibson, 1996; Kikas, 2004; Shiland, 1997). Although dealing with alternative conceptions is an important factor affecting learning, but unfortunately very few textbooks focus on this issue. For instance, Shiland (1997) examined eight secondary school texts that were about the mechanical model over the Bohr atomic model in terms of four elements of conceptual change model-dissatisfaction, intelligibility, plausibility, and fruitfulness. His findings showed that none of the conditions of four elements of the conceptual change model were met by the books. A similar study was conducted by Guzetti, et al. (1997) in exploring the influences of text structure on students' conceptual change. They used refutational texts that contrast some alternative conceptions and misconceptions with scientific truths. Additionally, students' alternative conceptions were addressed through a form of refutational discussion that is called as 'inquiry training'. The results of this study showed that in most of the cases a cognitive conflict does occur in students' minds when refutational texts are used. However, there were some cases that the refutational texts were unable to change the alternative conceptions of students. It is concluded that, in these cases, the texts may not direct enough as well as students' reading strategies may not be sufficient. Thus, inquiry training was found to be successful. Another reason for the negative effects of textbooks on the conceptualization of students was found to be an *oversimplification* of some concepts in these textbooks (Gibson, 1996). The researcher found this result after the analysis of science and non-science major textbooks on the climax concept of succession. It is concluded in this study, non-science major textbooks embrace an incorrect, outdated and misleading view of succession.

The third category about the factors as Limon states includes the teacher. For example, teachers may *overgeneralize some science concepts on the basis of analogy* which means that the teachers use analogies in order to relate the newly acquired knowledge with the existing one (Taylor and Coll, 1997 as cited in Kikas, 2004) however, students may take them too far so that some alternative conceptions may arise. In addition, *teachers' knowledge and the way they are educated* also affect students' conceptualization levels (Kikas, 2004). As it is stated in the literature teachers may also have some alternative conceptions and bring these alternative conceptions to teaching-learning activities. To sum up, the learner, the teacher, and the social context in which

learning takes place affect learners' conceptualization levels. Therefore, all factors related to these variables have a role in coping with these alternative conceptions.

In order to cope with alternative conceptions one of the earliest influential approaches was conceptual change model developed by Posner et. al. (1982). Learners' previous conceptions were considered to be important in their theoretical framework. They should be placed with the new conceptions in order attain conceptual change. However, it is stated that this replacement can occur if the following four conditions are fulfilled:

- Learners must feel dissatisfied with their existing conceptions
- There must be a new alternative conception and it must be intelligible
- The new conception must appear somewhat plausible
- The new conception should be fruitful

However, it is also shown that cognitive conflicts do not always cause conceptual change. If learners are not dissatisfied with their existing conceptions, it is meaningless for them to give up their ideas which are useful in everyday life, and thus it is not necessary to accept the new ideas which are called scientific knowledge. Furthermore, the learner may be dissatisfied with his/her naïve ideas, but if there is no alternative idea which is intelligible, there is no need for conceptual change according to the learner. Lastly, the learner may be dissatisfied with his/her existing idea, and there may be an intelligible alternative idea available to the learner, but it may not be plausible. There is also no reason for conceptual change to take place. *Chi's Ontological Theory of Conceptual Change* which was proposed by Chi (1992) may be another example of conceptual change theory. According to him, concepts are categorized into three ontological perspectives which are matter, process and mental states. Natural kinds and artifacts belong to the matter category. On the other hand, causal events, procedures, constraint-based interactions in which a system behaves with the interaction of two or more constraints belong to the category of processes. Lastly, mental states cope with emotions and intentions. According to this theory, if a concept is placed to an ontologically wrong category, it is needed to be put in a correct category. Conceptual change occurs if a particular concept is reassigned into an ontologically different category.

