EFFECTS OF GUIDED AND SEMI-GUIDED INVESTIGATIONS ON SIXTH GRADE STUDENTS' CONCEPTUALIZATION LEVELS

by

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B.S., Secondary School Science and Mathematics Education, 2003

Submitted to Graduate Studies in
Science and Engineering in partial fulfillment of
the requirement for the degree of
Master of Science

Graduate Program in Secondary School Science and Mathematics Education
Boğaziçi University

2006

ACKNOWLEDGEMENTS

When I compare the first and the last moment of this study, I think that the first person that I have to express my gratefulness is my thesis supervisor Assoc. Prof. Ayşenur Yontar-Toğrol. She is the person who was with me in every step of my study. She not only provided me with great support and valuable feedback for this study, but also motivated me in a time that I feel hopeless. Thank you for everything that you taught to me. It would be very hard to deal with this study without your guidance and smiles that you showed me.

I have to thank to Assoc. Prof. Dilek Ardaç who has unique contributions to my thesis with her valuable experiences. I have first felt the importance of these experiences in her first lecture to me and my friends in one of SCED 340 sessions. She talked about "everyday thinking vs. scientific thinking" in this session. Thank you for teaching how to think scientifically to me.

I would like to thank Assist. Prof. Esra M. Akgül who has valuable ideas for my thesis. She made crucial contribution to this study and these contributions shaped my thesis. I felt the comfort to ask the points that were difficult for me in the times that you were busy. Thank you for allocating time for me.

I want to thank to Prof. Ali Baykal for his contributions. With his unique vision, he has not only broadened my thoughts in this study, but also in every part of my life.

I have to express my gratefulness to Prof. Füsun Akarsu not only for the contributions to this thesis but also to my point of views about life. She taught me to make my mind "on". I cannot express her contributions to my life with words. Thank you for being my guide.

I would like to thank Dr. Buket Güzel for the critical interventions to my thesis. She gave important feedback especially in the parts that I have some doubts. I have to denote her moral support in addition to her valuable contributions to this study.

I want to thank to Nergiz Nazlıçiçek and Ebru Muğaloğlu, two precious academic members of our faculty for their valuable ideas and moral support.

My special thanks to Gülşen Pekcan, Miray Tekkumru and Özge Turhan. They always supported me throughout this study. Gülşen Anne, thanks for listening to me every morning about the obstacles that I faced with both in this study and in my life. Miray, my dear little friend, thank you for your moral support, valuable contributions to this study and motivating me. Now, it's your turn.

My friends Ezgi, Volkan, Mihriban, Zahid, Aysun, Yeliz, Leyla, Fatma, Serkan, and Özay. I want to thank to Ezgi and Volkan for their moral support. Mihriban, thanks for being with me throughout this study. I will miss our weekly lunches in which we talked about everything. Zahid, thank you for your advises to this study and your moral support. Although Aysun, Yeliz, Leyla, Fatma, Serkan, and Özay were far away from me, they did not forget to support and motivate me throughout my study.

Finally, I should express my gratefulness to my father, my mother, my sister and my brother. Their everlasting support and love in every phase of this study and of my life help me in believing myself. As all of you said, this is just the beginning. I also thank you very much to Ekban, my fiancée, for his love, patience and support. Without his support, this work would have been difficult to be produced.

ABSTRACT

EFFECTS OF GUIDED AND SEMI - GUIDED LABORATORY INVESTIGATIONS ON SIXTH GRADE STUDENTS' CONCEPTUALIZATION LEVELS

The present study attempts to understand the effect 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 Istanbul.

There were totally 156 sixth graders in the school. 80 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, 27 of the students in the first subgroup and 23 of the students in the second subgroup have completed the treatments. Science Attitude Scale (SAS) (Toğrol, 2000) was used in order to determine students' attitudes towards science. Science Concept Scale - Physical and Chemical Changes (SCS-PCC) is the second instrument developed by the researcher in order to measure students' conceptualization levels related to the selected science concepts-physical and chemical changes.

There were 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, while in semi-guided investigations students find out the procedures by themselves and continue their investigations according to their own procedures.

Results indicate that both types of investigations cause positive developments on six graders' conceptualization levels. In addition, analysis of covariance (ANCOVA) was conducted in order to examine 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 significant difference between the effects of these laboratory investigations on students' conceptualizations, it is found out that the number of incorrect answers or answers which include alternative conceptions for the students who were treated with guided investigations are more that the ones who were treated with semi-guided investigations. On the other hand, the number of completely correct answers for the students who were treated with semi-guided investigations are more than the ones who were treated with semi-guided investigations.

ÖZET

İKİ FARKLI LABORATUVAR UYGULAMASININ ALTINCI SINIF ÖĞRENCİLERİNİN KAVRAMSALLAŞTIRMA DÜZEYLERİNE ETKİSİ

Bu çalışmanın amacı, öğrencilerin fiziksel ve kimyasal değişim kavramlarıyla ilgili kavramsallaştırma düzeylerine farklı laboratuvar uygulamalarının etkisini ortaya çıkarmaktır. Çalışma, İstanbul'un ekonomik düzeyi düşük bölgelerinden birindeki okulda bulunan altıncı sınıf öğrencileriyle gerçekleştirilmiştir.

Okulda toplam 156 altıncı sınıf öğrencisi bulunmaktadır. Bu öğrencilerden 80'i çalışmanın örneklemi olarak seçilmiştir. Öğrencilerin *Fen Dersi Tutum Ölçeği*nden (Toğrol, 2000) aldıkları puanlar eşleştirilerek iki homojen grup (n=40) oluşturulmuştur. İlk gruptan 27 öğrenci laboratuvar uygulamalarını tamamlarken, ikinci gruptan 23 öğrenci laboratuvar uygulamalarının tamamına katılmıştır.

Fen Dersi Tutum Ölçeği (SAS), 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 (*yönlendirici* df=26, t=-7,13, p= ,000; *yarı-yönlendirici* df=22, t=-6,17, p= ,000). Son olarak, bu iki tür laboratuvar çalışmasına katılan öğrencilerin son test puanları ANCOVA yöntemiyle analiz edilmiş ancak grupların kavramsallaştırma düzeylerine farklı laboratuvar uygulamalarının etkisi arasında istatistiksel olarak anlamlı bir fark bulunamamıştır.

Çalışma sonuçları iki tür laboratuvar uygulamasının da altıncı sınıf öğrencilerinin fiziksel ve kimyasal değişim konusundaki kavramsallaştırma düzeylerine olumlu yönde etkisi olduğunu göstermektedir. Ayrıca, iki farklı laboratuvar çalışmasına katılan öğrencilerin kavramsallaştırma düzeyleri arasında fark olup olmadığını incelemek amacıyla kovaryans analizi (ANCOVA) yapılmıştır. Sonuçlar, iki tür laboratuar çalışmasına katılan öğrencilerin kavramsallaştırma düzeyleri arasında fark olmadığını göstermesine rağmen, yönlendirici laboratuar çalışmasına katılan öğrencilerin yanlış ya da yanlış kavramsallaştırma içeren cevap sayısının yarı yönlendirici laboratuar çalışmasına katılan öğrencilerinkinden daha fazla olduğu bulunmuştur. Bunun yanında, yönlendirici laboratuar çalışmasına katılan öğrencilerin tamamen doğru verilen cevap sayısının yarı yönlendirici laboratuar çalışmasına katılan öğrencilerinkinden daha az olduğu bulunmuştur.

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LIST OF SYMBOLS / ABBREVIATIONS

f	Frequency
M	Mean
N	Number
T	Total
Diff.	Difference
Max.	Maximum value
Min.	Minimum value
SAS	Science Attitude Scale
SCS-PCC	Science Concept Scale-Physical and Chemical Changes
Sig	Significant value
SD	Standard deviation
PRE	Test on conceptualization related to the concepts of physical and chemical changes 1
POST	Test on conceptualization related to the concepts of physical and chemical changes 2

1. INTRODUCTION

Science education is one of the most important disciplines which helps to improve people to think critically, make value judgments and decisions, have a better view of environment, and solve the problems that are being faced throughout our lives. For these reasons, and some more, science education is an important component of people's lives. Thus, not only the educators will give importance to science, but also the learners should understand the significance of science in their lives. Although some of the students find science courses interesting and amazing due to the fact that they have a chance to build a connection between their daily lives and the school lives, there are some other students who find it as an area that is difficult to learn and/or easy to be confused. The causes of these difficulties and confusions vary from one student to the other. Some of them may consider science as a confusing subject due to their previous life experiences, while some other may think that it is boring so that they do not want to learn or could not learn it. Therefore, it may be concluded that students' perceptions of their ability to learn science differ from one another, and these perceptions are called **attitudes towards science**.

One of the most important difficulties that today's teachers face with is to change their students' attitudes towards science. For this purpose, they should know about the factors that affect attitudes towards science. As it is stated in the literature, there are many factors affecting students' attitudes towards science. Gender, grade level, science curricula, science teacher, science anxiety, achievement in science courses, conceptualization difficulties in science concepts and teaching modes used by the teachers are among these factors (Freedman, 1997; Salta and Tzougraki, 2003; Gibson and Chase, 2002; Jarvis and Pell, 2002; Jones, et al., 2000; Butler, 1998; Greenfield, 1997; Dechsri, et al., 1997). Teachers' attempts to modify students' attitudes towards science could not be easy without taking into consideration of these factors.

One major factor affecting students' attitudes towards science is their difficulty in conceptualization of some science concepts. For instance, they develop some partially

correct ideas that cause some problems in further learning. Because some problems in previous learning have occurred, students may develop some ideas that are fully in conflict with scientific conceptions. Due to this conflict, these ideas are not correct. Thus, they may be called as **misconceptions**, **alternative conceptions**, or **alternative frameworks**. However, the lack of importance given to confronting and eliminating alternative conceptions in science education may create some problems in students' conceptualization of some scientific ideas, and reducing their attitudes towards science.

Moreover, the way teachers design and present the lesson is found to be an important factor affecting students' conceptual developments. Thus, one way to deal with alternative conceptions is to use different teaching modes in the lessons (Berry, et al., 1999; Wallace, et al., 2003). One of them is the laboratory work in which the teacher makes demonstrations or wants students to conduct the experiments that s/he pointed out.

However, teachers may use laboratory work in different ways in their lessons. For instance, some of them design lessons in which students conduct the experiments in the way that is presented to them. In other words, teacher tells the aim and the procedure (what should the students do during the experiment) to the students explicitly so that students are engaged in more structured laboratory activities. Secondly, some teachers may not tell the procedure of the experiment step by step, instead, they may want students to develop a procedure, and then conduct the experiment according to this procedure.

The present study is an attempt to understand the role of two different types of laboratory work on students' conceptualization levels of selected science concepts. Specifically, the researcher will try to investigate the changes in students' conceptualization levels related to the concept of physical and chemical changes when they learn the concepts via two different types of laboratory work.

2. LITERATURE REVIEW

Main purpose of science education is to make people scientifically literate (Atwater, et al., 1995; Colette and Chiapetta, 1989; Dechsri, et al., 1997; Jones, et al., 2000; Gibson and Chase, 2002; Salta and Tzougraki, 2003). In order to define the scientific literacy, one may state the criteria that a scientifically literate individual should have. Thus, a person who is scientifically literate has the following characteristics:

1. S/he should have a definite understanding of scientific interference as well as the nature of science.
2. S/he should have an interest towards science and technology.
3. S/he should understand the relationship between science, technology and the society, and should argue about the ways that these three influences one another.
4. S/he should use the scientific processes for the purposes of solving daily life problems and making some decisions.
5. S/he should make some value judgments and give decisions that are societal on the issues based on science.
6. S/he should have the science process skills that allow him to function in work, in daily life, and in society.
7. S/he should consider and figure out his environment in a better way as a result of science education.
8. S/he should have a firm science background. In other words, not only should s/he know the scientific facts, principles, and theories, but also s/he should be able to apply these facts, principles and theories in some circumstances. (Atwater, et al., 1995; Colette and Chiapetta, 1989; Dechsri, et al., 1997; Jones, et al., 2000; Gibson and Chase, 2002; Salta and Tzougraki, 2003).

As it is stated in the above criteria, scientifically literate person is the one who has a definite understanding of scientific interference and the nature of science; the science

process skills that allow him to function in work, in daily life, and in society; a firm science background. Although many people think that they have scientific conceptions, these conceptions may be incorrect or partially correct. One of the most important duties of a science teacher is to identify these incorrect or partially correct conceptions, and then put them in a form of scientific conception. Therefore, teachers should be aware of the fact that students' conceptualization levels in science concepts are important for the scientific literacy.

2.1. What is an Alternative Conception?

Throughout history, researchers and theorists opposed on the answers of the two questions about the origins of knowledge: Where does knowledge come from and how do people come to know? The first view, beginning with Aristotle, states that the primary source of knowledge is experience (Spelke, 1998). According to empiricists, who are the defenders of this view, individuals are born with basically no knowledge and they learn through interactions and associations with the environment. There are also teachers that agree with this view. Although these teachers believe that learners have incorrect ideas about many topics before instruction, they assume that these incorrect ideas can be overcome with the use of traditional modes of instruction (Gilbert, et al., 1982; Pope and Gilbert, 1983). On the other hand, according to the second view, which is rationalism, knowledge derives from reason without the aid of the senses (Schunk, 1991). The defenders of this view, Plato being the first, states that anything learned is gained by recalling or discovering what already exist in the mind. This means that there are some understandings that exist in people's minds, and individuals learn by recalling or discovering these ideas (Posner, et al., 1982; Resnik, 1983). There is an immense literature on these understandings about the everyday phenomena, and they evidence that learners' often have ideas that are in conflict with scientifically accepted ones (Driver, et al., 1998; Eryılmaz, 2002; Gazi, 1995; Haidar, 1997; Kikas, 2004; Noh and Scharmann, 1997; Osborne and Freyberg, 1990; Ozmen, 2004; Schmidt, et al., 2003; Schoon and Boone, 1998; Taber, 2001; Valanides, 2000; Yontar, 1989; Zafer, 2004). Furthermore, these are the ideas that prevent the formation of meaningful and permanent learning (Sönmez, et al., 2001). Various terms are used in different research studies for these scientifically incorrect

ideas, such as **preconceptions**, **naïve ideas**, **naïve beliefs**, **children's science**, **misconceptions** and **alternative conceptions**. Although these terms have minor differences, they are used interchangeably in many research studies. *Alternative conception* will be used in this study in order to describe students' ideas which are inconsistent with or in conflict with scientifically correct ideas.

Table 2.1 Common alternative conceptions about dissolution in the literature.

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.

As it is said before, many researchers have studied about these alternative conceptions. However, the ones which are related to physical and chemical changes will be analyzed in this study. Literature indicated that some students 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, some of them stated that dissolution, which is a physical change, is one of the concepts which some students have difficulties in the conceptualization (Çalık, 2005; Ebenezer and Erickson, 1996; Goodwin, 2002; Kabapınar, 2004). Some of them consider it as a chemical change, while

some of them conceptualize it as melting, absorbing, disappearing or transformation. Some examples from these studies are shown in the below table, and they are the ones which are related to students' alternative conceptions related to dissolving are given

Combustion, which is a chemical change, is another widely used concept by the researchers who have studies on conceptualization or alternative conceptions (BouJaoude, 1991; Watson, et al., 1995). Students' alternative conceptions on that concept are summarized in the below table.

Table 2.2. Common alternative conceptions about combustion in the literature.

Combustion of a metal is not a chemical reaction.
Combustion is a reduction to ashes.
Much of the combustible material disappears.
Burning of a candle is chemical because its not changing into a solid, it's changing into a gaseous state.
Burning of a candle is chemical. Because neither the rod or the candle changed physically, therefore it is a chemical change
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.
Burning of a candle is physical. Because you can physically see it.
Burning of a candle is physical. It gives off heat & light. The film is smoke film from the flame.
While alcohol is burning, it would weigh less due to the fact that it evaporates.
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

Moreover, there are some 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. Table 2.3. shows students'

alternative conceptions in differentiating some of the most common changes (Çepni, et al., 2001; Ayas and Coştu, 2001; Özmen, et al., 2001).

Table 2.3. Common changes that students' cannot differentiate as a physical or a chemical change.

Melting ice
Heating mercury oxide
Burning food
Heating sugar
Electrolysis of water
Vaporization and boiling

As it is summarized, students have a number of different ideas in science which are in conflict with scientifically accepted ones. In addition, many researchers conducted studies in this area. Therefore, one can ask about the reasons that these researchers studied on that topic. One reason for studying alternative conceptions depends on the fact that science is an area which includes many abstract concepts that are difficult to learn in a way that is acceptable by the scientists (Zoller, 1990). In addition to that, these abstract science concepts are related to each other. Thus, if an individual cannot construct the basic concepts of science, 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 fundamental science concepts cause difficulties in further learning (Çalık, 2005).

In order to prevent students' difficulties in further learning, teachers should be aware of these difficulties and confusions. One of the most important aims in determining learners' alternative conceptions is to inform teachers about the alternative conceptions before teaching any particular topic. In this way, they will be aware of the alternative conceptions which learners may bring to class. As it is know, if the problem is identified or determined, to find a solution to that problem becomes easier. Likewise, teachers can deal with the alternative conceptions if they identify them. In other words, without knowing about the confusions or difficulties in learners' minds, it is very difficult to eliminate them.

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. Students think that the things that they have learned in class and the observations or experiences that they come across in their real life are completely different. On the other hand, science is a part of people's lives. One of the criteria of scientific literacy is to make people have the science process skills that allow them to function in work, in daily life, and in society (Collette and Chiapetta, 1989). Thus, teachers should be informed about this difficulty so that they can prevent students' development of these ideas.

2.2. Possible Factors Affecting Conceptualization

As it is stated before, science has been regarded as a difficult subject for many learners. One important reason for this regard is learners' difficulties in conceptualization of some science concepts. Researchers studied the factors affecting the conceptualizations of learners (Kikas, 2004; Hasse and Anderson, 1992; Limon, 2001; Santos and Mortimer, 2003; Shiland, 1997; Guzetti, et al., 1997; Gibson, 1996; Johnson and Lawson, 1998).

Limon (2001) analyzed the cognitive conflict process model and identified the variables that might contribute to cognitive conflict. Following is the schema for this model:

Limon (2001) classified the factors affecting conceptualization into three categories. The first category includes the factors related to the learner. It is believed that students' ***prior knowledge*** has an important effect in their ability to obtain new concepts (Johnson & 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 & Lawson, 1998). Novak stated that students acquire knowledge in hierarchical order. Thus, if one of the levels is missing in this hierarchy, new concepts cannot be acquired properly.

Table 2.4. Variables that might contribute to cognitive conflict

Variables that are related to the learner	Values and attitudes toward learning Learning strategies and cognitive engagement in the learning tasks Epistemological beliefs (about learning and teaching and about the subject matter to be learned) Motivation and interest Prior knowledge Reasoning abilities
Variables related to the social context in which learning takes place	Role of peers Teacher-learner relationships
Variables related to the teacher	Domain-specific subject matter knowledge Motivation and interests Epistemological beliefs (about learning and teaching and about the subject matter taught) Values and attitudes toward learning and teaching Teaching strategies Level of training to be a teacher

In addition to prior knowledge, motivation and interest of the learners have also an effect on students' conceptualization (Limon, 2001). Pintrich, et al. (2003) stated that ***motivational constructs*** such as goals and values have an effect on concept formation. According to Pintrich, Marx & Boyle, 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.

