THE EFFECT OF CONTEXT-BASED INSTRUCTION INTEGRATED WITH LEARNING CYCLE MODEL ON STUDENTS' ACHIEVEMENT AND RETENTION RELATED TO STATES OF MATTER SUBJECT

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I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

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ABSTRACT

THE EFFECT OF CONTEXT-BASED INSTRUCTION INTEGRATED WITH LEARNING CYCLE MODEL ON STUDENTS' ACHIEVEMENT AND RETENTION RELATED TO STATES OF MATTER SUBJECT

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This study aims to explore the effectiveness of context-based instruction integrated with learning cycle model as compared to the traditional instruction on tenth grade students' achievement and knowledge retention on the states of matter subject and their attitudes toward chemistry. In order to achieve this aim, a quasi-experimental pre-test post-test control group research design was applied. A total of 150 tenth grade students of two high schools were the participants of the study. During the treatment, experimental group students received context-based instruction integrated with learning cycle model whereas control group students received traditional instruction. The treatment lasted for 6 weeks and the data were collected through "States of Matter Achievement Test" and "Affective Characteristics Questionnaire". These instruments were administered to both groups as pre-tests in order to determine students' level of prior knowledge of states of matter subject and prior attitudes toward chemistry before the treatment and as post-tests to monitor the effectiveness of the instructions following the treatment. "States of Matter Achievement Test" was also administered as a delayed post-test to assess knowledge retention of students four months later. By conducting MANCOVA, the main effects of the instructions and gender as well as their interaction effects were investigated. The context-based instruction integrated with learning cycle model resulted with significantly higher achievement scores and higher knowledge retention on the states of matter subject and better attitudes towards chemistry when compared to the traditional instruction. The interaction effects among independent variables were not significant for any of the dependent variables.

Keywords: Chemistry education, Context-based Approach, 5E Learning Cycle, States of Matter, Attitudes toward Chemistry

ÖZ

ÖĞRENME DÖNGÜSÜ MODELİ İLE DESTEKLENMİŞ YAŞAM TEMELLİ ÖĞRETİMİN ÖĞRENCİLERİN MADDENİN HALLERİ KONUSUNDAKİ BAŞARILARI VE BİLGİNİN KALICILIĞINA ETKİSİNİN İNCELENMESİ

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Bu çalışma; öğrenme döngüsü modeli ile desteklenmiş yaşam temelli öğretimin onuncu sınıf öğrencilerinin "Maddenin Halleri" konusundaki başarıları, bilginin kalıcılığı ve kimyaya yönelik geliştirdikleri tutum üzerine etkisinin geleneksel öğretim ile karşılaştırılmasını amaçlamaktadır. Yaşam temelli öğretimin ana amacı, öğrencilere bilimsel kavramları bağlamlar ve günlük yaşamdan seçilmiş olaylar ile sunmak ve böylece öğrencilerin gerçek yaşam konuları ile fen bilimleri arasındaki ilişkinin farkına varmalarını sağlamaktır. 150 öğrencinin dâhil edildiği bu çalışmada yarı deneysel öntest-sontest kontrol gruplu araştırma deseni kullanılmıştır. Deney grubunda 6 hafta süre ile öğrenme döngüsü ile desteklenmiş yaşam temelli öğretime uygun olarak hazırlanan ders planları uygulanırken kontrol grubu geleneksel yöntemle öğrenime devam etmiştir. Çalışmanın verileri "Maddenin Halleri Başarı Testi" ve "Duyuşsal Karakteristikler Anketi" ile elde edilmiştir. Bu testler her iki gruba da ön-test ve son-test olarak uygulanmıştır. Buna ek olarak, öğrencilerde bilginin kalıcılığını belirleyebilmek adına "Maddenin Halleri Başarı Testi" dört ay sonra her iki gruba da tekrar uygulanmıştır. Ortak Dağılımın Çok Değişkenli Analizi (MANCOVA) kullanılarak her iki öğretimin ve cinsiyetin ana etkileri, bunun yanı sıra bu bağımsız değişkenlerin etkileşimleri de incelenmiştir. Yapılan analizler; öğrenme döngüsü ile desteklenmiş yaşam temelli öğretimin geleneksel öğretimle kıyaslandığında öğrencilerin başarısı, bilginin kalıcılığı ve kimyaya karşı tutumları üzerinde istatistiksel olarak anlamlı bir fark yarattığını ortaya çıkarmıştır. Bununla birlikte bağımsız değişkenlerin herhangi bir bağımlı değişken üzerinde etkileşimi istatistiksel olarak anlamlı değildir.

Anahtar Kelimeler: Kimya Eğitimi, Yaşam-temelli Öğretim, 5E Öğrenme Döngüsü, Maddenin Halleri, Kimyaya Yönelik Tutum

In dedication to

my beloved husband

and

my wonderful family

for making me be who I am.

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My love and my all; you've bent over backwards for me all the time. You know how much you meant to me, thank you for never giving up holding my hand throughout these years.

TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF FIGURES

FIGURES

LIST OF ABBREVIATIONS

CBI	: Context-based Instruction
TI	: Traditional Instruction
ACQ	: Affective Characteristics Questionnaire
SMAT	: States of Matter Achievement Test
Pre-ACQ	: Students' Pre-test Scores on Affective Characteristics Questionnaire
pre-SMAT	: Students' Pre-test Scores on States of Matter Achievement Test
post-ACQ	: Students' Post-test Scores on Affective Characteristics Questionnaire
post-SMAT	: Students' Post-test Scores on States of Matter Achievement Test
EG	: Experimental group
CG	: Control group
DV	: Dependent variable
IV	: Independent variable
MANCOVA	: Multivariate Analysis of Covariance
MANOVA	: Multivariate Analysis of Variance
ANCOVA	: Analysis of Covariance
ANOVA	: Analysis of Variance
df	: Degrees of freedom
Sig	: Significance
MONE	: Ministry of National Education
STS	: Science-Technology-Society
ChiK	: Chemie im Kontext
ChemCom	: Chemistry in the Community
ChiP	: Chemistry in Practice
PLON	: Physics Curriculum Development Project (Dutch Acronym)
EPPI	: Evidence Policy and Practice Initiative

ARCS	: Attention-Relevance- Confidence- Satisfaction
GPA	: Grade Point Average
CORD	: Center for Occupational Research and Development
ERIC	: Educational Resources Information Center
OECD	: Organisation for Economic Co-Operation and Development
PISA	: Programme for International Student Assessment
UYSEG	: University of York Science Education Group
MCAR	: Missing Completely at Random
NSTA	: National Science Teachers Association

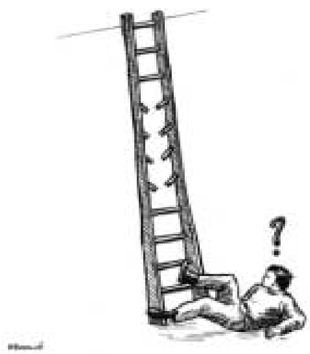
CHAPTER 1

INTRODUCTION

One of the challenges teachers face frequently is making learning scientific concepts relevant to the students. Among the most familiar questions to the teachers, the following two take their place at the top of the list: "Why should I learn this subject?" and "When am I going to use this information in my daily life?". It is not always simple for teachers to explain why a specific subject needs to be taught or learned. Not surprisingly, the answer is either (a) it is in the curriculum, (b) it is in the book, or; worst of all, (c) there are items assessing this content on national examinations.

One excellent ladder metaphor proposed by Schwartz (2006) provides a clear picture of the problems in science education:

> Most of us who are scientists have enjoyed climbing this ladder as part of our education. We revel in the lofty view from the top. Unfortunately, many students do not see the connection between the successive rungs. They are not told and do not discover why or where they are climbing before long they develop vertigo. Often they jump or fall off the ladder before they reach the top. All they take from the experience is distaste for science (p.953).



Pilot and Bulte (2006) resembled this ladder to an overloaded curriculum, with many rungs each of which correspond to another objective to achieve. The students do not have a clue about why they are climbing, similar to the failure to see the relevance of what they learn at school to their daily lives in science classes. The only thing they know is that each rung they climb will take them to the next step in their school life (Pilot & Bulte, 2006).

One of the most significant discussions seeking scapegoats for the problems in science education focuses on traditionally designed instructions which mainly give priority to the acquisition and recalling of the content. During a traditionally designed instruction, the teacher introduces the concepts, make arithmetical calculations on the board and rarely demonstrate experiments. In the meanwhile, students listen to the teacher, write down what is required to be learned and occasionally ask questions or make comments (Taasoobshirazi & Carr, 2008). Such an instruction possibly result in students memorizing facts, names, principles and formulas, solving problems in the same way as shown in the class and studying contents which are difficult to fit into a coherent framework. Context-based approaches are regarded as a way to deal with the problematic outcomes of traditionally designed instructions (Bulte, Westbroek, de Jong, & Pilot; 2006). In line with these, it is becoming increasingly difficult to ignore the reports linking the failure of students in science education with the inadequacies of traditionally designed science instruction throughout the world (Goodrum, Hackling, & Rennie, 2001; Fensham, 2004; Lyons, 2006; Tytler, 2007).

Even though the problems confronting science education can differ for various contexts and cultures, Gilbert (2006) summarized five main problems faced in chemistry education that would make sense to generalize for Turkey as well. According to Gilbert (2006) the inevitable consequence of "the ever-accelerating accumulation of scientific knowledge" (p.958) is the overload of curriculum with scientifically detached isolated facts. As regards, students lack knowledge of how to connect these isolated facts to a coherent mental schema. Due to the fact that solving problems mean solely drilling and practicing in rote fashion in classes, students are unable to transfer their learning to actual life experiences. Another problem, mentioned previously, is the lack of relevance of the content. Students fail to convince themselves about why they learn the content required. The great majority of the students consider chemistry as an obstacle they have to deal with for their further studies of own interest. Additionally, the emphases attributed to chemistry education are inadequate for advanced study of chemistry and dim the main goal of the course, namely scientific literacy (Gilbert, 2006).

From a broader perspective, scientific literacy can be regarded as one of the vital and central objectives of science education. The definition of the term "scientific literacy", suggested by the Organisation for Economic Co-Operation and Development (OECD), has four associated components which are *context, knowledge, competencies* and *attitudes*. *Context* refers to the life experiences of students involving science and technology similar to the context-based teaching of science. *Knowledge* component associates with comprehension of the world we live in by having information about the natural world and science itself. *Competencies* are mostly about scientific method and the ways of reaching scientific explanations. *Attitudes* are related with the emotions indicating interest, motivation and responsibility for what they learn and how they act (OECD, 2006).

It can be inferred from this definition of scientific literacy that the focus of science education is not merely on acquisition of scientific knowledge "but also the science-related skills needed for recognising and understanding science in questions about everyday life, for future career choices, and for decisions which pupils currently have to make on personal and societal issues" (Eilks, Rauch, Ralle & Hofstein, 2013, p.3).

The problems stated above and the objective of science education emphasizing scientific literacy can be addressed by context-based approaches which use meaningful contexts and daily life applications as the starting point of introducing chemistry concepts on the contrary to traditional approaches introducing chemical ideas first and make links to real life examples occasionally. Instruction designed to make use of real life contexts can be regarded as changing the focus of teaching to make chemistry more relevant and appealing for students. Integrating contexts which are familiar to students into chemistry curriculum attempts to bridge the gap between the abstract nature of chemistry and real world (Kortland, 2005).

Regarding the abstract nature of chemistry, there are some fundamental subjects that can be considered as prerequisites to almost all topics in chemistry. Every student once stepped in a science course experiences one of them; states of matter subject. Comprehension of how the arrangement and motion of particles change not only enables students to explain chemical phenomena but biological and physical phenomena as well (Harrison & Treagust, 2002). States of matter subject involves kinetic theory of particles which includes key ideas for developing chemical understanding of atomic structure, bond formation, chemical reactions, chemical equilibrium and electrochemistry (Harrison & Treagust, 2002, p.190). Acquisition of chemical concepts in states of matter subject can also be helpful in terms of understanding natural and technological phenomena around us. In addition to these, this subject lends itself to numerous daily life examples. The ever-lasting journey of water in different forms of matter, the air we breathe, the changes in weather can all be explained by understanding the states of matter. For this study, it is presumed that covering the facts, concepts and principles about states of matter subject in a context-based approach may result in an effective instructional practice.

Some of the courses taught at schools, like geography and history, have readily available contexts in nature which students mostly embedded in. However, science is taught in such a way that it is something isolated from the world we live in; out of our lives; to be learned but not discussed (Whitelegg &Parry; 1999). The role attributed to the context-based approach becomes vital at this point since it can be regarded as a way to show students that chemistry is all around us.

Due to the fact that concepts are driven from real life contexts during a context-based instruction, this approach is highly likely to provide answers to the questions of students stated at the beginning of the course: “Why should I learn this subject?” and “When am I going to use this information in my daily life?” (Glynn & Kobala, 2005; Taasoobshirazi & Carr, 2008). The contexts are expected to provide reasons for students to extend their knowledge and make the chemical concepts they learn meaningful (Bulte et al., 2006). Another essential feature of this approach is that scientific ideas are presented to the students on a need-to-know basis which means concepts are discussed as they arise during the flow of the instruction (Bennett, Grasel, Parchmann, & Waddington; 2005). The expectation is that context-based approaches help students to see the importance and relevance of what they are studying (Bennett, Lubben &Hogarth, 2006).

If students see the importance and relevance of what they are studying, this can contribute to their affective responses to chemistry courses by motivating them and developing more positive attitudes (Bennett et al., 2006). Affective characteristics of students have been identified as one of the contributing factors to students’ achievement. When students become more interested and more motivated due to their experiences in a context-based course, one may expect that these increased affective responses would result in higher engagement and understanding of chemistry (Bennett et al., 2006).

On the other hand; Bennett and Holman (2002) emphasize two outstanding features of context-based approaches to teaching chemistry. The first feature is that these approaches widely take their places in the curricula of various countries. The United Kingdom, The United States of America, The Netherlands, South Africa, Germany and Swaziland are the examples to countries in which courses adopting context-based approach are in use (Bennett et al., 2006). The physics curricula for secondary schools in Turkey have also been revised since 2008 with an attempt of Ministry of National Education (MONE) to adopt context-based approaches in physics courses. Secondly, "there is a surprising lack of systematic research-based evaluation into the effects of their use" (Bennett & Holman, 2002, p.167; Taasoobshirazi & Carr, 2008).

The reviews of the studies focusing on context-based approaches (Bennett et al., 2006; Taasoobshirazi & Carr, 2008) fail to offer unanimous findings about the effectiveness of context-based approaches on students understanding of science and their affective responses to science. The experimental and quasi-experimental studies present rather contradictory results, and there is no general agreement about the effectiveness of context-based instruction on student outcomes.

Medrich, Calderon and Hoachlander (2003) enlisted the reasons of not reaching a conclusion on the effects of context-based instruction on student outcomes. The first reason stated by the researchers is that conducting carefully designed context-based studies requires great efforts and is not cost-effective. In addition to these; many studies fail to include a comparison group or pre-tests, do not define context-based instruction regarding the philosophy behind the approach, do not apply a proper research methodology and exaggerate the role of anecdotal evidence while drawing conclusions of the results.

Considering this ambiguity of the results in the literature and the increasing interest of researchers on the context-based approach recently in Turkey, it is of great importance to design a context-based instruction and present the findings regarding the effectiveness of context-based instruction on students' understanding and affective responses to chemistry in Turkish context.

This current study gains its originality from including a control group, assessing students' outcomes prior to the treatment, defining each step of context-based instruction and drawing its conclusions based upon statistical evidence.

In the light of these points, the main objective of this study is to investigate the effects of the context-based instruction (CBI) in comparison with the traditional instruction (TI) on tenth grade high school students' achievement and knowledge retention on the states of matter subject and their attitudes towards chemistry.

The following sections present the questions addressed in this study.

1.1 The Main Problems of the Study

The three main problems of the study are as follows:

1. What is the effect of context-based instruction as compared to the traditional instruction on tenth grade high school students' achievement and knowledge retention on the states of matter subject and attitudes toward chemistry when the effects of students' prior knowledge of the states of matter subject and prior attitudes toward chemistry are controlled?

2. What is the effect of gender on tenth grade high school students' achievement and knowledge retention on the states of matter subject and attitudes toward chemistry when the effects of students' prior knowledge of the states of matter subject and prior attitudes toward chemistry are controlled?

3. Is there any interaction effect between instruction and gender on tenth grade high school students' achievement and knowledge retention on the states of matter subject and attitudes toward chemistry when the effects of students' prior knowledge of the states of matter subject and prior attitudes toward chemistry are controlled?

1.2 The Sub-Problems of the Study

The sub-problems of the study are as follows:

1. What is the effect of context-based instruction as compared to the traditional instruction on tenth grade high school students' achievement on the states of matter subject when the effects of students' prior knowledge of the states of matter subject are controlled?

2. What is the effect of gender on tenth grade high school students' achievement on the states of matter subject when the effects of students' prior knowledge of the states of matter subject are controlled?

3. Is there any interaction effect between instruction and gender on tenth grade high school students' achievement on the states of matter subject when the effects of students' prior knowledge of the states of matter subject are controlled?

4. What is the effect of context-based instruction as compared to the traditional instruction on tenth grade high school students' attitudes toward chemistry when their prior attitudes toward chemistry are controlled?

5. What is the effect of gender on tenth grade high school students' attitudes toward chemistry when their prior attitudes toward chemistry are controlled?

6. Is there any interaction effect between instruction and gender on tenth grade high school students' attitudes toward chemistry when their prior attitudes toward chemistry are controlled?

7. What is the effect of context-based instruction as compared to the traditional instruction on tenth grade high school students' knowledge retention on the states of matter subject when the effects of students' prior knowledge of the states of matter are controlled?

8. What is the effect of gender on tenth grade high school students' knowledge retention on the states of matter subject when the effects of students' prior knowledge of the states of matter subject are controlled?

9. Is there any interaction effect between instruction and gender on tenth grade high school students' knowledge retention on the states of matter subject when the effects of students' prior knowledge of the states of matter subject are controlled?

1.3 Definition of Important Terms

Main terms used in this study are defined as follows:

Context-based instruction is "a way of instruction adopted in science teaching, in which contexts and applications of science are used as the *starting point* for the development of scientific ideas which contrasts with more traditional approaches covering scientific ideas first and conclude with a brief mention of applications" (Bennett et al., 2006, p.348).

Traditional instruction is a teacher-centred instruction during which the teacher introduces the concepts, make arithmetical calculations on the board and rarely demonstrate experiments. In the meanwhile, students listen to the teacher, write down what is required to be learned and occasionally ask questions or make comments (Taasoobshirazi &Carr, 2008). Particularly; what is referred as traditional instruction in this study is "business as usual" instruction in the classroom (Taasoobshirazi & Carr, 2008, p.157).

The term "attitudes", as referred in this study, can be defined as "the feelings, beliefs and values held about an object that may be the enterprise of science, school science, the impact of science on society or scientists themselves" (Osborne, Simon & Collins, 2003, p.1053). For this study the object is determined as chemistry and the attitude towards chemistry is what is measured by Affective Characteristics Questionnaire (ACQ).

Chemistry achievement is the measurement of succeeding in reaching an aim related to the chemistry course objectives. In this study, it is what States of Matter Achievement Test (SMAT) measures.

Knowledge retention is a measure of the extent of retaining and remembering what students learned during instructional practices. In this study, it is what delayed post-test of the SMAT measures.

1.4 Significance of the Study

This study is important in terms of;

- *The aim of the study:* It is difficult to draw a healthy conclusion on the effects of the context-based instructon due to the inconsistent findings reported in the literature (Bennett et al., 2006; Taasoobshirazi & Carr, 2008). Keeping this in mind, this study is important in terms of the attempt to design a context-based instruction and present the findings regarding the effectiveness of context-based instruction on student outcomes. In order to be able to contribute to the answer of the question regarding the effectiveness of context-based instruction, this current study tried one's best by including a control group, assessing students' outcomes prior to the treatment, defining each step of context-based instruction and drawing conclusions based upon statistical evidence.

- *Including achievement and attitudes towards chemistry as dependent variables:* It is expected that if students replace the idea that chemistry is isolated from their lives with the one that it is all around us, they can develop more positive attitudes towards chemistry. It is also known that students' attitudes highly associate with their achievement. This can reflect on student outcomes as higher engagement and greater understanding of chemistry.

- *Including knowledge retention as a dependent variable:* There are not many studies reporting the effects of context-based instruction on students' knowledge retention. It is important to document what students retain following context-based instruction in order to see the long-term effects on students.

- *States of matter:* This subject is one of the essential and inter-disciplinary subjects of science. Understanding of states of matter subject can help students to explain not only chemical phenomena but biological and physical phenomena as well. Furthermore, it serves as a prerequisite to almost all subjects in chemistry.

- *Sample size:* The number of the students included in this study is 150 which enables to take results one step further. Sample size is adequate for generalization of the results to the accessible population of this study.

- *Research design:* It is stated previously that there is a lack of well-designed studies focusing on the effects of the context-based instruction and most of the studies focusing on context-based instruction have serious methodological problems (Medrich et al., 2003). This study applied a research design in which students' prior knowledge on states of matter subject and their prior attitudes towards chemistry were controlled as extraneous variables and compared with respect to their peers in the control group.

*The researcher is grateful to Remko Boom for the drawing in this chapter.

CHAPTER 2

LITERATURE REVIEW

In this chapter of the current study, an attempt to clarify the meaning of "context-based approach" is made firstly. Following this, the context-based projects that are referred throughout the study are explained in brief and theories underlying context-based education are discussed. Next, characteristics of a context-based instruction are summarized. The following sections include a literature review on national and international studies regarding context-based approaches. Last part of the chapter aims to give information about the two dependent variables of the study, which are attitude toward chemistry and knowledge retention of students.

2.1 What is meant by Context-based Approaches?

While a variety of definitions can be attributed to the context-based approaches, it would make sense to refer to the dictionaries to explore the meaning of the word "context" as a starting point. The Cambridge Advanced Learner's Dictionary (2012) gives the definition of "context" as "the situation within which something exists or happens, and that can help explain it". Oxford Dictionaries (2012) define the word with two parallel explanations; one of which is "the circumstances that form the setting for an event, statement, or idea, and in terms of which it can be fully understood" and the other is "the parts of something written or spoken that immediately precede and follow a word or passage and clarify its meaning".

The latter dictionary also provides information about the origin of the word from late Middle English, stating that the word originated from the Latin word "contextus" from *con-* 'together' and *-texere* 'to weave'. Gilbert (2006) integrates these definitions by stating that "a context must provide a coherent structural meaning for something new that is set within a broader perspective" (p.960). When the reflection of these descriptions on teaching is considered, it is seen that context-based approaches mainly aim to give meaning to scientific concepts within a context relevant to students' lives.

Whitelegg and Parry's (1999) definition of context-based learning clarifies the function of contexts in actual classroom practices:

> At its broadest, it means the social and cultural environment in which the student, teacher and institution are situated. (p.68)

One more definition is given by the developers of 'Salters family' (Bennett & Lubben; 2006) focusing on the attributes of contexts that they should make young people appreciate contribution of chemistry to their lives and provide a way to acquire a better understanding of the world:

> ...units of the course should start with aspects of the students' lives, which they have experienced either personally or via the media, and should introduce ideas and concepts only as they are needed (Campbell et al., 1994, pp.418-419 as cited in Bennett & Lubben; 2006).

Bennett and Lubben (2006) stated that the Salters' Courses mainly refer to this definition of context-based approach. Salters' courses target the whole of the secondary and pre-university age range in the UK and they will be explained further in the following sections.

By exemplifying fuel consumption, traffic safety and application of ionising radiation as contexts for developing physics concepts, Kortland (2005) defines context as a "coherent collection of practical situations that ask for better understanding and/or decisions to be made at a personal and/or societal level" (p.71) . He also explains the meaning of curriculum being context-based in their project as taking the students lives as a starting point and emphasizing on technological and natural phenomena, socio-scientific issues and the nature of science aspects.

For the case of Chemie im Kontext (ChiK), a chemistry course being applied in Germany, Parchmann et al. (2006) emphasize that "a context should enable students to see the relevance and possible application of their learning results on the one hand, and to tie the new topic into their pre-knowledge, interests, and ideas to enable successful learning processes, in the light of constructivist learning theories, on the other hand" (p.1046).

Furthermore; Parchmann et al. (2006) derived three different meanings of context from the analysis of Gilbert (2006) on context definitions that should not be ignored while designing a context-based instruction. The explanations of Parchmann et al. (2006) are included below:

> *Context as content:* The design of teaching units must connect relevant contexts, from which questions are derived, and the basic concepts that can be applied to answer such questions. Other competencies, such as the research and presentation of necessary results or experimental investigations to develop such results, are included by the design of the teacher's and the students' activities.
>
> *Context as learning stimulation:* Learning environments must stimulate students' personal mental activities to enable successful learning processes.
>
> *Context as frame for situated development and application of knowledge and competencies:* Learning processes in class must enhance and support the (social) development of competencies, especially the transfer of learning outcomes from one unit to another (p.1046).

Two aspects of context-based teaching of chemistry arise from the definitions stated so far. Firstly, the context is central to the teaching of chemical concepts. It should emphasize the relevance of the subject to students' lives by including social, economic, environmental, technological and industrial applications of chemistry (Bennett & Holman, 2002). The chemical ideas and concepts should be interwoven within the context, attributing a role to the context more than being "a mere motivational trick in the beginning to attract the students into the chemistry" (Nentwig, Demuth, Parchmann, Grasel & Ralle, 2007, p. 1441). The instruction making use of contexts should seek ways of linking students' prior knowledge with the subject to be learned first, and give them chance to raise questions regarding the features of context while proceeding along the context.

Second aspect of the context-based approach is that contexts provide students a "need to know" basis to extend their knowledge on the subject, that is, chemical ideas and concepts are introduced when students feel a need to develop further understanding of the features of the context being studied. Introducing concepts when they are needed help students to see the reason for extending their knowledge and make their learning intrinsically meaningful (Beasley & Butler, 2002; Bulte et al., 2006).

At this point, it would be appropriate to include the definition of the term Science-Technology-Society (STS) since the term is widely used interchangeably with the context-based approach in some countries:

> STS approaches [are] those that emphasize links between science, technology and society by means of emphasizing one or more of the following: a technological artifact, process or expertise; the interactions between technology and society; a societal issue related to science or technology; social science content that sheds light on a societal issue related to science and technology; a philosophical, historical, or social issue within the scientific or technological community (Aikenhead, 1994, pp.52-53).

As it can be inferred from the definition of STS, it is a broader term when compared to context-based approach although both of the initiatives share almost similar goals such as improving conceptual understanding of students by showing the relevance of science to their lives, making the scientific concepts more meaningful and engaging students in scientific activities (King, 2012). STS education moves these goals one step further; by orienting students on socio-scientific issues, it is aimed to promote general educational skills of students to prepare them as responsible citizens for participating in a democratic society (Eilks et al., 2013).

2.2 Projects Adopting Context-Based Approaches

With a primary aim of obtaining positive student outcomes in science courses, projects designed on context-based approaches have been in widespread use around the world from the early 1980s (Bennett et al., 2003).

The prominent projects that are of concern throughout this study and referred extensively are described formerly in this section. Brief explanations of seven projects which are The Salters' Approach in the UK (Bennett et al., 2005), Chemie im Kontext (ChiK) in Germany (Parchmann et al., 2006), Chemistry in the Community (ChemCom) (Sutman & Bruce, 1992; Ware & Tinnesand, 2005) and Chemistry in Context (CiC) in the USA (American Chemical Society, 2001; Schwartz, 2006), Industrial Science in Israel (Hofstein, Kesner, & Ben-Zvi, 2000; Hofstein & Kesner; 2006), Chemistry in Practice (ChiP) and

Physics Curriculum Development Project (PLON) in The Netherlands (Pilot & Bulte, 2006) are included in the following paragraphs.

The “Salters’ approach” refers to the context-based courses that emerged due to the concern held by science education community about current practice at schools in the UK during the early 1980s (Bennett & Lubben, 2006). The name “Salters” belongs to the sponsor of the projects and the courses and materials currently cover chemistry, physics and biology for the high school age range (11-18 years) in England and Wales with an overall aim to make school science more relevant and appealing to students. The two notable characteristics of Salters’ courses are that students’ lives serve as a starting point for the development of scientific ideas and a wide range of learning activities are included in classroom practices (Bennett & Lubben, 2006).

Salters Advanced Chemistry, which is in the scope of the current study, is one of the six Salters courses listed below:

- Chemistry: the Salters Approach (for students aged 14-16)
- Science: the Salters Approach (for students aged 14-16)
- Salters Science Focus (for students aged 11-14)
- Salters Advanced Chemistry (for students aged 17-18)
- Salters Horners Advanced Physics (for students aged 17-18)
- Salters Nuffield Advanced Biology (for students aged 17-18)

On the contrary to the curricula in Turkey, Salters curricula are not based on a “subject-specific, coherent list of predetermined concepts” (Bennett et al., 2005, p.143). The development of Salters courses are driven by context whereas Turkish chemistry courses are object driven with a list of predetermined concepts to be taught for each unit. For Salters courses, the development process overlaps with content selection that does not occur as the first step (Bennett & Lubben, 2006).

Similar to the emergence reason of The Salters’ Approach, the Chemie im Kontext (ChiK) project commenced when the results of TIMMS and PISA international comparisons for secondary chemistry education in 1997 mirrored the outcomes of the problematic practice at schools in Germany (Nentwig, Parchmann, Demuth, Graesel & Ralle, 2005). Due to the complex structures of the school systems, the project did not merely aim to improve chemistry education in secondary level but tried to provide the cooperation among teachers and science educators (Parchmann et al., 2006). Following the tradition of Salters’ courses, each teaching unit starts with a question or an issue, which is supposed to be relevant to students’ lives and the society they live in (Nentwig et al., 2005).