Conducting investigations in the laboratory is one of the instructional modes that conceptual change theories can be integrated. One important criterion of scientific literacy is to have a definite understanding of scientific interference as well as the nature of science. Thinking science as a way of investigation is one important step of understanding nature of science. So laboratory work can be used as way of investigation in science lessons and have a crucial role. A number of researchers stated the numerous benefits of laboratory work. First of all, laboratory work helps students to learn the scientific processes such as hypothesizing, experimenting, observing, and criticizing. Moreover, it not only provides opportunities for learning by doing, but also makes the experiences permanent. Furthermore, this technique may change students' attitudes towards science in a positive way. Lastly, it is suggested that laboratory activities play a crucial role in students' understandings of science concepts. One of the reasons for this crucial role depends on the fact that laboratory activities give some opportunities to the

students in engaging hands-on experiences. Furthermore, these hands-on activities may have positive effects on students' achievement in science (Freedman, 1997). However, students should understand the importance of laboratory work for their conceptual understanding. While some of the students realize the importance of laboratory work in their conceptualizations, some of them may not be able to realize it. Çepni, et al. (2001) interviewed some students and these students stated that science lessons should be supported with some experiments. On the other hand, in the study of Berry, et al. (1999), students' perceptions about laboratory were clarified, and it is concluded that many of the students do not know the aim of laboratory work. Only a number of students said that laboratory work helped them to understand the theory. Therefore, one duty of a science teacher is to make his/her students understand the importance of laboratory work in their science learning by designing experiments in a way that they have a clear idea of the purpose of the experiments that they will conduct. In order to attain this purpose, teachers may use different kinds of laboratory work. Domin (1999) stated that chemistry educators divided the laboratory instruction styles into four categories which are expository, inquiry, discovery, and problem-based. *Outcome, approach* and *procedure* are the main descriptors that are used for differentiating these four types of laboratory instructions. The outcome of the laboratory activities can be either predetermined or undetermined. As an approach, deductive approach in which students go from a general principle to a specific one as well as inductive approach in which students derive conclusions after facing with a specific instance can be used as approaches for laboratory instructions. In terms of procedure, students are either given a procedure for their laboratory experiences or generate their experiences by themselves. Thus, if the laboratory instruction is expository, outcome is predetermined, deductive approach is used, and the procedure of the laboratory work is given to the students. However, if the outcome and the approach are determined just in expository style, but the procedure is developed by the students, this laboratory instruction becomes problem-based. If the outcome is predetermined and the procedure was given, but the approach is inductive, it is considered as discovery laboratory instruction. In inquiry laboratory instructions, outcome is undetermined, procedure was developed by the students, and the approach is inductive. Students' understandings may change in these laboratory instructions. Students who engage in inquiry laboratories in which they work in groups of three to four cooperatively by concentrating on the inquiry tasks, such as asking questions related to the task, making plans for the investigations, forming hypothesis, observing, gathering data, and analyzing this data and the students who engage in traditional laboratories in which they are task-oriented, and have a little opportunity to engage in the activities that are mentioned for the inquiry laboratories differ in their understanding of some science concepts (Hofstein, et al., 2001). However, the way science is taught or learned should be determined thoroughly. Sciencing is especially composed of experimentation, observation, criticizing and laboratory investigations; however, public schools in Turkey have some disadvantages in integrating laboratory investigations to science lessons.

Experiential learning conducted in laboratories is considered to be a crucial way of eliminating alternative conceptions in science teaching. It engages students in real-life challenges so that they have a chance to solve these challenges in their minds by conducting some experiments in laboratories as being *minds-on students*. However,

there are different types of investigations which may take place in laboratories. For instance, in some kinds of laboratory work, science teachers give the procedure to the students and want them to conduct the experiments exactly like in the procedure. This type of laboratory work includes guided investigations (Domin, 1999). On the other hand, some teachers use laboratory work in which students are not told the way of conducting experiments. Instead the students themselves find the procedure with the appropriate teacher questioning. This type of laboratory work includes semi-guided investigations (Wallace, et al., 2003; Domin, 1999).

The purpose of the present study is to investigate the effects of guided and semi-guided laboratory investigations on sixth grade students' conceptualization levels related to the physical and chemical changes concepts.