The second category which includes factors affecting students' conceptualizations is related to the social context in which learning takes place (Limon, 2001). ***Common (non-***

scientific) word usage is among the reasons that cause alternative conceptions (Hasse 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, 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. 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). This result was found after the analysis of science and non-science major textbooks on the climax concept of succession. It is concluded in this study that non-science major textbooks embrace an incorrect, outdated and misleading view of succession.

The third category includes factors related to the teacher. Instance, teachers ***over generalize 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 arise.

In addition, ***teachers' knowledge and the way they are educated*** also affect students' conceptualization levels (Kikas, 2004). It is stated in the literature that teachers also have some alternative conceptions. Because they bring these alternative conceptions to teaching-learning activities, their students also form the similar kind of alternative conceptions.

To sum up, the learner, the teacher as well as 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. One important way to deal with the alternative conceptions will be summarized in the following section.

2.3. How to Deal with Alternative Conceptions: Conceptual Change Model

As it is seen, alternative conceptions occur due to a number of reasons. If these reasons are known, a way to cope with and diminish the number of these alternative conceptions can be developed. Thus, science educators concentrate on accomplishing this goal. One of the earliest influential approach on conceptual change was 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:

i. Learners must feel dissatisfy with their existing conceptions
ii. There must be a new alternative conception and it must be intelligible
iii. The new conception must appear somewhat plausible
iv. The new conception should be fruitful

However, it is shown that cognitive conflict do not always causes conceptual change to take place. 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, 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. Lastly, 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.

On the other hand, Vosniadou and Brewer (1994) argued that there is an intermediate stage in this conceptual change model. In other words, learners' naïve conceptions are converted to new conceptions via **synthetic models**. According to them, learners' existing ideas are first transformed to "synthetic models" in which learners take into account of both old and new information as much as possible. This means that synthetic models are the mixture of old knowledge and new knowledge. Thus, they define conceptual change as a gradual process in which initial naïve ideas are converted to scientifically correct ideas via synthetic models. This theory was proposed by Vosniadou and thus known as Vosniadou's framework theory of conceptual change.

Third conceptual change theory was proposed by Chi (1992) and known as Chi's ontological theory of conceptual change. 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.

As it is seen, there are different conceptual change theories in the literature. They can be used to apply in different teaching modes. To make investigations in the laboratory is one of the modes that these conceptual change theories can be integrated.

2.4. Laboratory Work

One important criterion of a scientifically 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 step of understanding nature of science. Thus, it can be concluded that investigations have a crucial role in science.

Laboratory work can be used as way of investigation in science lessons. Number of researchers stated the rich benefits of laboratory work. First of all, laboratory work helps students to learn the scientific processes such as hypothesizing, experimenting, observing, and criticizing. Moreover, not only does it provide opportunities for learning by doing, but also makes the experiences permanent. Furthermore, it increases students' attitudes towards science (Büyükkaragöz, et al., 1991). 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 have effects on students' achievement in science knowledge (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 with some students and the students that they interviewed 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 found out, and it is stated 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. Similarly, students perceive that they should either follow the instruction or get the right answer (Hofstein and Lunetta, 2003). 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 above duty, 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. In addition, **outcome**, **approach** and **procedure** are the three descriptors that are used for differentiating these four 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). Furthermore, conceptual understandings of students' levels who have constructivist learning beliefs and who have positivist learning beliefs are compared in another study. It is found out that the ones who have constructivist learning beliefs added more meaningful understanding than the ones who have positivist learning beliefs (Wallace, et al., 2003).

3. SIGNIFICANCE OF THE STUDY

Primary goal of the societies is to increase the level of their living standards. Science plays an important role in achieving this goal. Therefore, development of society is in parallel with the development of science in this society. However, the way science is taught or learned should be determined thoroughly. Because science is especially composed of experimentation, observation, criticizing; laboratory investigations help student to learn science more effectively. However, public schools in Turkey have some disadvantages in integrating laboratory investigations in their lessons. The school which this study is conducted was one of the schools having difficulties in using laboratory applications in science lessons. Due to the overcrowded classes (45 to 55 students in each class), teacher cannot use laboratory practices, because it is very difficult to work with 45 – 55 students in the laboratory. Thus, this study is conducted in order to satisfy the needs of the school in relation with laboratory practices.

4. STATEMENT OF THE PROBLEM

Experiential learning conducted in laboratories is considered to be a crucial way of eliminating alternative conceptions in science education. 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**. Thus, this type of teaching mode may affect students' conceptualization levels.

However, there are different types of investigations 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 (the procedure). 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 present study examined the effects of guided and semi-guided laboratory investigations on sixth grade students' conceptualization levels related to the **physical and chemical changes** concepts.

4.1. Hypotheses

This study hypothesizes that there will be a change in students' conceptualization levels related to **physical and chemical changes** concept after being treated with two types of investigations (guided and semi-guided) in laboratories. More specifically, the hypothesis of the study were:

- Guided investigations have a significant 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).*

- Semi-guided investigations have a significant 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)*

- 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.

4.2. Variables and Operational Definitions

The study aims to investigate the effects of guided and semi-guided investigations on students' conceptualization levels related to selected science concepts. Therefore, there are two variables of this study:

- **Dependent Variable:** Conceptualization levels related to the concept of physical and chemical changes
- **Independent Variable:** Types of laboratory investigations (as guided investigations and semi-guided investigations)

Conceptualization levels of students related to the concepts of physical and chemical changes refer to students' understanding of particular scientific concept, which is physical and chemical changes concept in this study. It is assessed by the instrument called *Science Concept Scale-Physical and Chemical Change (SCS-PCC).*

Guided investigations refer to students' engaging in activities in a way that they follow the given procedure step by step after being told about the things they will learn during the experiments.

Semi-guided investigations refer to students' engaging in activities in a way that they develop their own procedure for the given purpose and then conduct the experiments and activities according to this procedure with the questioning of teacher.

5. METHODOLOGY

5.1. Sample

This study was conducted in a public primary school called Çağdaş Yaşamı Destekleme Derneği Kağıthane Ferit Aysan Primary School, which is the laboratory school of Boğaziçi University Faculty of Education. The school is located in Kağıthane region which is a district where economically disadvantaged people live (see Appendix A).

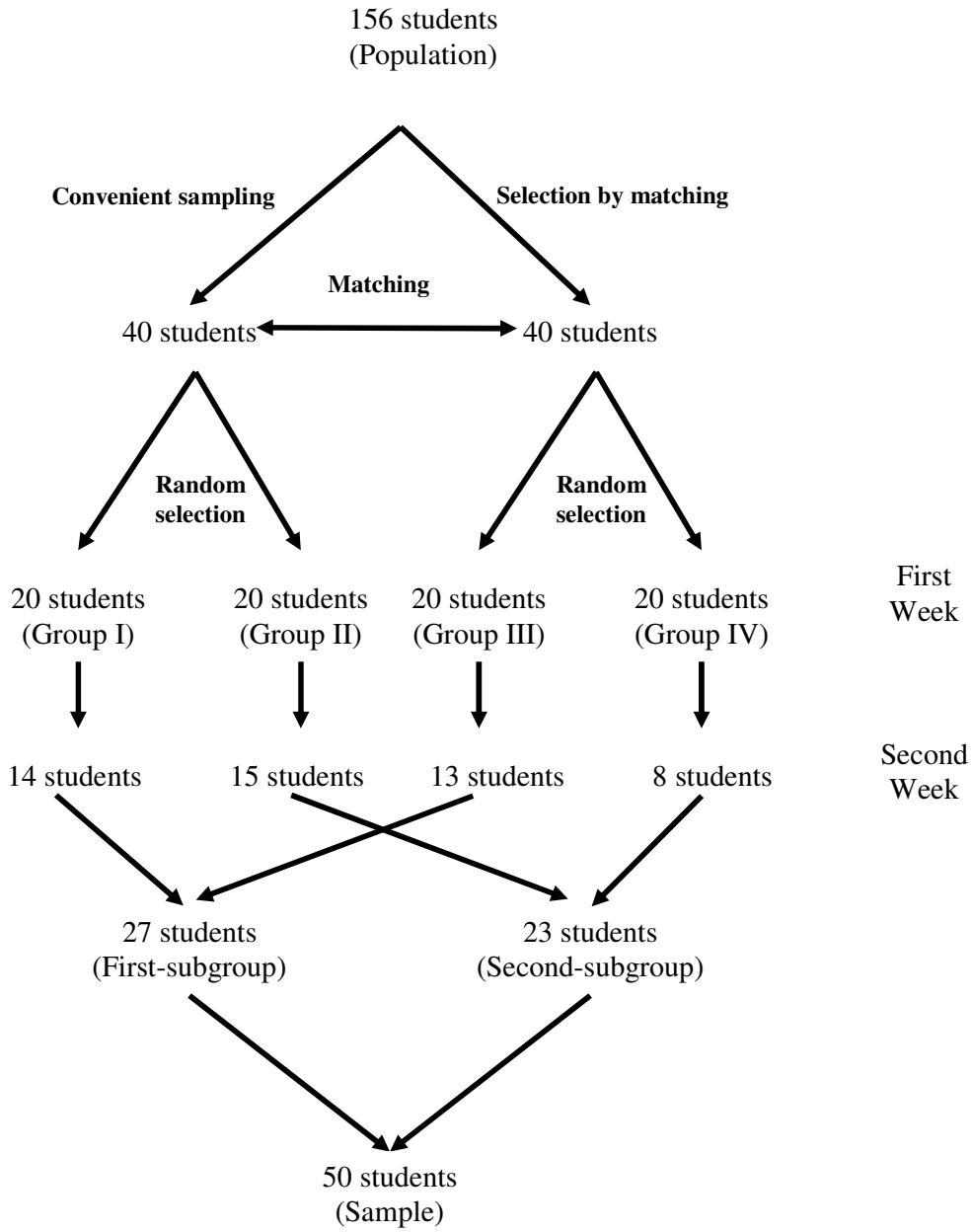
All sixth grade students (N=156) in this school are considered as the target population. 80 students were selected for this study due to some practical reasons such as the working conditions in laboratory and time restrictions. 40 of these 80 students were selected by the science teacher of the school according to her observations about these students. After science teacher nominated these 40 students, researcher 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 population in order to select the sample of the study. Students' SAS scores were the first criterion while their last three terms' science grades were the second criterion. Each student was matched with one another who has the closest SAS score and science grade. In order to show that there is not significant difference between these two sub-groups in terms of 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' SAS scores ($t=1.204$, $p=.232$). Secondly, an independent samples t-test was also conducted between these two group of students' means of last three terms' science grades, and no significant difference is found out ($t=1.204$, $p= .364$).

After the selection of 80 students, they were divided into four groups randomly. The reason behind this grouping depends on the fact that the every treatment was conducted in the groups that were composed of 20 students, because it is difficult to work

with students more than this number in the laboratory. As a result, there are four groups, group 1, group 2, gruop 3, and group 4. Students in the first and the third group were treated with guided investigations, while students in the second and the fourth groups were treated with semi-guided investigations. However, only 14 students of the first group, 15 students in the second group, 13 students in the third group, 8 students in the fourth group participated the second week of the treatment. Therefore, 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 this study is composed of 50 students.

As a result, the 14 students who were selected by the school's science teacher and 13 students who were selected by the researcher were treated with guided investigations. On the other hand, 15 students who were selected by the school's science teacher and 8 students who were selected by the researcher were treated with semi-guided investigations. There is no significant difference between the Science Attitude Scales mean scores of these two group of students ($t=0.197$, $p= 0.845$). However, they are different in terms of their means of previous three terms' science grades ($t= - 4{,}219$, $p=0.000$). The ones who were treated with semi-guided investigations had higher science grades in the previous three terms.

Figure 5.1. Processes of sample selection



5.2. Design

The design of the study is the pretest-posttest-comparison group design. As it is said before, target population of this study was 156 six graders of a public school in Istanbul. All these students were administered SAS at the beginning of the study. Then, the science teacher had selected 40 students and the researcher selected the other 40 students by matching them with the ones who were selected by the school's science teacher. These 80 students were randomly divided into four groups, and every group was exposed to a treatment. 40 of them treated with guided investigations, while the other 40 were treated with semi-guided investigations. Before, they were exposed to any treatment; SCS-PCC was administered to them. After the treatments had been completed, students were again administered SCS-PCC as a posttest. Lastly, a semi-structured interview was administered to 17 students depending on the evaluation sheets that the students had filled at the end of the treatments (see Appendix M). Convenient sampling was used while selecting these 17 students. Table 5.2. summarizes the design of this study.

Table 5.1. Design of the study

<table>
<tr><th>PRE-MEASUREMENT</th><th>TREATMENT</th><th>POST-MEASUREMENT</th><th></th></tr>
<tr><td rowspan="2">Science Attitude Scale (SAS)
(μ = 156)

Science Concept Scale on the concept of Physical and Chemical Changes (SCS-PCC)
(N = 80)</td><td>Guided investigations
(1st Treatment)
(n = 27)</td><td rowspan="2">Science Concept Scale on the concept of Physical and Chemical Changes (SCS-PCC)
(N = 50)</td><td rowspan="2">Interviews
(n = 17)</td></tr>
<tr><td>Semi-guided investigations
(2nd Treatment)
(n = 23)</td></tr>
</table>

5.3. Instruments

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

5.3.1. Science Attitude Scale (SAS)

In order to determine students' attitudes towards science at the beginning of the study, students were given science attitude scale (SAS) which was developed by Toğrol (2000). The duration for administering this test to the students was 20 minutes.

It is a paper and pencil test which contains 16 likert-scale response items (see appendix B). 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 conducted in the same school 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).

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

This instrument is composed of two parts, as **Part A** and **Part B** (see Appendix C). In part A, three situations about the physical and chemical changes in sugar were given, and then three open-ended questions about these situations were asked. Similarly, in part B, three situations about the physical and chemical changes in paper were given, and then the same three questions in part A were asked. In order to observe six graders' conceptualization levels related to the selected science concepts more precisely, it is preferred to develop the instrument with open-ended questions.

One important criterion in developing this instrument is to use daily life questions. In part A of the instrument, 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 some questions about changes in some newspapers.

The instrument was given to the sample as a pretest, in first 20 minutes of the first week of their treatments. Then, they were exposed to the treatments. The same instrument was also given as a posttest, in the last 20 minutes of the second week of the treatments. The same procedure was applied to all four groups of students who were exposed to a treatment.

In order to analyze the data gathered from the students who were administered this instrument, researcher developed a rubric, and gave it to nine judges. With the help of feedback that came from these judges, the researcher developed the second rubric, and gave it to three judges for their evaluations. According to the decisions of the judges, rubric took its original form and data were analyzed according to this original rubric by the researcher.

5.3.1.1. Validity and Reliability Analysis of the Instrument. The validity analysis of the instrument was done qualitatively. One experienced chemistry teacher and two academicians examined the test for the content validity.

Reliability is related to the consistence of scoring of a test. It is necessary for a test to be reliable, because there should be consistency in the scoring. If there in no consistency between the scores, this means that the scores obtained from one administration of a test would be very different with the scores when this test would be readministered. Therefore, 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 specialized in chemistry education was scored randomly selected 28 of the subjects' responses. She scored the items according to the original rubric that the researcher had developed. Then, Pearson r correlation coefficients were determined for each item. Statistical information about these analyses was given in Table 5.2.

Data were analyzed according to responses obtained from Science Concept Scale-Physical and Chemical Changes (SCS-PCC). Because items in this test were open-ended, a rubric was developed in order to analyze the data. Before the development of the rubric, the answers of all students were examined and the similar answers were combined together. As a result, the summary of the answers of the students to SCS-PCC was obtained. Then, these answers were categorized into six categories in order to analyze the data (see Appendix D).

Table 5. 2. Pearson r correlation coefficients of the two raters' scores for each item

Items	**Pearson r correlation coefficient**
Part A Question 1 a	0.689
Part A Question 1 b	0.885
Part A Question 1 c	0.836
Part A Question 2 a	0.966
Part A Question 2 b	0,920
Part A Question 3	0.815
Part B Question 1 a	0.823
Part B Question 1 b	0.830
Part B Question 1 c	0.812
Part B Question 2 a	0.901
Part B Question 2 b	0.818
Part B Question 3	0.812

This first rubric was distributed to nine judges in order to determine the scores that the data will be analyzed. Judges gave crucial feedback to this rubric. Table 5.3. lists feedback that came from the judges and point out the number of judges that gave the particular feedback.

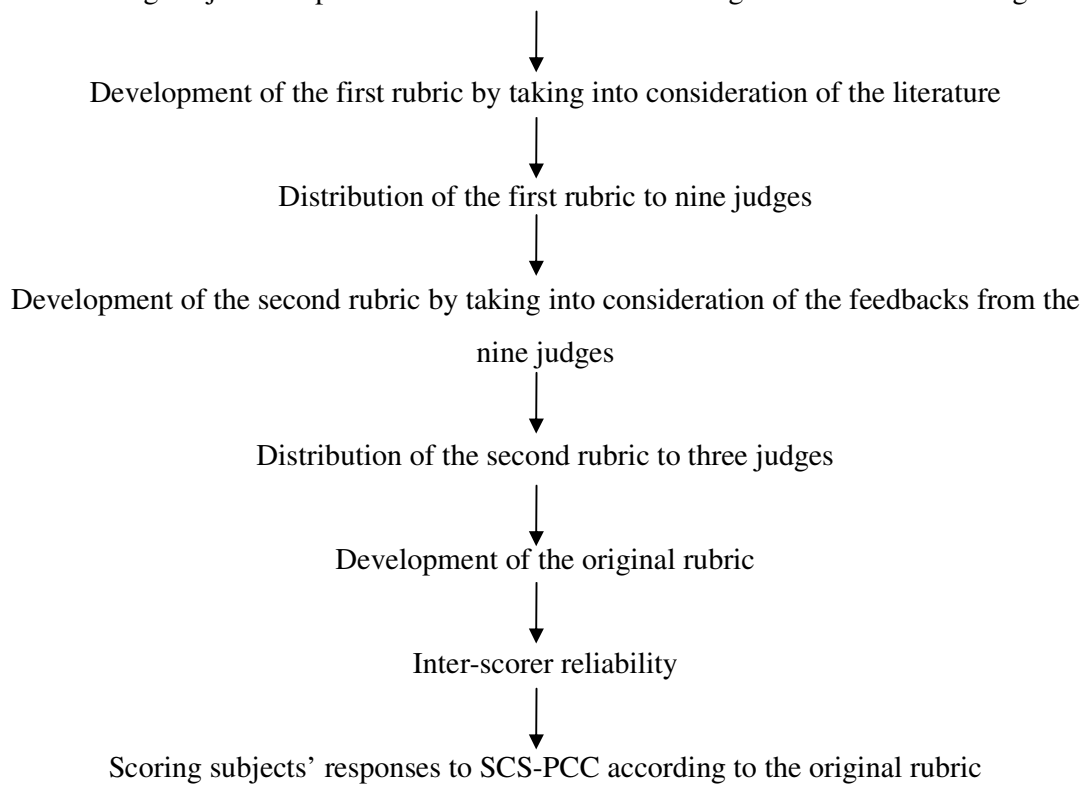
Table 5.3. Feedback given to the first rubric of SCS-PCC

Feedback	**Number of judges that gave the feedback**
There should be different criteria for different questions.	9
It is hard to differentiate between **incorrect answer** and **answer with alternative conception**	6

Due to the difficulties that the judges faced with related with the reasons stated in the above table, they could not score some items. Therefore, their responses were not analyzed quantitatively; instead their feedbacks were taken into consideration so that the second rubric was developed (see Appendix E). As it is seen, each question of SCS-PCC has different criterion for scoring. Secondly, **incorrect answer** and **answer with an alternative conception** were combined in one category.