A remarkable example to USA's experience of context-based approach is Chemistry in the Community (ChemCom). ChemCom is a one-year introductory chemistry course for US high school students which adopts a context-based, student-centred approach to chemistry, in which chemical concepts are presented on a need-to know basis addressing current societal themes (Schwartz, 2006; Ware & Tinnesand; 2005). The primary goals of the developers of ChemCom were to improve chemical literacy of students and prepare more informed adult decision-makers by emphasizing "chemistry for citizenship" (Ware & Tinnesand; 2005). It was realized that this was not possible with the materials in use which were encyclopaedic in nature and failed to integrate laboratory work in lecture hours. Hence, materials developed for ChemCom include various decision-making exercises for students to apply their chemistry knowledge in addressing issues in the society they live in. The examples of contexts included in ChemCom can be given as the air and water quality, mineral resources, sources of energy, industrial chemistry, food and nutrition. During the time when ChemCom materials were in use, the uptake of a formal chemistry course of American high school students became 62% in 2000 which was 32% in 1982 (National Center for Education Statistics, 2004 as cited in Schwartz, 2006).

The second context-based project disseminated in the USA is Chemistry in Context (CiC) which has a similar aim to that of ChemCom, that of improving the chemical literacy of the students. However; CiC was designed primarily for non-science majors who probably not continue with careers related to chemistry (Schwartz, 2006). The design criteria and the philosophy behind CiC were summarized by Schwartz (2006, p. 980-981) with the following statements:

- Real-world societal problems and issues with significant chemical content are the core to the curriculum.
- Chemical concepts are interwoven in the context and introduced on a need-to-know basis.
- Interdisciplinary links, especially to the social sciences are emphasized.
- Teaching chemistry as practising chemistry is essential.
- Methodology and theory regarding chemical phenomena are also included in the curriculum.
- Instruction integrates laboratory, library, and class work.
- A range of student-centred activities, mainly discussion and group work, are integrated.
- It is of great importance to develop problem-solving and critical thinking skills of students.

These descriptors are in line with the principles of most of the context-based courses. From the experience of the USA with context-based projects, one can conclude that a context-based approach in teaching chemistry is effective for the students who do not have intentions to expertise neither in chemistry nor chemistry-related professions (Schwartz, 2006).

The Industrial chemistry programme in Israel is one of the long-term context-based projects being on stage for almost 30 years (Hofstein & Kesner; 2006). The developers of the project thought that students should learn chemistry not only to proceed with chemistry-related professions but to become informed citizens of the society. Thus, to keep abreast of the times, chemistry instruction at schools should provide a way of emphasizing relevance of daily life and its role in industrial socio-economic and environmental contexts. Instead of merely focusing on chemical theories, key concepts and processes; teaching chemistry using industrial case studies and focusing on applied chemistry have the potential to lead positive student outcomes, especially in terms of their interest and motivation to study chemistry (Hofstein & Kesner, 2006).

The Netherlands is another country which extensively focuses on context-based approaches. There exist two important context-based programmes for the Netherlands: Chemistry in Practice (ChiP) and PLON (Physics Curriculum Development Project). Chemistry in Practice (ChiP) followed the tradition of PLON, so it would make sense to scrutinize PLON first. The PLON project is a context-based physics course implemented between the years 1972 and 1986. The point that differentiates PLON from the other context-based approaches is that it has different versions for various ability levels of students, that is, lower, average and pre-university levels (Kortland, 2005). It had a balancing role of teaching physics to students in order to prepare them for further study without ignoring the life roles of students being consumers and citizens in a technological society (Kortland, 2005). The commonality of each course was that the starting point of each lesson was an issue from students' lives although the emphasis changed within the levels. It was on technological and natural phenomena for students aged 13-14 whereas socioscientific issues and nature of science were emphasized for the students aged 15-17 (Kortland, 2005). Similar to the goals of PLON, Chemistry in Practice was designed to attain meaningful connection between students' learning of chemistry and lifeworlds (Pilot & Bulte, 2006). The framework of the project provides example units that make use of authentic practices based on a need-to-know principle.

Aforementioned projects have different aims, scopes and foci but they have coinciding characteristics at some point (Stolk, Bulte, de Jong & Pilot; 2009). The first characteristic is that a context-based lesson starts with a context or a daily life application that has a potential of capturing students' interest. Secondly, this context is expected to answer the questions raised by students regarding why it is needed to learn chemical concepts. And lastly; what is mentioned frequently from one project to another is the importance of student participation. Campbell et al. (1994, as cited in Waddington, 2005) expressed Salters' view as "The most important single factor influencing learning is the active engagement of the learner with the material. Obtain this and teach by whatever methods retain this engagement" (p.313). When Kortland (2005) makes a comparison between PLON and traditional courses, he comments that there is "less frontal classroom teaching and more giving guidance to small groups of students" (p.79) in context-based teaching. Nentwig et al. (2005) also emphasizes that learning processes in ChiK centre on student activities;

> The design of the learning environment stimulates the learners' activities and provides necessary resources…These learning activities are directed by the learners themselves, and they are only guided and supported by the teacher when necessary…The teacher's role consequently changes from that of transmitter of knowledge to one of provider of resources and scoffolder of learning processes (p.161).

In line with the emphasis attributed to student participation in context-based projects, this study made all efforts to include students in different range of activities during context-based instructional practices.

2.3 Theories Underlying Context-based Education

This part of the study aims to shed light on the theories mentioned by the developers of projects adopting context-based approaches to science teaching and can be considered as an organization of knowledge and a means to enhance the understanding of the theory and the philosophy behind the context-based approaches. In order to achieve this aim, studies elaborating the development of projects adopting context-based approaches in teaching are analysed in detail. This analysis revealed that several of the context-based projects started with a pre-determined theoretical background whereas the development of the rest of the projects under consideration was not based on a theory, but was driven primarily through the experiences of practitioners and their 'craft' knowledge (Brown & McIntyre, 1993), or stemmed from problems faced during actual classroom practices.

ChiK is one of the projects that have a pre-determined theoretical background. Nentwig et al. (2005) proposed three theoretical considerations for explaining the philosophy of the project which are "scientific literacy", "theories of motivation" and "theories of constructivism", in particular; situated learning and conceptual change models (p.156).

A relatively small-scale project, Design-Based Science curriculum, implemented in US and Israeli high schools also have a pre-determined theoretical base which focuses on the principles of "social constructivism" characterized by "active construction" and "situated cognition", being the two main learning features of the project (Mamlok-Naaman, Fortus, Dershimer, Krajcik & Marx; 2005). Likewise; the Swedish science curriculum, which follows the traditions of context-based approach, reflects "the theory of learning based on Vygotsky" by placing knowledge acquisition in a sociocultural context (Szybek, 2005, p.198). Partnership Industry and School (ParIS) project that was developed for chemistry lessons implemented in German secondary schools also based its framework on five interrelated theoretical considerations: "scientific literacy", "self-regulated learning", "cognitive apprenticeship", "resource-based learning" and "mind-mapping" (Graber et al., 2005).

An interesting point arises from PLON project which provides contrary views to the aforementioned projects. Kortland (2005) states that the assumptions made in constructing the curriculum "cannot be considered to be derived from general, research-based theories about teaching and learning-disregarding the question whether such general theories offer any useful guidelines for developing concrete teaching materials and adequate classroom practices" (p.70). He states that most of the assumptions "could be considered to stem from practitioners' experiences and intuitions about what constitutes attractive teaching and effective learning at classroom level which could grow into something that reflects an action-based theory" (p.70).

With a similar wording, Ware and Tinnesand (2005) highlight that the curriculum development of ChemCom was driven "primarily through the developers' own classroom experiences; they were convinced that once the students understood the relevance of what they were learning, they became more interested in learning chemistry and achieved at higher levels" (p.94). For Salters' courses, Campbell et al. (1994 as cited in Waddington, 2005) see this craft knowledge as crucial which "drew very considerably on the accumulated craft knowledge of many experienced science teachers' and the development involved an interplay between theoretical knowledge, drawn from the research literature, and the teachers' tacit craft knowledge" (p.312).

Bennett and Lubben (2006) state that their main concern is not the theory in the Salters' developments, they preferred to benefit from the advantages of different theories when appropriate. The starting point of the Salters' courses was the need to solve problems faced in actual classroom practices, thus; the developers did not base the courses to a single theory (Waddington, 2005). However; the development of Salters courses was based on two fundamental design criteria (Bennett & Lubben, 2006):

1- The scientific ideas and the contexts included in the courses should enhance students' appreciation of how chemistry contributes to their lives and the community they live in and help them to understand the natural environment in a better way.

2- The courses should include a wide range of activities in which students could actively engage both physically and mentally.

Thus, as stated previously, the two prominent characteristics of context-based approaches for Salters' courses are that they use students' lives as a starting point for the development of scientific ideas, and that a variety of learning activities are blended for each subject. Waddington (2005) stated that these general design criteria provided the direction for the development of courses without putting stringent constraints. Furthermore, Campbell et al. (1994 as cited in Waddington, 2005) emphasized the point that these criteria allowed "the content, contexts and learning activities of the curriculum to be shaped by the experience and professional knowledge of teachers" (p.312).

From a broader point of view, Gilbert (2006) emphasizes three approaches that have particular importance for the use of contexts in teaching which are constructivism, situated learning, and activity theory.

Constructivists believe that students construct their own knowledge through experiencing things and reflecting on those experiences based on their prior knowledge and transfer their knowledge to new situations by relating the new knowledge with their previous ideas and experiences (Berns & Erickson, 2001). Grounded on the theories of John Dewey (1900), constructivism mentions authentic learning activities that require higher-order thinking skills like problem solving and critical thinking (Briner 1999 as cited in Berns & Erickson, 2001). By using students real-worlds as the starting point for introducing scientific ideas, context-based approaches provide students authentic learning activities to reach these higher-order thinking skills providing a constructivist view. One of the six characteristics of constructivist learning described by Reinmann-Rothmeier and Mandl (2001, as cited in Mandl & Kopp, 2005) is learning being "situative" which means that "knowledge acquisition is tied to a specific context and situation" (p.16).

In a similar way, situated cognition theory defines learning being "inherently social in nature" (Hansman, 2001, p.45) by emphasizing the role of the context in which something is learned. In their model of situated cognition; Brown, Collins and Duguid (1989) proposed that learning will be meaningful unless it is isolated from the social and physical context within which it is developed. That is to say; situatedness of knowledge particularly refers being in part of the activity, context and culture in which it takes place (Brown, Collins & Duguid, 1989). In accordance with these; anchored instruction (Cognition and Technology Group at Vanderbilt, 1991), one of the instructional models developed based on situated learning, show similarities to the context-based instruction in terms of immersing students in real life contexts and engage them in authentic learning practices (Taasoobshirazi & Carr, 2008).

Activity theory has a notable point of view for context; it regards the components of the activity; like object, actions, and operation, as being the context itself (Nardi, 1992) without thinking the learner and the object being studied as separate entities (Vygotsky, 1978 as cited in Gilbert, 2006). Moreover; context is not something isolated from the activities people take part with their own objects. The reflection of activity theory on classroom practice is cognitive apprenticeship aiming to guide and support learners throughout the problem solving process as it is the case in context-based instruction.

For the current study, it is important for context-based instruction designed to enable students construct their own knowledge based on their prior knowledge and experiences (constructivism) with the guidance of their teachers supporting them throughout the instruction (activity theory) while engaging in a variety of activities in groups emerged within a context (situated cognition).

2.4 Characteristics of a Context-based Instruction

For instructional practices to be considered as context-based, there are not well-defined explicit steps to follow in the classroom. However, there is an underlying philosophy behind context-based approaches which implies the characteristics of context-based instruction.

Berns and Erickson (2001) define some key factors to be addressed if the instruction is intended to be context-based:

- While developing lesson plans, teachers should take into consideration students' social, emotional and intellectual development.
- Students are required to engage in group work to learn from each other.
- Students should be aware of their strengths and weaknesses and reflect on how they learn and how they overcome difficulties through conditions leading self-regulated learning.
- Students' individual differences should not be ignored. This is also crucial when choosing the contexts through which the concepts are introduced and including classroom activities in order to reduce bias among different student characteristics, especially gender bias.
- Activities should target a wide range of intelligence types since the students vary in their abilities.
- In order to enhance students' higher order thinking and problem solving skills, questions should be involved in every step of the instruction.
- Instead of assessing the recalling of factual information, the assessment should be authentic by evaluating students' ability in application of knowledge.

For a more concrete portrayal of what happens during a context-based instruction, Nentwig et al. (2005) define four stages of a ChiK unit which are contact phase, curiosity and planning phase, elaboration phase and nexus phase.

In the contact phase; the context that is expected to capture students' interests is presented to students using familiar materials like newspapers and photographs as an introduction to the chemistry topic.

The curiosity and planning phase is generally based on students' questions about the context. They raise their questions that they seek for the answers and the teacher guides them to structure their questions focusing on the chemistry subject.

During the elaboration phase, the aim is to find answers to the questions raised during the previous phase by involving students in group activities. The role of the teacher becomes a scaffolder of the process. The students may consult a wide range of resources for gathering information in order to be able to find answers to the questions. At the end, they are expected to present their findings to the class.

For the nexus phase, the teacher's role changes from a scaffolder to a strong guide that orients students to relate chemistry concepts with their prior knowledge and their questions. Table 2.1 represents an example to the phases of a ChiK lesson.

Table 2. 1 The phases of ChiK lessons

Contact phase	Story: "Bread and salt -presents of the gods" Brainstorming on students ideas and prior-knowledge on the topic 'table salt'
Curiosity and planning phase	Structuring with mindmaps, collecting students' questions, planning the work
Elaboration phase	Learning at stations on the properties of table salt and ionic bonding
Nexus phase	Presentations with posters and experiments on the different aspects of table salt, networking the content with other knowledge, e.g. atomic structure and bonding

Note. Adapted from *How to allocate the chemistry curriculum between science and society* by I. Eilks, F. Rauch, B. Ralle, and A. Hofstein, 2013. In I. Eilks & A. Hofstein (Eds.) Teaching chemistry – A Studybook. (pp.1-37). Rotterdam : Sense Publishers

The framework of ChemCom shows very similar characteristics to the pattern of ChiK. There are four main parts in a ChemCom unit (Ware & Tinnesand; 2005) which are listed below:

- Students are introduced a context that involves aspects of chemistry.
- The guidance of teacher leads students to feel a need to learn chemistry in order to evaluate the aspects of context.
- Students are required to develop chemical concepts and see the relevance of them to the context.
- Students should be involved in the activities that require decision-making skills related to the societal and technological aspects of the context.

The introduction part of a PLON unit is in line with the examples stated so far. It also starts with a question that is considered to be relevant to students' lives and the society they live in

(Kortland, 2005). However, the role of students as a consumer of scientific knowledge and as a citizen is taken into consideration while determining the question. In the second part of the instruction, students work in groups to find answers to the basic question by addressing relevant physics concepts. Following this, they share their findings with the other groups in class. For closing up, the basic question is directed again to reach the final answer. At this point, the required physics knowledge is extended by applying physics concepts to similar situations.

As it can be inferred from the descriptions of sample instructions, the role of the teacher is crucial during the implementation of context-based instruction. While designing the instruction, the teacher should be aware of every possibility since the instruction is mostly based on questions. On the contrary to the traditional instruction in which contents and questions are pre-determined, context-based instruction has a natural and spontaneous flow. This flow should be directed by the teacher when needed without restricting the flexibility in the meantime. Therefore, the teacher may play different roles for different parts of the context-based instruction. The main characteristics of a teacher in a context-based instruction can be enlisted as;

- scaffolding students with their difficulties,
- guiding them towards the main point,
- raising proper questions to elaborate the subject,
- extending students' scientific knowledge,
- emphasizing the importance of sharing ideas and group work.

On the other hand; students are expected to see the relevance of the topic with their lives and become more motivated to learn. In order to achieve this, they should be both mentally and physically active, collaborate with their peers, engage in activities that will orient them to investigations, discussions, questioning, and exploration; obtain reasonable answers for the questions of concern and share findings with their peers to reach a meaningful conclusion on the aspects of the context.

Regarding the essential features of context-based instruction stated so far; it is important to determine the framework of the context-based instruction design for this study. 5E learning cycle instructional strategy, with the E's standing for Engage, Explore, Explain, Elaborate, and Evaluate, was considered as an alternative at this point. 5E learning cycle instructional strategy adopted a constructivist view of learning and it provides a "planned sequence of instruction that places students at the center of their learning experiences, encouraging them to explore, construct their own understanding of scientific concepts, and relate those understandings to other concepts" (National Science Teacher Association, 2007, p.29).

Table 2.2 presents the explanations of each step of 5E learning cycle in general (Bybee et al. 2006).

Table 2. 2 Summary of 5E Learning Cycle

Step of 5E	Explanations
Engage	Students should become engaged in the learning task by mentally focusing on an object, problem, situation, or event that promote curiosity and elicit prior knowledge. This step should help students to make connections between past and present learning experiences as well.
Explore	Following the engagement step, students feel a psychological need to explore the ideas for understanding the science behind the learning task introduced. This step should preferably make students engaged in concrete and hands-on activities in order to enable them to explore questions and possibilities, establish relationships, observe patterns, identify variables, and question events. The teacher, being the facilitator, should initiate the activity and allow the students time and opportunity to investigate objects, materials, and situations based on each student's own ideas of the phenomena.
Explain	This step orients students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, skills, or behaviors. First, the teacher asks the students to give their explanations. Second, the teacher introduces scientific explanations in a direct, explicit, and formal manner. The teacher should base the initial part of this step on the students' explanations and clearly connect the explanations to experiences in the engagement and exploration steps.
Elaborate	This step is an opportunity to involve students in new situations and problems that require the transfer of identical or similar explanations. Generalization of concepts, processes, and skills is the primary goal. Group discussions and cooperative learning activities may be helpful in this step to provide opportunities for students to express their understanding of the subject and receive feedback from their peers and the teacher.
Evaluate	This step encourages students to assess their understanding and abilities and provides opportunities for teachers to evaluate student progress toward achieving the educational objectives.

Note. Adapted from *The BSCS 5E Instructional Model: Origins and Effectiveness* by Bybee et al., 2006. (pp.1-37). Colorado Springs, CO: BSCS.

As it can be inferred from Table 2.2, 5E learning cycle model shows congruence with the main points emphasized for context-based instruction and it can easily be integrated in this kind of instruction. Since learning cycle offers “a planned sequence of instruction” and this sequence is well-defined and detailed by numerous researchers, context-based instruction for this study was designed according to the steps of 5E learning cycle instructional strategy. Following the steps of this instructional strategy; teacher guides that served as lesson plans were prepared within a standard outline, details of which are presented in Methods section.

Here is the explanation of how 5E learning cycle shed light on the design of the context-based instruction for this study. Since the main aim of the Engagement step is to promote students’ curiosity and elicit their prior knowledge about the topic, students are engaged with a contextual question or an example that they are presumed to be familiar with at the beginning of the lesson and students’ responses and ideas about the context introduced are collected. This step of learning cycle can be considered as the introduction of the context. For the Exploration step, students are provided a chance of exploring the key concepts involved in the context that are planned to be covered during the lesson. Depending on the concepts included in each lesson for this study, students performed simple laboratory experiments, watched demonstrations, collected experimental data, sketched graphs and solved problems by mostly working with their peers in groups by referring to certain aspects of context where possible. Thus, this step is the exploration of the context. For the Explanation step, the teacher should seek ways of connecting students’ conceptual understanding and explanations by making a smooth transition from context-oriented explanations to scientific explanations. For the current study, the teacher tried to help students connect what they explored in the previous step with chemical ideas by orienting them towards scientifically correct explanations. So, this step can be considered as the introduction of chemical concepts referring to the context. Elaboration and Evaluation steps proceeded hand in hand for this study. The teacher mostly referred to the contextual question presented to the students at the beginning of the lesson during these steps. The students were also engaged in arithmetical and conceptual questions that challenge students to extend their understanding in a broader context. Thus, these steps can be considered as an extension and assessment of the learning.

When the point comes to how contexts might be used in chemical education, Gilbert (2006) identifies four different models including contexts implicitly or explicitly:

- *Model 1:* Context as the direct application of concepts
- *Model 2:* Context as reciprocity between concepts and applications
- *Model 3:* Context as provided by personal mental activity
- *Model 4:* Context as the social circumstances

In instructions based on Model 1, scientific concepts are taught in a traditional and one-directional manner. The only difference of this type of instruction from traditional instruction is that contexts are referred at the end of the instruction with an attempt to give meaning to the concepts learned. In Model 2, there exists reciprocity between scientific concepts and applications; concepts are related to the applications and applications affect the meaning of the concepts for different situations. What is ignored in this model is the social dimension of integrating contexts into teaching. Model 3 emphasizes the role of narratives which are "the links made between contexts and some on-going theme in the life of the learner" (p. 969). However, these links do not ensure that students see the value of the narratives in context. Model 4 places social dimension of the context at the centre of the instruction. The context should include aspects of students' lives and be important to the community. The examples to contexts can be given as genetic modification, global climate, healthy food and obesity (Gilbert, 2006). This model integrates scientific concepts into the context in a classroom environment in which students see themselves as the participants of a societal issue. As it can be inferred, the last model owns all the attributes of a real context-based instruction. However, due to the demanding nature of this model, it is difficult to achieve this kind of context-based instruction in practice. For the current study, an adapted version of Model 3 was used as a framework for integrating concepts and the context chosen "atmosphere and weather changes" since the context is directly relates to certain aspects of the students' lives.

2.5 Research Studies on Context-Based Approaches

There are various studies regarding the effects of context-based approaches in science education that focus on students' learning outcomes and their affective responses to science. Notwithstanding the number of the studies, it is difficult to reach a judgement about the effects of context-based instruction and conclude that it works better than "business as usual" instruction (Taasoobshirazi & Carr, 2008).

At this point; scrutinizing review and meta-analysis studies focusing on context-based approaches not only helps to evaluate the effectiveness of context-based studies but gives information about their characteristics in general.

In their review of 66 studies that focus on embedding science in context and encouraging the links between science, technology and society (STS), Bennett, Lubben and Hogarth (2003) used review methods developed by the Evidence Policy and Practice Initiative (EPPI) Centre in the UK. Their analysis revealed that most of the studies were conducted in the USA, the UK, the Netherlands and Canada, including students aged predominantly between 11and 16. 26 studies out of 66 applied some sort of experimental research designs including control groups. 5 studies among these (Barber, 2000; Ramsden, 1997; Wiersta, 1984; Wiersta & Wubbels, 1994; Yager & Weld, 1999) which reported the effect of context-based instruction on both students' understandings and attitudes were reviewed in-depth. According to this in-depth review, the following conclusions were drawn:

- There is some evidence to conclude that context-based approaches motivate students in science courses.

- There is evidence to conclude that context-based approaches help students to develop more positive attitudes to science in general.
- There is good evidence to support the claim that context-based approaches do not adversely affect pupils' understanding of scientific ideas.

Another review study, conducted by Bennett, Lubben and Hogarth (2006), can be considered as an extension of the previous one, presenting more detailed information about the studies focusing on context-based and STS approaches. The database search of the researchers came up with 2500 studies of which only 61 studies could meet the inclusion criteria. 35 of the studies focused on science in general where the rest focused on single-disciplines; 13 studies on chemistry, 10 on physics and 3 on biology. The number of the studies reporting on attitudes of students was 44 while 41 of the studies reported on understanding. With a simple calculation, it can be inferred that 24 studies reported both of the student outcomes. While collecting data, researchers mostly applied tests (27), questionnaires (27), Likert-type scales (21) and interviews (20).

As a second step, researchers of the review focused down on experimental studies. There were 24 experimental studies and 17 of them were rated as of medium or higher quality. The findings of this step indicated that instructions based on context-based/STS approaches resulted in understanding of students at least as good as in traditional approaches and development of better attitudes towards science. The findings also indicated that gender difference in attitudes is reduced.

Taasoobshirazi and Carr's (2008) study included ten studies that focused on context-based physics instruction and can be regarded as a critique to the methodological problems of the existing studies more than being a review. Their initial search was resulted with more than 500 studies but 10 of them met their inclusion criteria which included studies either applied context-based physics instruction or problems to evaluate achievement, motivation or problem solving skills of students. The students involved in these studies were mostly enrolled in introductory level high school or college. The conclusions of this study are presented below:

- It is not easy to draw conclusions about the effectiveness of context-based instruction since most of the studies have serious methodological problems.
- These problems regarding the methodology of the studies are enlisted as failure to include a pre-test, nonrandomized assignment of the participants and failure to include a comparison group receiving traditional instruction.
- Neither the quality of the interventions nor their durations were clearly stated.
- There is a lack of well-designed studies to assess the effectiveness of context-based instruction on student outcomes.

By putting aside methodological problems, international research includes studies on context-based instruction revealing that using contexts to present scientific concepts result in students learning at least as effectively as in traditional instruction (Barber, 2000; Barker & Millar, 1996; Cooper, Yeo & Zadnik, 2003; Gutwill-Wise, 2001; Lubben, Campbell & Dlamini, 1997; Murphy, Lunn & Jones, 2006; Ramsden, 1997; Rayner, 2005; Smith & Bitner, 1993; Wierstra, 1984; Wierstra & Wubbels, 1994), concluding that students develop better affective responses to science learning (Barber, 2000; Gutwill-Wise, 2001; Kaschalk, 2002; Parchmann et al., 2006; Ramsden, 1992, 1994, 1997; Rayner, 2005; Sutman & Bruce, 1992) and clearly see the relevance of science to their daily lives (Hofstein, Kesner & Ben-Zvi, 2000). The details of some of the studies are presented in the following paragraphs.

One of the comparisons of the performance of students following a context-based instruction and traditional instruction in high school chemistry was made by Ramsden (1997). In order to collect data, a questionnaire consisted of eight diagnostic questions was applied. The questions focused on the key chemical ideas that were assumed to be necessary for further study of chemistry which are elements, compounds and mixtures, conservation of mass in chemical reactions, chemical change and the periodic table. 216 students; 124 following context-based instruction (Salters chemistry) and 92 following traditional courses, responded to the questionnaire. The analysis of data indicated that there was little difference in levels of understanding between two groups of students. However; the researcher reported some benefits of the context-based instruction in terms of stimulating students' interest and enjoyment in chemistry (Ramsden, 1997). These results are consistent with an earlier study of the researcher (Ramsden, 1992), concluding that students enjoy chemistry more when they are given the chance of seeing the relevance of chemistry to their daily lives as compared to their peers in more traditional courses.

The study of Barber (2000) gathered information both on cognitive and affective outcomes of students experiencing context-based instruction. Two groups of students were involved in the study as in the study of Ramsden (1997); one group experiencing Salters Advanced Chemistry and the other following a more traditional instruction. Data were collected through interviews and questionnaires. The analysis of the questionnaire data revealed that students experiencing context-based instruction possessed higher levels of interest in chemistry and enjoyed the activities they were engaged in during the instruction. In line with the results of the questionnaire data, analysis of students' interviews showed that student interest and motivation was maintained throughout the two-year course unlike the students in the control group reporting a decline in their interest towards chemistry at the end of the course. However, the students below average stated during the interviews that they had difficulties in coping with the problems and assignments during context-based instruction.

A further example is the experimental study of Gutwill-Wise (2001) that aimed to determine the effect of the context-based instruction on students' understanding, reasoning skills, and attitudes toward chemistry in two different institutions. The researcher made use of "modules" that were designed for ChemConnections project that aimed to improve chemistry education for college students in the USA by emphasizing the role of contexts in teaching.

The results of the study for one institution revealed that students who experienced “modules” in chemistry classrooms came up with a better understanding of the chemistry concepts and developed more positive attitudes towards chemistry when compared to their peers in the control group. The students in this college “felt that they understood the material better, enjoyed the course more and would be more likely to recommend the course” (p. 688) than the students who followed a more traditionally designed instruction.

For the evaluation of ChiK project, Parchmann et al. (2006) collected data from teachers and students involved in the initial implementation of the context-based approach through interviews and questionnaires. They compared students that would experience context-based instruction (n = 216) and traditional instruction (n = 183) at the beginning of the school year in terms of their motivation to learn chemistry. While no significant difference was observed before the implementation of the instructions, the motivation of students following the traditional instruction decreased significantly when compared to their peers in ChiK group at the end of the school year. After completing two years in ChiK program, all the students expressed significantly higher interests in chemistry. Moreover, the percentage of the students who stated that they would like to continue with studying chemistry was 60% which can be considered as a high ratio.

With an attempt to challenge students to develop an understanding of the relationship between physics and their profession, Rayner (2005) contextualized her instruction in a first-year physics course in tertiary education level. In order to be able to comment on the effects of context-based instruction, the data were collected through surveying students’ educational background and their prior knowledge of core concepts, informal written feedback received throughout the course, questionnaires at certain points in the course, assessment outcomes, and centralised formal course evaluations. The analysis of data indicated that students tended to achieve at an 80% average or above on the assessments administered. Due to the students’ competencies in use of terminology and descriptions of interreleationships in assignment data, Rayner concluded that context-based instruction emerged with a clear understanding of the subject. Of greater significance, the researcher also stated that context-based instruction was very helpful both in terms of developing positive students’ perceptions of the course, in-depth understanding of the subject and relevance to students’ future professions.

Taken together the results of the studies, it can be stated that context-based instruction has the potential of effecting student outcomes; specifically their interest, attitude, motivation and understanding of the subject, in a positive way.

2.6 Research Studies on Context-Based Approaches in Turkey

Research studies focusing on context-based approach date back to less than 10 years in Turkey. The number of master theses and doctoral dissertations that aim to design context-based materials and assess the effectiveness of the context-based instruction has increased recently. Throughout this section, these studies conducted in Turkey are analyzed in detail.