Method

Design and Participants

The study was conducted in an economically disadvantaged public primary school located in İstanbul. 80 sixth grade students were selected for this study. 40 of these 80 students were selected by the science teacher of the school according to her personal observations related these students. After science teacher nominated these 40 students, researchers selected the other 40 students by matching them with the ones that the science teacher has selected. Matching was performed according to two criteria. *Science Attitude Scale (SAS)* was administered to all sixth graders (N=156) in order to select the sample of the study. Students' SAS scores were the first criterion also their science grade averages of previous three terms were the second criterion. Each student was matched with one another in terms of their SAS score and science grade average. In order to show that there is no significant difference between these two sub-groups in terms of their science attitude and science achievement, two independent samples t-tests were conducted. The first one is carried out between the two groups' SAS scores, and it is found out that there is no significant difference between these two groups' scores ($t=1.204$, $p=.232$). Second independent samples t-test was conducted between means of average science grades of two groups, and no significant difference is found ($t=1.204$, $p=.364$). Then, selected 80 students were randomly divided into four groups, and every group was exposed to one of type of treatments. 40 (20+20) of them treated with guided investigations, while the other 40 (20+20) were treated with semi-guided investigations. *Science Concept Scale Related to the Concept of Physical and Chemical Changes (SCS-PCC)* was administered to the sample, before, they were exposed to any treatment and after the treatments completed as pre and post test.

Unfortunately some of the subjects did not participate in all the treatment sessions so at the end of the treatments, 27 students (14 females, 13 males) completed the guided investigations, while 23 students (14 females, 9 males) completed the semi-guided investigations. As a result, sample of the study composed of 50 students. Independent sample t-test was repeated for the remaining groups of students and it is found that there was no significant difference between the *Science Attitude Scales* mean scores of these two groups ($t=.197$, $p=.845$). However, they were different in terms of

their means of previous average science grades ($t = -4.219$, $p = .000$) in favor of the group who were treated with semi-guided investigations.

Instruments

The instruments used in the study are designed to assess students' attitudes towards science and conceptualization levels related to the concept of physical and chemical changes.

Science Attitude Scale (SAS)

In order to determine students' attitudes towards science at the beginning of the study, *Science Attitude Scale-SAS* (Toğrol, 2000) was administered to all participants. The duration of the test is 20 minutes. It is a paper and pencil test which contains 16 likert-scale response items. The scale included such items as; "I like to study science lessons" "It is very enjoyable for me to study in science laboratories." Items were scored on a 3-point scale ranging as *yes*, *sometimes*, and *no*. Reliability analysis of the scale was performed with a sample composed of from the same school students with the current study. Sample for the reliability study was 52 sixth and seventh graders, and test-retest reliability coefficient was found to be .74 and alpha reliability coefficient for this sample was also found as .82 (Toğrol and Muğaloğlu, 2000).

Science Concept Scale Related to the Concept of Physical and Chemical Changes (SCS-PCC)

The instrument which was developed by the researchers composed of two parts. In part A, three situations about the physical and chemical changes in sugar were introduced, where as in part B, three situations about the physical and chemical changes in paper were given. Then in each part same three open-ended questions were repeated in order to understand the students' conceptualizations' related to the situations introduced. For probing sixth graders' conceptualization levels related to the selected science concepts more precisely, it is preferred to develop SCS-PCC with open-ended questions. Considering the related literature in developing the questions daily life situations were preferred. For example, students were asked to determine the changes in cube sugar after the cube sugar is exposed to some processes. Likewise, students were expected to answer similar questions about changes take place by using some newspapers. Before using the instrument one experienced chemistry teacher and two science educators examined the test qualitatively for the content validity purposes.

The instrument was administered to the participants as a pretest, in the first 20 minutes of the first week of their treatments. The same instrument was also given as a posttest, after they were exposed to the treatments - in the last 20 minutes of the last sessions. For reliability purposes, mainly for consistency of scoring a rubric was developed. For this purpose; first data were analyzed according to responses obtained from SCS-PCC. Before the development of the rubric, all the answers of students were transcribed and the similar answers were grouped. As a result, a kind of summary of answers given to SCS-PCC was obtained and a rubric was developed. This *first* rubric

was distributed to nine judges in order to determine the scores that the data will be analyzed and necessary feedback were received considering their comments. According to those comments *second* rubric was developed which was given to three judges who were experienced science educators. According to their decisions, rubric took its original form and data were analyzed according to this *original rubric*. During inter-rater reliability study as well as the all data gathered from SCS-PCC were analyzed according to this original rubric. Inter-rater reliability analysis was conducted in order to determine the consistency of scoring the items. In order to determine inter-rater reliability, an academician who was specialized in chemistry education scored 28 randomly selected response sheets. She scored the items according to the original rubric that the researchers had developed. Then, Pearson r correlation coefficients were determined for each item individually, except one of the questions ($r=.68$) coefficients ranges between .81 and .97 with an average of .84.