This second rubric was given to three judges, first one being an experienced science teacher, second being an experienced chemistry teacher, and the third being a research assistant in the department of science education. Data obtained from SCS-PCC was analyzed according to this original rubric.

Figure 5.2. Outline for the development of a rubric for data analysis.



5.3.3. Worksheets

As it is mentioned before, two different treatments were used in this study, one of them was guided investigations and the other is semi-guided investigations. During these two treatments, some worksheets were given to the students in order to follow their conceptual developments. There are both similarities and differences between the worksheets of the two treatments. For instance, because students work as cooperative groups in both treatments, they had found a group name and made some role distributions within the groups.

Second similarity between the worksheets of the two treatments is their parts. Worksheets in both treatments composed of five parts as:

Part A: Purpose of the experiment
Part B: Materials used
Part C: Procedure
Part D: Observations
Part E: Results

On the other hand, there are also some important differences between the worksheets of these two treatments. They are in **material** and **procedure** parts of the worksheets. In **materials** part of the guided investigation worksheets, the materials that were used during the experiments were written. However, they were not written in the semi-guided investigation worksheets. Similarly, in **procedure** part of the guided investigation worksheets, procedures were written, while they were not written in the semi-guided investigation worksheets. Instead, it was written that the students should form their procedures.

Worksheets were analyzed qualitatively. In terms of quality, every group's worksheet is filled out carefully so that there are very few parts that were not written something. Secondly, the number of alternative conceptions in each part of the worksheets was determined.

5.3.4. Evaluation Sheet and Interview

After the treatments, a semi-structured interview was conducted according to the evaluation sheets given to the students at the end of each treatment (see Appendix M). As it is seen in the evaluation sheet, students were asked to write down their likes and dislikes about the things that they faced during the treatments in the sheet. Similarly, the second aim of the interview was to determine the dislikes of the students during the treatments. These last two questions were asked to the students in order to get feedback from them. The interview was conducted with the 17 students.

5.4. Procedure

This section includes the description of the two treatments, which are guided investigations and semi-guided investigations. Subjects participated in 90-minute-sessions every week, and each treatment's duration was 3 hours. Table 5.4. shows the schedule of the weeks, the treatment types and the groups.

Table 5.4. Treatment Plan

Weeks	Treatment types	Groups
1st week	Guided investigations	Group 1
2nd week	Guided investigations	Group 1
3rd week	Semi-guided investigations	Group 2
4th week	Semi-guided investigations	Group 2
5th week	Guided investigations	Group 3
6th week	Guided investigations	Group 3
7th week	Semi-guided investigations	Group 4
8th week	Semi-guided investigations	Group 4

Treatment sessions may be accepted as curriculum enrichment activities which are arranged after all the classes were completed according to the schedule of the school.

5.4.1. Guided Investigations

This treatment 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. The lesson plans incorporated with these tasks and activities are summarized in Appendix F, which is the lesson plan of the first week and Appendix K, which is the lesson plan of the second week.

As it is seen in Appendix F, students were asked some daily life questions at the beginning of the lesson. After getting answers from the students, teacher gave a lecture about physical and chemical changes. In this lecture, **change** was defined, and it was divided into two, physical and chemical changes. After that, students conducted their experiments about physical and chemical changes in some materials as a group. The procedures were given to the students, and they conducted the experiments as stated in the procedures. When the experiments were finished, teacher summarized the lesson with a game. Lastly, a homework which students should find some examples to physical and chemical changes were given to the students.

In the second session of this treatment, students were firstly reminded for the definitions of a physical and a chemical change. After they recalled that information, they conducted similar experiments with the first lesson. As in the case of first lesson, procedures were given to the students, and they conducted these experiments according to these procedures. At the end, the teacher summarized the lesson with the students.

5.4.2. Semi-guided Investigations

This treatment also contains some hands on laboratory experiences that serve students to improve their conceptualization level related to the **physical and chemical changes** concepts. The lesson plans incorporated with these tasks and activities are summarized in Appendix N, which is the lesson plan of the first week and Appendix P, which is the lesson plan of the second week.

As it is seen in Appendix N, students were asked some daily life questions at the beginning of the lesson. After some answers were obtained from the students, they were introduced with the materials that they would use during their experiments. Among the materials there were sugar cube, paper, vitamin, and etc. Teacher, then, wanted students to change these materials in their own ways. After dividing the class into four groups, worksheets were distributed and they started to change their materials by writing their procedures, observations and conclusions on their worksheets. When the experiments terminated, every group told their ways of changing the given materials. Then, the differences between their ways were discussed and the teacher wanted them to divide these changes into two groups according to some criteria that they would form. After this division, 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 lesson of this treatment, students were asked to give some daily life examples to physical and chemical changes. Then, some other materials such as play dough, candle and apple were given. The aim was not only change these materials, but also to determine the type of change. After the experiments, their procedures, observations and conclusions were again discussed. Lastly, the lesson was summarized with the students.

6. DATA ANALYSIS

Data were analyzed according to scores obtained from SCS-PCC. These scores were at interval level. The instrument was administered to the first sub-group (the ones who were treated with guided investigations) of the study twice. The first one was before the treatment, while the second one was at the end of the treatment. Number of subjects that belong to this sub-group is 27. Because this number is below 30, it should be shown that the parametric tests can be applied. For this purpose, normality test was conducted and the results of this test will be shown in **Results** section of the study. According to the results of this test, it is proved that the pretest and posttest scores of the students in these two sub-groups are normally distributed. Therefore, in order to determine whether there is any significant effect of guided laboratory investigations on six graders' conceptualization levels, paired sample t-test was used between the pretest and posttest scores of the students who were treated with guided investigations.

The similar normality test will be conducted for the pretest and posttest scores of students who were treated with semi-guided investigations. It is also proved that these scores are normally distributed. Therefore, paired sample t-test was used between the pretest and posttest scores of the students who were treated with guided investigations in order to determine whether semi-guided investigations have an effect on six graders' conceptualization levels or not.

Furthermore, independent sample t-test was used in order to test whether there is any significant difference between posttest scores of the two sub-groups. Additionally, each part of the worksheets that the subjects filled during the treatments was analyzed in terms of the number of alternative conceptions. Then, subjects' responses to the interview will be used to provide a more detailed information of the findings. Lastly, some descriptive statistics and examples to subjects' responses for each item were given.

7. RESULTS

Because the sample sizes of the both subgroups are lower than 30, one should determine whether the SCS-PCC scores of the students are normally distributed or not. The results of the normality test applied to the pretest and posttest scores of the students in the two sub-groups will be given in the first part of this section. Then, analyses done on the hypotheses will be given in the second part. Thirdly, some descriptive statistics for each item of the SCS-PCC will be given and they will be supported with some examples of the students' responses to each item.

7.1. Normality Tests for the Pretest and Posttest Scores of the First and Second Sub-Group

In order to determine the distribution of the pretest and posttest scores of the students who were treated with guided investigations, histograms were drawn as it is seen in figures 7.1. and 7.2.

Figure 7.1. Histogram for the SCS-PCC pretest scores of the first sub-group

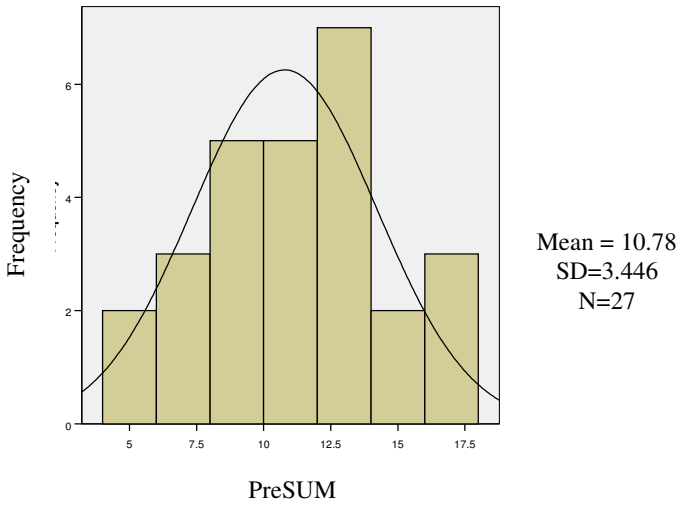
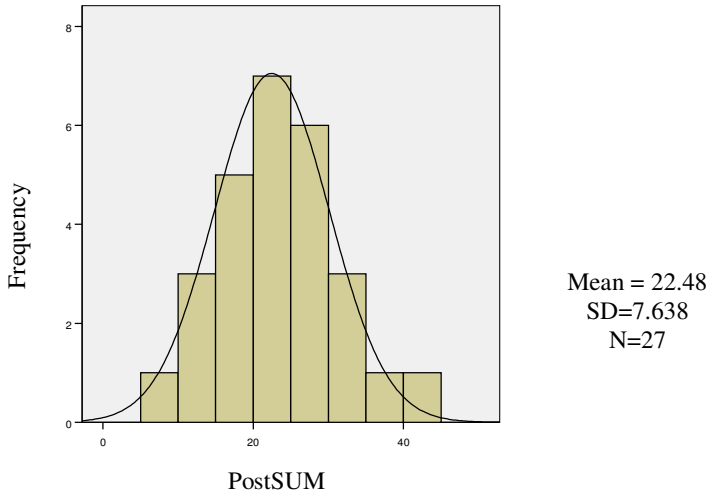


Figure 7.2. Histogram for the SCS-PCC posttest scores of the first sub-group



As it is seen, both pretest and posttest scores are normally distributed. However, one should look for the skewness and kurtosis for the allowance of the parametric tests. The results are shown in Table 7.1. and Table 7.2.

Table 7.1. Skewness and kurtosis statistics for pretest scores of the first sub-group

N	**27**
Skewness	0.288
Std. Error of Skewness	0.448
Kurtosis	-0.189
Std. Error of Kurtosis	0.872
Kurtosis / Std. Error of Kurtosis	-0.0217

Table 7.2. Skewness and kurtosis statistics for posttest scores of the first sub-group

N	**27**
Skewness	0.289
Std. Error of Skewness	0.448
Kurtosis	-0.050
Std. Error of Kurtosis	0.872
Kurtosis / Std. Error of Kurtosis	-0.057

Because Kurtosis / Std. Error of Kurtosis ratio is between -2 and +2 in pretest and posttest scores, parametric tests can be used (Field, 2000). Paired sample t-test was used, because the measure is repeated measures on two related samples.

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 investigations. The results of these tests (Table 7.3) show that these scores are not significantly different than the scores which have normal distribution.

Table 7.3. Kolmogorov-Smirnov(a) and Shapiro-Wilk
Normality tests' results for the pretest and posttest scores of first subgroup of students.

	Kolmogorov-Smirnov(a)			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
PreSUM	0.139	27	0.193	0.962	27	0.414
PostSUM	0.097	27	0.200	0.982	27	0.900

The same instrument (SCS-PCC) was also administered to the second sub-group (the ones who were treated with semi-guided investigations) of the study twice. The first administration took place before the treatment, whereas the second one was administered at the end of the treatment. The number of subjects that belongs to this sub-group is 23. As in the case of first sub-group, histograms of both the pretest and posttest scores were drawn (see Figure 7.3. and Figure 7.4.).

Figure 7.3. Histogram for the SCS-PCC pre-test scores of the second sub-group

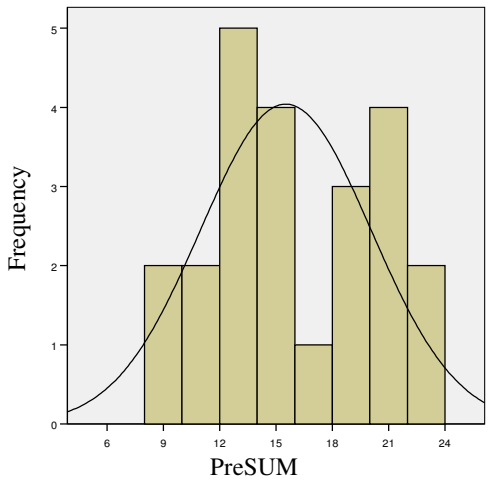
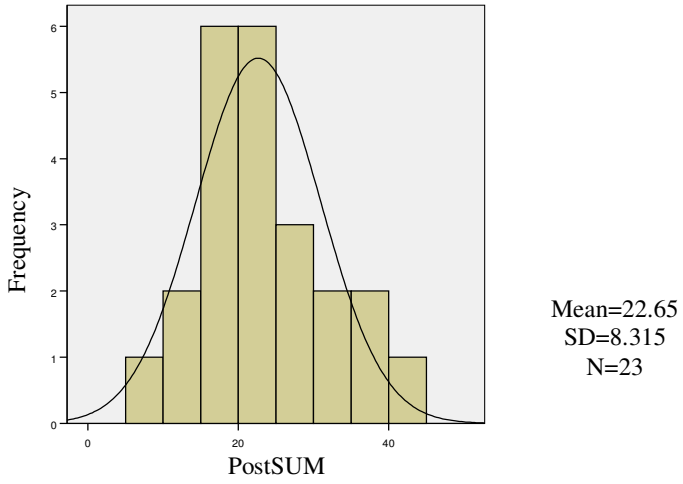


Figure 7.4. Histogram for the SCS-PCC post-test scores of the second sub-group



Then, in order to prove that parametric tests can be applied, skewness and kurtosis were determined for both pretest and posttest scores of the second sub-group. The results are shown in Table 7.3. and Table 7.4.

Table 7.4. Skewness and kurtosis statistics for pretest scores of the second sub-group

N	**23**
Skewness	0.150
Std. Error of Skewness	0.481
Kurtosis	-1.180
Std. Error of Kurtosis	0.935
Kurtosis / Std. Error of Kurtosis	-1.262

Table 7.5. Skewness and kurtosis statistics for posttest scores of the second sub-group

N	**23**
Skewness	0.543
Std. Error of Skewness	0.481
Kurtosis	-0.304
Std. Error of Kurtosis	0.935
Kurtosis / Std. Error of Kurtosis	-0.325

Because Kurtosis / Std. Error of Kurtosis ratio is between -2 and +2 in pretest and posttest scores, parametric tests can be used.

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 investigations. The results of these tests (Table 7.6) show that these scores are not significantly different than the scores which have normal distribution.

Table 7.6. Kolmogorov-Smirnov(a) and Shapiro-Wilk
Normality tests' results for the pretest and posttest scores of second subgroup of students.

	Kolmogorov-Smirnov(a)			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
PreSUM	0.129	23	0.200	0.947	23	0.248
PostSUM	0.103	23	0.200	0.965	23	0.576

7.2. Analyses Done on Hypotheses

Hypothesis 1: 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)

There were 27 participants who were treated with guided investigations. The mean of scores in both SCS-PCC pretest and posttest is calculated, and it is found to be M=11.70 in pretest and M=23.04 in posttest. Table 7.7. shows descriptive statistics related to pretest and posttest scores of these participants.

Table 7.7. 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

Total scores of participants who were treated with guided investigations both in pretest and posttest were presented in Appendix R

As it is seen in Appendix R, there is an increase in post-test scores of participants when compared with their pre-test scores. Paired-sample t-test was carried out between the pre-test and post-test scores of the participants in order to determine whether this increase is statistically significant or not (see Table 7.8).

Table 7.8. Paired-sample t-test results on pre-test and post-test scores of participants who were treated with guided investigations

Paired Differences					t	df	Sig. (2-tailed)
M	SD	Std. Error Mean	95% Confidence Interval of the Difference				
			Lower	Upper			
-11.704	8.655	1.666	-15.128	-8.280	-7.026	26	0.000

It is found out that there is a statistically significant difference between SCS-PCC pre-test and post-test scores of six graders who were treated with guided investigations.

Hypothesis 2: 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).

There were 23 participants who were treated with semi-guided investigations. The SCS-PCC pre-test and SCS-PCC post-test mean scores of these participants are calculated, and it is found to be M=15.39 in pretest and M=25.22 in posttest. Table 7.9. shows the data related to descriptive statistics of pre-test and post-test scores of these participants.

Table 7.9. 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
PRETEST2	15.52	23	4.541	0.947
POSTTEST2	22.65	23	8.315	1.734

Total scores of participants who were treated with semi-guided investigations both in pre-test and post-test were presented in Appendix S.

As it is seen in Table 7.9. there is an increase in posttest scores of participants when compared with their pretest scores. Paired-sample t-test was carried out on the pre-test and post-test scores of the participants in order to determine whether this increase is statistically significant or not. Table 7.10. shows the results of this analysis.

Table 7.10. Paired-sample t-test results on pre-test and post-test scores of participants who were treated with semi-guided investigations

Paired Differences					t	df	Sig.
M	SD	Std. Error Mean	95% Confidence Interval of the Difference				
			Lower	Upper			
-7.130	9.147	1.907	-11.086	-3.175	-3.739	22	0.001

It is found out that there is a statistically significant difference between SCS-PCC pre-test and post-test scores of six graders who were treated with semi-guided investigations.

Hypothesis 3: There is a significant difference between six graders' conceptualization levels who were treated with guided investigations and who were treated with semi-guided investigations.

In order to test this third hypothesis, one should determine whether the pre-test scores of students who were treated with guided investigations (first sub-group of the sample) and the ones who were semi-guided investigations (second sub-group of the sample) are significantly different or not. In order to determine this, an independent sample t-test will be carried on between the pretest scores of these two groups. Results of this analysis are shown in Table 7.11.

Table 7.11. Independent samples t-test results between the pre-test scores of students in the two subbgroups

	Levene's Test for Equality of Variances		t-test for Equality of Means						
	F	Sig.	t	df	Sig.	Mean Diff.	Std. Error Diff.	95% Confidence Interval of the Difference	
								Lower	Upper
PreSUM Equal variances assumed	3.955	0.052	-4.195	48	0.000	-4.744	1.131	-7.018	-2.470
Equal variances not assumed			-4.104	40.604	0.000	-4.744	1.156	-7.079	-2.409

As it is seen, there is a significant difference between pre-test scores of the two sub-groups. Therefore, these should be adjusted in order to determine whether there is a significant difference between posttest scores of these two sub-groups. For this purpose, analysis of covariance (ANCOVA) is carried out. The results of this analysis are shown in Table 7.12.

Table 7.12. ANCOVA results on the post-test scores of participants who were treated with guided and semi-guided investigations

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	0.410(a)	2	0.205	0.003	0.997
Intercept	2043.286	1	2043.286	31.612	0.000
PreSUM	0.048	1	0.048	0.001	0.978
TTT	0.161	1	0.161	0.002	0.960
Error	3037.910	47	64.636		
Total	28486.000	50			
Corrected Total	3038.320	49			

(a) R Squared = 0.000 (Adjusted R Squared = -0.042)

7.3 Descriptive and Qualitative Analysis on Items of Science Concept Scale-Physical and Chemical Changes (SCS-PCC)

The aim of this study is not to only answer the research questions by analyzing the data quantitatively, but also quanlitatively analyze the six graders' conceptualization levels related to selected science concepts. For this purpose, descriptive analyses were conducted on how six graders' answered to the question on SCS-PCC. Each item will be analyzed by frequency distribution of the answer categories in the pretest and posttest. Each category will be exemplified by selected student responses.

Part A Question 1a

In the *first question* of *part A*, students were asked to describe the changes in the sugar cube as a result of the three processes given in the question. In *section a* of this first question, students described the changes in sugar cube, when it is crashed and became powder.

Frequency distribution of the answers that students gave to the first question related to the first process is shown in Table 7.13.