Çam (2008) investigated the effect of context-based instruction on students' academic achievements, attitudes towards biology and scientific process skills in her study. The sample of the study was chosen as university students who were to be trained as elementary school teachers. A quasi-experimental pre-test-post-test control group design followed by the interviews was adopted as a research design. While instruction designed on context based approach were being implemented in experimental group which composed of 41 students, control group with 53 students carried on with their traditionally-designed biology courses. For quantitative data collection, achievement test, scientific process skills test and attitude towards biology test were used. On the other hand, an interview form including both open-ended and close-ended questions was utilized as a means of collecting qualitative data. Multivariate Analysis of Variance (MANOVA) was applied for the statistical analysis and results revealed that there was a significant difference between context-based instruction and traditional instruction in terms of students' achievement, students' attitudes towards biology and students' scientific process skills in favour of context-based instruction. These results were also supported by the data obtained via interviews.

The main purpose of Demircioğlu's (2008) study was to design a context-based material regarding "States of Matter"subject for general chemistry curriculum at university level and assess its effectiveness on 35 university students who were to be trained as elementary school teachers similar to the sample of Çam (2008) in terms of achievement, attitude towards chemistry, knowledge retention and eliciting alternative ideas of student teachers. She applied case study as a research method and collected data through Concept Achievement Test, clinical interviews, semi-structured interviews, attitude questionnaire and unstructured classroom observations. The quantitative data was analyzed with repeated measures ANOVA. Although the study did not include a comparison group, the results indicated that context-based materials caused a rise in students' academic achievements [$F (2; 66) = 100{,}546$; $p < 0{,}05$)] and attitudes [$F (1; 69) = 47{,}752$; $p < 0{,}05$)]. The researcher also concluded that using context-based materials resulted with high retention of learned concepts and increased motivation towards science learning.

Ünal (2008) conducted a four-week study to investigate the effect of context-based instruction on students' achievements and attitudes towards science and technology. The contexts were developed for the subject "Matter and Heat" and implemented in the experimental group that consisted of 22 high school students. In the meantime, control group ($N = 24$) continued to receive traditionally designed instruction. For data collection, science and technology achievement test and science and technology attitude scale were administered to both groups before and after the treatment. In order to verify quantitative results, the researcher also conducted interviews with 5 students in the experimental group following the treatment. Data analysis did not reveal any significant differences between the mean scores of students' on multiple choice questions in the achievement test ($t = 1{,}428$; $p > 0{,}05$), in their total scores on achievement test ($t = 1{,}954$, $p > 0{,}05$) and in their attitude test scores ($t = 1{,}008$; $p > 0{,}05$). However; significant differences between their mean scores of conceptual questions in the achievement test were reported ($t = 2{,}840$; $p < 0{,}05$) in favour of context-based instruction. On the other hand, students expressed positive feelings towards context-based approach during the interviews.

Turkish physics curricula for secondary schools were revised in 2007 with a general aim to increase student engagement in classrooms by adopting a context-based approach. Regarding the necessity to design new materials to be utilized in classroom practices with these changing conditions, Değermenci (2009) developed context-based materials for the subject "Waves" in physics and observed their implementation in a ninth grade classroom to assess their effectiveness. The research design of the study was determined as case study and lasted for 10 hours which correspond to the duration reserved for the subject in physics curriculum. Data were collected through semi-structured interviews and classroom observations. The results indicated that the teacher, students and parents had difficulties in understanding and getting familiar to the context-based approach as a classroom practice at schools.

Another study conducted by Yayla (2010) shared almost similar aims with the study of Değermenci (2009) on a different physics subject; to develop materials on the subject of "Electromagnetic Induction" based on the context-based approach regarding the reform in physics curriculum and evaluate its effectiveness on students' achievement and attitudes towards physics. The researcher applied action research methodology with 15 high school students in six-hour class period. An achievement test, semi-structured interviews, attitude questionnaire and classroom observations were used as data collection tools. Quantitative data analysis through t-tests revealed significant differences in terms of students' achievement and attitudes towards physics in favour of context-based instruction. Moreover; analysis of interviews and observation data showed that context-based materials helped learning to be more interesting for students.

Ilhan (2010) aimed to investigate the effectiveness of context-based instruction on the subject of "chemical equilibrium" for 11^{th} grade students in his doctoral dissertation. He applied a mixed-methods research design including both quantitative and qualitative data analysis. For the quantitative part of the study, a quasi-experimental pre-test-post-test control group design was utilized for a 7-week treatment. The dependent variables of the study were determined as achievement, motivation and contribution of context-based instruction to the constructivist learning environment. The sample of the study was consisted of 104 11^{th} grade students from four different classes, two of which received context-based instruction while the rest were carrying on with their traditional instruction. In order to collect quantitative data, "Chemical Equilibrium Achievement Test", "Chemistry Motivation Questionnaire" and "Constructivist Learning Environment Survey" were applied. For the qualitative part of the study, the data were collected through interviews with teachers and "Student Opinion Questionnaire" with an aim to determine participating students' and teachers' opinions about context-based instruction. The results made the researcher report that context-based instruction was more effective than traditional instruction in terms of improving student achievement [F (1, 95) =13,97, $p < 0.05$] and motivation [F (1, 91) = 6.845, $p < 0.05$]. It was also determined that context-based instruction contributed more to the constructivist learning environment [F (1, 90) = 4.630, $p < 0.05$]. The interviews conducted with teachers implementing context-based instruction in the experimental group revealed that teachers generally had positive feelings towards context-based instruction but their main concerns focused on time requirements and their students' performances in university entrance examinations.

The dissertation of Tekbıyık (2010) not only focused on context-based teaching of physics but also on a teaching methodology; 5E learning cycle. He applied a pre-test post-test one group experimental design including 83 ninth grade students to assess the effectiveness of context-based approach integrated with 5E model on "Energy" subject. As a first step to reach this aim, he developed materials for both students and teachers based on context-based approach integrated with 5E model. Applying these materials, the treatment lasted for 5 weeks and the data were collected through Energy Unit Conceptual Achievement Test, Physics Attitude Scale, classroom observation form and semi-structured interviews. The analysis of quantitative data was conducted through paired sample t-test, ANOVA and ANCOVA and the results were categorized according to school types; public high school, Anatolian high school and vocational high school. Regarding achievement of students and their attitudes towards physics, statistical analysis revealed that the mean difference between pre-test scores of students and post-test scores were statistically significant for both dependent variables and for all school types.

Similar to the study of Tekbıyık (2010), the study of Toroslu (2011) had mainly two aims, one of which is to investigate the effectiveness of 7E learning cycle embedded in a real-life context-based instruction on students' conceptual understandings and science process skills on the subject of "energy". The second aim is to eliminate the students' misconceptions related to the subject of concern. In order to achieve these aims, three different instruments were utilized which are misconceptions test, achievement test and science process skills test. The quasi-experimental pre-test-post-test control group design was used as a research design. The treatment lasted for two months and the data were analysed through Mann-Whitney U test and ANCOVA. Results of the analysis revealed that there was a statistically significant effect of 7E learning cycle integrated with real-life context-based instruction on students' conceptual understandings ($U = 723,00$; $p = 0,003$) and science process skills ($F = 39,875$; $p = 0,000$) when compared to the traditional instruction but the instruction was not effective in terms of eliminating students' misconceptions ($F = 0,092$; $p = 0,763$).

A noteworthy example is Kutu's (2011) study which integrates context-based approach with a motivation model and aims to explore the usability of context-based ARCS instructional model in teaching "Chemistry in Our Lives" subject in ninth grade high school students. To achive this goal, she designed context-based materials with the principles of ARCS (Attention-Relevance-Confidence-Satisfaction) motivation model (Keller, 2006) and investigated the effects of this model on 60 ninth grade students' retention of knowledge, motivation and attitude toward chemistry. The data of the study were collected through "Attitude toward Chemistry Scale", "Instructional Materials Motivation Survey", "Constructivist Learning Environment Survey", "Achievement Test", semi-structured interviews and classroom observations. Analysis of quantitative data with dependent sample t-tests indicated that the method implemented caused a rise on students' knowledge retention and motivation but did not have statistically significant effect on students' attitudes towards chemistry. It was also concluded that students perceived classroom environment in which context-based materials were implemented as a constructivist learning environment.

One more study including context-based instruction and physics combination is the study of Peşman (2012) that aimed to explore mainly method-approach interaction on the subject "impulse and momentum" in his dissertation. He treated teaching methods (learning cycle vs. traditional method) and teaching approaches (contextual vs. non-contextual), separately. Therefore; a 2x2x2 factorial research design was applied to analyze the data collected from 226 students. One of the sub-problems of the study is to determine the effect of context-based instruction on students' achievement and attitude towards physics course. MANCOVA and follow-up Analysis of Covariance tests (ANCOVAs) were utilized to analyse the data where students' GPA (grade point average) scores in the previous year's physics lesson and pre-test attitude scores served as the covariates. The results indicated that contextual and non-contextual groups significantly differ in conceptual scores obtained from achievement test [$F (1, 184) = 6,98$, $p = 0,009$; partial eta squared = 0,037] in favor of contextual groups. However, it was concluded that contextual and non-contextual groups did not differ significantly in their attitudinal scores [$F (1, 184) = 0,934$, $p = 0,335$; partial eta squared = 0,005].

Elmas (2012) applied a nonequivalent groups pre-test post-test research design for his doctoral dissertation and collected data from 222 ninth grade students from eight classes in two different types of high schools in Ankara with an aim to compare the effectiveness of context-based instruction as compared to the traditionally designed chemistry instruction on students' understanding of cleaning materials subject and their attitudes toward environment. MANCOVA was conducted for statistical analysis where students' science process skills served as the covariate. The results of the analysis revealed that the students who received context-based instruction acquired chemical concepts and ideas in a significantly better way when compared to the students in the control group. However, no significant difference was reported with respect to the mean scores of students on attitude toward environment scale and outcomes of students did not differ in terms of school type. The researcher also concluded that science process skills of students strongly contributed to the understanding of the cleaning materials subject.

Taken together, the context-based teaching of science has been receiving an outstanding attention from Turkish science educators. There are a lot more studies focusing on context-based teaching of physics (Akpınar & Tan, 2011; Ayvacı, 2010; Bülbül & Eryılmaz, 2010; Kaltakçı & Eryılmaz, 2011; Tekbıyık & Akdeniz, 2010; Ültay, 2012; Yayla, 2010), biology (Acar & Yaman, 2011; Gürsoy Köroğlu, 2011; Özay Köse & Çam Tosun 2010; Yaman, 2009), and chemistry (Demircioğlu, Demircioğlu & Ayas, 2006; Demircioğlu, Demircioğlu & Çalık, 2009; Kutu & Sözbilir, 2011; Sunar & Geban, 2012a; Ültay & Çalık, 2011). There are also studies aiming to shed light on the step of determination of contexts to apply in teaching process (Elmas, Bülbül & Eryılmaz, 2011; Sunar & Geban, 2012b; Yaman, 2009).

Table 2.3 presents a brief summary of the theses and dissertations focusing on context-based teaching of science in Turkey. For the reported outcomes, the “+” plus sign indicates a statistically significant result where “-” sign means the effect of context-based instruction on related outcome is not significant.

2.7 Attitude toward Chemistry

One of the main goals of science education is the development of positive attitudes towards science since feelings of students towards science subjects may have an impact on their understanding of science. Specifically, the purpose of this current study is to assess the effectiveness of context-based chemistry instruction both on students’ understanding of chemistry and their attitudes towards chemistry.

In order to clarify the meaning of the term “attitude”, Gardner (1975, as cited in Osborne et al., 2003) made a distinction between “scientific attitudes” and “attitudes towards science”. The former term associates with thinking styles of students and their position with respect to scientific method (Bennett & Hogarth; 2005) where the latter term, which serves for the purpose of clarifying the term “attitude” as referred in this study, can be defined as “the feelings, beliefs and values held about an object that may be the enterprise of science, school science, the impact of science on society or scientists themselves” (Osborne et al., 2003, p.1053).

The definition of Oppenheim (1992, as cited in Bennett & Hogarth; 2005) emphasized the components of attitudes as being a stimuli and a response:

> “...attitudes are normally a state of readiness or predisposition to respond in a certain manner when confronted with certain stimuli...attitudes are reinforced by beliefs (the cognitive component), often attract strong feelings (the emotional component) which may lead to particular behavioural intents (the action-tendency component)” (p.9).

The stimulus is chemistry in our case and “attitudes towards chemistry” refer to the feelings of students towards chemistry throughout the study.

As it can be inferred from the definitions, attitude is not a unidimensional construct; it consists of various components that contribute differently to what is defined by attitude (Gardner, 1995; Osborne et al., 2003). By going through a range of studies regarding attitudes, Osborne et al. (2003) listed some of these subconstructs as follows:

- the perception of the science teacher,
- anxiety toward science,
- the value of science,
- self-esteem at science,
- motivation towards science,

Table 2. 3 Summary of the theses and dissertations focusing on context-based approach in Turkey

Studies	PhD/ M.S	Subject	Sample Group	Sample Size	Research Methodology	Data Collection Tools	Reported Outcomes: Achievement	Motivation	Attitude	Retention	Science Process Skills	Eliciting Misconceptions	Contribution to Learning Env.
İlhan (2010)	PhD	Chemical equilibrium	11th grade students	104	Mixed-method design	Chemical Equilibrium Achievement Test, Chemistry Motivation Questionnaire, Constructivist Learning Environment Survey, Interviews, Student Opinion Questionnaire	+	+					+
Tekbıyık (2010)	PhD	Physics-Energy	9th grade students	83	pre-test-post-test one group experimental design	Energy Unit Conceptual Achievement Test, Physics Attitude Scale, Observation form Semi-structured interviews.	+		+			+	
Çam (2008)	M.S	Biology	1st year university students-primary teacher education	94	Mixed-method design	Achievement test, Scientific process skill test, Attitude test towards biology courses, Interview form	+		+		+		
Kutu (2011)	PhD	Chemistry in our Life	9th grade students	60	Instrumental case study	Attitude Toward Chemistry Scale, Instructional Materials Motivation Survey, Constructivist Learning Environment Survey, Achievement Test, Semi-structured interviews, Observation	+	+	-	+			+

Table 2. 3 (continued)

Studies	PhD/ M.S	Subject	Sample Group	Sample Size	Research Methodology	Data Collection Tools	Reported Outcomes						
							Achievement	**Motivation**	**Attitude**	**Retention**	**Science Process Skills**	**Eliciting Misconceptions**	**Contribution to Learning Env.**
Ünal (2008)	M.S	Science and Technology- Matter and Heat	6th grade students	46	Quasi-experimental	Science and Technology achievement test, Science and Technology attitude scale, Interviews	+		-				
Çekiç Toroslu (2011)	PhD	Physics-energy	10th grade students	95	pre-test-post-test design with control group	Misconception Test, Achievement Test, Science Process Skills Test	+				+	-	
Peşman (2012)	PhD	Physics- Impulse and momentum	11th grade students	226	2x2x2 facttorial design	Impulse and Momentum Achievement Test, Affective Characteristics Questionnaire	+						
Elmas (2012)	PhD	Chemistry in our Life	9th grade students	222	Nonequivalent groups pre-test post-test design	Cleaning materials achievement test, Attitude toward environment Science process skills test	+		-				
Yayla (2010)	M.S	Physics-Electromagnetic Induction	12th grade students	15	action research methodology	Achievement Test, Semi-structured interviews, Attitude questionnaire, Classroom observations	+		+				
Demircioğlu (2008)		Chemistry-States of Matter	University students-primary teacher education	35	Case study	Concept Achievement Test, Clinical interviews, Semi-structured interviews, Attitude questionnaire, Classroom observations	+		+	+		+	

- enjoyment of science,
- attitudes of peers and friends towards science,
- attitudes of parents towards science,
- the nature of the classroom environment,
- achievement in science,
- fear of failure on course (p.1054).

Regarding these subconstructs; Affective Characteristics Questionnaire, developed by Abak (2003), was adapted to chemistry for the current study. This questionnaire was chosen among many of the attitude scales due to including most of the attitudinal subconstructs which are categorized as importance of chemistry, interest in chemistry, extra activities related to chemistry, student motivation in chemistry, chemistry self-efficacy, chemistry self-concept, achievement motivation in chemistry and chemistry anxiety. Importance of chemistry refers to the value students give to the chemistry courses in terms of being necessary and important for them in their daily lives. Interest in chemistry is closely related with personal significance, positive feelings and readiness to pursue it (Wade, 2001). Chemistry self-efficacy is a construct that is about the evaluation of individual competencies in chemistry as referred in this study whereas self-concept can be defined as the general ideas about a student's own identity and relations to others at school (Koballa & Glynn, 2007). Student motivation in this study refers to the involvement in chemistry courses for its own sake (Abak, 2003). Achievement motivation is associated with the value given to the goals of the chemistry course and performing accordingly to achieve these goals (Koballa & Glynn, 2007). Anxiety is defined by Spielberg (1983) as an unpleasant feeling in response to the situations that are potentially threatening. These cases may be the chemistry course itself and taking chemistry examinations for this study. Extra activities refer to the degree of student engagement in out-of-school activities related to chemistry (Abak, 2003). The details of the questionnaire and factor loadings are explained thoroughly in Methods section.

The reason of the extensive effort on assessing attitudes in research studies may be that "they are essentially a measure of the subject's expressed preferences and feelings towards an object" (Osborne et al., 2003, p.1054). It is reasonable to expect that if students develop positive feelings towards what they study; their actions that are associated with their learning outcomes will be modified accordingly. The reflections of these feelings may possibly be that students attend the courses more regularly, read textbook assignments thoroughly and complete their homework more carefully (Koballa & Glynn, 2007).

The kind of science instruction students experience may play a crucial role in improving students' attitudes toward science. The research on attitudes toward science focuses on the approaches that positively influence student attitudes. The positive effect of various instructions on students' attitudes toward science was reported by numerous researchers. The following instructional strategies may be given as examples to classroom practices whose effects on attitudes were explored; learning cycle instructional strategy (Aydemir, 2012; Cavallo & Laubach, 2001; Ceylan, 2008; Şaşmaz Ören & Tezcan, 2009), computer-assisted instruction (Geban, Aşkar & Özkan, 1992; Kulik & Kulik, 1991; Morgil et al. 2005; Özmen, 2007; Pabuçcu, 2008; Soyibo & Hudson, 2000, Taşdelen, 2011), case-based teaching (Adalı, 2005; Çam & Geban, 2011) and laboratory work (Musasia, Abacha & Biyoyo, 2012; Thompson & Soyibo, 2002).

Koballa and Glynn (2007) also highlighted the role of instruction that emphasizes active learning and the relevance of science to daily life for positively affecting student attitudes. Context-based instruction is a way of instruction that engages learners in various activities and stresses the relevance of science to students' lifeworlds by referring to contexts or daily life applications. Thus, the results of context-based studies point out the success of context-based instruction on improving students' affective responses towards science (Barber, 2000; Gutwill-Wise, 2001; Kaschalk, 2002; Parchmann et al., 2006; Ramsden, 1992, 1994, 1997; Rayner, 2005; Sutman & Bruce, 1992).

Likewise the effect of instructional practices, the difference between girls and boys play a significant role on students' attitudes. In their review study, Osborne et al. (2003) identified gender as one of the most significant factors influencing attitudes towards science in general. Male students and female students differ in their attitudes towards science, often favouring males over females, and the underlying reasons of this difference may be both physiological and sociological (Koballa & Glynn, 2007).

Female students' less positive attitudes towards science have been the main concern of various studies. Weinburgh (1995) conducted a meta-analysis with 18 studies including 6753 subjects in total. One of the main aims of this study was to examine how males and females differ in attitudes towards science. Thirty-one calculated effect sizes indicated that female students had less positive attitudes towards science than male students. Furthermore; the study of Salta and Tzougraki (2004) with Greek students showed that female students had a tendency to express negative attitudes regarding the difficulty of chemistry even though they did not differ significantly in their reported attitudes regarding the interest and importance of chemistry with respect to their male peers.

The role of instructional practices that narrow the gap between males and females become vital at this point. Lubben, Bennett, Hogarth and Robinson (2005) focused on instructions designed on context-based and STS approaches with an aim to report their effects on male and female students. Their initial mapping of the studies came up with 61 studies but they focused down on 14 studies meeting their inclusion criteria. 12 of these studies included gender, 11 of them included gender and attitude and four of them included gender and understanding. They categorized each study as medium, medium-high or high quality. The findings of the study suggested that;

- Both male and female students following context-based courses had significantly more positive attitudes towards science when compared to their peers following more traditionally designed courses.

- The difference between male and female students' attitudes towards science was narrowed during context-based instructions.

- The nature of activities included in context-based courses influenced the reported enjoyment of male and female students. Female students enjoyed context-based materials more when they were engaged in non-practical activities whereas male students showed increased enjoyment while engaging with practical work.

The study conducted in Germany by Nentwig et al. (2007) presented similar findings based on the initial evaluation of ChiK. The results indicated no significant differences in terms of male and female students' scores in science subjects. The findings of the study of Tsai (2000) including 101 female students also showed that female students following STS-oriented instruction outperformed their peers who followed a more traditional instruction.

To sum up; it can be stated that integrating a context that is familiar to all students into the instruction is effective for both gender. The findings of the studies further imply that context-based instruction may have the potential to narrow the gap between male and female students' attitudes towards science.

2.8 Retention of Knowledge

Long-term effects of instructional practices, which associate with retention of knowledge, have potential to give information about the effectiveness of instructions (Bahrick, 2000). In their review of studies focusing on retention of school knowledge, Semb and Ellis (1994) emphasized one factor influencing the retention of knowledge as being the nature of instructional approach. The researchers stated that learners differed in their forgetting and retaining of knowledge with respect to different qualitative aspects of instructions; students in active learning environments forgot what they learned less than the students in relatively less student-centred classrooms.

One may expect that if students are able to see the relevance of science to their lives and perceive it as meaningful to learn, they will retain more of the knowledge that they learned during the instructional practices (Taasoobshirazi & Carr, 2008). It was revealed from the literature that there is a lack of context-based studies documenting the results on students' knowledge retention following the context-based instruction. Only the study of Lye, Fry and Hart (2001) focused on the teacher views regarding knowledge retention. From the interview data of teachers, the researchers concluded teachers' view as students retain more of the knowledge when the concepts are presented in a context.

In Turkish context, the number of studies that focused on the influence of context-based instruction on students' retention of knowledge is limited. Two studies were available that included retention as a dependent variable but both of the studies failed to include a comparison group. Applying a three-week retention interval following the context-based instruction, Kutu and Sözbilir (2011) reported a 95.75% retention rate for high school students' retention test scores when compared to their post-test scores in their study with a case study research method. With a similar research design, Demircioğlu (2008) stated that context-based instruction is effective in terms of students' retention of knowledge assessed by open-ended questions even four months following the treatment.

The reason of including retention as a dependent variable in this study is to present the findings regarding the effectiveness of context-based instruction on knowledge retention of students when compared to the traditional instruction and contribute to the existing literature on retention of knowledge. The context-based instruction can be a promising way of instruction that helps students to retain what they learn more easily with respect to the objectives to be attained and for applying knowledge to their daily lives over the long-term.

CHAPTER 3

METHODOLOGY

This chapter includes hypotheses, research type and design, population and sample, variables, instruments, procedure, analysis of data, assumptions and limitations.

3.1 Hypotheses

The problems stated in Chapter 1 are tested with the following hypotheses. The first three hypotheses test the main problems of the study whereas the rest covers the sub-problems.

$H_0$1: There is no statistically significant overall effect of the instructions (CBI and TI) on the population mean of the collective dependent variables of tenth grade high school students' post-test scores of SMAT, delayed post-test scores of SMAT and post-test scores of ACQ when the effects of their pre-test scores of SMAT and pre-test scores of ACQ are controlled.

$H_0$2: There is no statistically significant overall effect of gender on the population mean of the collective dependent variables of tenth grade high school students' post-test scores of SMAT, delayed post-test scores of SMAT and post-test scores of ACQ when the effects of their pre-test scores of SMAT and pre-test scores of ACQ are controlled.

$H_0$3: There is no statistically significant interaction between instruction and gender on the population mean of the collective dependent variables of tenth grade high school students' post-test scores of SMAT, delayed post-test scores of SMAT and post-test scores of ACQ when the effects of their pre-test scores of SMAT and pre-test scores of ACQ are controlled.

$H_0$4: There is no statistically significant difference between the population means of tenth grade high school students experiencing the CBI and TI with respect to their post-test scores of SMAT when the effects of their pre-test scores of SMAT are controlled.

$H_0$5: There is no statistically significant difference between the population means of males and females with respect to their post-test scores of SMAT when the effects of their pre-test scores of SMAT are controlled.

$H_0$6: There is no statistically significant interaction between instruction and gender of students with respect to their post-test scores of SMAT when the effects of students' pre-test scores of SMAT are controlled.

$H_0$7: There is no statistically significant difference between the population means of tenth grade high school students experiencing the CBI and TI with respect to their post-test scores of ACQ when the effects of students' pre-test scores of ACQ are controlled.

H_08: There is no statistically significant difference between the population means of males and females with respect to their post-test scores of ACQ when the effects of students' pre-test scores of ACQ are controlled.

H_09: There is no statistically significant interaction between instruction and gender of students with respect to their post-test scores of ACQ when the effects of students' pre-test scores of ACQ are controlled.

H_010: There is no statistically significant difference between the population means of tenth grade high school students experiencing the CBI and TI with respect to their delayed post-test scores of SMAT when the effects of students' pre-test scores of SMAT are controlled.

H_011: There is no statistically significant difference between the population means of males and females with respect to their delayed post-test scores of SMAT when the effects of students' pre-test scores of SMAT are controlled.

H_012: There is no statistically significant interaction between instruction and gender of students with respect to their delayed post-test scores of SMAT when the effects of students' pre-test scores of SMAT are controlled.

3.2 Research design

The pre-test-post-test control group design was used in this study to examine the effects of the context-based instruction when compared to the traditional instruction on students' chemistry achievement and knowledge retention as measured by the SMAT and attitude as measured by the ACQ. The design of the study can be characterized as a quasi-experimental design since students cannot be randomly assigned as individuals to the experimental group and control group (Fraenkel & Wallen, 2000). During the treatment, control group carried on with their "business as usual" instruction, otherwise stated; traditional instruction, while context-based instruction integrated with learning cycle model was implemented in the experimental group to determine whether these instructions had an effect on students' chemistry achievement, knowledge retention and attitude toward chemistry.

In order to verify that the students in the control and experimental groups do not differ significantly on relevant prior knowledge and to investigate the effect of the treatment on students' chemistry achievement and knowledge retention concerning states of matter subject, the SMAT was administered as pre-test, post-test and delayed post-test in all groups. The ACQ was also administered to both groups as pre-test and post-test.

Research design of the study is presented in the following table. In this table, EG represents experimental group experiencing the context-based instruction and CG represents control group experiencing the traditional instruction. As Table 3.1 indicates, pre-tests were administered to both of the groups prior to the treatment. Following these; students in the control group carried on with traditional instruction while context-based instruction was implemented in the experimental group for six weeks. Post-tests were administered to both groups at the end of the treatment. Finally, four months following the post-test administration, the students were administered the SMAT as a delayed post-test unannounced in order to evaluate their knowledge retention.

Table 3. 1 Research design of the study

Groups	Pre-tests	Treatment	Post-tests	Delayed post-test
EG	SMAT	Context-based	SMAT	SMAT
	ACQ		ACQ	
CG	SMAT	Traditional	SMAT	SMAT
	ACQ		ACQ	

3.3 Population and Sample

The target population of this study is all tenth grade students from Anatolian high schools in Bursa. The accessible population is all tenth grade students from Anatolian high schools located in İnegöl and Yenişehir districts of Bursa. The sample of the study was chosen from the accessible population by using convenience sampling. According to the website of Ministry of National Education (MONE, 2010), there are four Anatolian high schools in the accessible population, two of which were included in this study. All tenth grade students enrolled in science-mathematics classes in these two schools comprised the sample of the study. Table 3.2 presents the data related to the participants in each group.

Table 3. 2 Sample of the study in terms of gender and group

		Group		
		Experimental	Control	Total
Gender	Female	36	43	79
	Male	43	28	71
	Total	79	71	150

Random assignment of the treatments to intact groups was employed for the present study. In this case, three classes of one school were randomly assigned as the experimental group and three classes of the other school were assigned as the control group which received context-based instruction and traditional instruction, respectively.

The sample chosen from the accessible population was a sample of convenience for this study as stated previously since it would be difficult to select a random sample of individuals. Other reasons for non-random sampling procedure can be stated as to communicate easily and frequently with the teachers and to observe the classrooms frequently for treatment verification.

3.4 Variables

There are seven variables involved in this study, three of them are dependent and the remaining four of them are independent variables as shown in Table 3.3. Independent variables are divided into two groups as group membership and covariates. Instruction which refers to the group membership and gender are the independent variables of the study. Since random assignment of individuals to experimental and control groups was not possible; students' pre-test scores on States of Matter Achievement Test (pre-SMAT) and pre-test scores on Affective Characteristics Questionnaire (pre-ACQ) were considered as covariates to control pre-existing differences among groups. Moreover, dependent variables of the study are post-test and delayed post-test scores of the students on the SMAT and post-test scores of the students on the ACQ.

Table 3. 3 The name, type, nature and scale of the variables in the study

Name of variable	Dependent/Independent	Continuous/Categorical	Scale
Post-SMAT	DV	Continuous	Interval
Post-ACQ	DV	Continuous	Interval
Retention	DV	Continuous	Interval
Pre-SMAT	IV	Continuous	Interval
Pre-ACQ	IV	Continuous	Interval
Gender	IV	Categorical	Nominal
Instruction	IV	Categorical	Nominal

3.5 Instruments

Throughout the study, data was mainly collected through three different measuring tools; States of Matter Achievement Test (SMAT), Affective Characteristics Questionnaire (ACQ) and an observation checklist to evaluate the groups in order to verify the treatments. Details of these instruments are presented in the following sections.