Worksheets

As it is mentioned before, two different treatments were used in this study, one of them was guided investigation and the other one is semi-guided investigation. During these two types of treatments, some worksheets were given to the participants in order to understand the development that take place in their conceptualizations. There are similarities as well as differences between the worksheets of the two treatments. For instance, in both treatments the worksheets were composed of five parts including purpose of the experiment, materials used, procedure, observations and results. On the other hand, there were also some differences between the “*materials*” and “*procedure*” parts of the worksheets. The materials that were used during the experiments were written explicitly in the *materials* part of the guided investigation worksheets. However, they were not written in the semi-guided investigation worksheets. Similarly, in *procedure* part of the worksheets of guided investigation group, all the procedures were written in a detailed way, while this section was empty in the semi-guided investigation worksheets. Instead, it was written that the students should form their own group procedures. All worksheets were analyzed qualitatively. Every group filled out worksheets, and the number of alternative conceptions in each part of the worksheets was determined.

Treatments

Subjects participated in 90-minute-sessions for two weeks. These sessions were arranged after all the classes were completed according to the schedule of the school so the treatments could be considered as a curriculum enrichment activity.

Guided Investigations procedure contains a number of tasks that require students to engage in laboratory activities designed to improve their conceptualization levels related to the physical and chemical changes concepts. Students were asked some daily life questions at the beginning of the lesson. After receiving answers from the students, teacher gave a direct instruction about physical and chemical changes. In this session, *change* was defined, and it was divided into two as *physical* and *chemical*

changes. Then, students conducted experiments about physical and chemical changes using several materials as a group. All the steps of the procedures were given to the students, and they conducted the experiments as it is stated in the procedures part of their worksheets. When the experiments were over, teacher summarized the lesson with a game. At the end, a homework which students should find some examples to physical and chemical changes were given. In the second session of this treatment, the students were reminded of the definitions of a physical and a chemical change, and then they conducted similar experiments with the first session. As it was in the first lesson, students conducted these experiments according to the procedures given in their worksheets. As a concluding activity, the teacher and the students summarized the lesson together.

Semi-guided Investigations also includes some hands on laboratory experiences which serve to improve students' conceptualization levels related to the *physical and chemical changes* concepts. As it is stated in guided investigations, students were also answered some daily life questions at the beginning of the lesson. After receiving several answers from them, students were introduced with the materials that they would use during their experiments. Among the materials there were sugar cube, paper, vitamin, etc. The teacher, wanted students to change these materials by using their own procedures. After dividing the class into four groups, worksheets were distributed and they started to change their materials by writing their own procedures to do this change, observations and conclusions on their worksheets. When the experiments terminated, every group presented their ways of changing the given materials to others. Then, the differences between the procedures of different groups were discussed and the teacher wanted them to classify these changes into two groups according to some criteria that they would form. After this process, students were asked their predictions about the names of these two types of changes. Before summarizing the lesson, the teacher said that these changes are called *physical* and *chemical* changes. In order to summarize this session, students played a game about the subject. In the second session of this treatment, students were asked to give some daily life examples for physical and chemical changes. Then, some other materials such as play dough, candle and apple were given to them. The aim was not only change these materials by their own way, but also to determine the type of change take place. After the experiments, their procedures, observations and conclusions were discussed. At the end of the lesson a summarization was made by the students.