Table 7.13. Frequency distribution for the answers given to Part A Question 1 a in SCS-PCC both in pre-test and post-test

		PRETEST Frequency	**POSTTEST** Frequency
0	No answer	22 (44 %)	9 (18 %)
	Repetition of the question		
	Unrelated answer		
1	Incorrect answer	13 (26 %)	13 (26 %)
	Any answer that includes any alternative conception		
2	Incomplete but not incorrect answer	5 (10 %)	8 (16 %)
	Indirect but not incorrect answer		
3	Completely correct answer	10 (20 %)	20 (40 %)
N		50 (100 %)	50 (100 %)

The following are the example sentences that students' stated in answering this question and transcribed as category **0**:

"Küp halden toz hale geldi – It became powder form from cube form"

"Üflediğimizde gider, ezilmemiş halde ise uçup gitmez – When we blow, it goes away, if it not in a crashed form, it does not fly and go"

"Toz şekerden farkı kalmadı – There is no difference with the powder sugar"

As it is seen in Table 7.13., 22 (44 %) of the students either **could not give any answers** to the pretest question related to that process**, restate** the question itself**,** or gave an **unrelated answer** to the question (0) in the pretest**.** However, when the same question is asked in the posttest, only 9 (18 %) of them could not give any answer, repeat the question itself or gave an unrelated answer to the question. Of these nine students, six of them are the ones who were treated with guided investigations while three of them are the ones who were treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **1:**

"Katılık özelliği değişir – Its solidity property changes"
"Hali değişir – Its state changes"
"Katı şekli olmaz – It does not have its solid shape"
"Sertliği değişir – Its hardness changes"
"Tanecikleri birbirinden ayrılır – Its particles are separated from each other"

In pretest, 13 (26 %) of the answers that are given to the first question related to the first process in the pretest are either **incorrect** or include an **alternative conception** (1). This number stays the same in the posttest. Five of these 13 students are the ones who were exposed to guided investigations, while eight of them are the ones who were exposed to semi-guided investigations.

The following are the examples students' stated in this question and belong to category **2**:

"Büyük bir maddeyi küçük bir hale getirdik – We made big matter small"
"Ezince küçük hale gelir – It became small when it is crashed"
"Küçük ve büyük parçalara ayrıldı – It dissociates into small and big parts"
"Büyüklüğü değişir – Its size (largeness) changes"

The number of students who gave **incomplete** or **indirect** answers that are not incorrect (2) was five (10 %) in the pretest, however, it increases to eight (16 %) in the posttest. Six of these eight students are the ones who were exposed to guided investigations, while two of them are the ones who were exposed to semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **3**:

"Şekli değişir – Its shape changes"
"Biçimi değişir – Its form changes"
"Hacmi değişir – Its volume changes"

Only ten (20 %) of the students answered this question **correctly (3)** in the pretest, while this number is 20 (40 %) in the posttest. Half of these students are the ones who were treated with guided investigations.

Part A Question 1b

In this question, students were asked to describe the changes when a sugar cube is put into some water.

The following are the example sentences that students' stated in answering this question and transcribed as category **1**:

"Küp şeker erir – Sugar cube melts"
"Kaybolur, görünmez olur – It disappears and becomes invisible"
"Yok olur – It disappears"
"Sıvı hale dönüşür – It turns out to liquid form"
"Su haline geldi – It became water"
"Tat değişimi olur – Taste change occurs"
"Buharlaşır – It vaporizes"

As it is seen in Table 7.14., although 47 (94 %) of them gave either an **incorrect** answer or an answer that includes an **alternative conception** (1) in the pre-test, it decreases to 29 (58 %) in the post-test. When treatment types of these 29 students are analyzed, it is seen that 17 of them were treated with guided investigations, while 12 of them were treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **3:**

"Küp şeker çözünür – Sugar cube dissolves"
"Şekli değişir – Its shape changes"

Although there is nobody that answers this question **correctly (3)** in the pre-test, ten (20 %) of them answered it correctly in the post-test. Among these ten students, six of

them were treated with guided investigations, whereas four of them were treated with semi-guided investigations.

Table 7.14. Frequency distribution for the answers given to Part A Question 1 b in SCS-PCC both in pre-test and post-test

		PRETEST Frequency	**POSTTEST** Frequency
0	No answer	2 (4 %)	10 (20 %)
	Repetition of the question		
	Unrelated answer		
1	Incorrect answer	47 (94 %)	29 (58 %)
	Any answer that includes any alternative conception		
2	Incomplete but not incorrect answer	1 (2 %)	1 (2 %)
	Indirect but not incorrect answer		
3	Completely correct answer	0 (0 %)	10 (20 %)
N		50 (100 %)	50 (100 %)

The following are the example sentences that students' stated in answering this question and transcribed as category **0**:

"Alican'ın ezdiği şekerleri Alican suya attı. Ama şeker sulu bir şeker oldu – Alican put the sugars that he crashed into water, but it became watery sugar""

"Suya tat verdi – It gave taste to water"

"Küp şekeri suya attığımızda su tatlı oldu. Su tatlı değildi – When we put sugar cube into water, water become sweety. Sugar was not sweety"

On the other hand, if there is a student either **could not give any answers** to the pre-test question related to that process, **restate** the question itself, or gave an **unrelated** answer to the question, his/her answer belongs to the category (0)**,** There is only one student that gave an answer belonging to this category in the pre-test, and this number stays the same in the post-test. Furthermore, this student was treated with semi-guided investigations.

Part A Question 1c

In the *third process* of the *first question*, changes in the sugar cube when it is burned in a plate were asked to be described by the students both before and after the treatments. The results are sumarized in Table 7.15.

The following are the example sentences that students' stated in answering this question and transcribed as category **0**:

"Kullanılmaz, hiçbir anlamı kalmadı – It cannot be used, it is nonsense"
"Küp şekeri yakarsak – If we burn sugar cube"
"Ocakta şekerli su içmek istiyor – He wants to drink sugary water onto the hot plate"

Table 7.15. Frequency distribution for the answers given to Part A Question 1 c in SCS-PCC both in pre-test and post-test

		PRETEST Frequency	**POSTTEST** Frequency
0	No answer	7 (14 %)	5 (10 %)
	Repetition of the question		
	Unrelated answer		
1	Incorrect answer	22 (44 %)	18 (36 %)
	Any answer that includes any alternative conception		
2	Incomplete but not incorrect answer	8 (16 %)	9 (18 %)
	Indirect but not incorrect answer		
3	Completely correct answer	13 (26 %)	18 (36 %)
N		50 (100 %)	50 (100 %)

The number of students who **could not give any answer** to that question, **repeated** the question itself, or gave an **unrelated** answer (0) decreases form seven (14 %) to five (10 %) in this question. Four of these five students are the ones who were treated with guided investigations, while only one of them was treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category 1:

"Bir şey olmaz – Nothing happens"
"Uçar – It flies (goes away)"
"Buhar haline dönüşür /Buharlaşır – It became vapor /It vaporizes"
"Gaz haline geçer – It goes to a gas state"
"Erir – It melts"
"Toz şeker haline gelir – It goes to powdered sugar form"

However, the decrease in the number of students who gave incorrect answers or answers with alternative conceptions (1) is four. In other words, 22 (44 %) of the students gave an incorrect answer or an answer with an alternative conception in the pretest, while 18 (36 %) of them gave that kind of answers in the posttest. Six of these 18 students are the ones who were treated with guided investigations, while 12 of them are the ones who were treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **3**:

"Kokusu değişir – Its smell changes"
"Şekli değişir – Its shape changes"
"Rengi değişir – Its color changes"

Moreover, the number of students who gave **completely correct** answers (3) to that question increases from 13 (28 %) to 18 (36 %) after the treatments. Half of these 18 students were treated with guided investigations and the other half of them were treated with semi-guided investigations.

Part A Question 2a

In the section a of the second question, students were asked to select the processes that cause a physical change in sugar cube among the three processes that are given in the first question. First and second processes are the ones which cause a physical change in

sugar cube. The following are the example sentences that students' stated in answering this question and transcribed as category **0:**

"Üçüncü işlem – The third process"
"Birinci ve üçüncü işlem – The first and the third process"
"İkinci ve üçüncü işlem - Second and the third processes"
"Üçünü işlem. Çünkü şeker aynı kalmıştır - The third process, because the sugar remains the same"

As it is seen in Table 7.16., 29 (58 %) of the students **could not select these correct processes** (0) in the pretest. The number of these students decreases to nine (18 %) in the posttest. When the treatment types of these ten students are analyzed, it is seen that four of them were treated with guided investigations and five of them were treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **1:**

"Birinci işlem. Çünkü şeker hal değiştiriyor – The first process, because sugar changes its state"
"İkinci işlem. Çünkü sıvı hale geliyor – The second process, because it become liquid"
"Birinci işlem. Çünkü bütün bir maddeyi değişik bir hale getirmektir – The first process, because it is to make the whole into a different form"
"İkinci işlem. Suda erir. Nedeni, su içine dolar ve sonunda patlar – The second process, because water goes into it and then it explores"
"İkinci işlem. Çünkü küp şekeri suya atınca kayboluyor – The second process, because it disappears when it is put in water"

In addition, there are five (10 %) students that **selected one of the correct processes** causing a physical change, but **gave an incorrect reason for their selections** or **a reason that includes an alternative conception** (1) in the pre-test. On the other hand, there are two (4 %) students in this category in the posttest. Besides, these two students are among the students that were exposed to guided investigations.

Table 7.16. Frequency distribution for the answers given to Part A Question 2 a in SCS-PCC both in pretest and posttest

			PRETEST Frequency	**POSTTEST** Frequency
0	Could not select these correct processes	Reason is not important	29 (58 %)	9 (18 %)
1	Selected one of the correct processes	Gave an incorrect reason	5 (10 %)	2 (4 %)
		Gave a reason that includes an alternative conception		
2	Selected two of the processes correctly	Gave an incorrect reason	2 (4 %)	0 (0 %)
		Gave a reason that includes an alternative conception		
3	Selected one or two of the processes correctly	Gave an unrelated reason or no reason	13 (26 %)	12 (24 %)
4	Selected one of the two correct processes, but not the other	Gave a correct reason	1 (2 %)	20 (40 %)
6	Selected the two of the processes	Gave a reason for only one of the selection, but not for the other selection	0 (0 %)	1 (2 %)
7	Selected both of the correct processes	Gave the correct reason for both of selections	0 (0 %)	6 (12 %)
N			50 (100 %)	50 (100 %)

The following are the example sentences that students' stated in answering this question and transcribed as category **4**:

"Birinci işlem. Çünkü şeker aynı şekerdir – The first process, because the sugar is the same sugar"

"Birinci işlem. Çünkü şeker ezilse de tadı hala yerindedir. Yalnız toz haline dönüştü – The first process, because although the sugar is crashed, its tastes remains. It only turns to powdered form"

"İkinci işlemdir. Çünkü madde fiziksel olarak değişiyor – The second process, because the matter changes physically"

Furthermore, one (2 %) of the students **selected one of the two correct processes as the cause of a physical change,** but **not the other,** and **gave a correct reason for their selections** (4) in the pre-test. However, this number increases to 20 (40 %) in the post-test. 14 of these 20 students are the ones that were treated with guided investigations, while six of them are the ones that were treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **6:**

"Birinci ve ikinci işlem. Çünkü şeker aynı şekerdir. The first and the second processes, because the sugar is the same sugar"

Moreover, there is nobody who **selected the two of the processes as the cause of a physical change,** and **gave a reason for only one of their selection,** but **not the other selection** (6). On the other hand, there is one student (2 %) who gave an answer belonging to that category in the post-test, and this student was exposed to semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **7:**

"Birinci ve ikinci işlem. Çünkü şeker toz şeker haline getirildiğinde de aynı şekerdir. Suyun içine atıldığında da şeker yine şekerdir - The first and the second processes, because the sugar is the same sugar when it becomes powdered. When it is put into water, sugar is again the sugar"

"2 ve 1. Çünkü ikisinde de şeker hala şeker – 2nd and 3rd, because sugar is still sugar in both processes"

Lastly, there is not anybody who **selects both of the correct processes that cause a physical change,** and also **gives the correct reason for his/her both selections** (7) in the pre-test. Nevertheless, six (12 %) students gave answers that belong to this category in the

post-test, three being treated with guided investigations and the other three being treated with semi-guided investigations.

Part A Question 2b

In the section b of the second question in the test, students were asked to select the process that cause a chemical change in cube sugar among the three processes that are given in the first question. The only process that causes a chemical change in cube sugar is the third process.

The following are the example sentences that students' stated in answering this question and transcribed as category **0:**

"İkinci işlem – The second process"

"İkinci ve üçüncü işlem – The second and the third processes"

"İkinci ve üçüncü işlem. Çünkü şeker yok oluyor. Second and third processes, because sugar disappears"

35 (70 %) of the students could not select this correct process in the pre-test, as it is seen in Table 7.15. Among these 35 students, some of them either **did not give any answer** or **selected the first or the second processes as the cause of a chemical change** in cube sugar (0). This number decreases to 26 (52 %) in the posttest. 14 of these 26 students are the ones that are treated with guided investigations, while 12 of them were treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **1:**

"Üçüncü işlem. Çünkü buharlaştı- The third process, because it vaporized"

"Üçüncü işlem. Çünkü ocakta yanınca aynı şeker halinde – The third process, because when it is burned on the hot plate, it is still the same sugar"

"3. işlem. Çünkü, şeker sıvı hale geldi – 3rd process, because sugar became liquid"

Table 7.17. Frequency distribution for the answers given to Part A Question 2 b in SCS-PCC both in pre-test and post-test

			PRETEST Frequency	**POSTTEST** Frequency
0	Could not select the correct process	Reason is not important	35 (70 %)	26 (52 %)
1	Selected the correct process	Gave an incorrect reason	5 (10 %)	6 (12 %)
		A reason that includes an alternative conception		
2	Selected the correct process	Could not give any reason	9 (18 %)	10 (20 %)
		Gave an unrelated reason		
3	Selected the correct process	Gave the correct reason	1 (2 %)	8 (16 %)
N			50 (100 %)	50 (100 %)

Additionally, there are only five (10 %) students who **selected the correct process causing a chemical change,** but **gave an incorrect reason for their selection** or **a reason that includes an alternative conception** (1) in the pre-test. On the other hand, the number of responses that belong to this category increases to six (12 %) in the post-test. Among these six students, four of them are the ones that were exposed to guided investigations, and two of them are the ones that were treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **2:**

"Üçüncü işlem. Çünkü yakınca hiçbir anlamı kalmaz, işe yaramaz – The third process, because when it is burned it is nonsense, it is useless"

"Üçüncü işlem. Çünkü şekerin rengi değişiyor – The third process, because sugar's color changes"

Furthermore, there is only a slight difference between the number of students who **selected the third process as the cause of a chemical change,** but **could not give any reason for their selection** or **gave a reason that is unrelated with the question** (2) in pre-test and post-test. The number of these students is nine (18 %) in the pretest, and ten

(20 %) in the posttest. Half of these ten students were treated with guided investigations, and the other half of them were treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **3:**

"Üçüncü işlem. Çünkü, şeker artık şeker değil. The 3rd process, because it is not sugar any more.

"3. işlem. Çünkü şeker başka bir maddeye dönüşmüştür – The 3rd process, because sugar turn out to be different matter"

Lastly, there is only one student (2 %) that **selects the third process as the cause of a chemical change,** and **states the correct reason for his/her selection** (3) in the pre-test. However, this number increases in the post-test, and becomes eight (16 %). Furthermore, half of these eight students were treated with guided investigations, while the other half of them was treated with semi-guided investigations.

Part A Question 3

In this item of the instrument, students are asked to state their way of changing sugar cube by determining the type of change that their way causes to. The frequency distribution of the answers that students gave can be seen in Table 7.18.

The following are the example sentences that students' stated in answering this question and transcribed as category **0:**

"Bir küpe koyup şeklini değiştirirdim. Kimyasal bir değişime yol açardı – I would put it into a cube and change its shape. It causes to a chemical change"

"Buzdolabına koyardım. Kimyasal bir değişime yol açar – I would put into the refrigerator. It causes to a chemical change"

"Kırmızı renkli küçük şeker tanecikleri katar rengini değiştirirdim. Kimyasal bir değişime yol açardı – I would add red small sugar particles, and change its color. It causes to a chemical change"

"Toz şekeri boyardım. Kimyasal bir değişime yol açardı, çünkü rengi değişti – I would paint powdered sugar. It causes to a chemical change, because its color has changed"

Table 7.18. Frequency distribution for the answers given to Part A Question 3 in SCS-PCC both in pre-test and post-test

			PRETEST Frequency	**POSTTEST** Frequency
0	Could not give any other example to change sugar cube	State the type of change incorrectly	32 (64 %)	25 (50 %)
	Gave an example that is very similar to the ones that were asked in the test before			
	Stated a different way of changing sugar cube from the ones that were mentioned in the test before			
1	Gave a similar example with the ones asked before in the test	Could not state the type of change	10 (20 %)	7 (14 %)
		Gave an unrelated answer		
2	Stated a different way of changing sugar cube from the ones that were mentioned in the test before	Could not state the type of change	5 (10 %)	8 (16 %)
		Gave an unrelated answer		
3	Gave a similar example with the ones asked before in the test	Gave the correct reason	2 (4 %)	6 (12 %)
4	Stated a different way of changing sugar cube from the ones that were mentioned in the test before	Gave the correct reason	1 (2 %)	4 (8 %)
N			50 (100 %)	50 (100 %)

32 (60 %) of the students either **could not give any other example to change sugar cube,** or gave an example that is very **similar** to the ones that were asked in the test before, but **state the type of change** that their examples cause to **incorrectly** (0). However, this number decreases to 25 (50 %) in the post-test, 16 being treated with guided investigations and nine being treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **1:**

"Güneşe koyardım – I would put it in a sunny place"
"Şekerin kenarlarını fazla kırmam – I would not broke the edges of the sugar"

There is also a decrease in the number of students who gave **similar example** with the ones asked before in the test, and **could not state the type of change that it causes** or gave an **unrelated** answer with the question (1) in pre-test and post-test. This number is ten (20 %) in the pretest, but seven (14 %) in the posttest. Additionally, three of these seven students were treated with guided investigations, and only four of them were treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **2**:

"Kaynatırdım – I would boil it"
"Sobanın üstüne koyardım – I would put it onto stove"
"Şekeri boyayabiliriz – We can paint sugar"

Furthermore, there are only five (10 %) students that stated a **different way of changing sugar cube** from the ones that were mentioned in the test before, but **could not state the type of change** it causes to or gave an **unrelated** answer (2). However, this number increases to eight (16 %) in the post-test, three being treated with guided investigations and five being treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **3:**

"Ezerdim. Fiziksel bir değişime yol açar – I would crash. It causes to a physical change"
"Yakardım. Kimyasal bir değişime yol açar – I would burn. It causes to a chemical change"
"Ezmeyip de parçalar haline getirmek. Fiziksel – Not crash, but form some parts. Physical"

In both pretest and posttest, there are also students that stated a **similar way of changing the sugar cube** with the ones that were mentioned in the test before, and **explain the type of the change** that their example causes to **correctly** as well (3). The number of these students is two (4 %) in the pretest, but they increased to six (12 %) in the post-test. Half of these six students are the ones who were treated with guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **4:**

"8. veya 9. kattan attığımızda ikiye ayrılır. Bu bir fiziksel değişimdir – It divided into two when we throw it from 8th or 9th floor. It is a physical change"

"Yutmak. Kimyasal bir değişime yol açar – Swallow. It causes to a chemical change"

"Reçele koymak. Fiziksel bir değişime yol açar – To put it into jam. It causes to a physical change"

"Boya dökerdim. Fiziksel bir değişime yol açar – I would pour some paint on it. It causes to a physical change"

Finally, some students gave a **different example for changing the sugar cube,** and also **stated the type of change** that their example causes to **correctly** (4). The number of these students is only one (2 %) in the pre-test. However, this number increased to four (8 %) in the posttest, two being treated with guided investigations.