3.5.1 States of Matter Achievement Test (SMAT)

The SMAT was developed by the researcher with an aim to measure students' understanding in the states of matter subject. The content of this subject covers general properties of gases, gas laws, gas mixtures, real gases, liquids, change of states and solids. As a starting point, chemistry curriculum for tenth grades were analysed in order to identify the objectives of the subject and the concepts to be taught throughout the subject (Appendix B and Appendix C). Regarding these objectives and concepts, a pool of questions was obtained from the dissertations, course books, last 10 years' university entrance examinations and foreign course books that contain the related content. Following this step, the questions that were to be included in the instrument were determined by matching the questions with the objectives stated in the curriculum. The final version of the instrument comprised of 31 multiple-choice items. Afterwards, the instrument was reviewed by four PhD students and a professor, who study on chemistry education, in order to ensure face and content validity. Reviewers examined compatibility between objectives and questions, and made further suggestions about the instrument in general. The table of specification for SMAT is presented in Appendix D.

Table 3.4 indicates the sources of questions included in the SMAT. The dissertations referred for this instrument are İpek (2007), Demircioğlu (2008), Çetin (2009) and Yalçınkaya (2010). The course book is the MONE's chemistry textbook for tenth grades (MONE, 2009) and the foreign textbooks are Living by Chemistry (Stacy, 2010) and Salters Advanced Chemistry-Chemical Storylines (Denby, Otter & Stephenson, 2009) Most of the questions remained the same with the originals and a few of them were slightly changed in wording.

Table 3. 4 The sources of questions in the States of Matter achievement test

Source of Question	Number of Question
Dissertations	1, 2, 3, 4, 6, 7, 9, 12, 14, 17, 18, 21
Chemistry textbook	15, 16, 22
Foreign textbooks	5, 11, 13, 23, 24, 25, 26, 27, 28, 29, 30, 31
University entrance examinations	8, 10, 19, 20

Reliability analysis was conducted in order to see the degree to which the items that make up the SMAT collectively measure the construct under investigation. One of the most commonly used indicators of internal consistency is Cronbach's alpha coefficient. Ideally, the Cronbach’s alpha coefficient of a scale should be above 0,7 (Pallant, 2007, p. 95). Since the Cronbach’s alpha coefficient was found to be 0,744, which is above desired value of 0,7, it can be concluded that the reliability of the instrument is satisfactory. This means that 74,4 % of the observed score variance can be attributed to true score variance.

In order to ensure the appropriateness of the questions regarding their item difficulty and item discrimination indices, item analysis was conducted via the help of ITEMAN program. Proportion corrects which correspond to item difficulty is defined as the proportion of students who answer the item correctly (Crocker & Algina, 1986) and the values for this instrument range between 0,154 and 0,852 in this study. Point biserial values of all items, which correspond to item discrimination indices, are positive indicating that the students with high total test scores got the item correct whereas the students who scored low responded to item incorrectly. It may be concluded that item difficulty and item discrimination indices for items in SMAT were in acceptable ranges. Only one item (# 29) was not included in the statistical analysis since one of the alternatives belonging that item worked better than the correct alternative. When the item was examined, it was found that the drawing of the thermometer in the item lost its readability when printed. The item removed from the instrument is shown in Figure 3.1:

29. The thermometer shown below is measured in New York. What is the temperature in Celcius scale?

A) -2 °C B)5 °C C) 9 °C
D) 35 °C E) 88 °C

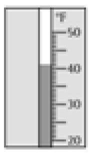


Figure 3. 1 The item removed from the SMAT after item analysis

The detailed output of ITEMAN is given in Appendix G whereas the summary of the scale statistics for the item analysis is shown in Table 3.5.

Table 3.5 Summary statistics of the ITEMAN for SMAT

Scale Statistics for SMAT	
N of Items	30
N of Examinees	149
Mean	16,362
Variance	23,654
Std. Dev.	4,864
Skewness	0,092
Kurtosis	-0,717
Alpha	0,772
SEM	2,324
Mean P	0,545
Mean Item-Tot.	0,362
Mean Biserial	0,48

3.5.2 Affective Characteristics Questionnaire (ACQ)

In order to determine students' attitudes towards chemistry, an adapted version of Affective Characteristics Questionnaire developed by Abak (2003) was used in this study. She used the original questionnaire to assess affective characteristics of students in physics. Hence, minor alterations were made in the items in order the questionnaire to serve for the purpose of the current study focusing on chemistry. For instance, the word "physics" was simply changed into chemistry. The questionnaire consisted of 53 items all of which were scaled on a 5-point Likert type scale and students were required to rate each item from strongly disagree (1) to strongly agree (5). If a student strongly agreed with the item, then the score for that item was 5. If the student responded the item as strongly disagree, then the score obtained from that item was 1. There were also some negatively stated items in the questionnaire; 4, 5, 6, 11, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39; all of them were reversed in the coding process and the scoring became vice versa.

The Cronbach's alpha reliability coefficient for the whole questionnaire was found to be 0,963 which can be considered as relatively high. The dimensionality of the 53-item ACQ was analysed based on an exploratory approach as recommended in Tabachnick and Fidell (2007). In their comparison of factor analysis and principal components analysis, Tabachnick and Fidell (2007) suggest to apply principle components analysis when the purpose is simply to obtain an empirical summary of the data set. The choice was made towards applying principle components analysis for this instrument since the primary purpose was to identify and compute constructs underlying the ACQ.

The Kaiser-Meyer-Olkin measure of sampling adequacy was found as 0,89 as shown in Table 3.6, exceeding the recommended value of 0,5 (Tabachnick & Fidell, 2007) which means the sample size is adequate to conduct factor analysis for ACQ. Bartlett's test of sphericity was also significant (p = 0,00) which led us to reject the hypothesis that the population correlation matrix was an identity matrix. This means that there is a strong relationship among variables under investigation and it is appropriate to conduct factor analysis.

Table 3. 6 Kaiser-Meyer-Olkin and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0,892
Bartlett's Test of Sphericity	Approx. Chi-Square	5826,453
	df	1378
	Sig.	0,000

Three criteria were used to determine the number of factors to rotate as recommended in Green & Salkind (2008); the a priori hypothesis that the attitudinal construct was unidimensional, the scree plot test and the interpretability of factor solution. The hypothesis of unidimensionality was rejected based on the scree plot shown in Figure 3.2. There came out ten factors that had eigenvalues greater than 1 as a result of the analysis. However; it was indicated that there were seven factors in the descent part of the plot before the eigenvalues start to level off. Based on the scree plot, seven interpreteable factors were rotated using a Varimax rotation procedure.

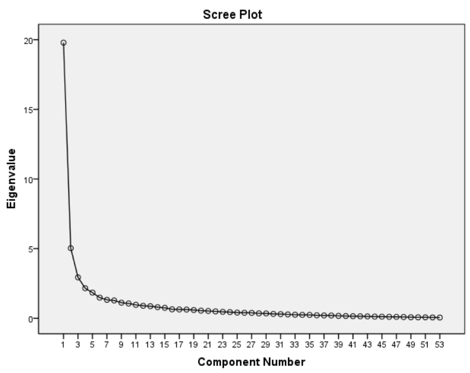


Figure 3. 2 Factors shown in scree plot for SMAT

These seven factors explain %65,205 of the total variance. The name of the factors, corresponding item numbers, the loadings of the items on each factor, Cronbach's alpha reliability values for each factor and the number of items loading together are presented in Table 3.7.

As it can be implied from Table 3.7, the items belonging to test anxiety and chemistry anxiety loaded together and named as anxiety differing from the study of Abak (2003). Not surprisingly, items regarding importance of chemistry and student motivation also clustered under the same factor. The items focusing on extra activities related to chemistry loaded together as in the study of Güngör, Eryılmaz and Fakıoğlu (2007) and Abak (2003). The factor loadings of 53 items range between 0,324 and 0,851 and they are all in acceptable range. On the other hand, internal consistencies for each of these factors were examined using Cronbach's alpha and the Cronbach's alpha reliability coefficients for each factor range between 0,767 and 0,916. The results of factor analysis and reliability analysis revealed that the ACQ serves its purpose as intended for the current sample of the study and it measures what it supposed to measure in a reliable way.

Before summing up, it would make sense to mention about the "good practice" that belongs to Coulson (1992) exemplified by Gardner (1996) in his study documenting the confusion on the dimensionality of attitude scales. Coulson (1992) developed an instrument in order to be able to measure attitudes towards science of first-year university students trained to be early childhood teachers. She defined attitude as a multidimensional construct and included four different subconstructs into the instrument which are confidence in doing science, enjoyment of science at school, personal usefulness of doing science and their evaluation of the appropriateness of science for young children. Varimax factor analysis provided strong support for these subconstructs and they had reliabilities from 0,83 to 0,88. Use of the summated scores of subconstructs in a combined scale was supported by principle components analysis resulting with a reliability of 0,94.

One may infer that the same procedure was applied for the Affective Characteristics Questionnaire in this study. The definition of the attitude toward chemistry referred throughout this study emphasizes the multidimensionality of the construct. As stated previously, Osborne et al. (2003) listed some of these subconstructs (See Attitude toward Chemistry, pp. 35-36). Regarding these subconstructs; Affective Characteristics Questionnaire was chosen among many of the attitude scales due to including most of the attitudinal subconstructs which are categorized by Abak (2003) as importance of chemistry, interest in chemistry, chemistry self-efficacy, chemistry self-concept, student motivation in chemistry, achievement motivation in chemistry, test and course anxiety in chemistry and extra activities related to chemistry. Varimax rotation supported these subcomstructs with slight alterations and the Cronbach's alpha reliability coefficients for each subconstruct range between 0,767 and 0,916. Eventually, use of the summated scores of subconstructs was supported by principle components analysis resulting with a reliability of 0,963 for the questionnaire.

Table 3. 7 Varimax rotated principal component analysis solution for ACQ

Factor	Item No	Loading	Cronbach's Alpha	Number of Items
Anxiety (% of Variance = 11.5)	Q35	0,827	0,767	11
	Q36	0,803		
	Q34	0,791		
	Q37	0,769		
	Q38	0,754		
	Q39	0,673		
	Q33	0,641		
	Q32	0,544		
	Q6	0,505		
	Q30	0,324		
	Q31	0,388		
Importance + Student Motivation (% of Variance = 10.7)	Q5	0,851	0,894	12
	Q17	0,766		
	Q18	0,707		
	Q20	0,698		
	Q15	0,634		
	Q22	0,632		
	Q13	0,614		
	Q14	0,585		
	Q16	0,519		
	Q12	0,496		
	Q19	0,381		
	Q21	0,382		
Extra Activities (% of Variance = 9.3)	Q28	0,761	0,911	7
	Q24	0,717		
	Q29	0,692		
	Q25	0,680		
	Q27	0,550		
	Q26	0,550		
	Q23	0,520		
Interest (% of Variance = 9.2)	Q7	0,718	0,916	9
	Q2	0,712		
	Q1	0,688		
	Q9	0,677		
	Q8	0,630		
	Q4	0,536		
	Q10	0,523		
	Q3	0,521		
	Q11	0,514		
Self-concept (% of Variance = 8.4)	Q41	0,748	0,893	6
	Q44	0,674		
	Q42	0,672		
	Q40	0,644		
	Q43	0,637		
Self-efficacy (% of Variance = 6.6)	Q49	0,753	0,895	4
	Q50	0,728		
	Q51	0,671		
	Q52	0,648		
	Q53	0,433		
Achievement motivation (% of Variance = 5.4)	Q46	0,825	0,861	4
	Q45	0,804		
	Q47	0,614		
	Q48	0,533		

3.5.3 Classroom Observation Checklist

The researcher observed both experimental and control groups during the treatment. That is why an observation checklist was developed by the researcher to assess whether the teacher of the experimental group follow the principles of context-based instruction and to ensure the treatment verification. The main features of the context-based instruction, the teacher guides and the checklist entitled "Are you teaching contextually?" developed by Center for Occupational Research and Development (CORD, 1999) were considered in the development process of the checklist. This observation checklist consisted of 14 items on a 3-point Likert type scale (yes/ partially/ no) which was included in Appendix I. The researcher sat silently at the rear of the classroom while observing both groups and did not ever interrupt the instructions. During the observations in experimental group, the researcher rated this instrument whereas she took notes while observing classrooms in the control group. This observation checklist for the experimental group and the notes taken in the control group enabled the researcher to have an overall judgement on various aspects of the instruction as well as the interaction between teacher and students, participation of students to the lessons and classroom atmosphere for both groups.

3.6 Procedure

The progress of this study can be examined in four parts; setting the scene, determination of the context, instructional materials and treatments, and analysis of data.

3.6.1 Setting the Scene

The interest of the researcher on context-based approaches of teaching science started with coming across to the studies conducted at the University of York Science Education Group (UYSEG) focusing on the approach. With an expectation to be able to offer an alternative solution to the problems faced in chemistry education in Turkish context, the main research problem of the study was determined. The literature review was an on-going process that commenced intensely before the statement of the main research problem and continued up to the completion of the study. The keywords and their combinations that were used during the literature review are presented in Appendix A. The databases accessed for the literature review are Educational Resources Information Center (ERIC), Social Science Citation Index (SSCI), International Dissertation Abstracts, Ebscohost, Science Direct, JSTOR, Taylor & Francis, Wiley Inter Science, ProQuest (UMI) Dissertations & Theses, METU Library Theses and Dissertations, Turkish Higher Education Council National Dissertation Center and TUBITAK Ulakbim databases.

With an aim to be embedded in research on context-based approach and complete the missing pieces of the puzzle, the researcher set forth to the University of York Science Education Group as a guest researcher. The main reasons of this one-year visit were to learn from the experiences of the "experts on context-based approach", to get familiar with the development and dissemination of context-based materials and to observe the implementation of the approach and the materials at schools. During her time at York, the researcher participated in a range of activities to help her with this current study. These included attending departmental seminars and talks for staff and other doctoral students, meetings with individual staff and visits to schools that apply context-based materials in classrooms. Fortunately, all the items on to-do list are checked during this one-year visit.

3.6.2 Determination of the Context

The decision on the context that would be used in this study was made following the intense review of materials used in different context-based projects.

When the main concern is student outcomes, it is of vital importance to select appropriate contexts for students. By deciding on a context that is familiar to all students and suggested by students themselves, the context-based instruction also promotes the self-actualization of the students (Whitelegg & Parry; 1999). Furthermore; de Jong (2008) defines certain criteria for selecting appropriate contexts:

- Contexts should be familiar and relevant to students' lives,
- Contexts should not be so interesting as to hinder students' attention from chemistry concepts,
- Contexts should not be too complicated for students,
- Contexts should not result with the confusion of students.

To begin with, the point how contexts are included in the projects were tried to be made clear. For the PLON project, the choice of contexts was made regarding long-term developments in society and curriculum developers considered the scope of national examinations (Kortland, 2005). The PLON curriculum for average ability stream consisted of ten chapters, referring to the contexts; weather changes, music, traffic, electrical machines, energy and quality, matter, light sources, ionising radiation and electronics.

The developers of ChemCom, on the other hand, initially decided on eight themes which were water supply, resource conservation, petroleum usage, nutrition, nuclear energy, air pollution and climate, health and the chemical industries. While choosing the contexts, they considered particular criteria like being important to society in long-term, meaningful in both local and global scope, requiring citizen decision-making at some point and attracting interest of many students (Ware & Tinnesand; 2005).

For the first Salters course, a group of administrators, industry-partners, experienced teachers, science educators and researchers worked together to develop materials. They primarily focused on what students would like to know about science and considered "the basic essentials for survival" (Bennett et al., 2005, p.132). The latest edition of Salters Advanced Chemistry involves the following contexts: elements of life, atmosphere, fuels, polymer revolution, medicine, the steel story, agriculture, oceans and protein engineering.

The developers of ChiK considered daily-life activities, natural and technical phenomena, cultural and societal issues and career perspectives while deciding on which contexts to include in the project (Parchmann et al., 2006). The examples to contexts included in ChiK are “The Chemist: Today’s Taster?” “Clean, Neat, and Tidy: Acetic Acid Household Cleaners”, “Alcohol: Too Precious for a Drink?”, “Fuels of the Future”, “Mobile Energy for Mobile Citizens”, “Cars without Polymers” (Nentwig et al., 2005).

In a study conducted by Sunar and Geban (2012b), the researchers analysed students’ questions that were submitted to a national ask-a-scientist website in order to reveal potential contexts that appeal Turkish students. They came up not only with the contexts that were used in the projects stated above but the contexts that would be meaningful specifically in Turkish context. Turkish students were interested in cleaning materials, atmosphere and weather, space vehicles, cars, fuels, electronics, health issues, food and interestingly; in precious mines and materials, biogas production and consumption.

OECD embeds assessment exercises of Programme for International Student Assessment (PISA) in personal, social and global contexts (OECD, 2006). Table 3.8 provides a list of contexts included in PISA 2006 science assessment.

When the contexts in use or potential contexts that would appeal students were scrutinized, it was seen that the context “atmosphere and weather changes” was mentioned more than once. Considering this commonality and de Jong’s criteria for selecting the contexts, “atmosphere and weather changes” was chosen as the main context of the study.

On the contrary to the majority of the projects having their general design criteria, Turkish chemistry curricula have a coherent list of predetermined concepts for each subject. Implementation of context-based approach differs at this point for Turkish context. Instead of concepts emerging on a need-to-know basis during the instruction, there are concepts to be taught and objectives of the courses are determined accordingly. The objective list and the concept list of the “States of Matter” subject were scanned in order to ensure that the concepts can be covered with the context chosen. It was seen that the concepts in the states of matter subject have a good fit with the context “atmosphere and weather changes”. The list of concepts included in the “States of Matter” subject in tenth grades’ chemistry curriculum is included in Appendix C.

In conclusion, for the reasons stated above, the context was chosen as “atmosphere and weather changes” and the content included the concepts in states of matter subject in tenth grade chemistry curriculum.

Table 3. 8 Contexts included in PISA 2006 science assessment

	Personal	**Social**	**Global**
Health	Maintenance of health, accidents, nutrition	control of disease, social transmission, food choices, community health	epidemics, spread of infectious diseases
Natural Resources	Personal consumption of materials and energy	maintenance of human populations, quality of life, security, production and distribution of food, energy supply	renewable and non-renewable, natural systems, population growth, sustainable use of species
Environment	environmentally friendly behaviour, use and disposal of materials	Population distribution, disposal of waste, environmental impact, **local weather**	Biodiversity, ecological sustainability, control of pollution, production and loss of soil
Hazard	natural and human-induced, decisions about housing	rapid changes (earthquakes, severe weather), slow and progressive changes (coastal erosion, sedimentation), risk assessment	climate change, impact of modern warfare
Frontiers of science and technology	Interest in science's explanations of natural phenomena, science-based hobbies, sport and leisure, music and personal technology	new materials, devices and processes, genetic modification, weapons technology, transport	extinction of species, exploration of space, origin and structure of the universe

*Note.*Adapted from *Assessing Scientific, Reading and Mathematical Literacy: A Framework for PISA 2006* by OECD, 2006.

3.6.3 Instructional Materials and Treatments

As a following step to the decision of the subject and contexts that would be used, the focus was on measuring tools. Many studies were reviewed in order to find the measuring tools that would serve for the purpose of the study. Eventually, Affective Characteristics Questionnaire developed by Abak (2003) was adapted for chemistry and the test for assessing students' understanding of the subject was developed regarding the objectives of tenth grade chemistry curriculum. The details of the adaptation and development process are given in Instruments Section.

As a next step, students' text, students' worksheets and teacher guides were developed for the experimental group. The resources that shed light on the development process of context-based materials are listed in Appendix J. The details of each material are presented in the following sections.

The population from which the sample will be drawn was determined as a first step of the implementation at schools. After calculating the required sample size, the decision was made towards convenience sampling. The schools in which the treatments would be implemented were determined and the negotiations with chemistry teachers were commenced. With the teachers' consent, the researcher applied for the required permissions to the Ministry of Education. The document of permission is included in Appendix O. The students in 6 classes of two chemistry teachers in two different schools participated in this study. While one of the teachers applied context-based instruction in the experimental group, the other teacher of the control group did not manipulate his instruction and carried on with traditional instruction. Students in both groups were instructed three 45-minute class hours per week.

The implementation of the study was conducted in March-April, 2012. The researcher started to observe both the classes in the experimental group and control group almost two weeks prior to the treatment in order to lessen the novelty. Afterwards, the students in both groups were administered pre-SMAT to assess students' prior knowledge in the states of matter subject and pre-ACQ in order to assess their prior attitudes toward chemistry. In the following week, the treatments were started. The implementers of the treatments were the chemistry teachers and the treatment lasted for six weeks. During the treatment, states of matter subject was covered as part of the regular tenth grade chemistry curriculum. The topics covered in both groups were general properties of gases, gas laws, gas mixtures, real gases, properties of liquids, phase changes, amorphous and crystal solids. When the subject of concern came to an end, the post-SMAT and post-ACQ were administered to both groups. Four months later, at the beginning of the following term, students responded to the delayed post-SMAT.

3.6.3.1 Treatment in the Experimental Group

As a first step, the teacher in the experimental group was informed about the philosophy behind the context-based approach via personal communication. Prior to the treatment, the researcher and the teacher worked extensively on the context-based materials. As stated previously, students' text, students' worksheets and teacher guides were developed for the experimental group. The details presented in the following sections and the examples of each context-based material included in the Appendices clarify what occurred in the classes of the experimental group during context-based instruction.

3.6.3.1.1 Teacher Guides (Lesson Plans) based on 5E Learning Cycle

Teacher guides are prepared to serve as detailed daily lesson plans. They include the purpose of each step and clearly present instructions for managing the activities. The key points in lesson plans are that each lesson starts with a question or an example from students' daily lives and the activities are all student-centred. The outline of the lesson plans is similar to the ones used in Living by Chemistry (Stacy, 2010), following the steps of 5E learning cycle instructional strategy. The explanations below indicate what occurs in each step of the learning cycle integrated within the lesson plans of this study (Bybee et al. 2006). Examples of teacher guides are included in Appendix K.

Engagement: This step is the introduction of the context. The aim of this step is to promote students' curiosity and elicit their prior knowledge about the topic. In this study, students are engaged within a contextual question or an example that they all have an idea from their daily lives at the beginning of the lesson. This engagement step can also help the teacher make students' prior knowledge explicit before proceeding with the new concepts. The examples of contextual questions directed to students during the implementation of the context-based instruction in this study are stated below:

- Weather changes affect all the living things and substances on Earth. You probably watch weather forecast on TV. Low pressure, high pressure, humidity, invasion of cold weather from the Balkans are the terms you hear frequently. Have you thought about what these terms mean to us? So, what causes weather changes?

- As most of us know, the air in the atmosphere is made up of a number of gases. These gases exert a force on the Earth's surface and on our bodies. We call this force as atmospheric pressure or air pressure. Although we are usually unaware of this pressure, similar to the the fish not feeling the pressing down of water on them, it actually presses down very hard, approximately equivalent to the weight of a truck on our bodies. So, how can we prove gases exert pressure?

- The coldest temperature on Earth was recorded as -89^{0}C in Antarctica. On the planets further away from the sun, researchers observe colder temperatures. For instance, they determined the surface temperature of one of the Neptune's satellites as -235 ^{0}C. So, how cold a substance can become?

- As different regions on Earth are affected by Sun's rays unevenly, the state of the air differentiates between different regions. Warm air expands and rises up while cold air condenses and sinks, which results with the flow of air. It is known that warm air occupies greater volume and weighs less than the cold air of the same amount. Cold air moves in and replaces the rising warm air. This is how wind formation occurs. So, how can we determine the volume of a gas?

- The water that occupies three fourth of our bodies, the substances that we use in our daily lives, for instance; dyes, thinner that dissolves dyes, nail polish, the acetone that dissolves nail polish, the tea, milk, coke we drink are all in liquid state under normal conditions. About 70 percent of the Earth's surface is covered with water and the oceans hold about 96.5 percent of all Earth's water. Our planet's water supply is constantly moving from one place to another and from one state to another. The main reason of this water cycle is phase change of water. The water that vaporizes with the heat received from the Sun forms clouds in the atmosphere. Clouds are consisted of tiny water droplets. When they come across a cold weather wave, they condense and drop towards the ground. This is called as rain, so:

    - Why do our clothes get wet when it rains but the water just slides down the umbrella?

    - What is the reason of water droplets having spherical shape?

    - The trees play a vital role in water cycle. How does water reach on top of the trees?

    - What would happen if the rain had fluidity like honey?

Exploration: This step can be considered as the exploration of the context and should provide students a chance of exploring the key concepts that are covered during the lesson. To achieve this, students might deal with different activities. Depending on the concepts included in each lesson for this study, students performed simple laboratory experiments, watched demonstrations, collected data, sketched graphs and solved problems.

For instance students made an experiment with syringes and scales to observe pressure regarding Boyle-Mariotte's law and collected data by measuring the weight of the air for different volumes in one of the lessons. They converted these weights to the pressure by simple calculations taught in physics course. Then, they sketched graph of the data they recorded during measurements which gave them the relationship between volume and pressure. During this experiment, the teacher was a facilitator for students to explore the relationship between volume and pressure. In another lesson, they conducted four different experiments, namely "Balloon in a bottle", "Paper resisting getting wet", "Paper resisting gravity" and "Crushed can" with an aim to explore the existence of air pressure. With these four experiments, the students proved the effect of the pressure exerted by the atmosphere themselves. As a further example, to be able to explore ideal gas law, they were engaged in a simple experiment that leaded students to calculate the number of moles of air in their breathes. For exploring surface tension, the factors effecting surface tension, adhesion, cohesion and viscosity, they were engaged in five different hands-on activities. The details of some of these activities are included in sample teacher guides in Appendix L.

Explanation: In this step of learning cycle, the teacher should seek ways of connecting students' conceptual understanding and scientific explanations. So, this step can be considered as the introduction of chemical concepts referring to the context. To achieve this, the teacher might clarify students' explanations of the concepts, focus on their misconceptions and introduce the new concepts using scientific terminology. For the current study, the list of possible misconceptions was given to the teacher of the experimental group. This list is included in Appendix K. During this step, the teacher tried to help students connect what they explored in the previous step with chemical ideas. She oriented them towards correct scientific explanations.

Elaboration: This step aims to develop better and deeper understanding of students and can be considered as the extension of learning. The teacher may present additional activities which challenge students to extend their understanding in a broader context.

Evaluation: The step during which students assess their own understanding is the evaluation step. The teacher might also use formal and informal assessment techniques to monitor the progress of students.

Elaboration and evaluation steps proceeded hand in hand for this study. The teacher mostly referred to the contextual question presented to the students at the beginning of the lesson during these steps. The students were also engaged in arithmetical questions. In addition to these, sample conceptual questions addressed in these steps of learning cycle can be exemplified as follows:

- What do you think of the coldest temperature reached in Celcius scale?
- Do you think a substance could ever reach absolute zero?
- Can the volume of a substance get negative values?
- A climber, going up to the Mount Everest, wants to drink water through a straw. Would it be easier on the top of the mountain or at the foothill?
- Which of the gas laws apply for a balloon rising up in the atmosphere?

3.6.3.1.2 Students' Text

The students' text was designed as a scaffolding tool for students. These texts were given to the students in the form of a booklet at the beginning of the treatment and they were informed about the role of the booklet as being their course book to follow during the implementation of the states of matter subject. Each part starts with a brief explanation of a daily life example about weather changes that can be considered as an orientation of the students to the context and then the question that aims to capture students' interest arises in line with the first two steps of the instruction. Following the question, the key concepts that help students to be able to find answers to the main question are listed. The text includes a following section for exploration of the concepts by referring to the activities. For the elaboration and evaluation steps, further explanations of the chemical concepts are presented, their meaning in the context are emphasized, misconceptions are addressed and "Did you know that…..?" questions are interspersed within the explanations. The text is enriched by the visuals like drawings, graphs and photos. When appropriate, interdisciplinary examples are also included. Finally, students are presented with questions to assess their own understanding and extend their knowledge to other contexts. An example to students' text is included in Appendix M.

3.6.3.1.3 Students' worksheets

The worksheets are the documents that students follow during the activities and they can be regarded as interactive tools for the flow of the lesson to some extent. They do not have a strict outline and differ with respect to the contents of each lesson. The worksheets provide students the steps of the activities; require students to write down what they observed and the reasons of their observations, drill and practice arithmetic problems, collect data during the activities, sketch graphs and made inferences about what they learned according to the content of the lesson.

The worksheets could have been included in the students' text, but the choice was made towards handing out the worksheets separately at the day of the activity. Following the implementation, students' worksheets were gathered in order to verify the treatment for the unobserved implementation hours. An example to students' text is included in Appendix N.

3.6.3.2 Treatment in the Control Group

Meetings with the teacher in the control group prior to the implementation assured that he instructed as what is defined by traditional instruction. As mentioned previously, what is referred as traditional instruction in this study is "business as usual" instruction in the classroom (Taasoobshirazi & Carr, 2008; p.157). It is not supposed to involve features of context-based instruction and any other type of specific instruction. The observations during the implementation led the researcher conclude that he mainly used lecturing as a way of instruction. He presented the topics to be learned either by standing in front of the table or being seated in his chair. Each lesson began with the teacher introducing the chemical concepts to the students. He rarely linked new concepts with students' prior knowledge and considered students' difficulties or possible misconceptions. When the students did not understand the subject, some of them requested for further explanation which resulted with the teacher using different wording to explain the same concepts. The questions directed to the students were mostly arithmetical and required numeracy skills. He also handed out worksheets full of arithmetical problems to be solved to the students. Following the introduction of the concepts, he solved some arithmetical problems on the board and asked students to solve the problems written on their course book or on their worksheets. Uncompleted problems on these worksheets were assigned as homework to the students.

In summary, his way of teaching started with introducing the chemical concepts to be learned at the beginning of the lesson, followed by solving arithmetical problems on the board and leading students to drill and practice for the remaining class hour. He occasionally made connections to daily life examples; neither conducted experiments with the students nor enriched the lessons with the activities.