Data Analysis and Results

Data were analyzed according to scores obtained from SCS-PCC. The instrument was administered to the sub-groups of the study twice. The first one was before the treatment, while the second one was at the end of the treatment. Because the number of the subjects in each sub group were below 30 (23 and 27), in order to find out if the parametric tests can be applicable, normality tests were conducted. Normality tests of Kolmogorov-Smirnov and Shapiro-Wilk were conducted for both the SCS-PCC pretest and posttest scores of students who were treated with guided and semiguided-investigations. Histograms were drawn and skewness and kurtosis for the allowance of

the parametric tests were calculated. The results of these tests show that the scores are not significantly different than the scores which have normal distribution so it is proved that the pretest and posttest scores of the students in both sub groups are normally distributed -

There were totally 27 participants who were treated with guided investigations. The mean of scores in both SCS-PCC pretest and posttest is calculated, and found to be $M=10.78$ in pretest and $M=22.48$ in posttest. Table 3 shows descriptive statistics related to pretest and posttest scores of these participants.

Table 3. Descriptive statistics related to pre-test and post-test scores of participants who were treated with guided investigations.

	n	Min.	Max.	M	SD
Pretest	27	5	18	10.78	3.446
Posttest	27	9	41	22.48	7.638

There is an increase taking place in the post-test scores of participants when compared with their pre-test scores. In order to test the first hypothesis of the study - *Guided investigations have an effect on six graders' conceptualization levels related to physical and chemical changes concepts as measured by Science Concept Scale-Physical and Chemical Changes*. Paired-sample t-test results indicated significant differences between pre-test and post-test scores ($t=-7.026$, $p=.000$).

Semi-guided investigations have an effect on six graders' conceptualization levels related to physical and chemical changes concepts as measured by Science Concept Scale-Physical and Chemical Changes (SCS-PCC) was the second hypothesis of the study. There were 23 participants who were treated with semi-guided investigations. The SCS-PCC pre-test and post-test mean scores of these participants are calculated, and as it is seen in Table 4, an increase takes place in the means of posttest scores of participants when compared with their pretest scores. Paired-sample t-test indicated a statistically significant difference between SCS-PCC pre-test and post-test scores of six graders who were treated with semi-guided investigations.

Table 4. Descriptive statistics related to pre-test and post-test scores of participants who were treated with semi-guided investigations

	M	n	SD	Std. Error Mean
Pre test	15.52	23	4.541	.947
Post test	22.65	23	8.315	1.734

The third hypothesis of the study was stated as; *There is a significant difference between six graders' conceptualization levels who were treated with guided investigations and who were treated with semi-guided investigations as measured by Science Concept Scale-Physical and Chemical Changes (SCS-PCC) in favor of students who were treated with semi-guided investigations.* In order to test the third hypothesis, an independent sample t-test was carried out between the pretest scores of these two groups.

Analysis of the Worksheets

Observations and results parts of both types of worksheets were the same in which students wrote their observations and conclusions, respectively. There were 17 alternative conceptions in the observations part of the worksheets of the participants who were treated with guided investigations, while this number was 11 in the worksheets of the participants who were exposed to semi-guided investigations. In addition, there were 19 alternative conceptions in results part of the worksheets of the participants who were treated with guided investigations and this number was only 10 in the worksheets of the participants who were treated with semi-guided investigations.

Conclusions and Implications

This study is conducted in order to determine the effects of two different types of laboratory work on six grade students' conceptualization levels related to the concepts of physical and chemical changes by using a pretest-posttest comparison group design. *Science Concept Scale-Physical and Chemical Changes* was administered to the students both before and after the treatment. The mean score of the participants who were treated with guided investigations was found to be $M=10.78$ before the treatment, it increased to $M=22.48$ after the treatment. Therefore, it is concluded that laboratory investigations have a significant effect on students' conceptualization levels related to the concepts of physical and chemical changes ($t= -7.026$, $p= .000$). It is stated in the literature that laboratory activities have a central role on students' conceptualization levels (Garnett, et al., 1995; Hodson, 1990; Hofstein and Lunetta, 2003; Lazarowitz and Tamir, 1994; Lunetta, 1998; Tobin, 1990). Although the significant effect of guided laboratory investigations was expected, this sharp increase in students' posttest scores was not expected. The reason behind this result may be due to the fact that this was the first time that participants engaged in hands-on activities.