7.3.7. Part B Question 1a

Students were asked to determine the changes on some papers as a result of the three processes given in this question. Specifically, students identified the changes in a piece of paper when it is toured to small pieces in *section a* of this first question.

Frequency distribution of the answers that students gave to the first question related to the first process is shown in Table 7.19.

The following are the example sentences that students' stated in answering this question and transcribed as category **0:**

"Yırtık olmasını istiyor – He wants it to be tore"

"İyi değildir – It is not good"

"Hiçbir anlama gelmiyor – It does not make any sense"

"Kötü, çirkin görünüme yol açar – It causes to be seen bad and ugly"

Table 7.19. Frequency distribution for the answers given to Part B Question 1 a in SCS-PCC both in pretest and posttest

		PRETEST Frequency	**POSTTEST** Frequency
0	No answer	20 (40 %)	16 (32 %)
	Repetition of the question		
	Unrelated answer		
1	Incorrect answer	10 (20 %)	4 (8 %)
	Any answer that includes any alternative conception		
2	Incomplete but not incorrect answer	10 (20 %)	13 (26 %)
	Indirect but not incorrect answer		
3	Completely correct answer	10 (20 %)	17 (34 %)
N		50 (100 %)	50 (100 %)

Table 7.19. shows that 20 (40%) of students **could not give any answers** to the pretest question related to that process or **restate** the question itself (0). However, this number decreases to 16 (32%) in the posttest. Nine of these 16 students are the ones who were treated with guided investigations, while seven of them are the ones who were treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **1:**

"Hali değişir – Its state changes"

"Hiçbir özelliği değişmez – None of its properties changes"

"Yok olur – It disappears"

"Aynı biçimde kalır – It stays in the same shape"

"Kalınlığı incelir – Its thickness becomes thin"

In addition, ten (20%) of the answers that are given to the first question related to the first process in the pre-test are either **incorrect** or include an **alternative conception** (1). However, there are only four (8 %) students that gave an answer which is incorrect or include an alternative conception in the post-test. Three of these four students were exposed to guided investigations, while one of them was exposed to semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **2:**

"Düz bir kağıt iken parça parça olur – While it is a straight paper, it forms some parts"
"Buruşur, eskisi gibi düz değildir – It creases, it is not as straight as before"
"Küçük parçalar haline gelir – It becomes to small parts"

The number of students who gave **incomplete** or **indirect** answers (2) to that question was ten (20 %) in the pre-test. However, it increases to 13 (26 %) in the post-test. Seven of these 15 students are the ones that were exposed to guided investigations, while six of them are the ones that were exposed to semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **3:**

"Boyu, eni değişir – Its width and length changes"
"Şekli değişir – Its shape changes"
"Büyüklüğü değişir – Its size changes"

Finally, ten (20 %) of the students answered this question **correctly (3)** in the pretest, whereas this number increases to17 (34 %) in the post-test. Eight of these students were treated with guided investigations; nine of them were exposed to semi-guided investigations.

Part B Question 1b

In this question, students were asked to decide on the changes when old pieces of newspapers are burned in the stove.

Table 7.20. Frequency distribution for the answers given to Part B Question 1 b in SCS-PCC both in pre-test and post-test

		PRETEST Frequency	**POSTTEST** Frequency
0	No answer	12 (24 %)	6 (12 %)
	Repetition of the question		
	Unrelated answer		
1	Incorrect answer	9 (18 %)	3 (6 %)
	Any answer that includes any alternative conception		
2	Incomplete but not incorrect answer	20 (40 %)	17 (34 %)
	Indirect but not incorrect answer		
3	Completely correct answer	9 (18 %)	24 (80 %)
N		50 (100 %)	50 (100 %)

The following are the example sentences that students' stated in answering this question and transcribed as category "0":

"Kullanılmaz hale gelir – It becomes unusable"

"İçindeki yazılar kaybolur – Writings on it disappear"

"O gazete kağıtlarını yakmak yerine okursak bilgi dağarcığımız gelişir – Instead of burning it, if we read them, our knowledge develops"

As it is seen in Table 7.20., there are 12 (24 %) students that **could not give any answers** to the pretest question related to that process or **restate** the question itself (0). However, this number decreases to six (12 %) in the posttest, two being treated with guided investigations and four being treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **1:**

"Hiç bir şey değişmez – Nothing changes"
"Kağıt hala kağıt olarak kalır – Paper still stays as paper"
"Beyaza döner – It turns to white"
"Erir – It melts"

Secondly, although nine (18 %) of them gave either an **incorrect** answer or an answer that includes an **alternative conception (1)** in the pre-test, there are three (6 %) students that gave an answer like that in the post-test, and all of them were treated with guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **2:**

"Büyük ve beyaz iken simsiyah olur – From being large and white, it becomes black"
"Fiziksel özellikleri değişir – Its physical properties change"

Thirdly, the number of students who gave **incomplete** or **indirect** answers (2) to that question is 20 (40 %) in the pre-test, but 17 (34 %) in the post-test. 12 of these 17 students were treated with guided investigations, while the other five were exposed to semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **3:**

"Her şeyi değişir. Örneğin rengi, biçimi – Everything changes, such as color and shape"
"Rengi değişir – Its color changes"

Although there are nine students (18 %) that answers this question **correctly (3)** in the pre-test, this number increases to 24 (48 %) in the post-test. Among these 24 students, ten of them were treated with guided investigations, whereas 14 of them were treated with semi-guided investigations.

Part B Question 1c

In the third process of this first question, changes in our notebook when some ink is dropped onto it were asked to be determined by the students. The frequency distribution of the answers in both pretest and posttest can be seen in Table 7.21.

Table 7.21. Frequency distribution for the answers given to Part B Question 1 c in SCS-PCC both in pre-test and post-test

		PRETEST Frequency	**POSTTEST** Frequency
0	No answer	19 (38 %)	12 (24 %)
	Repetition of the question		
	Unrelated answer		
1	Incorrect answer	3 (6 %)	3 (6 %)
	Any answer that includes any alternative conception		
2	Incomplete but not incorrect answer	10 (20 %)	9 (18 %)
	Indirect but not incorrect answer		
3	Completely correct answer	18 (36 %)	26 (52 %)
N		50 (100 %)	50 (100 %)

The following are the example sentences that students' stated in answering this question and transcribed as category **0:**

"Deftere yazı yazılmaz – Cannot be written onto the notebook"

"Hiçbir şey değişmez. Defteri çöpe atmalıyız – Nothing changes. We should throw it to garbage"

"Deftere mürekkep dökülünce defteri boya olduğunu söylüyor – When an ink is poured onto the notebook, he says his notebook become painted"

The number of students that **could not give any answers** to that question or **repeat** the question itself (0) was 19 (38 %) in the pre-test, yet it decreased to 12 (24 %) in the post-test. Eight of these 12 students are the ones who were treated with guided investigations, while four of them were treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **1:**

"Mürekkep sayfayı sıvı hale getirir – Ink makes the page liquid"
"Beyaz kağıt kaybolur – White paper disappears"
"Kimyasal özelliği değişir, masmavi bir hal alır – Its chemical property changes, it becomes blue"
"Defterimize mürekkep döküldüğünde defterde değişiklik olur. Çünkü defterde defter diye bir şey kalmaz – When an ink is poured onto our notebook, some change occurs in the notebook. Because there is nothing as notebook in the notebook"

However, there is no difference in the percentage of students who gave **incorrect** answers or answers with **alternative conceptions** (1) in pre-test and post-test, and the number of these students is three. Two of these three students were treated with guided investigations, whereas one of them was treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **2:**

"Düzlüğü gidiyor –Its straightness disappears"
"Kuru iken yaş olur – While it is dry, it becomes wet"
"Beyaz kağıt mürekkebin aynı rengi oldu – White paper becomes in the color of the ink"

Thirdly, the number of students who gave **incomplete** or **indirect** answers (2) to that question does not change very much in pretest and posttest. It was nine in the pre-test, while nine in the post-test. Six of these ten students were treated with guided investigations, while three of them were exposed to semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **3:**

"Ağırlığı değişir – Its weight changes"
"Rengi değişir – Its color changes"
"Şekli değişti – Its shape changes"

Moreover, the number of students who gave **completely correct** answers (3) to that question increases from 18 (36 %) to 26 (52 %) after the treatments. 11 of these 26 students are the ones who were treated with guided investigations, while 15 of them were treated with semi-guided investigations.

Part B Question 2a

In the *section a* of this second question, students were asked to select the processes that cause a physical change in paper among the three processes that are given in the first question. First and third processes are the ones that cause a physical change in paper.

The following are the example sentences that students' stated in answering this question and transcribed as category **0:**

"Üç işlem de birden. Çünkü yanmasında kağıdın külleri kalıyor, çünkü yanınca kağıttan kalan sadece kül oluyor – Three processes altogether, because in its burning, paper's ashes remains, because when it is burned the only remained thing is the ash"

"Hepsi – All of them"

"İkinci olay, çünkü gazete tamamen değişiyor – The second event, because newspaper completely changes"

"İkinci olay. Çünkü kağıtlar sobaya atılırsa yanar ve Alican'ın ödevi de yanmış olur – Second event, because if papers are thrown into the stove, they burn and Alican's homework also burns"

As it is seen in Table 7.22., 27 (54 %) of the students **could not select these correct processes** (0) in the pre-test. The number of these students decreases to seven (14 %) in the post-test. When the treatment types of these seven students are analyzed, it is seen that three of them were treated with guided investigations and four of them were treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **1:**

"Birinci olay. Çünkü şekli değişir – The first event, because its shape changes"

"Kağıdın tüm özelliği kaybolur. Çünkü kağıdın yırtılması olayıdır – Paper's all properties disappears, because it is the tearing of the paper event"

Table 7.22. Frequency distribution for the answers given to Part B Question 2 a in SCS-PCC both in pre-test and post-test

			PRETEST Frequency	**POSTTEST** Frequency
0	Could not select these correct processes	Reason is not important	27 (54 %)	7 (14 %)
1	Selected one of the correct processes	Gave an incorrect reason	2 (4 %)	1 (2 %)
		A reason that includes an alternative conception		
2	Selected the two processes correctly	Stated the reason for choosing them incorrectly	4 (8 %)	1 (2 %)
3	Selected the two processes correctly	Did not state the reason for choosing them	15 (30 %)	16 (32 %)
		Gave a reason that is not related with the question		
4	Selected one of the two correct processes, but not the other	Gave a correct reason	2 (4 %)	13 (26 %)
7	Selected both of the correct processes	Gave the correct reason for both of selections	0 (0 %)	12 (24 %)
N			50 (100 %)	50 (100 %)

In addition, there are two (4 %) students that **selected one of the correct processes** causing a physical change, but gave an **incorrect reason** for their selections or a **reason that includes an alternative conception** (1) in the pre-test. On the other hand, there is only one student (2 %) in this category in the post-test. Besides, this student is among the students that were exposed to guided investigations.

There are four students who **selected the two processes** causing a physical change **correctly,** but stated the **reason** for choosing them **incorrectly** (2) in the pre-test**,** whereas this number decreases to one in the post-test. This student was treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **3:**

"3. işlem. Çünkü mürekkep dökersek defterin her yanı mürekkep olur- The 3rd process, because if we pour an ink, all the parts of the notebook become inked"

"Üçüncü olay. Defterimiz kirlendiği için fizikseldir – The third event. Because our notebook become dirty, it is physical"

"Birinci olay. Çünkü defter yaprağı yırtılınca yerinden çıkmış olur – The first event, because when the page is tore, it is separated from its place"

Besides, the number of students who **selected the two processes** causing a physical change **correctly,** but **did not state the reason** for choosing them or gave a **reason** that is **not related** with the question (3) is 15 (30 %) in the prtest, but 16 (32 %) in the post-test. Of these 16 students, five of them are the ones that were treated with guided investigations, whereas 11 of them are the ones that were exposed to semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **4:**

"Birinci işlem. Yine aynı daldır - The first process, because it is the same page"

"Üçüncü işlem. Çünkü kağıt yine kağıttır – The third process, because the paper is again the paper"

Furthermore, two (4 %) of the students **selected one of the two correct processes** as the cause of a physical change, but not the other, and gave a **correct reason** for their selections (4) in the pre-test. However, this number increases to 13 (26 %) in the post-test. 11 of these 13 students were treated with guided investigations, while two of them were treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **7:**

"Birinci ve üçüncü olay. Çünkü hala kağıt First and the third event, because paper is still paper"

Lastly, there is not anybody that **selects both of the correct processes** that cause a physical change, and also gives the **correct reason** for his/her both selections (7) in the pre-test. Nevertheless, 12 students (24 %) gave answers that belong to this category in the post-test, seven being treated with guided investigations and five being treated with semi-guided investigations.

Part B Question 2b

In the *section b* of the second question in the instrument, students were asked to select the process that cause a chemical change in paper among the three processes that are given in the first question. The only process that causes a chemical change in paper is the second process.

The following are the example sentences that students' stated in answering this question and transcribed as category **0:**

"Üçüncü olay. Çünkü mürekkep dökünce olay kimyasaldır. Çünkü birşeyi elde edilememesi kimyasaldır – The third event, because when the ink is poured, the event is chemical. Because, not to obtain something is chemical"

"Üçüncü olay. Çünkü kağıt değişmiyor, sadece rengi değişiyor – The third event, because paper does not change, its color changes"

"Hiçbiri değil – None of them"

"İkinci olay. Çünkü siyah renge dönüşüyor. üçüncü olay. Çünkü defter yaprağı hem ıslanır hem renk değişimi olur – The second event, because it turns to black color. The third event, because notebook page both becomes wet and color change occurs"

As it is seen in Table 7.23., 41 (82 %) of the students could not select only this correct process in the pre-test. Among these 41 students, some them either **did not give any answer** or **selected the first or the second processes** as the cause of a chemical change in cube sugar (0). This number decreases to 17 (34 %) in the post-test. In addition, 11 of these 17 students are the ones that were treated with guided investigations, while six of them were treated with semi-guided investigations.

Table 7.23. Frequency distribution for the answers given to Part B Question 2 b in SCS-PCC both in pre-test and post-test

			PRETEST Frequency	**POSTTEST** Frequency
0	Could not select the correct process	Reason is not important	41 (82 %)	17 (34 %)
1	Selected the correct process	Gave an incorrect reason	3 (6 %)	0 (0 %)
		A reason that includes an alternative conception		
2	Selected the correct process	Could not give any reason	4 (8 %)	13 (26 %)
		Gave an unrelated reason		
3	Selected the correct process	Gave the correct reason	2 (4 %)	20 (40 %)
N			50 (100 %)	50 (100 %)

The following are the example sentences that students' stated in answering this question and transcribed as category **1:**

"İkinci olay. Çünkü sadece sobada yanınca kağıt erir – Second event, because paper melts only burned in stove"

Additionally, there are only three (6 %) students who **selected the correct process** causing a chemical change, but gave an **incorrect reason** for their selection or a reason that includes an **alternative conception** (1) in the pre-test. On the other hand, there is not any student belonging to that category in the post-test.

The following are the examples students' stated in this question and belong to category **2:**

"İkinci olay – Second event"

"Yakmaktır. Çünkü neden yakıyor ki – Burning, because why is it burning?"

Furthermore, there is also a difference between the number of students who **selected the third process** as the cause of a chemical change, but **could not give any reason** for their selection or gave a **reason** that is **unrelated** with the question (2) in pre-test and post-test. The number of these students is four (8 %) in the pretest, but 13 (26 %) in the posttest. Five of these 13 students were treated with guided investigations. The number of students among these 13 students that were treated with semi-guided investigations is eight.

The following are the example sentences that students' stated in answering this question and transcribed as category **3:**

"İkinci olay. Çünkü artık gazete değil – Second event, because it is not newspaper anymore.

"İkinci olay. Çünkü gazete yandığında rengi değişir ve kül olur – Second event, because when newspaper burns, its color changes and it becomes ash"

Lastly, there are only two (4 %) students who **selected the third process** as the cause of a chemical change, and states the **correct reason** for his/her selection (3) in the pretest. However, this number increases in the posttest, and becomes 20 (40 %). Furthermore, nine of these eight students were treated with guided investigations, while 11 of them were treated with semi-guided investigations.

Part B Question 3

In this item of the instrument, students are asked to state their way of changing a piece of paper by determining the type of change that their way causes to. The frequency distribution of the answers that students gave can be seen in Table 7.24.

The following are the example sentences that students' stated in answering this question and transcribed as category **0:**

"Defterin üzerinde kalem kırılması. Kimyasal bir değişime yol açar – To broke a paper onto the notebook causes a chemical change"

"Su dökülmesi.kimyasal bir değişime yol açar – To pour some water causes a chemical change"

"Islatıca fiziksel görünüme dönüşürdü – When it is made wet, it turns to a physical appearance"

The number of students who either **could not give any other example to change sugar cube,** or gave an **example** that is very **similar** to the ones that were asked in the test before, but **state the type of change** that their examples cause to **incorrectly** (0) is 22 in the pretest, and it decreases to 19 in the post-test. Moreover, 16 of them were treated with guided investigations and three of them were treated with semi-guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **1:**

"Katlayıp çöpe atardım. Çünkü çöpe atınca kağıt yok oluyor – I would throw it to the garbage, because when it is thrown to the garbage it disappears"

There is also a decrease in the number of students that gave a **similar example** with the ones asked before in the test, and **could not state the type of change** that it causes or gave an **unrelated answer** with the question (1) in pre-test and post-test. This number is five (10 %) in the pretest, but only two (4 %) in the posttest. Additionally, these two students were treated with guided investigations.

The following are the example sentences that students' stated in answering this question and transcribed as category **2:**

"Kalemle çizmek ve buruşturmak – To drawn something with pencil and make it folded"

"Birilerinin kağıtlara basması. Beyaz kağıtta ayak izi çıkması – One's stepping on the papers. Leaving footprints on the white papers"

"Kağıtların renk değiştirmesi – Papers' changing of color"

Furthermore, there are 14 (28 %) students that **stated a different way of changing sugar cube** from the ones that were mentioned in the test before, but **could not state the type of change it** causes to or gave an **unrelated answer** (2). However, this number decreases to five (10 %) in the post-test, only one being treated with guided investigations and four being treated with semi-guided investigations.

Table 7.24. Frequency distribution for the answers given to Part B Question 3 in SCS-PCC both in pre-test and post-test

			PRETEST Frequency	**POSTTEST** Frequency
0	Could not give any other example to change sugar cube	State the type of change incorrectly	22 (44 %)	19 (38 %)
	Gave an example that is very similar to the ones that were asked in the test before			
	Stated a different way of changing sugar cube from the ones that were mentioned in the test before			
1	Gave a similar example with the ones asked before in the test	Could not state the type of change	5 (10 %)	2 (4 %)
		Gave an unrelated answer		
2	Stated a different way of changing sugar cube from the ones that were mentioned in the test before	Could not state the type of change	14 (28 %)	5 (10 %)
		Gave an unrelated answer		
3	Gave a similar example with the ones asked before in the test	Gave the correct reason	1 (2 %)	0 (0 %)
4	Stated a different way of changing sugar cube from the ones that were mentioned in the test before	Gave the correct reason	8 (16 %)	24 (48 %)
N			50 (100 %)	50 (100 %)

The following are the example sentences that students' stated in answering this question and transcribed as category **3:**

"İkiye ayırdım. Fiziksel bir değişime yol açar – I would divide it into to. It causes a physical change"

There is also a student that **stated a similar way of changing the sugar cube** with the ones that were mentioned in the test before, and **explain the type of the change** that their example causes to **correctly** as well (3) in the pre-test**.** However, there is nobody that gave this kind of an answer in the post-test.