3.7 Analysis of Data

An SPSS data file was formed with the data obtained through administration of measuring tools. The variables included in the data file were id numbers, gender, group membership, school, class, pre-SMAT, pre-ACQ, post-SMAT, post-ACQ and delayed post-SMAT scores of the students. As a first step to the analysis of data, missing data analysis was conducted as explained in the first part of the Results section. The data file was prepared for the descriptive and inferential statistics. In order to describe the variables; mean, standard deviation, skewness, kurtosis, range, minimum, maximum values and the histograms were obtained for both groups. Following descriptive statistics, the variables were checked for the assumptions of MANCOVA in order to be able to proceed with inferential statistics. Since no serious violations to assumptions were observed, MANCOVA was conducted to be able to generalize results obtained from the sample to the population. In MANCOVA, pre-SMAT and pre-ACQ scores of the students were assigned as covariates, the independent variables were the instruction and gender where the post-SMAT, post-ACQ and delayed post-SMAT scores of the students were the dependent variables. These analyses were explained in detail in Results section.

3.7.1 Power Analysis

In order to estimate required sample size for achieving adequate power at the end of the study, a priori power analysis was conducted. The probability of rejecting the null hypothesis when it is true, namely α, was set to be 0,05 whereas β, the probability of failing to reject the null hypothesis when it is false, was set to 0,20 (Cohen & Cohen, 1983). Power ($1-\beta$), which means the probability of detecting a true effect when the effect exists, became 0,80. The effect size (f^2) was set to medium effect size which has a value of 0,15 as recommended in Cohen, Cohen, West and Aiken (2003).

To be able to calculate the required sample size for the desired power, the formula ($n = L / f^{2} {}^{+} k_A + k_B + 1$) given by Cohen and Cohen (1983, p.155) was utilised. The "L" value in this formula was obtained from the L values table (Cohen & Cohen, 1983, p.527) using $\alpha = 0,05$, power = 0,80 and $k_B = 2$ which corresponds to the number of fixed factors calculated by subtracting 1 from levels of each factor (instruction and gender in this case). The L value was found to be 9.64 from the table. The remaining value, k_A, is the number of covariates, and it is 2 for this study. When initially determined and calculated values were substituted into the formula, the required sample size to achieve the desired power was determined as 69,26.

In the current study, data were collected from 150 students. The L value for medium effect size was found to be 22,05 which corresponds to a power value greater than 0,99 in the table. In conclusion, the probability of failing to reject a false null hypothesis is less than 0,01 for this study.

3.7.2 Unit of Analysis and Experimental Unit

In this study, individual students were determined as the unit of analysis. In order to assure independence of observations, unit of analysis and experimental unit should match congruently. However, this is not always possible especially for the experimental studies. Experimental unit of a study can be defined as the entity which is exposed to the treatment independently of the other units. Since it is impossible to expose treatments to the individuals, the experimental unit of the current study is each intact class to which treatments are assigned randomly.

In line with these explanations, it would be unfair to say that independence of observations was totally assured for this study. Nevertheless, students were not allowed to interact with each other at the time of instrumentation. Therefore, independence of observation was achieved during the data collection process.

3.8 Treatment Fidelity and Treatment Verification

Borelli et al. (2005) define treatment fidelity as "the methodological strategies used to monitor and enhance the reliability and validity of behavioural interventions" (p.852). In order to ensure that the changes observed on the student outcomes in this study are attributable to the treatment, and not to any other factors, ways of increasing treatment fidelity was considered. As a first step to enhance treatment fidelity, the definitions of context-based instruction and traditional instruction that were referred throughout the current study were made as clear as possible with an in-depth literature review. Secondly, instructional materials were developed considering the principles emerged during the review of the studies and the objectives in the chemistry curriculum. These materials were reviewed by the supervisor of the study and the specialists at UYSEG to check whether they were consistent with the context-based instruction or not. The revisions were made according to the feedbacks received and every step of the context-based instruction was made clear in teacher guides.

Treatment verification helps researcher to ensure that the treatment was implemented as intended in the study (Shaver, 1983). Prior to the treatment, the researcher and the teacher of the experimental group worked extensively on the principles of context-based instruction and instructional materials developed for the treatment. For the traditional instruction, the researcher interviewed the teacher of the control group to ensure that the practice in control group classrooms was consistent with the definition of traditional instruction referred in this study. Moreover, an observation checklist including the main features of the context-based instruction was formed with an aim to conclude that a proper context-based instruction was performed in the experimental group. This observation checklist consisted of 10 items on a 3-point Likert type scale (yes/ partially/ no) which was included in Appendix I. The observer was the researcher herself and observed almost 60 % of the lessons during the treatment both in the experimental and control group. She rated context-based instruction for each lesson in the experimental group using the checklist while she took notes in the control group to monitor the instruction as being "business as usual" in the classroom.

In addition to these, student worksheets were prepared so that they could serve as a further precaution of treatment verification for the lessons that were not observed by the researcher. Student worksheets were gathered at the end of each lesson to assure that the teacher followed the steps presented in teacher guides.

The rating of the observation checklist, student worksheets and the notes helped the researcher conclude that classroom practices in both experimental and control groups were in line with what was referred with context-based instruction and traditional instruction.

3.9 Assumptions and Limitations

The findings in this study are subject to at least five assumptions:

- The students responded to items in each measurement tool independently, honestly and frankly.
- All the measurement tools and instructions were administered under standard conditions.
- Personal characteristics of the teachers did not affect the outcomes of the study.
- The teacher in the experimental group followed the instructions in teacher guides.
- The teachers were not biased towards any of the instructions.
- Independence of observations was verified.

A number of important limitations need to be considered for this study.

- This study is limited to States of Matter subject in tenth grade chemistry program.
- This study included tenth grade high school students in two districts of Bursa who are registered to schools with average success in Turkey and whose families mostly belong to medium socioeconomic status.
- The concepts to be taught were predetermined in tenth grades chemistry curriculum.

CHAPTER 4

RESULTS

This chapter includes the results of the study with the following sections; missing data analysis, descriptive statistics, inferential statistics, assumptions and the results of MANCOVA and follow-up ANCOVAs.

4.1 Missing Data Analysis

Missing data analysis was carried out for the data gathered before going through with descriptive and inferential statistics. Due to the states of matter subject being implemented towards the end of the term, some of the students were absent on the day of post-test administration in both groups. The summary of the initial missing data for the variables preach (pre-SMAT), preatt (pre-ACQ), postach (post-SMAT), postatt (post-ACQ) retention (delayed post-SMAT) is presented in Table 4.1. Throughout this chapter, the names of the variables are used interchangeably due to the naming procedure of the variables in SPSS.

Table 4. 1 Summary of the initial missing data

		Pre-SMAT	Post-SMAT	Pre-ACQ	Post-ACQ	Delayed post-SMAT
N	Valid	161	150	167	149	166
	Missing	11	22	5	23	6
	Missing (%)	6,4	12,7	2,9	13,4	3,6

The students, who lack the scores on at least two of the dependent variables among post-SMAT, post-ACQ and delayed post-SMAT, were excluded listwise from the whole data. There remained 152 students for further data analysis. The summary of the missing data after excluding the students lacking the scores on at least two post-tests is presented in Table 4.2.

In order to test whether data are missing completely at random (MCAR), Little’s (1988) chi-square statistic was obtained as explained in IBM SPSS Missing Values 20 (2011). The null hypothesis is that the data are missing completely at random and p is significant at the 0,05 level. Little’s MCAR test supported the conclusion that the data are missing completely at random (Chi-Square = 21,191, df = 16, Sig. = 0,171) which means that the data being missed are unrelated to any other observed variables of interest.

Table 4. 2 Missing Data Analysis after Excluding Absentees

		Pre-SMAT	Post-SMAT	Pre-ACQ	Post-ACQ	Delayed post-SMAT
N	Valid	142	150	147	149	150
	Missing	10	2	5	3	2
	Missing (%)	6,6	1,3	3,2	1,9	1,9

To handle with the remaining missing values, imputation based on expectation-maximization (EM) method was addressed since it "offers the simplest and most reasonable approach to imputation of missing data when the preliminary analysis provides evidence that scores are missing randomly" (Tabachnick & Fidell, 2007, p.71). Furthermore; it gives consistent and unbiased estimates when the data are MCAR (IBM SPSS Missing Values 20, 2011). This method assumes a distribution for the partially missing data, forms a missing data correlation or covariance matrix and bases inferences about missing values on the likelihood under that distribution (IBM SPSS Missing Values 20, 2011; Tabachnick & Fidell, 2007). The details of EM method are included in the following paragraph:

> "Each iteration consists of an E step and an M step. The E step finds the conditional expectation of the "missing" data, given the observed values and current estimates of the parameters. These expectations are then substituted for the "missing" data. In the M step, maximum likelihood estimates of the parameters are computed as though the missing data had been filled in. 'Missing' is enclosed in quotation marks because the missing values are not being directly filled in. Instead, functions of them are used in the log-likelihood" (IBM SPSS Missing Values 20, 2011, p.7).

Through the missing value analysis with EM method in SPSS, a new, missing value-free data sheet was obtained and this new data sheet was used for further descriptive and inferential statistical analysis.

4.2 Descriptive Statistics

Gender distribution of the students included in the study is almost equal. Fifty-three per cent of 150 students included in the study are female whereas forty-seven of them are male. 79 students were assigned to experimental group and 71 students took their place in the control group. The summary of the descriptive statistics for the variables pre-SMAT, post-SMAT, pre-ACQ, post-ACQ and delayed post-SMAT categorized with respect to instruction and gender are presented in Table 4.3.

The highest scores that one can get from SMAT and ACQ are 30 and 265 respectively. Students' pre-SMAT scores range between 4 to 19 with a mean 11,77 in total. The mean of the pre-SMAT scores for the control group is 12,51 where it corresponds to 11,10 in the experimental group. The mean of the post-SMAT scores rises to 15,09 for the control group and 18,63 for the experimental group following the treatments. When the point comes to attitude scores of the students, it is seen that the mean of pre-ACQ scores for control group is 183,72 and its correspondence is 179,83 for the experimental group. The mean values of post-ACQ scores became 185,58 and 193,34 for the control group and experimental group, respectively.

Prior to the treatment male students and female students did not differ to a great degree in their mean pre-SMAT scores in both groups. In terms of pre-ACQ scores, while male and female students had similar mean scores in the control group, female students reported more positive attitudes towards chemistry when compared to their male peers in the experimental group. The mean pre-ACQ scores for males are 175,93 where it is 184,40 for females. For the post-SMAT, post-ACQ and delayed post-SMAT mean scores, female and male students in both groups have almost similar mean scores.

An interesting point arises when the mean scores of both groups in terms of SMAT are analyzed in a continuum. For the control group, the mean pre-SMAT scores of students is 12,51 which gives information about their pre-existing knowledge on the subject prior to the treatment. At the end of the six-week period, this mean score rises to 15,09. Four months later, their mean score slightly rises to 15,38 in their delayed post-SMAT scores where one may expect a fall due to the fact that it becomes diffult to recall knowledge as time passes. However, the progress of SMAT scores in the experimental group show congruence with the expectations. As stated previously, the mean pre-SMAT scores of students in the experimental group is 11,10. It rises to 18,63 at the end of the context-based instruction. Then, their mean delayed post-SMAT scores shows a slight decrease and becomes 17,19 four months following the treatment.

The significance of the differences between mean scores for both SMAT and ACQ are tested and discussed in the following sections.

4.3 Inferential statistics

Multivariate Analysis of Covariance (MANCOVA) was used to test the main hypotheses of the study. Random assignment of subjects to treatment groups was not possible as classes were already formed. Therefore; intact groups of students were randomly assigned to treatment groups. MANCOVA has two potential benefits for such an experimental design (Hinkle, Wiersma & Jurs; 2003). Firstly, it helps to adjust for pre-existing differences that may exist among the intact groups prior to the research. The second benefit of MANCOVA is that the precision of the research increases due to reducing error variance by partitioning out the variation attributed to the covariates.

In this section, determination of covariates that are included in the inferential statistics is presented firstly. It is followed by the explanation of the steps to verify the assumptions of MANCOVA. Subsequently, the results of MANCOVA and follow-up ANCOVAs are discussed.

Table 4. 3 Descriptive Statistics for the variables

		N	Min	Max	Mean	SD	Skewness	Kurtosis
Pre-SMAT								
	Female	43	8	19	12,46	2,04	0,502	1,455
CG	Male	28	6	17	12,60	2,34	-0,306	1,046
	Total	71	6	19	12,51	2,14	0,120	1,072
	Female	36	8	16	11,25	2,197	0,264	-0,786
EG	Male	43	4	18	10,97	3,282	0,228	-0,238
	Total	79	4	18	11,10	2,82	0,187	-0,015
Total		150	4	19	11,77	2,61	-0,046	0,247
Pre-ACQ								
	Female	43	81	245	183,91	35,88	-0,786	1,140
CG	Male	28	73	253	183,43	48,00	-0,725	0,130
	Total	71	73	253	183,72	40,76	-0,757	0,621
	Female	35	81	236	184,40	32,41	-1,343	2,647
	Male	41	91	235	175,93	35,38	-0,522	-0,203
EG	Total	76	81	236	179,83	34,08	-0,844	0,581
Total		147	73	253	181,71	37,38	-0,760	0,619
Post-SMAT								
	Female	43	9	25	14,37	3,87	0,849	-0,077
CG	Male	28	8	25	16,19	4,62	-0,046	-0,965
	Total	71	8	25	15,09	4,24	0,467	-0,765
	Female	36	10	28	18,50	4,11	0,338	0,281
EG	Male	43	12	28	18,74	3,69	0,463	-0,196
	Total	79	10	28	18,63	3,86	0,379	0,019
Total		150	8	28	16,95	4,41	0,223	-0,462
Post-ACQ								
	Female	43	104	237	186,30	29,67	-0,759	0,946
CG	Male	28	130	253	184,46	29,48	0,023	-0,272
	Total	71	104	253	185,58	29,40	-0,449	0,329
	Female	36	129	231	195,92	22,26	-0,939	1,356
EG	Male	43	119	257	191,19	33,32	-0,323	-0,379
	Total	79	119	257	193,34	28,74	-0,547	0,210
Total		150	104	257	189,67	29,21	-0,490	0,196
Delayed post-SMAT								
	Female	43	10	27	15,53	3,64	1,641	1,082
CG	Male	28	9	19	15,14	3,13	-0,356	-1,209
	Total	71	9	27	15,38	3,44	1,082	2,129
EG	Female	36	11	25	17,77	3,40	-0,030	-0,414
	Male	43	7	24	16,70	3,79	-0,326	-0,210
	Total	79	7	25	17,19	3,64	-0,254	0,210
Total		150	7	27	16,33	3,64	0,328	0,068

4.3.1 Determination of Covariates

Stevens (2009) and Tabachnick and Fidell (2007) stated that possible covariates for a study should be considered as any variables those theoretically correlate with the dependent variables. For this study, the scores students obtained from the pre-SMAT and pre-ACQ tests are considered initially to serve as covariates since one may expect them to correlate with post-test scores of students on SMAT and ACQ. As stated previously, covariates help researchers to adjust for pre-existing differences among treatment groups. In order to see on which variables the treatment groups differ at the beginning of the study, independent samples t-tests for pre-SMAT and pre-ACQ were performed. Table 4.4 presents the summary of the independent samples t-tests for pre-SMAT and pre-ACQ.

Table 4. 4 Independent samples t-tests for pre-SMAT and pre-ACQ

	Equal variances	Levene's Test		T-test for equality of means	
		F	Sig.	df	Sig.(2-tailed)
Pre-SMAT	Assumed	4,26	0,041	148	0,001
	Not assumed			144,16	0,001
Pre-ACQ	Assumed	1,27	0,262	145	0,530
	Not assumed			138,83	0,533

As presented in Table 4.4, the mean difference between the pre-SMAT scores of students in control group and experimental group is significant ($t(148) = 4{,}26$, $p < 0{,}05$). On the other hand, there is no significant mean difference ($t(145) = 0{,}530$, $p > 0.05$) between the EG and the CG with respect to students' pre-ACQ scores. According to this result, pre-SMAT scores of students can be used as a covariate during inferential statistics.

As a second step, correlations among all variables were calculated with an aim to see the relationships between the potential covariates and the dependent variables. Stevens (2009, p.293) also stated that covariates should have significant correlations with the dependent variables and have low correlations among themselves. Table 4.5 indicates the correlations among independent and dependent variables.

When the correlations among the variables are examined, it is seen that pre-SMAT and pre-ACQ scores of the students have significant correlations with at least one of the dependent variables. Therefore; pre-SMAT and pre-ACQ scores of the students can be used as covariates for the inferential statistics of the study.

Table 4. 5 Correlations between potential covariates and dependent variables

		Pre-SMAT	Post-SMAT	Pre-ACQ	Post-ACQ	Delayed post-SMAT
EG	Pre-SMAT	1,00				
	Post-SMAT	0,368**	1,00			
	Pre-ACQ	0,020	0,333**	1,00		
	Post-ACQ	0,063	0,320**	0,734**	1,00	
	Delayed post-SMAT	0,403**	0,627**	0,359**	0,357**	1,00
CG	Pre-SMAT	1,00				
	Post-SMAT	0,178	1,00			
	Pre-ACQ	0,099	0,045	1,00		
	Post-ACQ	-0,172	0,009	0,378**	1,00	
	Delayed post-SMAT	0,251*	0,563**	0,241*	0,155	1,00
Total	Pre-SMAT	1,00				
	Post-SMAT	0,139	1,00			
	Pre-ACQ	0,067	0,136	1,00		
	Post-ACQ	-0,067	0,203*	0,574**	1,00	
	Delayed post-SMAT	0,251**	0,627**	0,272**	0,286**	1,00

*. Correlation is significant at the 0.05 level (2-tailed); **. Correlation is significant at the 0.01 level (2-tailed).

4.3.2 Assumptions of MANCOVA

Similar to most of the statistical analyses, MANCOVA has a number of assumptions. These are discussed in the following sections titled as sample size, normality, homogeneity of regression, multicollinearity and singularity and homogeneity of variance-covariance matrices.

4.3.2.1. Sample Size

When using MANCOVA, it is necessary to have more cases than dependent variables in each cell (Pallant, 2006; Tabachnick & Fidell, 2007). The absolute minimum should be 4 for each cell in this study due to having 3 dependent variables. Since there are many more cases than the required number of cases per cell, this assumption is verified.

4.3.2.2. Normality

Before going through multivariate analysis, it is important to evaluate both univariate and multivariate normality of the variables (Pallant, 2007). Firstly, Shapiro-Wilk's test was utilized to determine whether the distributions of continuous variables are normal or not. According to the Table 4.6, it was concluded that pre-SMAT and delayed post-SMAT scores of the students are normally distributed ($p > 0,05$) whereas the null hypothesis was rejected for pre-ACQ, post-SMAT and post-ACQ. As a second step for normality check, skewness and kurtosis values were considered. All the values, except kurtosis value of delayed post-SMAT scores of the control group with a value 2,129, fall between -2 to +2 which are acceptable for normality (George & Mallery, 2003, pp. 98-99). This exception is not a serious violation since the sample size of the study is considerably large (Tabachnick & Fidell, 2007, p.80).

Table 4. 6 Results of Shapiro-Wilk's test

	Shapiro-Wilk		
	Statistic	df	Sig.
Pre-SMAT	0,984	150	0,089
Pre-ACQ	0,957	147	0,000
Post-SMAT	0,982	150	0,045
Post-ACQ	0,980	150	0,025
Delayed post-SMAT	0,984	150	0,083

Figure 4.1 displays the histograms on which normal curves displayed related to the post-SMAT, post-ACQ and delayed post-SMAT for both of the CBI and TI groups which can be considered as a crosscheck for normality. Since they seem as normal, these histograms can be considered as supporting the evidence of normal distribution for all of the dependent variables.

For multivariate normality, Mahalanobis distances were calculated as explained in Pallant (2006). Mahalanobis distances can be explained as "the distance of a case from the centroid of the remaining cases where the centroid is the point created at the intersection of the means of all the variables" (Tabachnick & Fidell, 2007, p.74). The calculations of Mahalanobis distances are used to identify any cases that have unusual pattern of scores across the dependent variables. The maximum value for the Mahalanobis distance was found to be 15,02 for the dependent variables. The chi-square table was used to find the critical value with the number of dependent variables as the degrees of freedom. The critical value was stated as 16,27 (Tabachnick & Fidell, 1996 as cited in Pallant, 2006) for three dependent variables. Since the maximum value for Mahalanobis distance is less than the critical value, it can be concluded that there are no substantial multivariate outliers in the data. Moreover, the new variable appearing in the data file (MAH_1) was sorted to see whether there exist any scores exceeding the critical value. It was seen that all the values are below the critical value assuring multivariate normality assumption.

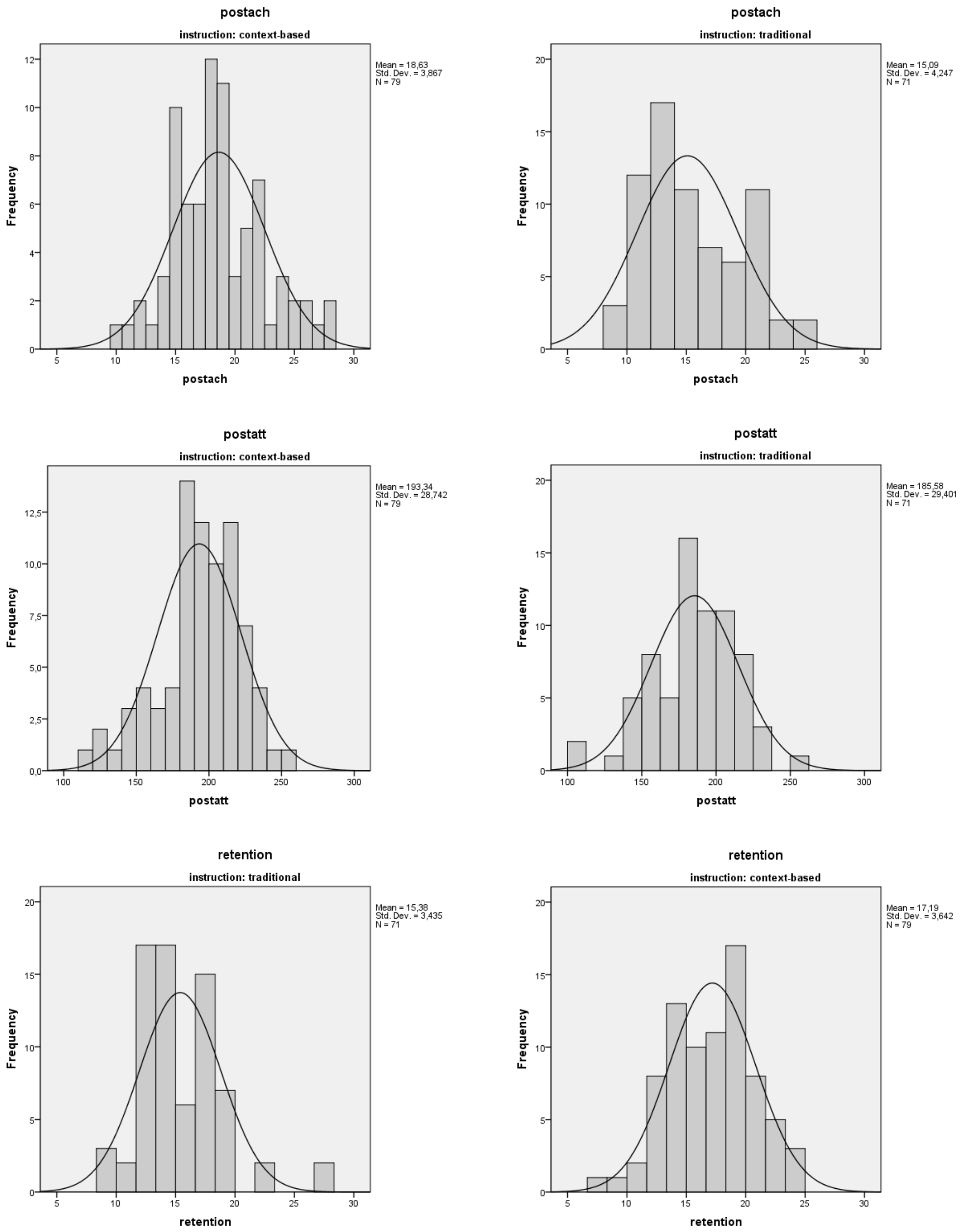


Figure 4. 1 The histograms related to the post-SMAT, post-ACQ and delayed post-SMAT

4.3.2.3. Multicollinearity and Singularity

To obtain more precise results with MANCOVA, the dependent variables should only be moderately correlated. When there are high correlations among the dependent variables, this is known as multicollinearity (Pallant, 2006). The simplest way to check multicollinearity is to determine the strength of correlations among the dependent variables. These correlations were examined during the step regarding determination of covariates. As indicated in Table 4.5, there is no reason for concern since all correlations between dependent variables are less than 0,80. Consequently, the assumption of multicollinearity is verified.

4.3.2.4. Homogeneity of Variance-Covariance Matrices

MANCOVA works best when variance-covariance matrices within each cell of the study are sampled from the same population variance-covariance matrix and can rationally be pooled to create a single estimate of error (Tabachnick & Fidell, 2001, p.330). This is known as the assumption of homogeneity of variance-covariance matrices. In order to check whether the data violates this assumption, The Box’s Test of Equality of Covariance Matrices was examined as shown in Table 4.7. Since the significance value is greater than 0,001 (Pallant, 2006, p.286), this assumption was not violated.

Table 4. 7 Box's Test of Equality of Covariance Matrices

Box's Test of Equality of Covariance Matrices[a]	
Box's M	19,820
F	1,058
df1	18
df2	57277,676
Sig.	0,389

4.3.2.5. Homogeneity of Regression

In order to reduce the probability of making Type II error for the statistical analysis of concern, it should be ensured that the slopes of the regression lines are the same for each group formed by the independent variables and measured on dependent variables (Garson, 2012). Since, there are two covariates included in this study; the assumption becomes parallelism of the regression planes (Stevens, 2009).

Due to the violation of this assumption indicates an interaction effect between the independent variables and covariates (Garson, 2012), the interactions between the covariates and the independent variables are included in MANCOVA model in SPSS as a first step to check this assumption. The results are presented in the Table 4.8.

Garson (2012) emphasized that any significant interaction effect indicates the violation of the assumption of homogeneity of regression. As shown in Table 4.8, all the interaction effects for the independent variable of main concern, namely “instruction”, are nonsignificant with p values greater than 0,05; resulting with the verification of homogeneity of regression assumption. However, the interaction effect of gender with preach and the interaction effect of gender with preatt on postatt are significant (p = 0,008 and p = 0,023; respectively).

Table 4. 8 The summary of MANCOVA model including interaction effects

Source	DV	df	F	Sig.	Partial Eta Squared	Observed power
instruction * preach	postach	1	2,058	0,154	0,015	0,296
	postatt	1	0,326	0,569	0,002	0,088
	retention	1	1,669	0,199	0,012	0,250
instruction * preatt	postach	1	1,449	0,231	0,011	0,223
	postatt	1	0,038	0,846	0,000	0,054
	retention	1	1,328	0,251	0,010	0,208
instruction * preach * preatt	postach	1	2,478	0,118	0,018	0,346
	postatt	1	0,692	0,407	0,005	0,131
	retention	1	1,965	0,163	0,014	0,285
gender * preach	postach	1	1,107	0,295	0,008	0,181
	postatt	1	7,308	0,008	0,051	0,765
	retention	1	0,976	0,325	0,007	0,165
gender * preatt	postach	1	0,682	0,410	0,005	0,130
	postatt	1	5,319	0,023	0,038	0,629
	retention	1	1,541	0,217	0,011	0,234
gender * preach * preatt	postach	1	0,969	0,327	0,007	0,165
	postatt	1	6,473	0,012	0,046	0,714
	retention	1	1,082	0,300	0,008	0,178

As a further crosscheck, the syntax in Figure 4.2 were written to check the parallelism of the regression planes considering the explanations in Tabachnick and Fidell (2007, pp.281-284) and Stevens (2009, pp.303-308).

The output indicated that the interaction effect between the independent variables and the covariates are nonsignificant for postach (F (6,135) = 0,99, p = 0,435 > 0.01) and retention (F (6,135) = 0,50, p = 0,809 > 0.01) whereas this interaction effect is significant for postatt (F (6,135) = 6,70, p = 0,00 < 0.01). These results are parallel with the results obtained by MANCOVA model in SPSS as suggested by Garson (2012). It was seen that homogeneity of regression planes assumption was verified for all of the dependent variables except postatt in gender related combinations. Due to the verification of assumption for the other dependent variables, the choice is made towards proceeding with all variables as presumed in MANCOVA. It is safe to conclude that there is no statistically significant interaction between the type of the instruction and the covariates.

```
MANOVA     postach,postatt,retention,preach,preatt BY
instruction(1,2) gender (1,2)
/PRINT=SIGNIF(BRIEF)
/ANALYSIS=postach, postatt,retention
/DESIGN=preach,preatt,instruction,gender,instruction BY gender
       POOL(preach,preatt) BY instruction +
       POOL(preach,preatt) BY gender +
       POOL(preach,preatt) BY instruction BY gender
/ANALYSIS=postach

    /DESIGN=preach,preatt,instruction,gender,instruction BY
gender
       POOL(preach,preatt) BY instruction +
       POOL(preach,preatt) BY gender +
       POOL(preach,preatt) BY instruction BY gender
/ANALYSIS=postatt

    /DESIGN=preach,preatt,instruction,gender,instruction BY
gender
       POOL(preach,preatt) BY instruction +
       POOL(preach,preatt) BY gender +
       POOL(preach,preatt) BY instruction BY gender
/ANALYSIS=retention

    /DESIGN=preach,preatt,instruction,gender,instruction BY
gender
       POOL(preach,preatt) BY instruction +
       POOL(preach,preatt) BY gender +
       POOL(preach,preatt) BY instruction BY gender.
```

Figure 4. 2 Syntax for checking the parallelism of the regression planes

4.3.3 Results of MANCOVA

Since no serious violations to assumptions were observed, statistical analyses were performed through SPSS 20 to test the hypotheses of the study. As stated previously, the independent variables of the study are the instruction (CBI vs. TI) exposed to both groups and gender of students; the dependent variables are post-achievement (post-SMAT), post-attitude (post-ACQ) and retention (delayed post-SMAT) scores of the students where students' pre-achievement (pre-SMAT) and pre-attitude (pre-ACQ) scores served as covariates.