Among the students who were treated with guided investigations, there are only two students whose posttest scores are not higher than the pretest scores. Posttest score of the first student got one point lower than her pretest score. When the answer sheet of this student was examined, it is realized that there were some communication problems between the members of the group which the student participated. Her answer to the third part of the evaluation sheet - in which students wrote the things that they did not like the most - clarified that, the relationship between the group members affected students' motivation related to the laboratory activities so that she had difficulties in understanding the subject matter, and was not able to engage in the investigations, as a

result, she became confused. There are nine point differences between the pretest and posttest scores of the second student. Her pretest and posttests were examined for the second time, and it is found out that the student confused the physical and chemical change; in other words, she understood a chemical change as a physical change, and vice versa.

The second group of students was treated with semi-guided investigations in which students were engaged in activities in a way that they developed their own procedure and then conducted the experiments according to this procedure. Similarly, they were administered SCS-PCC both before and after the treatment. While the mean scores of the participants was found to be $M=15.52$ before the treatment, and $M=22.65$ after the treatment. Thus, it is also concluded that semi-guided investigations have a significant effect on students' conceptualization levels related to the physical and chemical changes concepts ($t=-3.739$, $p=.001$). It is stated in the literature that students engaging in this type of laboratories enhance their conceptual understanding (Hofstein et.al., 2001). Therefore, the results of this study also support this argument. However, there are five students whose posttest scores are lower than the pretest scores. When the pretest and posttest of these students were examined for the second time, it is seen that this lower scores in the posttest depends on the answers that they wrote to the third item of the instrument (SCS-PCC). In this item, students are expected to write any process that should cause a change in sugar cube and newspapers, and that process should not be the same with the ones that are mentioned in the instrument. Although they wrote different processes in the pretest, they did not give different examples to them in the posttest. Instead, they wrote the processes which are exactly the same with the ones in the first item of the instrument, because they conduct experiments related to this first item. As a result, they lost points in the posttest, because they should not write the same processes that are mentioned in the instrument before. By using ANCOVA no significant difference was found between the posttest scores of the students who were treated with guided investigations and the ones who were treated with semi-guided investigations ($p=.960$). The reason for this result may depend on several factors. First of all, this was the first time that these students engaged in hands on laboratory activities. Therefore, it may be more beneficial for them to be guided with the given procedure. In other words, students were given some materials such as sugar cube, paper, play dough, vitamins and so on, and then they were expected to change these materials during semi-guided investigations. Because they used these materials in their science lessons for the first time, and sometimes they did not concentrate on the subject matter but instead, they paid more attention to the materials which they will use during the activity. If they are used to attend some laboratory activities before this study, they may not pay this much attention to these materials. Second reason for not observing any significant difference in students' conceptualization levels who were treated with guided investigations and who were treated with semi-guided investigation may be due to the fact that nearly all of their lessons are structured, and they accustomed with guided activities during their instructions. If some hands on activities are used in other lessons, they would not be unfamiliar with these kinds of activities. Other reason for not determining the differences on the conceptualization levels of students who were treated with different types of laboratory investigations may depend on the fact that the participants were not accustomed group work. Direct instruction is the most widely used

method by the teachers of this school, and they do not use any group work during their lessons because of the crowded classes. Therefore, students devoted some time to adopt themselves to group work during the treatment sessions. As it is stated in the literature, group work has positive effects on students' conceptualization levels and achievement if certain conditions are fulfilled. One of the most important conditions is the time devoted for the group work. Its positive effects can be seen when students become familiar to use it (Hofstein and Lunetta, 2003). So if the duration of the treatments is longer the result of the study may change. Students were more accustomed with guided investigations type of lessons. They may be more successful in the lessons that they were guided. Furthermore, it is stated in the literature that when open investigations have been used over a long period of time, it is effective in improving learners' conceptual knowledge qualitatively (White and Frederiksen, 1998). If the duration of the treatments were longer than it was, a significant difference may be observable between the conceptualizations of the students who were treated with guided investigations and the ones who were treated with semi-guided investigations. Although there is no significant difference between the posttest scores of students who were treated with guided investigations and the ones who were treated with semi-guided investigations. Another point is related to the timing or period that the treatment sessions took place. Students attended these sessions, after they participate in daily school work. The reason behind the occurrence of this limitation depends on the fact that these treatments were carried out as curriculum enrichment activities. Therefore, some of the participants were tired and could not concentrate on the subject matter in some parts of the treatments. Thus, their difficulty in focusing on the tasks of the subject matter or the activities during the treatment sessions decreased the efficiency of the study.