"Uçak yaparım. Fiziksel bir değişime yol açar – I would make a plane. It causes a physical change"

"Geri dönüşüm kutusuna atardım. Hem fiziksel hem kimyasal olurdu – I would prefer to recycle it. Both physical and chemical change occurs"

Finally, some students **gave a different example for changing the sugar cube,** and also **stated the type of change** that their example causes to **correctly** (4). The number of these students is only eight (16 %) in the pretest. However, their number increased to 24 (48 %) in the post-test, eight being treated with guided investigations and 16 being treated with semi-guided investigations.

In order to summarize the above results, the numbers of incorrect answers or answers that include alternative conceptions are calculated in the posttests of the students who were treated with guided investigations and who were treated with semi-guided investigations. It is found out that there are totally 107 incorrect answers or an answer that includes an alternative conception in students' post-tests who were treated with guided investigations. This number is 75 in the post-test of the students who were treated with semi-guided investigations. However, because the number of subjects in each treatment group is different, the number of incorrect answer or an answer that includes an alternative conception per see is calculated by dividing this total number to the number of subjects in the group. This number is calculated as 3.693 for the post-tests of the students who were treated with guided investigations, and 3.261 for the post-tests of the students who were treated with semi-guided investigations. On the other hand, the frequency of correct answers was calculated in the posttests of the students who were treated with guided and semi-guided investigations. This number is 96 for the students who were treated with

guided investigations and 103 for the students who were treated with semi-guided investigations. The number of correct answers per see is found to be 3.55 for the students who were treated with guided investigations and 4.478 for the students who were treated with semi-guided investigations.

7.4. Analysis of the Worksheets

In procedure part of the guided worksheets, procedures were given to the students, whereas students themselves developed their procedures in semi-guided worksheets. In this part of the semi-guided worksheets, there were only six alternative conceptions.

Observations and **results** parts of both kinds of worksheets were the same in which students wrote their observations and conclusions, respectively. There were 17 alternative conceptions in "Part D" of the worksheets of the participants who were treated with guided investigations, while this number is 11 in the worksheets of the participants who were exposed to semi-guided investigations. In addition, there were 19 alternative conceptions in **Part E** of the worksheets of the participants who were treated with guided investigations and this number is only ten in the worksheets of the participants who were treated with semi-guided investigations. The below table summarizes these numbers:

Table 7.25. Number of alternative conceptions on the parts of participants' worksheets

Type of the treatment	Part C	Part D	Part E
Guided investigations	-	17	19
Semi-guided investigations	6	11	10

8. DISCUSSION AND CONCLUSION

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. The first laboratory work used in the treatment procedure of these students includes guided investigations in which students are given a procedure of the experiments explicitly, while students who were treated with the second type of laboratory work developed their procedure by themselves. The study presents both quantitative and qualitative data obtained from 50 six graders, 27 being treated with guided investigations and 23 being treated with semi-guided investigations. This section summarizes the aims, methods and the results of this study and discusses the interpretations of these results by taking into consideration of the related literature. Lastly, the limitations and the implementations of the study are presented.

Firstly, the study aims to determine the changes in the conceptualization levels of the students when they are exposed to a treatment which includes guided laboratory investigations.

Similarly, second purpose of this study is to determine the changes in the conceptualization levels of six graders in a laboratory work which includes semi-guided investigations.

The third aim is to compare the effectiveness of these two types of laboratory work in eliminating students' alternative conceptions related to the selected science concepts which are physical and chemical changes.

Lastly, the study aims to examine deeply the characteristics of the alternative conceptions that are present in the sample.

In addition to these four aims, students' perceptions and feelings about the laboratory work in science lessons are also examined.

The method used in this study is a pretest-posttest comparison group design. First group of students were given a pretest in order to determine their initial conceptualization levels in the selected science concepts. Then, they were exposed to a treatment (guided investigations for two weeks. At the end of two weeks, they were given the same instrument as a posttest. The similar procedure was also repeated to the second group of students who were exposed to a treatment which includes semi-guided laboratory investigations. During these treatments, students conducted their experiments in groups of five. Therefore, they were given the laboratory worksheets as a group. In other words, every group has only one worksheet, and they filled out this worksheet as a group. In addition to the instrument given both as a pretest and a posttest, an evaluation form was also given to each student in order to determine the perceptions of these students about laboratory activities.

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. However, it increased to M=22.48 after the treatment. Therefore, it is concluded that guided laboratory investigations have a significant effect on students' conceptualization levels related to the concepts of physical and chemical changes (t= -7.026, p=0.000). It is also stated in the literature that laboratory activities have a central role on students' conceptualization levels (Garnett, et al., 1995; Hodson, 1990; Hofstein and Lunetta, 1982, 2004; 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 ecpected. The reason behind this result may be due to the fact that this was the first time that participants engaged in hands-on activities. In addition, all the students were asked to write the things that they liked the most and the things that they liked the least about the treatments in the evaluation form. Some responses from the students who were treated with guided investigations include the following statements:

"Deneylerin bizim için çok yararlı olduğunu düşünüyorum ve deney yapmayı çok seviyorum – I believe that experiments are very beneficial for us, and I like doing experiments very much"

"Bu derste en sevdiğim şeyler, deney yapmak ve soruları cevaplamak - Thing that I liked most is to do experiment and to answer the questions."

"Bu derste en sevdiğim şeyler, yaptığımız deneyler ve ilginç konular üzerinde durup onları araştırmak - Thing that I liked most is the experiments that we had conducted, and to focus on interesting subjects and to search for them"

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 mentioned student is one point lower than the pretest scores. When the evaluation sheet of this student is examined, it is realized that there were some arguments between the members of the group which this student had worked with. The reason behind this claim depends on the fact that she wrote **my group members argument** to the third part of the evaluation sheet in which students wrote the things that they did not like the most. Thus, the relationship between the group members affects students' motivation to the lesson so that they have difficulties in understanding the subject matter. Due to these arguments, students may not be able to engage in the laboratory investigations. As a result, her mind may become confused. This student is among the ones who were interviewed at the end of the study. She supported her ideas also during the interview. Below statements are taken from the interview with her:

I: What was the thing that you liked most during these laboratory activities?
S: I liked to play with the doughs. We formed some shapes with them. This attracted me the most.
I: What was the thing that you did not like the most during these laboratory applications?
S: Some of our group members did nothing. Only I and one of my friends conducted all the experiments. Thus, this made us nerveous.

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 mixed up the physical and chemical change in her mind. In other words, she understood a chemical change as a physical change, and vice versa.

Second group of students were treated with semi-guided investigations in which students were engaged in activities in a way that they developed their own procedure for the given purpose 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=0.001). It is stated in the literature that students engaging in this type of laboratories enhance their conceptual understanding (Hofstein and Waldberg, 1995). 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 their 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.

No significant difference is 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=0.960). 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, subjects 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, they sometimes concentrate on the subject matter. Instead, they

paid more attention to the materials. If they are used to attend some laboratory activities before this study, they may not pay much attention to these materials.

Second reason for not observing the 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 most of their lessons are structured, and they accustomed with this type of instructions. If some hands on activities are used in other lessons, they would not be unfamiliar with these kinds of activities.

One 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 subjects were not accustomed group work. Lecturing is the most widely used method by the teachers of this school, and they do not use group work in their lessons. Therefore, students devoted some time to adopt themselves to group work during the sessions. As it is stated in the litarature that group work has positive effects on students' conceptualization levels and achievement if certain conditions are fullfilled. 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).

As it is stated in the results part, subjects who were treated with semi-guided investigations have higher science grades in the previous three terms that the participants who were treated with guided investigations. In spite of this difference, the gain difference between the pretest and posttest results of the students who were treated with guided investigations that the ones who were treated with semi-guided investigations. The reason behind this result may depend on the fact that students are not familiar with semi-guided investigations. They are more accostumed with guided investigations type of lessons. They may be more successful in the lessons that they were guided.

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, some differences were found to be in the incorrect answers or answers that include alternative conceptions and also the correct answers. The number of incorrect answers or answers that include alternative conceptions per see is found to be

3.693 in guided investigations, and 3.261 in guided investigations. Similarly, the number of correct answers per see is found to be 3.55 in guided investigations and 4.478 in semi-guided investigations. This difference would be significant if the operational definitions of guided and semi-guided investigations would be differentiated in a more detailed manner. Because different definitions for guided and semi-guided investigations are used in different studies, the differences between these two types of instructions would be emphasized more clearly (Wallace, et al., 2003). In addition to the definition, the actual applications of the guided and semi-guided investigations may be differentiated in a more detailed way. One reason for not observing significant differences on the conceptualization levels of students who were treated with guided and semi-guided investigations may depend on the ineffective differentiation of the application of the treatment sessions.

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 treatment is longer than it was, a significant difference may be observable between the conceptualization of the students who were treated with guided investigations and the ones who were treated with semi-guided investigations.

8.1. Limitations

This study was conducted under certain circumstances so that it includes some limitations. First of all, the conclusions of this study cannot be generalized to all six grade students. This is due to the fact that the sample size is small in both of the treatments. This study is conducted with 50 students (n = 27 for the first subgroup, and n = 23 for the second subgroup) in Çağdaş Yaşamı Detsekleme Derneği Kağıthane Ferit Aysan Primary School. Furthermore, the samples were not selected randomly. There were some students who were selected by the school's science teacher, and some were selected by the researcher by matching. Findings are valid only for this sample.

Another limitation for this study is related to the 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 subjects 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 mater or the activities during the treatment sessions decreased the efficiency of the study.

8.2. Recommendations for Further Research and Implications

Laboratory work helps students develop ideas that are parallel with the scientific truths. This study may give important information on how to design learning environments that the students develop their conceptualization levels. However, science teacher is the key element in designing as well as applying these laboratory investigations. Therefore, one should pay more attention to the science teacher. One important reason for paying attention to the science teacher depends on the fact that there are some science teachers who cannot facilitate the science laboratory applications. That is to say, more research studies should be conducted in order to determine the effectiveness of different professional development models for the science teachers and which are related to the laboratory applications.

Moreover, with the development of the computer technologies, new resources can be used to enrich the effectiveness of science lessons. For instance there are some computer programs which conduct experiments with the guiding of the students. Furthermore, some animations are used for some experiments. Therefore, the effectiveness of the science laboratories which are conduced with real materials or equipments and the ones which are conducted as a simulation can be compared in further research studies.

One important difficulty in conducting open-investigations in science laboratories stems from the difficulty in assessing learners in such a unique environment. In order to cope with this difficulty, authentic assessment techniques can be used. Thus, the development of these assessment tools can be the issue for the further research.

APPENDIX A: RANK OF KAĞITHANE AMONG OTHER DISTRICTS IN ISTANBUL IN TERMS OF GNP

		GSYİH (Alıcı fiyatlarıyla)	Pay (%)	Pay (%)
	İSTANBUL	3,140,021,242 TL	21.256416	100
23	ŞİŞLİ	282,085,748 TL	1.9095833	8.98356179
05	BAKIRKÖY	272,068,224 TL	1.8417695	8.6645345
16	KADIKÖY	262,391,289 TL	1.7762614	8.35635393
09	BEYOĞLU	225,989,028 TL	1.5298358	7.1970541
10	EMİNÖNÜ	205,787,028 TL	1.3930781	6.55368267
27	ZEYTİNBURNU	157,063,833 TL	1.0632457	5.00199906
13	FATİH	133,840,292 TL	0.9060337	4.26240084
07	BEŞİKTAŞ	132,929,980 TL	0.8998713	4.23341023
06	BAYRAMPAŞA	113,238,106 TL	0.7665669	3.60628472
18	KARTAL	110,417,521 TL	0.7474729	3.51645777
14	GAZİOSMANPAŞA	103,316,375 TL	0.6994016	3.29030814
26	ÜSKÜDAR	99,891,956 TL	0.67622	3.18125097
19	KÜÇÜKÇEKMECE	95,535,644 TL	0.6467298	3.04251585
02	AVCILAR	91,089,770 TL	0.6166334	2.90092847
04	BAHÇELİEVLER	84,475,110 TL	0.5718554	2.69027193
03	BAĞCILAR	79,737,791 TL	0.5397861	2.53940293
17	**KAĞITHANE**	**77,259,372 TL**	**0.5230084**	**2.46047291**
15	GÜNGÖREN	74,602,930 TL	0.5050255	2.37587343
25	ÜMRANİYE	73,802,496 TL	0.499607	2.35038205
21	PENDİK	60,843,648 TL	0.4118819	1.93768269
28	BÜYÜKÇEKMECE	58,287,244 TL	0.3945763	1.85626909
12	EYÜP	57,805,696 TL	0.3913164	1.84093328
20	MALTEPE	44,729,356 TL	0.302796	1.42449215
31	SULTANBEYLİ	42,836,743 TL	0.2899839	1.36421824
22	SARIYER	39,782,390 TL	0.2693074	1.26694654
11	ESENLER	38,875,954 TL	0.2631713	1.23807934
08	BEYKOZ	38,622,107 TL	0.2614529	1.22999509
29	ÇATALCA	24,014,579 TL	0.162567	0.76479033
30	SİLİVRİ	23,867,307 TL	0.1615701	0.76010017
24	TUZLA	20,533,021 TL	0.1389986	0.65391345
32	ŞİLE	11,773,328 TL	0.0796997	0.3749442
01	ADALAR	2,527,378 TL	0.0171091	0.0804892

APPENDIX B: SCIENCE ATTITUDE SCALE (SAS)

Adı Soyadı: .....

Cinsiyet: Kız ( ) Erkek ( )

Tarih:

Fen Dersi Tutum Ölçeği

Aşağıdaki cümleleri dikkatli okuduktan sonra, her bir cümlede belirtilen durumun sizin için ne kadar geçerli olduğunu yanlarındaki resimlerin üzerine (X) işareti koyarak belirtiniz.

Örnek:

Okula gitmeyi seviyorum.	evet	bazen	hayır
Müzik dinlemek bana zevk verir.	evet	bazen	hayır

1. Fen dersine çalışmaktan hoşlanırım.	evet	bazen	hayır
2. Bilimsel bilgileri araştırmak bana sıkıcı gelir.	evet	bazen	hayır
3. Bilimsel çalışma benim için zordur.	evet	bazen	hayır
4. Gelecekte bir bilim insanı olmak isterim.	evet	bazen	hayır
5. Tüm insanlar bilimi anlamalıdırlar, çünkü bilim yaşamımızı etkiler.	evet	bazen	hayır
6. Benim için fen laboratuvarında çalışmak çok eğlencelidir.	evet	bazen	hayır

7. Fen bilgisi dersi okulda en sevdiğim derstir.	 evet	 bazen	 hayır
8. Herhalde fen dersi olmasaydı okulu daha çok severdim.	 evet	 bazen	 hayır
9. Fen dersinde öğrendiğimiz bilgiler günlük yaşamımızı kolaylaştırır.	 evet	 bazen	 hayır
10. Boş zamanlarımda bilim ve fen ile ilgili kitaplar okurum.	 evet	 bazen	 hayır
11. Fen derslerinde sıkılıyorum.	 evet	 bazen	 hayır
12. Genelde fen dersine çalışmayı sevmem.	 evet	 bazen	 hayır
13. Fen dersinin çok önemli ve gerekli olduğunu düşünüyorum.	 evet	 bazen	 hayır
14. Fen dersindeki konuları hiç ilgi çekici bulmuyorum.	 evet	 bazen	 hayır
15. Fen dersinde öğretilen konuların günlük yaşama uygulanabileceğine inanmıyorum.	 evet	 bazen	 hayır
16. Fen deneyleri yapmak isterim.	 evet	 bazen	 hayır

TEŞEKKÜR EDERİZ

APPENDIX C: SCIENCE CONCEPT SCALE – PHYSICAL AND CHEMICAL CHANGE

Bölüm A:

Annesi Alican'a birkaç tane küp şeker verdi ve bu küp şekerlerde herhangi bir değişiklik yapmasını istedi. Alican, şekere aşağıdaki işlemleri uyguladı.

1. İşlem: Küp şekerlerden birini ezerek toz şeker haline getirmek
2. İşlem: Küp şekeri suya atmak
3. İşlem: Küp şekeri bir kaba koyup ocakta yakmak

Soru 1: Yukarıya bir maddeyi değiştirmek amacıyla uygulanabilecek üç işlem yazılmıştır. Bu işlemler maddenin hangi özelliklerini değiştirir? Bu soruyu, yukarıdaki üç işlem için ayrı ayrı cevaplayınız:

1. İşlem: Küp şekerlerden birini ezerek toz şeker haline getirmek:

2. İşlem: Küp şekeri suya atmak:

3. İşlem: Küp şekeri bir kaba koyup ocakta yakmak:

Soru 2: a) Yukarıda şekeri değiştirmek için yapılan üç işlemden hangileri şekerde fiziksel bir değişime yol açar? Neden?

b) Yukarıda şekeri değiştirmek için yapılan üç işlemden hangileri şekerde kimyasal bir değişime yol açar? Neden?

Soru 3: Alican'ın yerinde olsaydınız siz şekere başka ne gibi işlemler uygulardınız? Bu uyguladığınız işlemler maddede fiziksel bir değişime mi yoksa kimyasal bir değişime mi yol açar?

Bölüm B:

Alev, bir hafta boyunca etrafındaki kağıtlarda (defter, gazete, dergi…) meydana gelen değişimlere yol açan olaylar gözlemlemiş ve bu olayları defterine aşağıdaki gibi yazmıştır:

1. Olay: Defter yaprağının yırtılması
2. Olay: Eski gazete kağıtlarının sobada yakılması
3. Olay: Defterimize mürekkep dökülmesi

Soru 1: Yukarıda çevremizdeki kağıtlarda değişime neden olacak iki olay yazılmıştır. Bu olaylar sonunda maddenin hangi özellikleri değişir? Bu soruyu, yukarıdaki üç işlem için ayrı ayrı cevaplayınız:

1. Olay: Defter yaprağının yırtılması:

2. Olay: Eski gazete kağıtlarının sobada yakılması:

3. Olay: Defterimize mürekkep dökülmesi:

Soru 2: a) Yukarıda belirtilen üç olaydan hangileri kağıtta fiziksel bir değişime yol açar? Neden?

b) Yukarıda belirtilen üç olaydan hangileri şekerde kimyasal bir değişime yol açar? Neden?

Soru 3: Siz, çevrenizdeki kağıtlarda herhangi bir değişime yol açacak başka bir olay gözlemlediniz mi? Gözlemlediyseniz, bunlar nelerdir? Bunlar maddede fiziksel bir değişime mi yoksa kimyasal bir değişime mi yol açar?

APPENDIX D: CATEGORIES USED IN THE FIRST RUBRIC

Aşağıda altıncı sınıf öğrencilerinin fiziksel ve kimyasal değişimler konusunda kavramsallaştırma düzeylerini ölçmek amaçlı uygulanan teste verdikleri cevaplar sıralanmıştır. Bu cevaplar altı gruba ayrılmak istenmektedir. Grupların puanları ve özellikleri aşağıdaki gibidir:

5 puan alacak bir öğrenci verilen soruya doğru ve istenildiği gibi net cevap vermiştir.