The first three null hypotheses of the study test the effect of instruction, gender and instruction*gender interaction on the population means of the collective dependent variables of tenth grade high school students' post-SMAT, delayed post-SMAT and post-ACQ scores when students' pre-SMAT and pre-ACQ scores were controlled. MANCOVA was performed to test these hypotheses with an aim to determine the effect of the instructions, gender and instruction*gender interaction on dependent variables of the study.

Table 4.9 presents the results of the statistical analysis of MANCOVA. The Wilks' Lambda with a value of 0,765 for the independent variable instruction is significant, F (3, 139) = 4,25, p = 0,00; partial eta squared = 0,235, which resulted with the rejection of the first null hypothesis. It can be concluded that there is a significant mean difference on the population mean of the collective dependent variables of tenth grade high school students' post-SMAT, delayed post-SMAT and post-ACQ scores when students' pre-SMAT and pre-ACQ scores were controlled. The value of the partial eta squared, 0,235, indicates that almost 24% of the variability in the dependent variables is explained by the independent variable; instruction.

Table 4. 9 Results of MANCOVA

Effect	**Wilks' Lambda**	**F**	**Hypothesis df**	**Error df**	**Sig.**	**Partial Eta Squared**	**Observed Power**
Intercept	0,607	30,034	3	139,00	0,000	0,393	1,000
Preatt	0,634	26,719	3	139,00	0,000	0,366	1,000
Preach	0,860	7,534	3	139,00	0,000	0,140	0,985
instruction	0,765	14,255	3	139,00	0,000	0,235	1,000
Gender	0,926	3,723	3	139,00	0,013	0,074	0,798
instruction * gender	0,994	0,285	3	139,00	0,836	0,006	0,104

The Wilks' Lambda with a value of 0,926 for gender is also significant, F (3,139) = 3,72, p = 0,013, partial eta squared = 0,074, indicating that it is reasonable to reject the second null hypothesis. To conclude, the overall effect of gender on the population mean of the collective dependent variables of tenth grade high school students' post-SMAT, delayed post-SMAT and post-ACQ scores when students' pre-SMAT and pre-ACQ scores were controlled is significant.

When the point comes to the interaction effect of instruction and gender, the value of Wilks' Lambda is 0,994 and it is not statistically significant (F (3,139) = 0,285, p = 0,836, partial eta squared = 0,006). This results with a failure to reject the third null hypothesis which means that the interaction effect between instruction and gender on the population mean of the collective dependent variables of tenth grade high school students' post-SMAT, delayed post-SMAT and post-ACQ scores when students' pre-SMAT and pre-ACQ scores were controlled is not significant.

The observed power value associated with the instruction is 1,0 and it is greater than the assigned power (0,80) at the beginning of the study. The effect size (f^2) was set to medium effect size (0,15) as recommended in Cohen et al. (2003). Table 4.9 indicates that the calculated effect size of the study is 0,24 and it corresponds approximately to large effect size (f^2 = 0,25) as stated in Tabachnick and Fidell (2007, p.55). This means that 24 % of the multivariate variance of the dependent variables can be explained by the independent variable instruction.

The table also indicated that covariates, namely preach (Wilks' Lambda = 0,860, F (3,139) = 7,53, p = 0,000, partial eta squared = 0,140) and preatt (Wilks' Lambda = 0,634, F (3,139) = 26,71, p = 0,000, partial eta squared = 0,366) had a significant contribution to the adjustment of the dependent variables.

4.3.4 Follow-up ANCOVAs

Univariate analyses of covariance (ANCOVA) for each dependent variable were conducted as follow-up tests to the MANCOVA. Applying the Bonferroni method for controlling Type I error rates for multiple comparisons (Tabachnick & Fidell, 2007), each hypothesis was tested at the p < 0,017 (0,05/3) level due to the intention of performing tests for three different dependent variables. Table 4.10 presents the results of ANCOVAs for the rest of the null hypotheses.

The forth null hypothesis of the study is "There is no statistically significant difference between the population means of tenth grade high school students experiencing the CBI and TI with respect to their achievement on the states of matter subject when the effects of students' prior knowledge of the states of matter subject is controlled" .

ANCOVA was conducted to determine the effect of the context-based instruction and traditional instruction on students' post-SMAT scores when their pre-SMAT scores were controlled. As indicated in Table 4.10, the difference between post-SMAT mean scores of tenth grade students who received context-based instruction and those who received traditional instruction is statistically significant when the effects of students' prior knowledge on the states of matter subject is controlled (F (4,145) = 35,532, p = 0,00, partial eta squared = 0,197). Accordingly, the forth null hypothesis was rejected.

When the means of post-SMAT scores of the students, shown in Table 4.3, are examined, it can be inferred that this difference is in favour of the experimental group. In conclusion, the students taught with context-based instruction got higher mean scores on the SMAT than the students taught with traditional instruction when their prior knowledge of the subject of concern is controlled.

The fifth null hypothesis tests the effect of gender on achievement of the students on the states of matter subject when the effects of students' prior knowledge of the states of matter subject are controlled. ANCOVA results indicated that mean post-SMAT scores of male students and female students do not differ significantly when the effects of students' pre-SMAT scores are controlled (F (4,145) = 2,718, p = 0,101, partial eta squared = 0,018).

Table 4. 10 Results of follow-up ANCOVAs

DV	**Source**	**df**	**F**	**Sig.**	**Partial Eta Squared**	**Observed power**
Postach	Corrected Model	4	11,929	0,000	0,248	1,000
	Intercept	1	58,155	0,000	0,286	1,000
	Preach	1	12,683	0,000	0,080	0,943
	İnstruction	1	35,532	0,000	0,197	1,000
	Gender	1	2,718	0,101	0,018	0,374
	instruction * gender	1	1,158	0,284	0,008	0,188
Postatt	Corrected Model	4	20,148	0,000	0,362	1,000
	Intercept	1	118,236	0,000	0,454	1,000
	Preatt	1	75,148	0,000	0,346	1,000
	İnstruction	1	7,160	0,008	0,048	0,757
	Gender	1	0,025	0,875	0,000	0,053
	instruction * gender	1	0,062	0,803	0,000	0,057
Retention	Corrected Model	4	8,057	0,000	0,182	0,998
	Intercept	1	65,807	0,000	0,312	1,000
	Preach	1	19,000	0,000	0,116	0,991
	İnstruction	1	19,971	0,000	0,121	0,993
	Gender	1	1,596	0,209	0,011	0,241
	instruction * gender	1	0,193	0,661	0,001	0,072

The sixth null hypothesis focuses on the interaction effect of instruction and gender on post-SMAT scores of the students when the effects of students' students' pre-SMAT scores are controlled. It was found that there is no statistically significant interaction effect between instruction and gender on students' post-SMAT scores when their pre-SMAT scores are controlled ($F (4,145) = 1,158$, $p = 0,284$, partial eta squared = 0,008).

Associated with the students' attitudes towards chemistry, the seventh, eighth and ninth hypotheses were tested. Another follow-up ANCOVA was conducted to determine the effect of the instruction on students' post-ACQ scores when their pre-ACQ scores are controlled. As indicated in Table 4.10, the difference between post-ACQ mean scores of tenth grade students who received context-based instruction and those who received traditional instruction is statistically significant when the effects of students' pre-ACQ scores are controlled ($F (1,147) = 7,231$, $p = 0,08$, partial eta squared = 0,048). Accordingly, the seventh null hypothesis of the study was rejected.

When the means of students' post-ACQ scores, shown in Table 4.3, are examined, it can be inferred that the students taught with context-based instruction developed more positive attitudes towards chemistry than the students taught with traditional instruction when their prior attitudes towards chemistry were controlled.

Meanwhile, the effects of gender and instruction*gender interaction are not significant on the population means of post-ACQ scores of tenth grade high school students when the effects of students' pre-ACQ scores are controlled ($F (4,145) = 0,025$ $p = 0,875$, partial eta squared = 0,000 for gender and $F (4,145) = 0,062$ $p = 0,803$, partial eta squared = 0,000 for instruction*gender interaction). Thus, the eighth and ninth hypotheses were not rejected.

The remaining three hypotheses test the effect of instruction, gender and the interaction effect between instruction and gender on students' knowledge retention when the effects of students' prior knowledge of the states of matter subject is controlled.

ANCOVA results showed that the difference between delayed post-SMAT mean scores of tenth grade students who received context-based instruction and those who received traditional instruction is statistically significant when the effects of students' pre-SMAT scores are controlled ($F (4,145) = 19,971$ $p = 0,00$, partial eta squared = 0,121). Accordingly, the tenth null hypothesis of the study was rejected with a conclusion that students in experimental group retained what they learned during instruction more when compared to the students in the control group.

On the other hand, the effects of gender and the interaction effect between instruction and gender on students' delayed post-SMAT scores are not statistically significant when the effects of students' pre-SMAT scores are controlled ($F (4,145) = 1,596$ $p = 0,209$, partial eta squared = 0,011 for gender and $F (4,145) = 0,193$ $p = 0,661$, partial eta squared = 0,001 for instruction * gender interaction). The interaction plots for each dependent variable are presented in Figure 4.3.

The plots verify the results of ANCOVA for interaction effects, by not indicating any significant interaction effect between independent variables. It is apparent from the plots that context-based instruction contributes to both males' and females' post-SMAT, post-ACQ and delayed post-SMAT scores. Although the interaction effects are not significant, the descriptive statistics reported that the gain scores of the means for post-ACQ are greater for male students even though female students got higher scores in post-ACQ. It can be stated that the context-based instruction is effective for both gender and for all dependent variables by concluding that male students seem to benefit more from context-based instruction in terms of developing more positive attitudes toward chemistry.

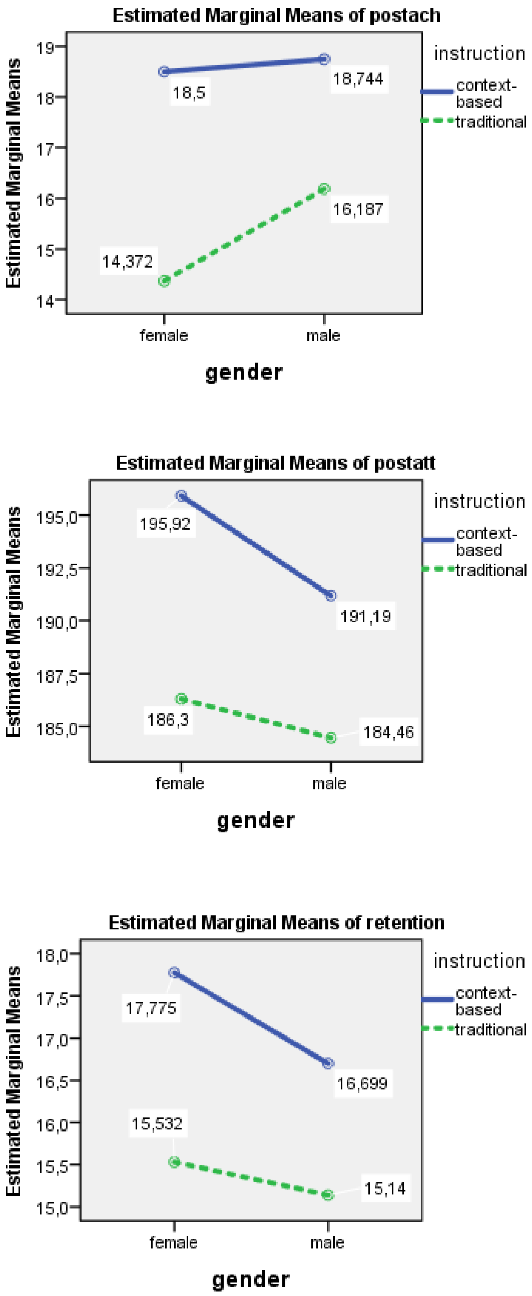


Figure 4. 3 The interaction plots for each dependent variable

4.3.5 Summing up the results

The following conclusions can be drawn from the results section of the study;

- The context-based instruction resulted with significantly higher achievement scores on the states of matter subject when compared to the traditional instruction.
- The students who received context-based instruction developed better attitudes towards chemistry when compared to the students those received traditional instruction.
- The context-based instruction produced higher knowledge retention, indicating students who received context-based instruction retained what they learned more during instructional practices more when compared to the students in the control group.
- There was no significant interaction effect between instruction and gender on students' achievement on the states of matter subject, their attitudes towards chemistry and their knowledge retention on the states of matter subject.
- Although the interaction effects are not significant, male students seem to benefit more from context-based instruction in terms of developing more positive attitudes toward chemistry.

CHAPTER 5

DISCUSSION, IMPLICATIONS and RECOMMENDATIONS

There are five sections in this chapter; these sections begin with a discussion of the results. Internal validity and external validity are presented next. Afterwards, ethical considerations are mentioned. Finally implications of the results and recommendations for further research are included.

5.1 Discussion of the Results

The main purpose of the present study was to report findings regarding the implementation and effectiveness of context-based instruction as compared to the traditional instruction in Turkish classrooms. In order to achieve this aim, a quasi-experimental pre-test post-test control group design was applied with 150 students. The independent variables were the instruction types (context-based instruction vs. traditional instruction) and the gender of the students. Students' achievement and knowledge retention on the states of matter subject and their attitudes towards chemistry were assigned as student outcomes of concern and they were included as dependent variables in statistical analysis where students' prior knowledge of the states of matter subject and prior attitudes towards chemistry were tried to be controlled by serving as covariates.

As it is stated previously, although the number of studies focusing on context-based instruction increases year by year, it is difficult to draw healthy conclusions on the effects of context-based instruction on student outcomes. The main reasons of this lack of evidence can be stated as the failure of researchers to include a comparison group or pre-tests, not defining context-based instruction regarding the philosophy behind the approach, not applying a proper research methodology and the overvalued role of anecdotal evidence (Medrich et al., 2003).

Keeping this in mind, this study is important in terms of the attempt to design a context-based instruction and present the findings regarding the effectiveness of context-based instruction on students' understanding and attitudes towards chemistry. In order to be able to contribute to the answer of the question regarding the effectiveness of context-based instruction, this current study made all possible efforts by including a control group, assessing students' outcomes prior to the treatment, defining each step of context-based instruction and drawing conclusions based upon statistical evidence.

Most of the context-based curricula are not based on a "subject-specific, coherent list of predetermined concepts" (Bennett, Holman, Lubben, Nicholson & Otter, 2005, p.143). Scientific concepts arise on a need-to-know basis which means new concepts are introduced when students need them to extend their conceptual knowledge. Due to the highlycentralized educational system in Turkey, the components of the instructions for each course, such as objectives, concepts, etc., are pre-determined by Ministry of National Education. Consequently, Turkish chemistry courses are object driven with a list of predetermined concepts to be taught for each subject. While designing a context-based instruction for Turkish chemistry curricula, the first obstacle emerged as the determination of the context that would cover most of the pre-determined concepts for the states of matter subject in the curriculum. The context, that served as an umbrella for the chemical concepts, was chosen as "weather changes and the atmosphere" for the states of matter subject following the scrutinization of context determination procedures for large-scale projects and studies focusing on students' interest in different contexts. It was assumed that the context chosen was not a gender-biased one and familiar to all students included in the study.

The interest of researchers regarding context-based approaches in Turkey is ascending as well. However; the number of studies that aimed to design context-based chemistry instruction and assessed the outcomes of the implication in Turkish high schools (Ekinci, 2010; Elmas, 2012; İlhan, 2010; Kutu & Sözbilir, 2011) do not lend itself to extend generalizations for Turkish context. This study can be considered as one of the first attempts to design a context-based chemistry instruction for high school students and assess its effectiveness in a research design including pre-tests and a control group.

When the point comes to the reported findings of this study on the effects of context-based instruction, one may infer that context-based instruction resulted in a significantly better understanding of states of matter subject in comparison with the traditional instruction. Students in the experimental group scored higher on the states of matter achievement test than their peers in the control group at the end of the treatment and this difference was found to be statistically significant. This result is consistent with the international research including studies on context-based instruction revealing that using contexts to present scientific concepts result in students understanding at least as effectively as in traditional instruction (Barber, 2000; Barker & Millar, 1996; Cooper, Yeo & Zadnik, 2003; Gutwill-Wise, 2001; Lubben, Campbell & Dlamini, 1997; Murphy, Lunn & Jones, 2006; Ramsden, 1997; Rayner, 2005; Smith & Bitner, 1993; Wierstra, 1984; Wierstra & Wubbels, 1994). National research also supports this evidence; the studies resulted with higher achievement of students receiving context-based chemistry instruction are İlhan (2010) on "chemical equilibrium" subject, Kutu (2011) and Elmas (2012) on "chemistry in our lives" subject and Demircioğlu (2008) on states of matter subject. Studies concluding the positive effect of context-based instruction in other disciplines in Turkish contexts can be listed as the studies of Tekbıyık (2010), Yayla (2010), Çekiç Toroslu (2011), Peşman (2012) and Ültay (2012) for physics; Çam (2008), Yaman (2009) and Özay Köse and Çam Tosun (2011) for biology and Ünal (2008) for science and technology courses.

Knowledge retention of the students is another area of research that requires further systematic evidence. The need to conclude the effect of instructional initiatives on knowledge retention becomes vital for science educators to see the long-term effects of the instructions. The extent of retaining and remembering what is already learned for long-term maintenance is an important issue for also attaining curricular objectives. For context-based instruction, one may expect that if students are able to see the relevance of science to their lives and perceive it as meaningful to learn, they will retain more of the knowledge that they learned during the instructional practices (Taasoobshirazi & Carr, 2008). It was revealed from the literature that there is a lack of context-based studies documenting the results on students' knowledge retention following the context-based instruction. The reason of including knowledge retention as a dependent variable in this study was to present the findings regarding the effectiveness of context-based instruction on knowledge retention. The results of this study revealed that students receiving context-based instruction can retain and remember what they learned during the treatment in a greater extent when compared to the students in control group after four months following the treatment. However; a noteworthy point arises for the control group in terms of knowledge retention. The mean post-SMAT scores of the students in the control group was 15,09 where the mean for their delayed post-SMAT scores slightly increased to 15,38 on the contrary to the expected fall due to the four-month time interval. It was also stated that their mean pre-SMAT scores was 12,51 indicating that mean scores of students in the control group on SMAT in a continuum do not differ extensively. One may conclude that traditional instruction did not contribute remarkably to neither students' understanding of states of matter subject nor their retention of knowledge.

As stated previously; there is a lack of studies focusing on knowledge retention in context-based instruction. The study of Lye, Fry and Hart (2001) focused on the teacher views regarding knowledge retention of students. From the interview data of teachers, the researchers concluded teachers' view as students retain more of the knowledge when the concepts are presented in a context which is consistent with the result of this study. Kutu and Sözbilir (2011) included a retention test into their study in order to determine the extent of students retaining the knowledge after three weeks following their context-based treatment. The researchers reported a 95.75% retention rate which can be considered as considerably high. These conclusions are consistent with the finding of higher knowledge retention of students in experimental group for the current study.

The findings of the studies focusing on the effects of context-based instruction on the affective responses of students show more congruence than the studies reporting their cognitive outcomes. In their review of context-based and STS studies; Bennett et al. concluded that there is evidence to support that context-based approaches help students to develop more positive attitudes to science in general. In addition to this judgement; there are considerable amount of studies concluding that students develop better affective responses to science learning as a result of context-based instruction both in international research (Barber, 2000; Gutwill-Wise, 2001; Kaschalk, 2002; Parchmann et al., 2006; Ramsden, 1992, 1994, 1997; Rayner, 2005; Sutman & Bruce, 1992) and national research (Çam, 2008; Demircioğlu et al., 2009; Gürsoy Köroğlu, 2011; İlhan, 2010; Tekbıyık, 2010; Ültay & Çalık, 2011). One of the main concerns of this study was the change on students' attitudes towards chemistry receiving context-based and traditional instruction. The results obtained are consistent with the literature concluding that students in the experimental group developed better attitudes towards chemistry when compared to their peers in the control group at the end of the treatment.

Although the interaction effects are not significant, male students seem to benefit more from context-based instruction in terms of their attitudes towards chemistry according to their gain scores. However, the mean scores of post-ACQ are greater for female students. One reason for this difference may be their initial positive attitudes to chemistry but it is also known that boys and girls respond differently to different instructions, classroom activities and contexts. The group work was essential during context-based instruction in this study. Accordingly, this result may associate with Nieswandt's study (2005) emphasizing female students' preference of social interaction with their peers in class activities while vice versa is valid for the review study conducted by Lubben et al. (2005). They reported that female students enjoyed context-based courses more when they were engaged in non-practical activities. To conclude; it can be stated that integrating a context that is familiar to all students into the instruction and engaging them in a variety of learning activities is effective for both gender and for all dependent variables by concluding that male students seem to benefit more in terms of their attitudes toward chemistry. This finding further implies that context-based instruction may have the potential to narrow the gap between male and female students' performance in learning science.

The underlying reasons of the positive outcomes of the context-based instruction may closely be associated with the characteristics of the context-based instruction in this study. By starting each lesson with an aspect of the context, the instruction encouraged students to eliminate the existing questions in mind, mostly criticizing the reason of why they have to learn that subject. By emphasizing the relevance of the chemical concepts to students' daily lives in each step of the instruction, students perceive the reason of why they need to learn chemistry. The probable prejudgement of students on chemistry being just an aggregation of memorizable facts smoothly transferred into the feeling that chemistry is all around us. Consequently, the instruction persuaded students to actively participate in the lesson and learn chemistry more willingly. As suggested by Bennett and Lubben (2006), the context-based instruction included a wide range of activities in which students could engage both mentally and physically. Depending upon the content of the lesson, students in this study dealed with hands-on activities, collected data based on their experiments, worked mostly with their peers, sketched graphs and etc. Thus, they were enabled to explore the chemical concepts and the relationships among them instead of passively receiving the knowledge. All these endeavors are assumed to make chemistry more meaningful to the students, so they became more interested in chemistry lessons. This interest reflected on student outcomes in this study as a greater understanding and knowledge retention of the states of matter subject and better attitudes towards chemistry.

It is believed that the context-based materials, in particular; the students' text and worksheets, contributed to the success of the experimental group for this study. All the chemical concepts were introduced by emphasizing an aspect of the context during the instruction and the context-based materials were the concrete reflection of instruction on written documents. Students' text presented the chemical concepts and how they relate both with each other and students' lives in a more meaningful way when compared to the textbooks that students were familiar with. These materials provided a framework for the context-based instruction so that while engaging with the materials, students felt involved in chemistry and inferred that chemistry is all around us. This result is in line with the conclusions of Demircioğlu et al.'s study (2009) reporting the effectiveness of chemical storylines embedded in context-based instruction for university students.

The detailed lesson plans based on 5E learning cycle also contributed to the effectiveness of the instruction. The teacher of the experimental group felt safe with the treatment due to having the teacher guides that served as lesson plans. Since the learning cycle offers a planned sequence of instruction and this sequence is well-defined and detailed in teacher guides, it was ensured that the teacher applied instruction as intended in lesson plans.

Taken together, this study obtained statistically significant results regarding the effects of context-based instruction on students' achievement, knowledge retention and attitudes towards chemistry. When the point comes to the practical utility of the results, one may refer to the effect size calculated during statistical analysis. The observed power value associated with the instruction is 1,0; indicating that the probability of detecting a true effect when the effect exists is large enough for this study. Furthermore, the effect size was calculated as 0,24 which corresponds approximately to large effect size ($f^2 = 0,25$) as stated in Tabachnick and Fidell (2007, p.55). This means that 24 % of the multivariate variance of the dependent variables associates with the instruction. These results have shown that the findings of this study have both statistical and practical significance and realistically meaningful.

Returning to the research questions posed at the beginning of this study, it is now possible to state that context-based instruction is an effective way of instruction and is promising to address problems faced in chemistry education.

5.2 Internal Validity

If a study has internal validity, it means that "observed differences on the dependent variable are directly related to the independent variable and not due to some other unintended variables" (Fraenkel & Wallen, 2000, p.190). There are some possible threats to internal validity of a study. These are; subject characteristics, mortality, location, instrumentation (instrument decay, data collector characteristics, and data collector bias), testing, history, maturation, attitude of subjects (Hawthorn effect, John Henry effect, and demoralization effect), regression, and implementer threats. In the following paragraphs, the present study is analysed in terms of all possible threats.

Research design of the study (pre-test-post-test control group design) is effective to some extent in controlling the following threats (Fraenkel &Wallen, 2000, p.302); subject characteristics, mortality, instrument decay, testing, history, maturation, and regression. However, these threats may possibly still occur in this design. Characteristics of the students can still be a threat to the present study since it was not possible to assign students randomly to the treatments. Two characteristics of the students, which are pre-test scores of students on the SMAT and pre-test scores of students on the ACQ are considered as confounding variables for the study and included in the covariate set to statistically equalize students on these variables. Some other subject characteristics such as students' intelligences, prior science experiences and socioeconomic levels are assumed to be equally distributed among the groups.

Probably the most important threat in experimental studies is attitudinal threat. Hawthorne and John Henry effects can produce short term effects due to special attention to the experimental group and the desire of the control group to exceed the performance of the experimental group, respectively. For instance, in the present study, students in the experimental group may improve due to extraordinary nature of the context-based instruction or students in the control group may do poorly due to perceived unfairness. To eliminate these effects, the teacher of the experimental group was informed about making context-based instruction sessions less novel and part of a regular routine. In addition to these, observation of both groups started two weeks prior to the implementation to lessen the novelty for students.

Since pre-tests are used in this study, testing threat may occur in such a way that students' improvement may be caused from the practice on the pre-test, discussion of opinions regarding pre-test, and students' awareness of what is important to learn. However, these issues are valid for both the control and experimental groups and do not function in only one of the groups. Therefore, testing threat is minimal for this study.

History and location threats are tried to be controlled by administrating the tests to all groups approximately at the same time and in similar conditions. Data collector characteristics and data collector bias are controlled by training the teachers so that they use standard procedures while collecting data. Implementation is not a serious threat for this study since teachers are informed about standard procedures and observed by the researcher throughout the implementation of each group at random times. Furthermore, teachers and the researcher had meetings several times during the implementation period in order to ensure standardization of implementation procedures.

In order to control mortality threat, test administration times were determined by considering teachers' recommendations and were announced several times to the students in each group prior to the administration. Even though, there were absent students at the time of the administration of each test. The researcher had some of those students take the test they missed in the following times. Besides these efforts, there were still students who missed the tests. As a further control to mortality threat, missing data analysis was conducted in detail.

5.3 External Validity

The external validity refers to "the extent that the results of a study can be generalized from a sample to a population" (Fraenkel & Wallen, 2000, p.124). Like most of the experimental studies, this study also seeks ways of generalization of its findings in nature. Since random sampling was not feasible for the current study, the sample should be described in detail. The accessible population of the study was all tenth grade students from Anatolian high schools located in İnegöl and Yenişehir districts of Bursa. According to the website of Ministry of National Education (MONE, 2010), there are four Anatolian high schools in the accessible population, two of which were included in this study. All tenth grade students enrolled in science-mathematics classes in these two schools comprised the sample of the study exceeding 10% of the accessible population. Hence; the findings of the current study can be generalized to the accessible population.

The number of students in each classroom is generally 30 or less. The enrollment rate of students graduated from these schools to the universities was 60% in average in 2012 (MONE, 2012). The socioeconomic status of the families in the neighbourhood can be defined as medium. Both teachers involved in the study have 20 years of teaching experience. The physical conditions of the classrooms is similar to each other, they are not technologically-equipped; there exists students' desks, teacher's desk and blackboards. Interested researchers can judge these descriptions for the degree to which and to whom the findings of this study can be applied.

5.4 Ethical Considerations

While conducting a research study, the researcher should be aware of three ethical considerations which are protecting participants from any kind of harm, ensuring confidentiality of data and avoiding deception of the subjects (Fraenkel & Wallen, 2000, p.43). The present study was designed so carefully that all the participants were protected from physical and psychological harm. It was also ensured that no one else had access to the research data and the names of the subjects were only used when assigning numbers to each completed measuring tool by the students. Deception was not an issue for this study. Both the students and the teachers were informed about the purpose of each measuring tool and they participated in the study on a voluntarily basis. In addition to these, prior to the implementation step, ethical committee of METU examined all the materials and measuring tools to be used during the study and approved necessary legal permissions.

5.5 Implications

Context-based instruction can be regarded as a solution to problems faced in chemistry teaching practices at schools. This study showed that it is effective in terms of promoting students' achievement and developing better attitudes towards chemistry. It was also concluded that students receiving context-based instruction retained what they learned more during instructional practices.Thus, context-based instruction can be applied during chemistry courses to make students more competent and interested in chemistry.

In order to increase student achievement and their affective responses to chemistry, the Ministry of National Education should prompt alternative instructions to traditional teaching of chemistry that foster student engagement. By showing the relevance of chemistry to students' lives, context-based instruction promises positive student outcomes without requiring abundant financial and technical support. Curriculum developers may consider adopting school chemistry to context-based instruction at least for raising chemically literate students. Furthermore; teachers should be informed about the philosophy and principles of context-based instruction by means of in-service trainings and should be provided support about implementation procedure. The availability of context-based materials is limited for our country, hence; it would be better to grant studies aiming to develop and disseminate context-based materials.

Teacher training programs at universities should also include context-based instruction to their courses in which methods of teaching are presented to pre-service teachers. Science educators should aid pre-service teachers with implementation procedure and accessing proper context-based materials.

5.6 Recommendations for Further Research

The findings of this study provide the following insights for future research:

- Future studies may explore the effect of context-based instruction on different student outcomes like their motivation to study chemistry, self-efficacy, problem solving skills and etc.

- Similar studies may be conducted by altering the main parameters like grade levels, chemistry subjects, school type, and etc.