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Yönlendirici ve Yarı-Yönlendirici Laboratuvar Uygulamalarının Altıncı Sınıf Öğrencilerinin Kavramsallaştırma Düzeylerine Etkisi

Özet

Bu çalışmanın amacı, öğrencilerin fiziksel ve kimyasal değişim kavramlarıyla ilgili kavramsallaştırma düzeylerine farklı laboratuvar uygulamalarının etkisini ortaya çıkarmaktır. Çalışma, İstanbul'un ekonomik olarak dezavantajlı bölgelerinden birinde bulunan bir devlet okulunun altıncı sınıf öğrencileriyle gerçekleştirilmiştir. 80 öğrenci çalışmanın örneklemini olarak seçilmiştir. Öğrencilerin Fen Dersi Tutum Ölçeğinden (Toğrol, 2000) aldıkları puanlar ve fen dersi notları eşleştirilerek iki homojen grup (n=40) oluşturulmuştur. Ancak ilk gruptan 27 ile ikinci gruptan 23 öğrenci laboratuvar uygulamalarının tümünü tamamlamışlardır. Fen Dersi Tutum Ölçeği, öğrencilerin fen derine karşı tutumlarını ölçmek amacıyla, Fiziksel ve Kimyasal Değişim – Kavramsallaştırma Düzeyi Belirleme Ölçeği ise öğrencilerin fiziksel ve kimyasal değişim konusundaki kavramsallaştırma düzeylerini belirlemek amacıyla kullanılmıştır. Çalışmada, yönlendirici laboratuvar çalışması olarak adlandırılan ve öğrencilere yapılacak deneylerin işlem basamaklarının detaylı olarak verildiği laboratuvar çalışması ile yarı-yönlendirici laboratuvar çalışması olarak adlandırılan işlem basamaklarının öğrenciler tarafından oluşturulmasının beklendiği iki tür laboratuvar uygulaması kullanılmıştır. Her bir laboratuvar uygulamasının öğrencilerin kavramsallaştırma düzeylerine etkisi olup olmadığını anlamak amacıyla öntest ve sontest sonuçlarını karşılaştıran analizler gerçekleştirilmiştir. Çalışma sonuçları iki tür laboratuvar uygulamasının da altıncı sınıf öğrencilerinin fiziksel ve kimyasal değişim konusundaki kavramsallaştırma düzeylerine olumlu yönde etkisi olduğunu göstermektedir (yönlendirici $df=26$, $t=-7.13$, $p=.000$; yarı-yönlendirici $df=22$, $t=-6.17$, $p=.000$). Her iki farklı laboratuvar çalışmasına katılan öğrencilerin kavramsallaştırma düzeyleri arasında fark olup olmadığını incelemek amacıyla Kovaryans Analizi (ANCOVA) yapılmıştır. Sonuçlar, iki tür laboratuvar çalışmasına katılan öğrencilerin kavramsallaştırma düzeyleri arasında istatistiksel olarak anlamlı fark olmadığını göstermesine rağmen, yönlendirici laboratuvar çalışmasına katılan öğrencilerin yanlış ya da alternatif kavramsallaştırma içeren cevap sayısının diğer gruba göre daha fazla olduğunu yansıtmaktadır. Yönlendirici laboratuvar çalışmasına katılan öğrencilerin tamamen doğru verdikleri cevap sayısının diğer gruba göre daha az olduğu görülmüştür.

Anahtar kelimeler: Yönlendirici ve yarı-yönlendirici laboratuvar uygulamaları, fiziksel ve kimyasal değişim, kavramsallaştırma