Örnek: *"Küp şekeri ezerek toz haline getirdiğimizde küp şekerin hangi özellikleri değişmiştir?"* sorusuna aşağıdaki gibi cevap veren öğrenciler 5 puan alacaklardır:

- Hacmi değişmiştir.
- Şekli değişmiştir.
- Biçimi değişmiştir.

4 puan alacak bir öğrenci verilen soruya doğru ancak dolaylı ya da eksik olarak cevap vermiştir.

Örnek: *Küp şekeri ezerek toz haline getirdiğimizde küp şekerin hangi özellikleri değişmiştir?"* sorusuna aşağıdaki gibi cevap veren öğrenciler 4 puan alacaklardır:

- Küp haldeyken kapladığı yer ile toz haldeyken kapladığı yer farklıdır.
- Büyük halden küçük hale geldi.

3 puan alacak bir öğrenci verilen soruya yanlış bir kavramsallaştırma ile cevap vermiştir. Cevabın bir kısmı doğru da olsa herhangi bir yerinde yanlış kavramsallaştırma olduğunda bu öğrenci bu sorudan 3 puan alacaktır.

Örnek: *Küp şekeri ezerek toz haline getirdiğimizde küp şekerin hangi özellikleri değişmiştir?"* sorusuna aşağıdaki gibi cevap veren öğrenciler 3 puan alacaklardır:

- Bir taneyken birden fazla olacaktır.
- Şekli, hacmi değişir ve katı halden toz hale geçer.
- Sertliği değişir.

2 puan alacak bir öğrenci verilen soruya ilgisiz bir cevap vermiş ya da neden sorulan sorularda neden belirtmemiştir . Yani cevapta doğru yargılar olabilir ancak cevap, istenen cevap değil ise öğrenci bu sorudan 2 puan alacaktır.

Örnek: *Küp şekeri ezerek toz haline getirdiğimizde küp şekerin hangi özellikleri değişmiştir?"* sorusuna aşağıdaki gibi cevap veren öğrenciler 2 puan alacaklardır:

- Üflediğimizde gider. Ezilmemiş halde ise uçup gitmez.
- Katı halde olur.
- Çay içerken onu kullanabiliriz.

1 puan alacak bir öğrenci verilen soruya yanlış bir cevap vermiştir. Yanlış kavramsallaştırma ya da eksik cevap değil de tamamen yanlış bir yargı yazan öğrenciler bu 1 puanı alacaklardır.

Örnek: *Küp şekeri ezerek toz haline getirdiğimizde küp şekerin hangi özellikleri değişmiştir?"* sorusuna aşağıdaki gibi cevap veren öğrenciler 1 puan alacaklardır:

- Katı halden sıvı hale geldi.
- Çözülür.
- Katılığı değişir.

0 puan alacak bir öğrenci verilen soruya ya hiç cevap vermemiştir (boş bırakmıştır) ya da sorunun aynısını yazmıştır. Ayrıca aşağıdaki verilen testin üçüncü sorusuna testin diğer sorularında verilen örnekler cevap olarak yazıldığında da öğrenci 0 puan alacaktır.

Örnek: *Küp şekeri ezerek toz haline getirdiğimizde küp şekerin hangi özellikleri değişmiştir?"* sorusuna aşağıdaki gibi cevap veren öğrenciler 0 puan alacaklardır:

-
- Küp halden toz hale gelmiştir.
- Küp şekerin bazı özellikleri değişmiştir.

APPENDIX E: CATEGORIES USED IN THE ORIGINAL RUBRIC

Aşağıda altıncı sınıf öğrencilerinin fiziksel ve kimyasal değişimler konusunda kavramsallaştırma düzeylerini ölçmek amaçlı uygulanan teste verdikleri cevaplar sıralanmıştır. Bu cevaplar puanlanacaktır. Her sorunun puanlama sistemi farklıdır. Bu yüzden her soruya ait öğrenci cevaplarından önce puanlar hakkında bilgi verilmiştir. Öğrenci cevaplarının yanındaki kutucuklara bu cevaba ait puanı yazınız.

Yardımlarınız için şimdiden teşekkürler. 

Bölüm A:

Annesi Alican'a birkaç tane küp şeker verdi ve bu küp şekerlerde herhangi bir değişiklik yapmasını istedi. Alican, şekere aşağıdaki işlemleri uyguladı.

1. İşlem: Küp şekerlerden birini ezerek toz şeker haline getirmek
2. İşlem: Küp şekeri suya atmak
3. İşlem: Küp şekeri bir kaba koyup ocakta yakmak

Soru 1: Yukarıya bir maddeyi değiştirmek amacıyla uygulanabilecek üç işlem yazılmıştır. Bu işlemler maddenin hangi özelliklerini değiştirir? Bu soruyu, yukarıdaki üç işlem için ayrı ayrı cevaplayınız:

Bu sorudaki üç işlem için de (1. işlem, 2. işlem, 3. işlem) aynı puanlama yöntemi kullanılacaktır. Puanlar ve her puana ait cevapların özellikleri aşağıdaki gibidir:

Puan	*Bu puanlara ait cevapların özellikleri*
3	Tam doğru cevap
2	Eksik olan doğru cevap Dolaylı olarak verilmiş doğru cevap
1	Yanlış cevap Yanlış kavramsallaştırma içeren cevap
0	Soruyla ilgisi olmayan bir cevap Sorunun tekrarını içeren cevap Cevap verilmemiş

Soru 2: a) Yukarıda şekeri değiştirmek için yapılan üç işlemden hangileri şekerde fiziksel bir değişime yol açar? Neden?

Bu sorunun cevaplarının puanları ve her puana ait cevapların özellkleri aşağıdaki gibidir:

Puan	*Bu puanlara ait cevaplar*	*Bu puana ait neden*
7	1. ve 2. işlem	Her iki işlemin de seçilmesinin tam ve doğru nedeni verilmişse
6	1. ve 2. işlem	İşlemlerden birinin seçilmesinin tam ve doğru nedeni verilmişse ama diğerinin seçilmesinin nedeni soruyla ilgisi olmayan bir nedense
6	1. ve 2. işlem	İşlemlerden birinin seçilmesinin tam ve doğru nedeni verilmişse ama diğerinin seçilmesinin nedeni hiç verilmemişse
5	1. ve 2. işlem	İşlemlerden birinin seçilmesinin tam ve doğru nedeni verilmişse ama diğerinin seçilmesinin nedeni yanlış verilmişse
2	1. ve 2. işlem	İşlemlerden birinin seçilmesinin nedeni yanlış verilmişse ve diğerinin seçilmesinin nedeni yanlış verilmişse
4	Sadece 1. VEYA Sadece 2. işlem	İşlemin seçilmesinin tam ve doğru nedeni verilmişse
3	Sadece 1. VEYA Sadece 2. işlem	İşlemin seçilmesinin nedeni soruyla ilgisi olmayan bir nedense
3	Sadece 1. VEYA Sadece 2. işlem	Hiçbir neden verilmemişse
1	Sadece 1. VEYA Sadece 2. işlem	İşlemin seçilmesinin nedeni yanlış verilmişse
0	1. ve 3. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.
0	2. ve 3. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.
0	Sadece 3. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.
0	1., 2. ve 3. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.

2. b) Yukarıda şekeri değiştirmek için yapılan üç işlemden hangileri şekerde kimyasal bir değişime yol açar? Neden?

Bu sorunun cevaplarının puanları ve her puana ait cevapların özellkleri aşağıdaki gibidir:

Puan	*Bu puanlara ait cevap*	*Bu puanlara ait neden*
3	Sadece 3. işlem	İşlemin seçilmesinin tam ve doğru nedeni verilmişse
2	Sadece 3. işlem	İşlemin seçilmesinin nedeni soruyla ilgisi olmayan bir nedense
2	Sadece 3. işlem	İşlemin seçilmesinin nedeni verilmemişse
1	Sadece 3. işlem	İşlemin seçilmesinin nedeni yanlış verilmişse
0	Sadece 2. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.
0	Sadece 1. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.
0	1. ve 2. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.
0	1. ve 3. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.
0	2. ve 3. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.
0	1., 2. ve 3. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.

Soru 3: Alican'ın yerinde olsaydınız siz şekere başka ne gibi işlemler uygulardınız? Bu uyguladığınız işlemler maddede fiziksel bir değişime mi yoksa kimyasal bir değişime mi yol açar?

Bu sorunun cevaplarının puanları ve her puana ait cevapların özellkleri aşağıdaki gibidir:

Puan	*Bu puanlara ait cevap (şekere uygulanan işlemler)*	*Bu cevabın hangi değişime örnek olduğunun belirtilmesi durumu*
4	Bu testte geçen örneklere benzer bir örnek değil de bunlardan farklı bir örnek verildiyse	Hangi değişim olduğunu doğru belirttiyse
2	Bu testte geçen örneklere benzer bir örnek değil de bunlardan farklı bir örnek verildiyse	Hangi değişim olduğunu belirtmediyse
2	Bu testte geçen örneklere benzer bir örnek değil de bunlardan farklı bir örnek verildiyse	Soruyla ilgisi olmayan bir cevap verdiyse
0	Bu testte geçen örneklere benzer bir örnek değil de bunlardan farklı bir örnek verildiyse	Hangi değişim olduğunu yanlış belirttiyse
3	Daha önce testte geçen örneklere benzer bir örnek verdiyse	Hangi değişim olduğunu doğru belirttiyse
1	Daha önce testte geçen örneklere benzer bir örnek verdiyse	Hangi değişim olduğunu belirtmediyse
1	Daha önce testte geçen örneklere benzer bir örnek verdiyse	Soruyla ilgisi olmayan bir cevap verdiyse
0	Daha önce testte geçen örneklere benzer bir örnek verdiyse	Hangi değişim olduğunu yanlış belirttiyse
0	Hiç örnek vermediyse	

Bölüm B:

Alev, bir hafta boyunca etrafındaki kağıtlarda (defter, gazete, dergi…) meydana gelen değişimlere yol açan olaylar gözlemlemiş ve bu olayları defterine aşağıdaki gibi yazmıştır:

1. Olay: Defter yaprağının yırtılması
2. Olay: Eski gazete kağıtlarının sobada yakılması
3. Olay: Defterimize mürekkep dökülmesi

Soru 1: Yukarıda çevremizdeki kağıtlarda değişime neden olacak iki olay yazılmıştır. Bu olaylar sonunda maddenin hangi özellikleri değişir? Bu soruyu, yukarıdaki üç işlem için ayrı ayrı cevaplayınız:

Bu sorudaki üç işlem için de (1. işlem, 2. işlem, 3. işlem) aynı kategorizasyon yöntemi kullanılacaktır. Bu kategoriler ve her kategoriye ait cevapların özellikleri aşağıdaki gibidir:

Kategori	*Bu kategoriye ait cevapların özellikleri*
3	Tam doğru cevap
2	Eksik olan doğru cevap Dolaylı olarak verilmiş doğru cevap
1	Yanlış cevap Yanlış kavramsallaştırma içeren cevap
0	Soruyla ilgisi olmayan bir cevap Sorunun tekrarını içeren cevap Cevap verilmemiş

Soru 2: a) Yukarıda belirtilen üç olaydan hangileri kağıtta fiziksel bir değişime yol açar? Neden?

Bu sorunun cevaplarının puanları ve her puana ait cevapların özellkleri aşağıdaki gibidir:

Puan	*Bu puana ait cevap*	*Bu puana ait neden*
7	1. ve 3. işlem	İşlemlerden ikisinin de seçilmesinin tam ve doğru nedeni verilmişse
6	1. ve 3. işlem	İşlemlerden birinin seçilmesinin tam ve doğru nedeni verilmişse ama diğerinin seçilmesinin nedeni soruyla ilgisi olmayan bir nedense
6	1. ve 3. işlem	İşlemlerden birinin seçilmesinin tam ve doğru nedeni verilmişse ama diğerinin seçilmesinin nedeni hiç verilmemişse
5	1. ve 3. işlem	İşlemlerden birinin seçilmesinin tam ve doğru nedeni verilmişse ama diğerinin seçilmesinin nedeni yanlış verilmişse
2	1. ve 3. işlem	İşlemlerden birinin seçilmesinin nedeni yanlış verilmişse ve diğerinin seçilmesinin nedeni yanlış verilmişse
4	Sadece 1. işlem VEYA Sadece 3. işlem	İşlemin seçilmesinin tam ve doğru nedeni verilmişse
3	Sadece 1. işlem VEYA Sadece 3. işlem	İşlemin seçilmesinin nedeni soruyla ilgisi olmayan bir nedense
3	Sadece 1. işlem VEYA Sadece 3. işlem	Hiçbir neden verilmemişse
1	Sadece 1. işlem VEYA Sadece 3. işlem	İşlemin seçilmesinin nedeni yanlış verilmişse
0	1. ve 2. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.
0	2. ve 3. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.
0	Sadece 2. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.
0	1., 2. ve 3. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.

2. b) Yukarıda belirtilen üç olaydan hangileri kağıtta kimyasal bir değişime yol açar? Neden?

Bu sorunun cevaplarının puanları ve her puana ait cevapların özellkleri aşağıdaki gibidir:

Paun	*Bu puana ait cevap*	*Bu puana ait neden*
3	Sadece 2. işlem	Bu işlemin seçilmesinin tam ve doğru nedeni verilmişse
2	Sadece 2. işlem	Bu işlemin seçilmesinin nedeni soruyla ilgisi olmayan bir nedense
2	Sadece 2. işlem	Bu işlemin seçilmesinin nedeni verilmemişse
1	Sadece 2. işlem	Bu işlemin seçilmesinin nedeni yanlış verilmişse
0	Sadece 2. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.
0	Sadece 1. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.
0	1. ve 2. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.
0	1. ve 3. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.
0	2. ve 3. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.
0	1., 2. ve 3. işlem	Neden ne olursa olsun bu soruya puan verilmeyecektir.

Soru 3: Siz, çevrenizdeki kağıtlarda herhangi bir değişime yol açacak başka bir olay gözlemlediniz mi? Gözlemlediyseniz, bunlar nelerdir? Bunlar maddede fiziksel bir değişime mi yoksa kimyasal bir değişime mi yol açar?

Bu sorunun cevaplarının puanları ve her puana ait cevapların özellkleri aşağıdaki gibidir:

Puan	*Bu puana ait cevap (şekere uygulanan işlemler)*	*Bu cevabın hangi değişime örnek olduğunun belirtilmesi durumu*
4	Bu testte geçen örneklere benzer bir örnek değil de bunlardan farklı bir örnek verildiyse	Hangi değişim olduğunu doğru belirttiyse
2	Bu testte geçen örneklere benzer bir örnek değil de bunlardan farklı bir örnek verildiyse	Hangi değişim olduğunu belirtmediyse
2	Bu testte geçen örneklere benzer bir örnek değil de bunlardan farklı bir örnek verildiyse	Soruyla ilgisi olmayan bir cevap verdiyse
0	Bu testte geçen örneklere benzer bir örnek değil de bunlardan farklı bir örnek verildiyse	Hangi değişim olduğunu yanlış belirttiyse
3	Daha önce testte geçen örneklere benzer bir örnek verdiyse	Hangi değişim olduğunu doğru belirttiyse
1	Daha önce testte geçen örneklere benzer bir örnek verdiyse	Hangi değişim olduğunu belirtmediyse
1	Daha önce testte geçen örneklere benzer bir örnek verdiyse	Soruyla ilgisi olmayan bir cevap verdiyse
0	Daha önce testte geçen örneklere benzer bir örnek verdiyse	Hangi değişim olduğunu yanlış belirttiyse
0	Hiç örnek vermediyse	

APPENDIX F: LESSON PLAN FOR THE FIRST SESSION OF THE GUIDED INVESTIGATIONS

Lesson Science

Grade 6th

Subject Physical & Chemical Change

Time 90 minutes

Objectives Students should be able to

1. characterize a physical change
2. characterize a chemical change
3. differentiate between physical and chemical change
4. give examples to physical changes from dailiy life
5. give examples to chemical changes from daily life

Teaching-Learning Methods Cooperative learning, inquiry-based learning

Content

1. Teacher starts the lesson by stating that they will learn the physical and chemical changes in this lesson.
2. Then, she asks the some questions to the students. The ones who have the answer will hold up their hand and say that "That's me!". While asking the questions, teacher can show some pictures or materials related to the question. Here are the questions:
    a). Who burns wood in his/her house (in the stove)?
    b). Who cuts the wood into small pieces?
    c). Who can make origami?
    d). Who can make a cake?
    e). Who waits for the melting of ice in a fruit juice before drinking it in order not to be sick?
    f). Who likes romantic films in which the pairs burn some candles in dinner?

3. After the students answered the question a, teacher makes the following explanation:

    "When we burn wood in the stove, the wood changes. There are two kinds of changes in matter. The first one is a physical change, while the second one is a chemical

change. The changes which do not cause the formation of a new matter (in other words, the changes in which the chemistry of a substance do not change) are called physical changes while the ones which cause the formation of a new matter are called chemical changes. In the case of wood, wood turns to be another matter, which is ash. Thus, burning a wood is a chemical change."

4. Teacher makes the similar explanations for questions b, c, d, e, and f.
5. However, in question "c", students may not be able to know the meaning of origami, and how it is made. So, no student may hold up his/her hand. Thus, teacher makes a small model from an origami paper, and tells that the shape of the paper has changed, but a new matter did not form. Thus, making an origami is a physical change.
6. Then, she tells that they will observe these changes with some experiments.
7. Teacher explains that they should work in groups of five. Thus, there will be four groups in the class.
8. In order to form the groups, teacher prepares the cards in Appendix G.
9. Then, she puts them in a box and wants everybody to pick up one card.
10. With these cards they will form their groups. Here are the groups:

    a). Group 1: The name of this group is "FRUITS". Thus, the teacher pastes fruit pictures in Appendix H on one desk in the laboratory and wants the students who have a fruit name on their cards to come to this desk.

    b). Group 2: The name of this group is "DRINKS". Thus, the teacher pastes drinks pictures in Appendix H on one desk in the laboratory and wants the students who have a drink name on their cards to come to this desk.

    c). Group 3: The name of this group is "DESSERTS". Thus, the teacher pastes dessert pictures in Appendix H on one desk in the laboratory and wants the students who have a dessert name on their cards to come to this desk.

    d). Group 4: The name of this group is "NUTS". Thus, the teacher pastes nut pictures in Appendix H on one desk in the laboratory and wants the students who have a nut name on their cards to come to this desk.

11. She distributes the following materials to the students:
    a). Mortar
    b). Spatula
    c). Potasium iodide solution
    d). Lead nitrate solution
    e). Sugar cube
    f). Paper
    g). Vitamin
    h). Water
12. While the teacher distributing the materials to the students, she shows them to the class and says their names.
13. Then, she gives gives Appendix I to all the groups and wants every group to select a writer and a group leader.
14. She explains that the leader will be responsible for the group, and s/he manages the group.
15. She explains that the writer is responsible for writing the groups' ideas in the given appendixes.
16. After every group selects their writers' and leaders' teacher wants them to start their experiments, and fill in this appendix
17. After all the groups finished their experiments, teacher wants every group to explain what they have done and what they have found out with a small presentation starting from the "FRUITS" group.
18. During the presentations, students also explain their answers in the appendixes.
19. Teacher differentiates the physical and chemical changes by repeating that the changes which do not cause the formation of a new matter (in other words, the changes in which the chemistry of a substance do not change) are called physical changes while the ones which cause the formation of a new matter are called chemical changes.
20. Teacher wants to summarize the lesson with a game. In this game, students will be divided into two groups. For instance, group FRUITS and DRINKS may come together to form one group, let's say group A, and the other groups may come together to form group B.
21. Then, teacher explains the rules of the play:

a). A volunteer from group A will come near to teacher.

b). Teacher shows a card to him/her (see Appendix J)

c). An example of a physical or a chemical change is written in the card.

d). The volunteer should tell this change to the group members without using the other words written in the card.

e). However, the first thing s/he should do is to state whether this is a physical or a chemical change. If s/he picks up his/her thumb, this means that it is a chemical change, but if s/he picks down his/her thumb, this means that it is a physical change.