- Future studies may focus on the effect of context-based instruction on the outcomes of high-achievers and low-achievers.

- The same design can be applied with the same chemistry subject but different contexts that students are definitely interested in.

- Interested researchers may carry out studies with longer durations and/or greater sample sizes by covering the whole semester or the year to see the long term effects of the context-based instruction.

- Future studies may also focus on the effects of context-based instruction on students' outcomes by grouping the students according to their possible career choices. For instance, it would be interesting to assess the effects of context-based instruction on students' planning a chemistry-related career and the others.

- Two different assessment techniques for achievement can be considered for future studies, one comprised of context-based questions and the other with traditional chemistry questions like the ones included in this study. This could help the researcher to anticipate students' performances for different assessment techniques.

- Similar studies can be designed with teachers differing on pedagogical content knowledge to see the interaction effect of teacher characteristics and context-based instruction.
- Researchers may carry out studies that monitor what is going on during a context-based instruction by applying qualitative research methods.

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APPENDIX A

LIST OF KEYWORDS for LITERATURE REVIEW

- Context-based teaching
- Context-based learning
- Context-based approach
- Context-based instruction
- Contextual teaching
- Contextual learning
- Contextual instruction + science
- Context-based teaching + science
- Context-based learning+ science
- Context-based approach+ science
- Context-based instruction+ science
- Contextual teaching+ science
- Contextual learning+ science
- Contextual instruction+ science
- Context-based teaching+ chemistry
- Context-based learning+ chemistry
- Context-based approach+ chemistry
- Context-based instruction+ chemistry
- Contextual teaching+ chemistry
- Contextual learning+ chemistry
- Context-based teaching+ gender
- Context-based learning+ gender
- Context-based approach+ gender
- Context-based instruction+ gender
- Contextual teaching+ gender
- Contextual learning+ gender
- Context-based teaching + achievement
- Context-based learning+ achievement
- Context-based approach+ achievement
- Context-based instruction+ achievement
- Contextual teaching+ achievement
- Contextual learning+ achievement
- Context-based teaching + attitude
- Context-based learning+ attitude
- Context-based approach+ attitude
- Context-based instruction+ attitude
- Contextual teaching+ attitude
- Contextual learning+ attitude
- Affective characteristics

APPENDIX B

OBJECTIVES OF THE STATES OF MATTER SUBJECT

1. Gazların genel özellikleri ile ilgili olarak öğrenciler;

    1.1. Gazların sıkışma/genleşme sürecindeki davranışlarını sorgulayarak gerçek gaz-ideal gaz ayrımı yapar.

    1.2. İdeal gazın davranışlarını açıklamada kullanılan temel varsayımları (kinetik teori varsayımları) irdeler.

    1.3. Gazları nitelemek için gerekli büyüklükleri betimler.

    1.4. Gaz basıncını molekül hareketleri temelinde açıklar.

2. Gaz kanunları ile ilgili olarak öğrenciler;

    2.1. Belli miktarda gazın sabit sıcaklıkta basınç-hacim ilişkisini irdeler (Boyle Kanunu).

    2.2. Belli miktarda gazın basıncı sabitken sıcaklık-hacim; hacmi sabitken de sıcaklık-basınç ilişkisini irdeler (Charles Kanunu).

    2.3. Charles Kanunundan yararlanarak mutlak sıcaklık eşelini açıklar.

    2.4. Belli sıcaklıkta bir gazın, sabit basınç altında mol sayısı-hacim ve sabit hacimde iken mol sayısı-basınç ilişkisini açıklar (Avogadro Kanunu).

    2.5. İdeal gaz denklemini kullanarak bir gazın, basıncı, kütlesi,mol sayısı, hacmi, yoğunluğu ve sıcaklığı ile ilgili hesaplamaları yapar.

3. Gaz karışımları ile ilgili olarak öğrenciler;

    3.1. Kısmi basınç ve kısmi hacim kavramlarını açıklar.

    3.2. Gaz karışımları ile ilgili hesaplamaları yapar.

4. Gerçek gazlar ile ilgili olarak öğrenciler;

    4.1. İdeal gaz kavramının fiziksel gerçekliğini irdeler.

    4.2. Gazların hangi hâllerde ideallikten uzaklaştığını fark eder.

    4.3. Gerçek gazların sıvılaşması sürecini moleküller arası bağlar ile ilişkilendirir.

    4.4. Gerçek ve ideal gazlarda Joule-Thomson olayını açıklar.

    4.5. Joule-Thomson olayının gündelik hayatta uygulamalarına örnekler verir.

    4.6. “Gaz” ve “buhar”kavramları arasında ayırım yapar.

5. Sıvılar ile ilgili olarak öğrenciler;

    5.1. Sıvı ve gaz fazları, moleküller arası bağlar ve molekülleri öteleme hareketleri temelinde karşılaştırır.

    5.2. Sıvıların yüzey gerilimini moleküller arası bağlar temelinde açıklar.

5.3. Adhezyon ve kohezyon kuvvetlerini karşılaştırır.

5.4. Yüzey gerilimi, adhezyon ve kohezyon sonucu ortaya çıkan olguları örnekler üzerinden açıklar.

5.5. Sıvıların yüzey gerilimine sıcaklığın ve sıvıya katılmış maddelerin etkisini açıklar.

5.6. Sıvıların viskozitelerini, moleküller arası bağlar ve molekül biçimi ile ilişkilendirir.

5.7. Sıvıların viskoziteleri ile akış hızlarını ilişkilendirir.

5.8. Viskozitenin sıcaklıkla değişiminden yararlanılan uygulamalara örnekler verir.

6. Hâl değişimleri ile ilgiliolarak öğrenciler;

6.1. Maddenin dört hâlinde yapı taşı olan türleri ve bunların yerleşim düzenini karşılaştırır.

6.2. Hâl değişim olayları ile ısı alış verişi arasında ilişki kurar.

6.3. Katı hâlden gaz hâle kadar ısıtma/soğutma süreçlerini gösteren grafikler üzerinde erime- donma, buharlaşma-yoğuşma, kaynama ve yalnızca ısınma olaylarının yer aldığı bölgeleri ayırt eder.

6.4. Kapalı kaplarda buharlaşma-yoğuşma süreçleri üzerinden denge buhar basıncını ve normal kaynama noktasını açıklar.

6.5. Kaynama sıcaklığı ile coğrafi irtifa ve dış basınç arasında ilişki kurar.

6.6. Denge buhar basıncı üzerinden bağıl nem ile ilgili problemleri çözer.

6.7. Buharlaşma hızını etkileyen faktörleri açıklar.

7. Katılar ile ilgili olarak öğrenciler;

7.1. Amorf ve kristal katılar arasındaki farkı örnekleriyle açıklar.

7.2. Kristalleri, örgüde yer alan türlere gore sınıflandırır.

7.3. Kristallerin fiziksel özellikleri ile örgüde yer alan bağ türleri arasında ilişki kurar.

APPENDIX C

CONCEPT LIST FOR STATES OF MATTER SUBJECT

Ünitede Önerilen Konu Başlıkları	**Suggested Subject Titles**
1. Gazların Genel Özellikleri **2.** Gaz Kanunları **3.** Gaz Karışımları **4.** Gerçek Gazlar **5.** Sıvıların Özellikleri **6.** Hâl değişimleri **7.** Amorf ve Kristal Katılar	**1.** General properties of gases **2.** Gas Laws **3.** Gas Mixtures **4.** Real Gases **5.** Properties of liquids **6.** Phase changes **7.** Amorphous and crystal solids
Ünitenin Kavram Listesi	**Concept List**
• Kinetik Teori • İdeal gaz • Gerçek gaz • Mutlak sıcaklık • Standart koşul • Kısmi basınç • Kısmi hacim • Difüzyon • Gazların sıvılaştırılması • Yüzey gerilimi • Akışkanlık • Viskozite • Adhezyon • Kohezyon • Kapilarite • Yüzey aktif madde • Denge buhar basıncı • Bağıl nem • Amorf katı • Kristal katı	• Kinetic Theory • Ideal Gas • Real Gas • Absolute Temperature • Standard condition • Partial pressure • Partial volume • Diffusion • Liquefaction of gases • Surface tension • Fluidity • Viscosity • Adhesion • Cohesion • Capillarity • Surface active substance • Equilibrium vapor pressure • Relative humidity • Amorphous solid • Crystal solid

APPENDIX D

TABLE of SPECIFICATION

for

THE OBJECTIVES STATED in CHEMISTRY CURRICULUM

	Questions	Knowledge	Comprehension	Application	Analysis	Synthesis	Evaluation
Gazların genel özellikleri	1, 2, 3, 6, 7, 12, 13, 26	1.3	1.4		1.1		1.2
Gaz kanunları	8, 9, 10, 11, 23, 24		2.1, 2.2, 2.3	2.4, 2.5			
Gaz karışımları	4	3.1		3.2			
Gerçek gazlar	14		4.4, 4.5, 4.6	4.3	4.2		4.1
Sıvılar	15, 16		5.2, 5.3, 5.5, 5.7, 5.8	5.4, 5.6	5.1		
Hal değişimleri	17, 18, 19, 20, 25, 27		6.4, 6.7	6.2, 6.5, 6.6	6.1, 6.3		
Katılar	21, 22		7.1	7.3	7.2		

APPENDIX E

STATES OF MATTER ACHIEVEMENT TEST

MADDENİN HALLERİ TESTİ

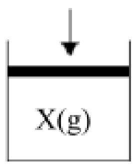
Sevgili Öğrenciler;
Aşağıda maddenin halleri konusu ile ilgili sorulardan oluşan bir test bulunmaktadır. Lütfen soruları dikkatli bir şekilde okuduktan sonra uygun gördüğünüz seçeneği işaretleyiniz. Cevaplarınız gizli tutulacak ve yalnızca araştırma amaçlı kullanılacaktır. Katkınız için teşekkür ederim.

Ad-soyad:	Cinsiyet: Kız □ Erkek □
Sınıf:	Okul Adı:

1. Gazlarla ilgili aşağıdakilerden hangisi doğrudur?

A) Gaz basıncı aşağı doğrudur.
B) Gaz halden sıvı ya da katı hale geçerken tanecikler küçülürler.
C) Gaz tanecikleri arasında yok denecek kadar az çekim kuvveti vardır.
D) Gazlar molekül ağırlıklarına göre farklı hacimler kaplarlar.
E) Gaz basıncı, gaz taneciklerinin içerdiği atom sayısına ve cinsine bağlıdır.

2. Sabit sıcaklıkta, ideal davranıştaki X gazı pistonlu bir kabın içine konuluyor ve piston itilerek sıkıştırılıyor. Sıkıştırma işlemi sonunda bu gaz ile ilgili aşağıdaki yargılardan hangisi yanlıştır?



A) Basıncı artar.
B) Tanecikler arası uzaklık azalır.
C) Birim hacimdeki tanecik sayısı artar.
D) Taneciklerin ortalama hızı azalır.
E) Taneciklerin sayısı değişmez.

3. Gaz hâldeki bir madde ile dolu kapalı bir kap ısıtıldığında kap içindeki basıncın arttığı gözleniyor. Aşağıdakilerden hangisinde bu olayın sebebi en doğru şekilde açıklanmıştır?

A) Gaz hâldeki maddenin taneciklerinin büyümesi
B) Gaz hâldeki maddenin taneciklerinin ısındıkça sayısının artması
C) Isı alan gaz hâldeki maddenin ağırlaşması
D) Isı alan gaz hâldeki maddenin taneciklerinin çarpma sayısının artması
E) Isı alan gaz hâldeki maddenin taneciklerinin kabın çeperlerinde yoğunlaşması

4. Eşit kütledeki He ve CH_4 gazlarının oluşturduğu bir karışımın toplam basıncı 25P olduğuna göre, He gazının kısmi basıncı kaç P dir? (H: 1, He: 4, C: 12)

A) 3P B) 5P C) 10P D) 12P E)20P

5. Bir dağa tırmanırken yükseklik arttıkça aşağıdakilerden hangisinin gerçekleşmesi beklenir?

A) Basınç artar.
B) Sıcaklık azalır.
C) Oksijen moleküllerinin sayısı artar.
D) Belli miktardaki havanın hacmi azalır.

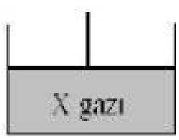
6.

Sabit sıcaklık ve basınçta, içinde hava bulunan 1.durumdaki şırınganın pistonu bir miktar itilerek içindeki hava sıkıştırılıp 2.duruma getirilmektedir. Sıkıştırma sonucunda havayı oluşturan tanecikler için aşağıdaki ifadelerden hangisi doğrudur?

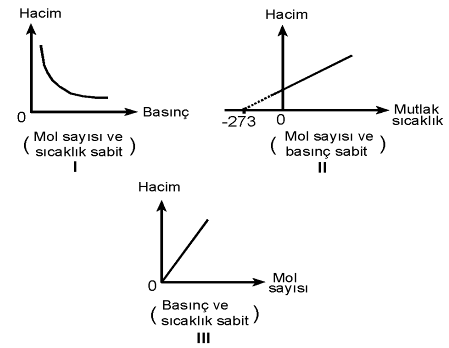
A) Tanecikler birbirine yapışır.
B) Taneciklerin hepsi şırınganın ucuna toplanır.
C) Tanecikler küçülür.
D) Tanecikler arasındaki ortalama uzaklık azalır.
E) Tanecikler yüksek basınçtan dolayı patlar.

7. Şekilde görülen pistonlu kapta bulunan X gazının aşağıda verilen özellikleri, sıcaklık artırılırsa nasıl değişir?

	Hacim	*Basıncı*	*Moleküllerin Ortalama Kinetik enerjisi*
A)	Artar	Artar	Artar
B)	Artar	Değişmez	Artar
C)	Azalır	Azalır	Azalır
D)	Azalır	Artar	Değişmez
E)	Artar	Değişmez	Değişmez



8. Gazların hacmi ile ilgili üç grafik şöyledir:



İdeal davranıştaki gazlar için bu grafiklerden hangileri doğrudur?

A) Yalnız I B) Yalnız II C) I ve II

D) I ve III E) II ve III

9. 8 gram CH_4 gazının 127 ^0C ve 4,1 atm basınçta hacmi kaç litredir? (CH_4: 16, R: 0,082)

A) 2 B) 4 C) 6 D) 8 E)10

10.Belli miktardaki H_2, O_2, N_2 gazları aşağıdaki tabloda I ile gösterilen başlangıç sıcaklığından, II ile gösterilen sıcaklığa ulaşana kadar ayrı ayrı ısıtılmaktadır.

	Sıcaklık (°C)	
Gaz	I	II
H_2	50	100
O_2	100	373
N_2	0	273

Isıtma işlemi sonunda bu gazlarda meydana gelecek değişimlerle ilgili aşağıdaki ifadelerden hangisi doğrudur?
(Gazlar ideal davranışta kabul edilecektir.)

A) Sabit basınçta H_2 ve O_2nin hacimleri iki katına çıkar.
B) Sabit basınçta yalnız N_2nin hacmi iki katına çıkar.
C) Sabit hacimde yalnız O_2nin basıncı iki katına çıkar.
D) Sabit hacimde yalnız H_2nin basıncı iki katına çıkar.
E) Her üçünün de moleküllerinin ortalama hızları aynı oranda artar.

11. Tabloyu en iyi şekilde dolduran değerler hangileridir?

Basınç	Hacim	Sıcaklık	Mol
0.5 atm	22.4 L	0 ^{0}C	0.5 mol
0.5 atm	22.4 L	273 ^{0}C	0.25 mol
1.0 atm	44.8 L	0 ^{0}C	2.0 mol
1.0 atm	?	273 ^{0}C	?

A) 44.8 L, 4.0 mol
B) 44.8 L, 0.5 mol
C) 22.4 L, 0.5 mol
D) 22.4 L, 1.0 mol
E) 22.4 L, 2.0 mol

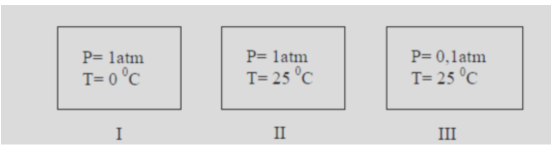
12. Normal koşullarda hacmi 2 litre olan kapalı bir kaba 1 litre helyum ve 1 litre azot gazları konulduğunda, bu kaptaki helyum ve azot gazlarının hacimleri hakkında aşağıdakilerden hangisi doğrudur? (Gazlar arasında kimyasal tepkime gerçekleşmemektedir.)

A) Her iki gazın hacmi de birer litredir.
B) Her iki gaz da ikişer litre hacim kaplar.
C) Gazların hacimleri kapta bulunan gazların taneciklerinin sayıları ile orantılıdır.
D) Azotun moleküler ağırlığı daha fazla olduğu için azot daha çok hacim kaplar.
E) Helyum ve azot gazlarının kimyasal özelliklerine bağlıdır.

13. He atomlarının balonun iç çeperlerine çarpmasıyla oluşan kuvvete ne denir?

A) Isı B) Basınç C) Sıcaklık
D) Hacim E) Mutlak sıcaklık

14.Asağıdaki kapların üçünde de H_2 gazı bulunmaktadır. Bu gazlar ideal gaz davranışına yakınlığına göre nasıl dizilir?



A) I < II < III B) III < II < I C) II < III < I
D) II < I < III E) I < III < II

15. Aşağıda verilen örneklerden hangisi viskozitenin gündelik hayattaki kullanım alanları ile ilgili değildir?

A) Yollara asfalt dökülürken ziftin ısıtılması
B) Çorbalara kıvam arttırıcı eklenmesi
C) Reçelin sıcakken kavanozlara doldurulması
D) Etin pişirilmeden önce sosa bulanması
E) Süte nişasta katılarak muhallebi yapılması

16. Bir sıvının yüzey gerilimini aşağıdaki etmenlerden hangisi değiştirmez?

A) Sıvıya yüzey aktif bir madde eklemek
B) Sıvıyı ısıtmak
C) Sıvıyı soğutmak
D) Sıvıya içinde çözünebilen başka bir sıvı eklemek
E) Sıvının hacmini değiştirmek

17. Sabit sıcaklıkta, bir maddenin katı hâlden sıvı hâle, sıvı hâlden gaz hâle geçtikçe, taneciklerinin aşağıda verilen özelliklerinden hangisi ya da hangileri değişir?

I. Büyüklüğü
II. Kinetik enerjileri
III.Tanecikler arasındaki ortalama uzaklık

A) Yalnız I B) Yalnız II C) Yalnız III
D) I ve III E) I, II ve III

18. Bir parfüm ya da kolonya şişesinin ağzını açtığımızda, belli bir süre sonra kokusu bütün odayı kaplar.

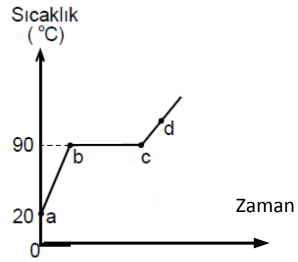
Meydana gelen bu olayı aşağıdaki ifadelerden hangisi en iyi şekilde tanımlar?

A) Kaynama B) Difüzyon C) Çözünme
D) Yoğunlaşma E) Donma

19. Bazı katılar, hal değişimi sırasında, sıvılaşmadan gaz haline geçebilir. Böyle bir hal değişimi ile ilgili aşağıdaki ifadelerden hangisi <u>yanlıştır</u>?

A) Fiziksel bir olaydır.
B) Süblimleşme olayıdır.
C) Taneciklerin düzensizliği artar.
D) Taneciklerin toplam enerjisi değişmez.
E) Tanecikler arası çekim kuvvetleri azalır.

20. Aşağıda, *sıvı hâldeki* bir miktar X bileşiğinin ısıtılmasıyla ilgili sıcaklık-zaman grafiği verilmiştir. Bu grafiğe göre X bileşiğiyle ilgili aşağıdaki ifadelerden hangisi <u>yanlıştır</u>?



A) a-b aralığında (a dan b ye doğru) taneciklerinin ortalama kinetik enerjileri artar.
B) b de kaynamaya başlar.
C) b-c aralığında (b den c ye doğru) taneciklerinin potansiyel enerjileri artar.
D) c den sonra gaz hâlindedir.
E) d de tanecikleri arasındaki uzaklık a dakinden daha azdır.

21. Katılarla ilgili aşağıdaki ifadelerden hangisi doğrudur?

A) Metalik katılar düşük erime ve kaynama noktasına sahiptirler.
B) Katıların molekülleri, atomları ya da iyonları arasındaki çekim kuvvetleri düşüktür.
C) Amorf katılar düzensiz, kristal yapılı katılar düzenli molekül yapısına sahiptirler.
D) İyonik katılar kolay şekil alırlar ve erime noktaları düşüktür.
E) Moleküler katılar sert ve kırılgandırlar ve düşük erime noktasına sahiptirler.

22. CaO bileşiği hangi tür katıya örnektir?

A) Amorf B) Metalik C) Kovalent

D) İyonik E) Moleküler

23. 1 atm basınçta hidrojen gazı ile doldurulan meteoroloji balonunun hacmi 150 L'dir. Balon, basıncın 0,75 atm olduğu 2500 m yüksekliğe ulaştığı zaman, bu yükseklikte sıcaklığın sabit kaldığı kabul edilirse balonun hacmi ne olur?

A) 100 B) 180 C) 200 D) 220 E) 400

24. Aşağıdakilerden hangisinin sıfır Kelvin'de (0 K) geçekleştiği varsayılır?

A) Tanecikler en hızlı hallerine ulaşır.
B) Karbondioksit gaz halden katı hale geçer.
C) Gazların hacmi sıfır olur.
D) Su sıvı halden katı hale geçer.
E) Madde yok olur.

25. Yağmur yağdığında hangi hal değişimi gerçekleşir?

A)Buharlaşma B) Yoğunlaşma C)Süblimleşme

D) Donma E) Erime

26. He ile dolu bir balon atmosferde yükseldikçe, balonun çapı artar. Balonun hacmindeki bu değişikliğin sebebi nedir?

A) Atmosferik basıncın azalması
B) Sıcaklığın azalması
C) Balonun içine hava girmesi
D) He atomlarının büyümesi
E) Sıcaklığın artması

27. Bir havuzdaki suyun buharlaşma hızı;

A) Sadece suyun sıcaklığına bağlıdır.
B) Sadece havanın sıcaklığına bağlıdır.
C) Su kaynamıyorsa sıfırdır.
D) Her zaman sıfırdan büyüktür.
E) Havuzun büyüklüğüyle ilgisi yoktur.

28. Bir gaz karışımının toplam basıncı ile karışımı oluşturan gazların kısmi basınçları arasındaki ilişki nedir?

A) Her birinin kısmi basıncı toplam basınca eşittir.
B) Kısmı basınçların toplamı gaz karışımının toplam basıncına eşittir.
C) Kısmi basınçların çarpımı gaz karışımının toplam basıncına eşittir.
D) Bu ilişki karışımın içeriğine göre değişir.
E) Bu ilişki gaz karışımını oluşturan gazların mol sayılarından bağımsızdır.

29. 1 atm basınçta bir voleybol topunun hacmi 2.3 L'dir. Sıcaklığın sabit olduğu düşünüldüğünde, topun 1.7 atm basınçtaki hacmini bulmak için hangi gaz kanununu kullanırsınız?

A. $P_1V_1 = P_2V_2$

B. $P_1V_1T_1 = P_2V_2T_2$

C. $\frac{V_1}{T_1} = \frac{V_2}{T_2}$

D. $PV = nRT$

30. Kinetik teoriye göre aşağıdakilerden hangisi tüm gazlar için doğrudur?

A) Gaz tanecikleri her zaman hareket halindedir.
B) Bir gazdaki tüm tanecikler aynı hızda hareket eder.
C) Gaz tanecikleri birbirleriyle çarpışmaz, kabın çeperleriyle çarpışır.
D) Gaz tanecikleri yer çekiminden dolayı aşağı doğru hareket etme eğilimindedir.

APPENDIX F

SCORING KEY FOR STATES OF MATTER ACHIEVEMENT TEST

1	C	**11**	C	**21**	C
2	D	**12**	B	**22**	D
3	D	**13**	B	**23**	C
4	E	**14**	A	**24**	C
5	B	**15**	D	**25**	B
6	D	**16**	E	**26**	A
7	B	**17**	C	**27**	D
8	D	**18**	B	**28**	B
9	B	**19**	D	**29**	B
10	B	**20**	E	**30**	A
				31	A

APPENDIX G

ITEMAN OUTPUT FOR THE STATES OF MATTER ACHIEVEMENT TEST

MicroCAT (tm) Testing System

Item and Test Analysis Program -- ITEMAN (tm) Version 3.00

Item analysis for data from file sunar.dat Page 1

		Item Statistics			Alternative Statistics				
Seq. No.	Scale -Item	Prop. Correct	Biser.	Point Biser.	Alt.	Prop. Endorsing	Biser.	Point Biser.	Key
1	1-1	0.718	0.565	0.424	1	0.040	-0.608	-0.268	
					2	0.067	-0.389	-0.202	
					3	0.718	0.565	0.424	*
					4	0.020	-0.513	-0.178	
					5	0.128	-0.231	-0.144	
					Other	0.027	-0.232	-0.089	
2	1-2	0.638	0.447	0.349	1	0.134	-0.072	-0.046	
					2	0.074	-0.483	-0.259	
					3	0.134	-0.365	-0.232	
					4	0.638	0.447	0.349	*
					5	0.013	-0.590	-0.177	
					Other	0.007	0.782	0.180	
3	1-3	0.832	0.748	0.502	1	0.013	-0.590	-0.177	
					2	0.034	-0.477	-0.198	
					3	0.027	-0.477	-0.183	
					4	0.832	0.748	0.502	*
					5	0.081	-0.548	-0.301	
					Other	0.013	-0.590	-0.177	
4	1-4	0.262	0.585	0.433	1	0.020	-0.116	-0.040	
					2	0.470	-0.168	-0.134	
					3	0.081	-0.290	-0.159	
					4	0.074	-0.217	-0.116	
					5	0.262	0.585	0.433	*
					Other	0.094	-0.264	-0.152	
5	1-5	0.752	0.215	0.158	1	0.114	-0.294	-0.179	
					2	0.752	0.215	0.158	*
					3	0.040	-0.242	-0.107	
					4	0.087	0.020	0.011	
					Other	0.007	0.341	0.078	
6	1-6	0.839	0.574	0.382	1	0.034	-0.570	-0.236	
					2	0.054	-0.290	-0.140	
					3	0.040	-0.449	-0.198	
					4	0.839	0.574	0.382	*
					5	0.027	-0.344	-0.132	
					Other	0.007	-0.321	-0.074	

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Item analysis for data from file sunar.dat Page 2

		Item Statistics			Alternative Statistics				
Seq. No.	Scale -Item	Prop. Correct	Biser.	Point Biser.	Alt.	Prop. Endorsing	Biser.	Point Biser.	Key
7	1-7	0.268	0.475	0.353	1	0.550	-0.205	-0.163	
					2	0.268	0.475	0.353	*
					3	0.054	-0.504	-0.244	
					4	0.087	-0.128	-0.072	
					5	0.034	0.133	0.055	
					Other	0.007	-0.541	-0.124	
8	1-8	0.195	0.418	0.291	1	0.027	0.146	0.056	
					2	0.208	-0.136	-0.096	
					3	0.208	-0.049	-0.035	
					4	0.195	0.418	0.291	*
					5	0.275	-0.066	-0.049	
					Other	0.087	-0.311	-0.175	
9	1-9	0.510	0.642	0.512	1	0.047	-0.078	-0.036	
					2	0.510	0.642	0.512	*
					3	0.101	-0.254	-0.149	
					4	0.067	-0.346	-0.180	
					5	0.148	-0.197	-0.128	
					Other	0.128	-0.541	-0.339	
10	1-10	0.376	0.479	0.375	1	0.087	-0.232	-0.131	
					2	0.376	0.479	0.375	*
					3	0.060	-0.499	-0.251	
					4	0.383	-0.129	-0.101	
					5	0.074	-0.177	-0.095	
					Other	0.020	-0.229	-0.079	
11	1-11	0.154	0.254	0.167	1	0.322	-0.179	-0.137	
					2	0.322	0.072	0.055	
					3	0.154	0.254	0.167	*
					4	0.107	0.069	0.041	
					5	0.034	0.003	0.001	
					Other	0.060	-0.291	-0.146	
12	1-12	0.255	0.401	0.295	1	0.148	0.114	0.074	
					2	0.255	0.401	0.295	*
					3	0.174	-0.244	-0.165	
					4	0.221	0.116	0.083	
					5	0.128	-0.343	-0.215	
					Other	0.074	-0.395	-0.211	

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Item analysis for data from file sunar.dat

		Item Statistics			Alternative Statistics				
Seq. No.	Scale -Item	Prop. Correct	Biser.	Point Biser.	Alt.	Prop. Endorsing	Biser.	Point Biser.	Key
13	1-13	0.879	0.532	0.328	1	0.040	-0.512	-0.226	
					2	0.879	0.532	0.328	*
					3	0.034	-0.403	-0.167	
					4	0.013	-0.069	-0.021	
					5	0.013	0.011	0.003	
					Other	0.020	-0.626	-0.217	
14	1-14	0.295	0.336	0.254	1	0.295	0.336	0.254	*
					2	0.329	-0.060	-0.046	
					3	0.114	-0.015	-0.009	
					4	0.107	-0.148	-0.088	
					5	0.060	-0.233	-0.117	
					Other	0.094	-0.215	-0.123	
15	1-15	0.617	0.415	0.326	1	0.081	-0.188	-0.103	
					2	0.074	-0.237	-0.127	
					3	0.107	-0.193	-0.115	
					4	0.617	0.415	0.326	*
					5	0.081	-0.216	-0.118	
					Other	0.040	-0.337	-0.149	
16	1-16	0.799	0.721	0.505	1	0.040	-0.528	-0.233	
					2	0.034	-0.551	-0.228	
					3	0.060	-0.383	-0.193	
					4	0.047	-0.359	-0.167	
					5	0.799	0.721	0.505	*
					Other	0.020	-0.711	-0.246	
17	1-17	0.349	0.347	0.270	1	0.027	-0.588	-0.226	
					2	0.020	-0.598	-0.207	
					3	0.349	0.347	0.270	*
					4	0.067	-0.219	-0.114	
					5	0.503	-0.049	-0.039	
					Other	0.034	-0.200	-0.083	
18	1-18	0.852	0.496	0.323	1	0.034	-0.311	-0.129	
					2	0.852	0.496	0.323	*
					3	0.047	-0.514	-0.238	
					4	0.054	-0.277	-0.134	
					5	0.000	-9.000	-9.000	
					Other	0.013	-0.310	-0.093	