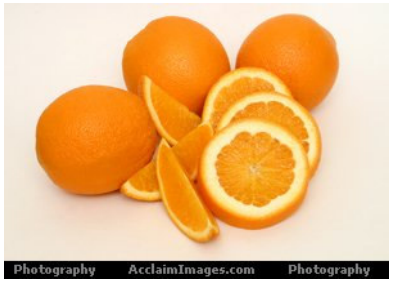
f). After this volunteer finishes telling his/her change, a volunteer from group B comes and plays the game in the same way.

g). This will be repeated for four times.

h). The winner will be rewarded with some foods that belong to their group names. For instance if group A (which is a combination of FRUITS and DRINKS) wins the game, the teacher gives some fruits and drinks to this group.

22. As homework, teacher wants them to find examples of physical and chemical changes.

APPENDIX G: CARDS PREPARED FOR THE FORMATION OF THE GROUPS

 ELMA	 MANDALİNA
 PORTAKAL	 MUZ
 ARMUT	 MEYVE SUYU

 SU	 SÜT
 ÇAY	 IHLAMUR
 ÜZÜMLÜ KEK	 PUDİNG

 KURU PASTA	 KADAYIF
 BAKLAVA	 FINDIK
 LEBLEBİ	 CEVİZ

	
BADEM	ÇEKİRDEK

APPENDIX H: CARDS USED FOR THE GROUP NAMES

 MEYVELER	 İÇECEKLER
 TATLILAR	 KURUYEMİŞLER

APPENDIX I: WORKSHEETS USED IN THE FIRST SESSION OF THE GUIDED INVESTIGATIONS

Grup Adı: **Grup Üyeleri:**

Grup Lideri: **Grup Yazıcısı:**

A. Amaç:

Çeşitli maddelerdeki fiziksel ve kimyasal değişiklikleri gözlemlemek.

B. Kullanılan Malzemeler:

- ✓ Spatula
- ✓ Potasyum İyodür çözeltisi
- ✓ Kurşun Nitrat Çözeltisi
- ✓ Küp şeker
- ✓ Kağıt
- ✓ Vitamin
- ✓ Su

C. Yapılan İşlemler:

Aşağıdaki bölümlerde verilen işlemleri yapınız ve her işlemden sonra maddelerde meydana gelen değişikliklerle ilgili gözlemlerinizi "D" bölümündeki "Gözlemler" kısmına yazınız.

1. **Bölüm:** Bir küp şekeri havanda toz haline getiriniz.

2. **Bölüm:** Toz haline getirdiğiniz şekeri suda çözünüz.

3. **Bölüm:** Kağıt parçasını yırtarak daha küçük parçalara ayırınız.

4. **Bölüm:** Bir kağıt parçasını öğretmeninizin yardımıyla yakınız.

5. **Bölüm:** Vitamini suyun içine atınız.

6. **Bölüm:** Potasyum iyodür ve kurşun nitrat çözeltilerinden dereceli silindirle 5'er ml. alıp bir beherde karıştırınız.

D. Gözlemler: Deneyi yaparken neler gözlemlediniz? Kullandığınız maddelerde ne tür değişiklikler oldu? (Renk değişimi, hacim ya da miktar değişimi, hal değişimi, gaz çıkışı gibi…)

1. **Bölüm:**

2. **Bölüm:**

3. **Bölüm:**

4. **Bölüm:**

5. **Bölüm:**

6. **Bölüm:**

E. Sonuçlar: Gerçekleştirdiğiniz deneylerde meydana gelen değişimlerin ne tür değişimler olduğunu (fiziksel ya da kimyasal) her bölüm için ayrı ayrı yazınız.

1. **Bölüm:**

2. **Bölüm:**

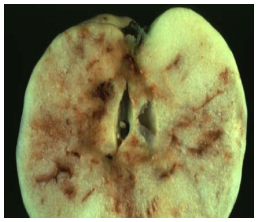
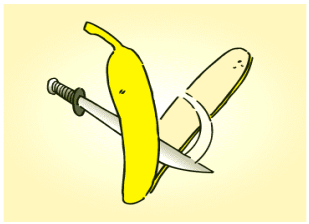
3. **Bölüm:**

4. **Bölüm:**

5. **Bölüm:**

6. **Bölüm:**

APPENDIX J: GAME CARDS

Cards of Group A	Cards of Group B
 **Elmanın çürümesi** ✓ Meyve ✓ Kırmızı ✓ Yemek ✓ Ağaç	 **Muzun dilimlenmesi** ✓ Meyve ✓ Sarı ✓ Yemek ✓ Kesmek
 **Sütten peynir yapılması** ✓ Beyaz ✓ İçmek ✓ İnek ✓ Yemek	 **Yoğurttan ayran yapılması** ✓ Beyaz ✓ Kaymaklı ✓ İnek ✓ Koyun

Cards of Group A	Cards of Group B
 **Ağaçtan kağıt elde edilmesi** ✓ Bitki ✓ Yazmak ✓ Çizmek ✓ Toprak	 **Ağacının kesilmesi** ✓ Dal ✓ Testere ✓ Balta ✓ Orman
 **Şekerin çayda çözünmesi** ✓ Sıcak ✓ Kahvaltı ✓ Küp ✓ Toz	 **Demirin paslanması** ✓ Metal ✓ Oksijen ✓ Hava ✓ Bakır

APPENDIX K: LESSON PLAN FOR THE SECOND SESSION OF THE GUIDED INVESTIGATIONS

Lesson Science

Grade 6th

Subject Physical & Chemical Change

Time 90 minutes

Objectives Students should be able to

1. observe examples to physical and chemical changes
2. give examples to physical changes from dailiy life
3. give examples to chemical changes from daily life

Content

1. Teacher starts the lesson by stating that they will conduct some experiments about physical and chemical changes that they learned last session.
2. Then, she asks their examples to physical and chemical changes, because this was the homework for this session.
3. While the students are giving their answers, she askes the type of change their their example causes to. Thus, she summarizes what they have learned in the last session.
4. After getting answers from the students, she wants them to form their groups as in the last session. However, they should not have the same duty with the last session. They should change their duties in the groups.
5. She, then, distributes the following materials to the students:
    a). Play dough
    b). Candle
    c). Apple
    d). Solution A
    e). Solution B
    f). Solution C
6. While the teacher distributing the materials to the students, she shows them to the class and says their names.
7. Then, she gives gives Appendix L to all the groups and wants every group to select a writer and a group leader.
8. She reminds that the leader will be responsible for the group, and s/he manages the group.

9. She explains that the writer is responsible for writing the groups' ideas in the given appendixes.
10. After every group selects their writers' and leaders' teacher wants them to start their experiments, and fill in this appendix.
11. After all the groups finishes their experiments, teacher wants every group to explain what they have done and what they have found out with a small presentation starting from the "FRUITS" group.
12. During the presentations, students also explain their answers in the appendixes.
13. Teacher differentiates the physical and chemical changes by repeating that the changes which do not cause the formation of a new matter (in other words, the changes in which the chemistry of a substance do not change) are called physical changes while the ones which cause the formation of a new matter are called chemical changes.
14. Teacher summarizes the lesson lecturing what they have done during the experiments.

APPENDIX L: WORKSHEETS USED IN THE SECOND SESSION OF THE GUIDED INVESTIGATIONS

Grup Adı: **Grup Üyeleri:**

Grup Lideri: **Grup Yazıcısı:**

A. Amaç:

Çeşitli maddelerdeki fiziksel ve kimyasal değişiklikleri gözlemlemek.

B. Kullanılan Malzemeler:

- ✓ Oyun Hamuru
- ✓ Mum
- ✓ Elma
- ✓ A Çözeltisi
- ✓ B Çözeltisi
- ✓ C Çözeltisi

C. Yapılan İşlemler:

Aşağıdaki bölümlerde verilen işlemleri yapınız ve her işlemden sonra maddelerde meydana gelen değişikliklerle ilgili gözlemlerinizi "D" bölümündeki "Gözlemler" kısmına yazınız.

1. **Bölüm:** Elmayı öğretmeninizden bıçak isteyerek ikiye ayırınız ve bu bölüm hakkındaki gözlemlerinizi bütün deneyleri tamamladıktan sonra yazınız.

2. **Bölüm:** Oyun hamuruyla çeşitli şekiller yapınız.

3. **Bölüm:** Mumlardan birini kırarak küçük parçalara ayırınız.

4. **Bölüm:** Öğretmeninizden diğer mumu yakmasını isteyiniz.

5. **Bölüm:** B Çözeltisinden 10 damla erlenlerden birine damlatınız. A çözeltisinden de 10 damla diğer erlenmayere damlatınız. B çözeltisi ile A çözeltisini karıştırınız.

6. **Bölüm:** C Çözeltisinden 10 damla erlenlerden birine damlatınız. A çözeltisinden de 10 damla diğer erlenmayere damlatınız. C çözeltisi ile A çözeltisini karıştırınız.

D. Gözlemler: Deneyi yaparken neler gözlemlediniz? Kullandığınız maddelerde ne tür değişiklikler oldu? (Renk değişimi, hacim ya da miktar değişimi, hal değişimi, gaz çıkışı gibi…)

1. **Bölüm:**

2. **Bölüm:**

3. **Bölüm:**

4. **Bölüm:**

5. **Bölüm:**

6. **Bölüm:**

E. Sonuçlar: Gerçekleştirdiğiniz deneylerde meydana gelen değişimlerin ne tür değişimler olduğunu (fiziksel ya da kimyasal) her bölüm için ayrı ayrı yazınız.

1. **Bölüm:**

2. **Bölüm:**

3. **Bölüm:**

4. **Bölüm:**

5. **Bölüm:**

6. **Bölüm:**

APPENDIX M: EVALUATION SHEET

Bu derste öğrendiklerim:

Bu derste en sevdiğim şeyler:

Bu derste en sevmediğim şeyler:

APPENDIX N: LESSON PLAN FOR THE FIRST SESSION OF THE SEMI-GUIDED INVESTIGATIONS

Content

1. The teacher starts the lesson by explaining that they will start the lesson by answering some joyful questions. Teacher will ask some questions, and the ones who have the answer will hold up their hand and say that "That's me!". While asking the questions, teacher can show some pictures or materials related to the question. Here are the questions:

    a). Who burns wood in his/her house (in the stove)?

    b). Who cuts the wood into small pieces?

    c). Who can make origami?

    d). Who can make a cake?

    e). Who waits for the melting of ice in a fruit juice before drinking it in order not to be sick?

    f). Who likes romantic films in which the pairs burn some candles in dinner?

2. After students answered the question "a", the teacher says, "The wood has changed, hasn't it?"
3. Again, she says the same thing after the question "b".
4. However, in question "c", students may not be able to know the meaning of origami, and how it is made. So, no student may hold up his/her hand. Thus, teacher makes a small model from an origami paper, and asks again "The paper has changed, hasn't it?"
5. Then, similar type of questions will be asked for questions "e" and "f".
6. After all the questions answered, teacher says that these changes may not be the same changes. In other words, there may be some differences between these changes. We'll learn whether they are different or not, and if we decide that that they are different, we will try to find out the way they differ.
7. Teacher explains that they should work in groups of five. Thus, there will be four groups in the class.
8. In order to form the groups, teacher prepares the cards in Appendix G
9. Then, she puts them in a box and wants everybody to pick up one card.
10. With these cards they will form their groups. Here are the groups:

a). Group 1: The name of this group is “FRUITS”. Thus, the teacher pastes Appendix H on one desk in the laboratory and wants the students who have a fruit name on their cards to come to this desk.

b). Group 2: The name of this group is “DRINKS”. Thus, the teacher pastes Appendix H on one desk in the laboratory and wants the students who have a drink name on their cards to come to this desk.

c). Group 3: The name of this group is “DESSERTS”. Thus, the teacher pastes Appendix H on one desk in the laboratory and wants the students who have a dessert name on their cards to come to this desk.

d). Group 4: The name of this group is “NUTS”. Thus, the teacher pastes Appendix H on one desk in the laboratory and wants the students who have a nut name on their cards to come to this desk.

11. After all the groups have formed, the teacher gives the following materials to each group:

a). Mortar

b). Spatula

c). Potasium iodide solution

d). Lead nitrate solution

e). Sugar cube

f). Paper

g). Vitamin

h). Water

12. While the teacher distributing the materials to the students, she shows them to the class and says their names.

13. Then, she wants them to change some of them using the given materials. She also explains that they can want some other materials from the teacher by explaining the reason. If the teaher finds the reason logical, she will give that material.

14. After this explanation, teacher gives Appendix O to the groups and wants every group to select a writer and a group leader.

15. She explains that the leader will be responsible for the group, and s/he manages the group.

16. She explains that the writer is responsible for writing the groups’ ideas in the given appendixes.

17. After every group selects their writers' and leaders' teacher wants them to start their experiments, and fill in the Appendix O.
18. After all the groups finished their experiments, teacher wants every group to explain what they have done with a small presentation starting from the "FRUITS" group.
19. When each group finishes their explanations, teacher asks them whether the changes that they performed are the similar changes or not.
20. For example, some of the groups may try to get a powder sugar, while the others may try to dissolve it in water or burn it.
21. The teacher considers these specific examples and by asking questions, she makes them find out that they are different changes.
22. The conclusion that they should have drawn is that some changes occur only in the shape, in the volume or in the quantity of matter, while some other may cause to form new matters.
23. Thus, the teacher explains that the changes which do not cause the formation of a new matter (in other words, the changes in which the chemistry of the substance do not change) are called physical changes while the ones which cause the formation of a new matter are called chemical changes. She also writes this on the board afte she explains it.
24. After this explanation, teacher wants to summarize the lesson with a game. In this game, students will be divided into two groups. For instance, group FRUITS and DRINKS may come together to form one group, let's say group A, and the other groups may come together to form group B.
25. Then, teacher explains the rules of the play:

a). A volunteer from group A will come near to teacher.
b). Teacher shows a card to him/her (see Appendix J)
c). An example of a physical or a chemical change is written in the card.
d). The volunteer should tell this change to the group members without using the other words written in the card.
e). However, the first thing s/he should do is to state whether this is a physical or a chemical change. If s/he picks up his/her thumb, this means that it is a chemical change, but if s/he picks down his/her thumb, this means that it is a physical change.
f). After this volunteer finishes telling his/her change, a volunteer from group B comes and plays the game in the same way.

g). This will be repeated for four times.

h). The winner will be rewarded with some foods that belong to their group names. For instance if group A (which is a combination of FRUITS and DRINKS) wins the game, the teacher gives some fruits and drinks to this group.

26. As homework, teacher wants them to find examples of physical and chemical changes.

27. At last, the teacher gives Appendix M to the students and wants them to fill this appendix individually.

APPENDIX O: WORKSHEETS USED IN THE FIRST SESSION OF THE SEMI-GUIDED INVESTIGATIONS

Grup Adı: **Grup Üyeleri:**

Grup Lideri: **Grup Yazıcısı:**

A. Amaç: Bu deneyi yapma amacınız nedir?

B. Kullanılan Malzemeler: Deney süresince kullandığınız malzemeler nelerdir?

C. Yapılan İşlemler: Deney sırasında neler yaptınız?

D. Gözlemler: Deneyi yaparken neler gözlemlediniz?

E. Sonuç(lar): Bu deneyden hangi sonuç ya da sonuçları çıkardınız?

APPENDIX P: LESSON PLAN FOR THE SECOND SESSION OF THE SEMI-GUIDED INVESTIGATIONS

Content

1. The teacher starts the lesson by explaining that they will change some materials in this session.
2. Teacher explains that they should work in groups of five. Thus, there will be four groups in the class. The groups will be the same with the previous session, but role distribution will be different.
3. After all the groups have formed, the teacher gives the following materials to each group:

    a). Play dough
    b). Candle
    c). Apple
    d). Solution A
    e). Solution B
    f). Solution C

4. While the teacher distributing the materials to the students, she shows them to the class and says their names.
5. Then, she wants them to change some of them using the given materials. She also explains that they can want some other materials from the teacher by explaining the reason. If the teaher finds the reason logical, she will give that material.
6. After this explanation, teacher gives Appendix Q to the groups and wants every group to select a writer and a group leader.
7. She explains that the leader will be responsible for the group, and s/he manages the group.
8. She explains that the writer is responsible for writing the groups' ideas in the given appendixes.
9. After every group selects their writers' and leaders' teacher wants them to start their experiments, and fill in the Appendix Q.

10. After all the groups finished their experiments, teacher wants every group to explain what they have done with a small presentation starting from the “FRUITS” group.
11. When each group finishes their explanations, teacher asks them whether the changes that they performed are the similar changes or not.
12. The teacher considers specific examples and by asking questions, she makes them find out that they are different changes.
13. The conclusion that they should have drawn is that some changes occur only in the shape, in the volume or in the quantity of matter, while some other may cause to form new matters.
14. Thus, the teacher asks that the name of the changes which do not cause the formation of a new matter (in other words, the changes in which the chemistry of the substance do not change) and the ones which cause the formation of a new matter. She writes the answers of the students on the board.
15. After this explanation, teacher wants to summarize the lesson. For this purpose, she asks some questions to the students related to the experiments that they conducted and gets answers from them.

APPENDIX Q: WORKSHEETS USED IN THE SECOND SESSION OF THE SEMI-GUIDED INVESTIGATIONS

Grup Adı: **Grup Üyeleri:**

Grup Lideri: **Grup Yazıcısı:**

A. Amaç: Bu deneyi yapma amacınız nedir?

B. Kullanılan Malzemeler: Deney süresince kullandığınız malzemeler nelerdir?

C. Yapılan İşlemler: Deney sırasında neler yaptınız?

D. Gözlemler: Deneyi yaparken neler gözlemlediniz?

E. Sonuç(lar): Bu deneyden hangi sonuç ya da sonuçları çıkardınız?

APPENDIX R: SCS-PCC PRETEST AND POSTTEST SCORES OF STUDENTS WHO WERE TREATED WITH GUIDED INVESTIGATIONS

Pretest Total Score	Posttest Total Score	Difference
12	20	8
5	26	21
11	30	19
8	23	15
9	17	8
7	25	18
12	11	-1
11	15	4
12	28	16
8	25	17
5	31	26
11	27	16
7	22	15
6	15	9
12	41	29
10	24	14
12	12	0
18	9	-9
13	21	8
14	28	14
9	21	12
17	24	7
10	17	7
14	14	0
17	30	13
12	35	23
9	16	7

APPENDIX S: SCS-PCC PRETEST AND POSTTEST SCORES OF STUDENTS WHO WERE TREATED WITH SEMI-GUIDED INVESTIGATIONS

Pretest Total Score	Posttest Total Score	Difference
15	16	1
14	37	23
16	18	2
14	20	6
12	27	15
19	31	12
20	27	7
8	22	14
19	15	-4
21	41	20
21	24	3
18	12	-6
23	9	-14
10	21	11
13	28	15
9	21	12
12	24	12
12	17	5
15	14	-1
12	30	18
23	35	12
20	16	-4
11	16	5

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