Item and Test Analysis Program -- ITEMAN (tm) Version 3.00

Item analysis for data from file sunar.dat

		Item Statistics			Alternative Statistics				
Seq. No.	Scale -Item	Prop. Correct	Biser.	Point Biser.	Alt.	Prop. Endorsing	Biser.	Point Biser.	Key
19	1-19	0.792	0.420	0.297	1	0.054	-0.290	-0.140	
					2	0.087	-0.102	-0.057	
					3	0.020	-0.286	-0.099	
					4	0.792	0.420	0.297	*
					5	0.034	-0.459	-0.190	
					Other	0.013	-0.711	-0.213	
20	1-20	0.497	0.575	0.459	1	0.034	-0.292	-0.121	
					2	0.141	-0.041	-0.026	
					3	0.242	-0.496	-0.361	
					4	0.074	-0.168	-0.090	
					5	0.497	0.575	0.459	*
					Other	0.013	-0.590	-0.177	
21	1-21	0.617	0.491	0.385	1	0.067	-0.548	-0.285	
					2	0.101	-0.262	-0.153	
					3	0.617	0.491	0.385	*
					4	0.074	-0.247	-0.132	
					5	0.087	-0.041	-0.023	
					Other	0.054	-0.264	-0.128	
22	1-22	0.483	0.429	0.342	1	0.181	-0.135	-0.092	
					2	0.081	-0.317	-0.174	
					3	0.128	-0.072	-0.045	
					4	0.483	0.429	0.342	*
					5	0.074	-0.325	-0.174	
					Other	0.054	-0.252	-0.122	
23	1-23	0.537	0.733	0.584	1	0.067	-0.166	-0.086	
					2	0.067	-0.527	-0.274	
					3	0.537	0.733	0.584	*
					4	0.161	-0.162	-0.108	
					5	0.020	-0.343	-0.119	
					Other	0.148	-0.628	-0.408	
24	1-24	0.309	0.315	0.240	1	0.161	-0.224	-0.149	
					2	0.181	0.143	0.097	
					3	0.309	0.315	0.240	*
					4	0.188	-0.021	-0.015	
					5	0.101	-0.238	-0.140	
					Other	0.060	-0.383	-0.193	

		Item Statistics			Alternative Statistics				
Seq. No.	Scale -Item	Prop. Correct	Biser.	Point Biser.	Alt.	Prop. Endorsing	Biser.	Point Biser.	Key
25	1-25	0.705	0.527	0.399	1	0.195	-0.183	-0.127	
					2	0.705	0.527	0.399	*
					3	0.060	-0.741	-0.372	
					4	0.007	-0.321	-0.074	
					5	0.027	-0.544	-0.209	
					Other	0.007	-0.174	-0.040	
26	1-26	0.604	0.743	0.585	1	0.604	0.743	0.585	*
					2	0.121	-0.292	-0.180	
					3	0.081	-0.548	-0.301	
					4	0.087	-0.406	-0.228	
					5	0.081	-0.354	-0.194	
					Other	0.027	-0.455	-0.175	
27	1-27	0.456	0.447	0.356	1	0.188	-0.349	-0.241	
					2	0.121	-0.196	-0.121	
					3	0.060	0.055	0.027	
					4	0.456	0.447	0.356	*
					5	0.154	-0.089	-0.059	
					Other	0.020	-0.598	-0.207	
28	1-28	0.383	0.316	0.248	1	0.255	0.083	0.061	
					2	0.383	0.316	0.248	*
					3	0.094	-0.256	-0.147	
					4	0.121	-0.216	-0.133	
					5	0.087	-0.198	-0.111	
					Other	0.060	-0.245	-0.123	
29	1-29	0.799	0.652	0.457	1	0.799	0.652	0.457	*
					2	0.047	-0.359	-0.167	
					3	0.054	-0.467	-0.226	
					4	0.074	-0.424	-0.227	
					5	0.000	-9.000	-9.000	
					Other	0.027	-0.611	-0.234	
30	1-30	0.591	0.345	0.273	1	0.591	0.345	0.273	*
					2	0.094	-0.149	-0.085	
					3	0.134	-0.193	-0.122	
					4	0.161	-0.190	-0.127	
					Other	0.020	-0.428	-0.148	

```
                     MicroCAT (tm) Testing System
Copyright (c) 1982, 1984, 1986, 1988 by Assessment Systems Corporation

       Item and Test Analysis Program -- ITEMAN (tm) Version 3.00

Item analysis for data from file sunar.dat                       Page  6


There were 149 examinees in the data file.


Scale Statistics
----------------

  Scale:          1
               -------
N of Items        30
N of Examinees   149
Mean          16.362
Variance      23.654
Std. Dev.      4.864
Skew           0.092
Kurtosis      -0.717
Minimum        6.000
Maximum       28.000
Median        16.000
Alpha          0.772
SEM            2.324
Mean P         0.545
Mean Item-Tot. 0.362
Mean Biserial  0.488
```

APPENDIX H

AFFECTIVE CHARACTERISTICS SCALE

Kimya Tutum Ölçeği

Bu anket sizin kimya ve kimya dersleri hakkındaki görüşlerinizi öğrenmek için geliştirilmiştir. İçeriğinde kimya ve kimya dersine yönelik sorular bulunmaktadır. Cevaplarınız önümüzdeki yıllarda kimya derslerinin sizin görüşleriniz doğrultusunda şekillenmesine katkıda bulunabileceğinden dolayı önem taşımaktadır. Lütfen bütün soruları yanıtlayınız. İsimleriniz verileri eşlemekte kullanılacağından yazılması gereklidir. Araştırmada toplanılan tüm bilgiler ve katılımcıların isimleri kesinlikle gizli tutulacaktır ve ders notlarına etki etmeyecektir.

Teşekkürler...

Adınız-Soyadınız:	
Sınıfınız:	
Okulunuz:	
Cinsiyetiniz:	**K:** □ **E:**□

		Kesinlikle katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Kesinlikle katılmıyorum
1.	Bu dönem kimya dersi eğlencelidir.					
2.	Bu dönem kimya dersini ilgi çekici buluyorum.					
3.	Bu dönem kimya dersine girmek için can atıyorum.					
4.	Bu dönem kimya dersi sıkıcıdır.					
5.	Bu dönem kimya dersinde öğrendiklerimizin gerçek hayatta kullanılmayacağını düşünüyorum.					
6.	Bu dönem kimya dersinde öğrendiğim şeyleri bir daha kullanmayacağım için bu derse ihtiyacım olmadığını düşünüyorum.					
7.	Kimya derslerini severim.					
8.	Kimya derslerine karşı olumlu hislerim vardır.					
9.	Benim için kimya dersleri eğlencelidir.					
10.	(Okulda) kimya çalışmaktan hoşlanırım.					
11.	Bugüne kadar aldığım bütün kimya dersleri sıkıcıdır.					
12.	Kimya becerilerimi geliştirmek istiyorum.					

		Kesinlikle katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Kesinlikle katılmıyorum
13.	Kimya ile ilgili daha çok şey öğrenmek istiyorum.					
14.	Zorunlu kimya dersi dışında seçmeli kimya dersleri de almak istiyorum.					
15.	Eğitim hayatım boyunca alabildiğim kadar çok kimya dersi almak istiyorum.					
16.	Herkesin kimya öğrenmesi gerektiğini düşünüyorum.					
17.	Kimyanın ilerdeki meslek hayatımda önemli bir yeri olacağını düşünüyorum.					
18.	Kimya dersinde öğrendiklerimin günlük hayatta işime yarayacağını düşünüyorum.					
19.	Kimya derslerinin zekayı geliştirmeye yararı olacağını düşünüyorum.					
20.	Kimya dersinde öğrendiklerimin hayatımı kolaylaştıracağını düşünüyorum.					
21.	Kimyanın, gelecekte gittikçe önemi artan bir alan olacağını düşünüyorum.					
22.	Kimya derslerinin, ilerdeki çalışmalarımda bana yararlı olacağını düşünüyorum.					
23.	Günlük hayattaki kimya ile ilgili konuları okumaktan hoşlanırım.					
24.	Kimya ile ilgili kitaplar okumaktan hoşlanırım.					
25.	Bana hediye olarak bir kimya kitabı veya kimyayla ilgili nesneler verilmesi hoşuma gider.					
26.	Kimya ile ilgili kafama bir şey takılınca; bir ders kitabı, ansiklopedi, vb' ye başvurmaktan hoşlanırım.					
27.	Okulumuzda kimya topluluğu olsaydı üye olmak isterdim.					
28.	Kimya ile ilgili televizyon programlarını izlemekten hoşlanırım.					
29.	Arkadaşlarla kimya ile ilgili meseleleri konuşmaktan hoşlanırım.					
30.	Yakın bir zamanda olacağım bir kimya sınavını düşünmek beni kaygılandırır.					
31.	Kimya dersinde sınav olmak beni kaygılandırır.					
32.	Kimya sınavları beni korkutur.					
33.	Kimya sınavına çalışmak beni kaygılandırır.					
34.	Kimya sınavları kendimi sinirli hissetmeme sebep olur.					
35.	Kimya dersinde kendimi gergin hissederim.					
36.	Kimya dersine girmek beni kaygılandırır.					
37.	Kimya dersi, kendimi tedirgin ve şaşkın hissetmeme neden olur.					

		Kesinlikle katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Kesinlikle katılmıyorum
38.	Kimya çalışmak, kendimi ormanda kaybolmuş gibi hissetmeme neden olur.					
39.	Kimya dersiyle uğraşmak zorunda olmak beni dehşete düşürür.					
40.	Kimya dersinde iyi notlar alma yeteneğine sahibim.					
41.	Kimya dersindeki yeteneğimle gurur duyarım.					
42.	Kimya dersindeki çalışmalarım beni tatmin eder.					
43.	Kimya dersindeki başarılarımla gurur duyarım.					
44.	Kimya dersinde, kendimi sınıfımdaki diğer kişiler kadar başarılı hissederim.					
45.	Kimya dersinde başarılı olmak için elimden geleni yaparım.					
46.	Kimya dersinde elimden gelenin en iyisini yapmaya çalışırım.					
47.	Kimya dersinde başarısız olduğumda daha çok çabalarım.					
48.	Kimya dersinde yapılacak iş ne kadar zor olursa olsun, elimden geleni yaparım.					
49.	Kimya öğrenebileceğimden eminim.					
50.	Daha zor kimya problemleri ile başa çıkabileceğimden eminim.					
51.	Kimya dersinde başarılı olabileceğimi biliyorum.					
52.	Kimya dersinde zor işleri yapabileceğimden eminim.					
53.	Yeterince vaktim olursa en zor kimya problemlerini bile çözebileceğimden eminim.					

APPENDIX I

CLASSROOM OBSERVATION CHECKLIST

School and Classroom :…………………… …………………………..

Date :……………

	Questions	Yes	Partially	No
1.	Does the teacher start the lesson with the context or a question?			
2.	Are new concepts presented in contexts and experiences that are familiar to the students?			
3.	Are concepts in examples and student exercises presented in the context of their use?			
4.	Are new concepts presented in the context of what the student already knows?			
5.	Do examples and student exercises include many real, believable problem-solving situations that students can recognize as being important to their current or possible future lives?			
6.	Do examples and student exercises cultivate an attitude that says, "I need to learn this"?			
7.	Do students gather and analyse their own data as they are guided in discovery of the important concepts?			
8.	Are opportunities presented for students to gather and analyse their own data for exploration and extension?			
9.	Do lessons and activities encourage the student to apply concepts and information in useful contexts?			
10.	Are students expected to participate regularly in interactive groups where sharing, communicating, and responding to the important concepts and decision-making occur?			
11.	Do lessons, exercises, and labs improve students' reading and other communication skills in addition to scientific reasoning and achievement?			
12.	Do students follow their worksheets during the activities?			
13.	Do students read the student text before coming to the class?			
14.	Is it appropriate to call the lesson as "context-based"?			

APPENDIX J

RESOURCES USED FOR DEVELOPING CONTEXT-BASED MATERIALS

The resources that shed light on the development process of context-based materials are listed below:

- Stacy, A.M., (2010). *Living by chemistry*. Key Curriculum Press. Emeryville, Calif.
- Watt, F. & Wilson, F. (2010*), Hava ve İklim*. Ankara: TÜBİTAK Popüler Bilim Kitapları
- Bingham, J. (2010). *Bilimsel Deneyler*. Ankara: TÜBİTAK Popüler Bilim Kitapları
- Çelik, S. (2008). *İlköğretim Öğrencileri için Meteoroloji.* Retrieved fromhttp://www.mgm.gov.tr/cocuklar/kitap-meteoroloji.aspx
- Kılıç, A. (2008). *Herkes için Meteoroloji.* Retrieved from http://www.dask.org.tr/yararli_bilgiler/herkesicinmeteoroloji/
- http://www.fenokulu.net/portal/Sayfa.php?Git=KonuKategorileri&Sayfa=KonularKonuYazdir&KonuID=106
- http://www.weatherwizkids.com/
- http://kids.discovery.com/tell-me/curiosity-corner/weather

APPENDIX K

LIST OF MISCONCEPTIONS

- Gazların kütlesi yoktur.
- Taneciklerin boyutları katı halden sıvı hale, sıvı halden de gaz hale geçerken büyür.
- Taneciklerin boyutları gaz halden sıvı hale, sıvı halden de katı hale geçerken küçülür.
- Sıvılar buharlaşınca tanecikler yok olur.
- Hava maddenin hallerinden biridir.
- Gazlar görünmez taneciklerden oluşur.
- Temiz havada oksijenden başka gaz yoktur.
- Hava basıncı sadece aşağı doğrudur.
- Gazlar sıkıştırıldığında tanecikler birbirine yapışır.
- Hava taneciklerden oluşmamıştır, süreklilik gösteren bir yapısı vardır.
- Gazların hareketi sıvıların hareketi gibidir.
- Sıvılar her zaman gazlardan daha hafiftir.
- Gazlar bulundukları kabın tabanına yakın kısımlarda yer alır.
- Katı tanecikleri arasında hiç boşluk yoktur.
- Katı tanecikleri hareketsizdir.

APPENDIX L

SAMPLE TEACHER GUIDES

Üstümde bi ağırlık var!

Hava Basıncı

Temel Fikirler

Gazlar, temas ettikleri tüm yüzeylere basınç uygular. Çünkü gaz molekülleri sürekli hareket halindedir. Atmosferdeki gazlar, yani "Hava" da tüm yüzeylere olduğu gibi vücudumuza bir basınç uygular. Bu basınç **atmosfer basıncı** ya da **hava basıncı** olarak adlandırılır. Balıklar nasıl suyun basıncını hissetmiyorsa biz insanlar da etrafımızdaki havanın basıncını hissetmeyiz.

Bu dersin sonunda öğrenciler;

- Gazları nitelemek için gerekli büyüklükleri betimler.
- Gaz basıncını molekül hareketleri temelinde açıklar.
- Hava basıncına neyin sebep olduğunu açıklar.
- Basit hava basıncı hesaplamalarını gerçekleştirir.

Odak Noktası

Öğrenciler genellikle atmosferin vücudumuza uyguladığı basıncı hissetmedikleri için anlamakta zorluk çekmektedir. Bu basıncın varlığına kanıt görmeleri onların basınçla ilgili olguları anlamalarına yardımcı olacaktır.

Temel Kavramlar

Basınç, Atmosfer basıncı (hava basıncı), atm

İzlenecek Süreç

Öğrenciler hava basıncı ile ilgili gösteri deneylerine dâhil edilirler. Gözlemlerini not alırlar, çeşitli basınçları göstermek için şekiller çizerler ve arkadaşlarıyla fikir alışverişi yaparlar. Daha sonra her gösteri deneyi sınıf kapsamında tartışılır. Tartışmanın büyük kısmı yapılan aktivitelerle ilişkilendirilir. Son olarak, Basınç, Atmosfer basıncı (hava basıncı), atm kavramları genel olarak tanımlanır.

Materyaller

- Öğrenci çalışma yaprağı

Gösteri Deneyi Materyalleri

- Çeşitli balonlar
- 2 lt'lik plastik şişe
- 1 ya da 2 teneke meşrubat kutusu
- Isıtıcı
- Maşa
- Çeşitli büyüklükte beherler
- Şırınga

Hava Basıncı

Giriş (5 dakika)

Temel soru: Gazlar, temas ettikleri tüm yüzeylere basınç uygular. Çünkü gaz molekülleri sürekli hareket halindedir. Atmosferdeki gazlar, yani "Hava" da tüm yüzeylere olduğu gibi vücudumuza bir basınç uygular. Bu basınç **atmosfer basıncı** ya da **hava basıncı** olarak adlandırılır. Balıklar nasıl suyun basıncını hissetmiyorsa biz insanlar da etrafımızdaki havanın basıncını hissetmeyiz. Peki;

Gazların basınç uyguladığına dair ne gibi kanıtlarımız var?

Etkinlik: Bir balon kullanarak öğrencilere sorular yöneltilebilir.

Bir balonu şişirip elinizden bırakırsanız, sınıfın içinde uçar ve düşer.

1. Balonun içindeki gaz niye dışarı çıktı?
2. Balonun daha hızlı hareket etmesi için ne yapılabilir?
3. Bu etkinlik hava basıncının var olduğunu nasıl ispatlar?

Örnek Öğrenci Cevapları: 1. Bazı öğrenciler balonun ağzının açık olduğunu söylerken bazıları balonun içinde daha fazla basınç olduğunu söyleyebilir. 2. Balonun içine daha çok hava konulursa, daha hızlı hareket eder. 3. Bu etkinlikle hava moleküllerinin kütlesi olduğunu ve rüzgâr gibi basınç uyguladığını görebiliyoruz.

Tartışma Soruları

1. Balonu elinizden bıraktığınızda niye olduğu yerde kalmıyor?
2. Balon niye hızlı hareket ediyor? Bunu nasıl değiştirebiliriz?
3. Hava basıncının ne olduğunu düşünüyorsunuz? Bunu hava olayları ile ilişkilendirebilir misiniz?

Keşfetme (20-25 dk.)

- Öğrencileri de dâhil ederek gösteri deneylerini gerçekleştirin. Öğrenciler çalışma yapraklarını doldururken bireysel ya da ikişerli gruplar halinde çalışabilir.
- Bir sonraki bölümde 4 farklı gösteri deneyi detaylarıyla anlatılacaktır. Materyallerin ulaşılabilirliğine ve zaman planlamasına göre hepsini ya da bir kısmını tamamlayabilirsiniz.
- Her gösteri deneyinden sonra öğrencilerin açıklamalarını sorunuz. Öğrencilerin gözlemlerini not etmeleri ve çalışma yaprağındaki soruları cevaplayabilmeleri için zaman tanıyın. Öğrencilere her deneyde gözlemlediklerini açıklayabilmeleri için farklı bir kâğıda diyagramlar çizmelerini önerebilirsiniz.
- Öğrencilerden her kap için kabın iç çeperindeki ve dış çeperindeki basınçları göz önünde bulundurmalarını isteyebilirsiniz. Şekil üzerinde basıncın varlığını göstermek için okları kullanabilirler. Daha çok ok, daha fazla basınç anlamında kullanılabilir.

Deneyler

1. Şişedeki Balon

Not: Deneyi gerçekleştirecek her öğrenci için ayrı balon kullanılmalıdır.
2 litrelik bir pet şişenin içine balonu şekildeki gibi yerleştiriniz. Öğrencilerden balonu şişirmelerini isteyiniz. Bu aşamayı, bir öğrenciye normal balonu diğerine şişenin içindeki balonu şişirmesini söyleyerek eğlenceli bir yarış haline getirebilirsiniz.
Soru: Şişenin içindeki balonu şişirmek neden bu kadar zor?

2. Teneke Kutu

Boş bir teneke kutunun içine 5ml su koyunuz. Teneke kutunun ağzından buhar çıkana kadar kutuyu ısıtınız. Bir maşa yardımıyla, yarısına kadar su dolu bir kabın içine teneke kutuyu hızlıca ters çeviriniz. Kutunun aniden şekil değiştirdiğini göreceksiniz.
Soru: Kutudaki ani şekil değişikliğinin sebebi nedir?

3. Islanmayan Kâğıt

Büyük bir beherin üçte ikisini su ile doldurunuz. Bir parça kâğıdı buruşturun ve plastik bir bardağın dibine sıkıştırın. Bardağı ters çevirin, kâğıdın orda durduğundan emin olun. Bardağı ters çevirip su dolu kaba tamamen batırın. Bardağı olabildiğince dik tutmaya çalışın. Bardağı sudan çıkarın ve kâğıdın hala kuru olduğunu görün.
Soru: Kâğıt neden ıslanmadı?

4. Düşmeyen Kağıt

Plastik bir bardağı su ile doldurunuz. Ağzını sertçe bir kâğıtla kapatınız. Bardağı kâğıtla birlikte hızlı bir şekilde ters çeviriniz. Kâğıdın orda durduğunu ve suyun dökülmediğini gözlemleyiniz.
Soru: Kâğıt neden düşmedi?

Değerli Öğretmenim;

Aşağıdaki çalışma kâğıdındaki sorulara örnek öğrenci cevaplarını bulabilirsiniz:

Hava Basıncı

Amaç: Hava basıncı ile ilgili durumları gözlemlemek ve araştırmak

Yönerge: Her deney için gözlemlerinizi ve açıklamalarınızı aşağıdaki tabloda ilgili kısımlara yazınız.

Deney	Ne gözlemlediniz?	Açıklayınız.
Şişedeki Balon	*Şişenin içindeki balonu şişirmek daha zor.*	*Şişenin içinde daha fazla havanın girmesi için yer yok.*
Teneke Kutu	*Isıtılan teneke kutu soğutulduğunda şekil değiştiriyor.*	*Su önce buhara dönüştü, sonra tekrar sıvı hale geçince teneke kutuyu sıkıştırdı.*
Islanmayan Kağıt	*Kağıt ıslanmadı. Bardağı ters çevirince içinde hava kaldı.*	*Su kağıda hiç değmedi. Bardağın içindeki hava yer kapladığı için suyun yükselmesini engelledi.*
Düşmeyen Kağıt	*Kağıt üzerinde su olmasına rağmen düşmüyor.*	*Kağıdı yukarı doğru iten basınç aşağı doğru itenden daha büyük.*

Sorular

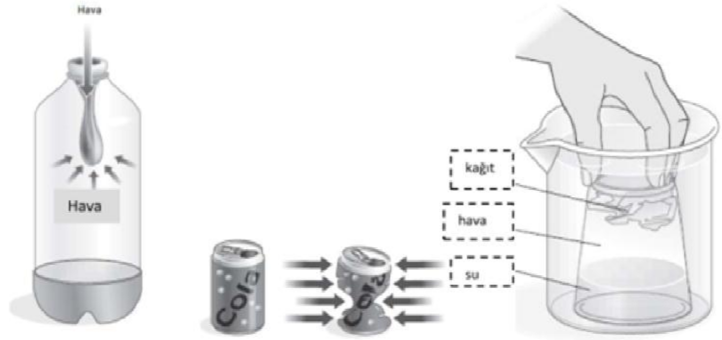
1. Deneyler hava basıncının var olduğunu nasıl kanıtlıyor?

2. Kendi cümlelerinizle hava basıncının ne olduğunu açıklayınız.

Açıklama ve Derinleştirme (10 dk)

Her bir deney hakkında tartışın.

- Deneylerin tekrar üzerinden geçin. Öğrencilere her deneyde ne olduğuyla ilgili fikirlerini sorun.
- Gruplar halinde öğrencilerden cisimlere etki eden hava basıncını oklarla şekiller üzerinde göstermelerini isteyiniz. Her grubun şeklini tahtada sınıfa göstererek doğruluğunu tartışınız.



Şişedeki balon Teneke Kutu Islanmayan kağıt

Temel kavramlar

Her deneyde hava bir yerlerde sıkışmış bulunmaktadır. Tüm deneylerde ya sıkışmış havanın basıncı değişmiş ya da havanın bulunduğu kabın dışına yapılan basınç değişmiştir.

- **Şişedeki balon:** Şişenin içinde zaten hava mevcuttur. Şişenin içindeki balonun içine hava üflerken, şişede var olan havayı itmeye çalışıyoruz.
- **Teneke kutu:** Teneke kutuyu ısıtmak içindeki suyun buhara dönüşmesine neden olur. Teneke kutuyu soğuk suda ters çevirince, kutunun açık olan ağzı tıkanır. Kutunun içindeki su buharı hızlıca soğur ve sıvı hale geri döner. Bu da kutunun içindeki hava basıncının aniden düşmesine neden olur. Kutunun şekli değişebilir çünkü bir anda kutunun dışındaki hava basıncı içindeki basınçtan çok büyük hale gelir.
- **Islanmayan kağıt:** Bardak suda ters çevrildiğinde, bardağın içinde hava vardır ve bu hava yer kaplamaktadır. Bunun sonucunda su bardağın içinde çok az ilerleyebilmektedir ve böylece kağıt kuru kalmaktadır.
- **Düşmeyen kağıt:** Kağıda yukarı doğru etki eden atmosferden kaynaklı hava basıncı kağıdın ve suyun ağırlığından daha fazladır. Böylece kağıt düşmeden durabilmektedir.

Hava Basıncını Tanımlama

Örnek Sorular

- Deneyler boyunca yaptığınız hangi gözlemler gazların yer kapladığına kanıt olarak gösterilebilir?
- Gazların sıkıştırılabilir olduğunu deneylerden örnekler vererek kanıtlayınız.
- Deneyler boyunca yaptığınız hangi gözlemler gazların basınç uyguladığına kanıt olarak gösterilebilir?

- Hava basıncı nedir, nasıl tanımlarsınız?

Temel Noktalar

Kinetik teoriye göre gaz molekülleri bulundukları kaba homojen olarak dağılırken hem birbirlerine hem de kabın çeperlerine çarparak çarptıkları yüzeye bir kuvvet uygulamış olurlar. Bu kuvvete **gaz basıncı** denir ve **P** ile gösterilir.

Basınç: Belli bir yüzeye uygulanan kuvvet

Basınç$=\frac{kuvvet}{alan}$

$P = \frac{F}{S}$

Bugünkü örneklerde de gördüğümüz gibi kapalı kaplardan bahsederken genellikle göz önünde bulundurmamız gereken 2 çeşit gaz basıncı vardır: kabın içindeki gazın basıncı ve kabın dışındaki atmosfer basıncı. İstisnasız bütün gazlar basınç uygular. Hava basıncıyla ilgili öğrendiğimiz her şey helyum, oksijen, flor gibi diğer gazlar için de geçerlidir.

Dünyamızı saran atmosfer bir gaz karışımıdır ve yeryüzüne basınç uygular. Biz atmosferi basitçe "hava" olarak adlandırırız. Aslında bu havanın vücudumuza uyguladığı sürekli bir basınç vardır. Üzerinizdeki havanın basıncını hissetmeseniz bile, havayı oluşturan gazların basıncı **atmosfer basıncı** olarak adlandırılır. Bu basınca o kadar alışmışızdır ki varlığını fark etmeyiz bile.

Atmosfer Basıncı: Atmosferde bulunan gaz moleküllerinin yeryüzünde bulunan cisimlerin birim yüzeylerine uyguladıkları kuvvete denir. Deniz seviyesinde ve 25°C'de atmosfer basıncı, 1.105 Pa (N/m^2) dır.

Değerlendirme (5 dakika)

Everest Dağı'na tırmanan bir dağcı, suyu pipet yardımıyla içmek isterse en kolay dağın zirvesinde mi yoksa eteklerinde mi içer?

Sıfırrrr .....bırrrrrrr

Sıcaklık, Kinetik Teori

Giriş (5 dakika)

Yeryüzünde ölçülmüş en soğuk derece -89^{0}C ile Antartika'da görülmüştür. Güneş'e daha uzak gezegenlerde daha da düşük sıcaklıklar gözlenmektedir. Araştırmacılar Neptün'ün uydularından birinin yüzey sıcaklığını -235 ^{0}C olarak ölçmüşlerdir. Peki;

Temel soru: Bir madde en fazla ne kadar soğuk olabilir?

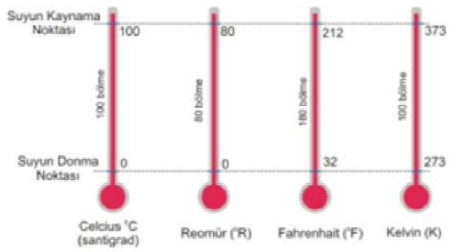
Araştırmacılar Neptün gezegeninin uydularından birindeki sıcaklığı -235^{0}C olarak ölçmüşlerdir.

1. Sizce karbondioksit bu sıcaklıkta hangi halde bulunur?
2. Sizce bir madde en çok hangi sıcaklığa kadar soğuyabilir?
3. Maddeler soğudukça tanecikleri birbirine yaklaşır mı, uzaklaşır mı?

Derse yukarıdaki örnekle başlayınız. 1. Soru için karbondioksitin donma sıcaklığını -57^{0}C olarak verebilirsiniz. 2. Soru için öğrencilerin cevaplarını tahtaya yazınız ve dersin sonunda doğru cevaba ulaşacaklarını belirtiniz.

Keşfetme (10 dk)

- Öğrenci metnindeki tanımlardan yararlanarak sıcaklık ve ısı kavramlarının üzerinden geçiniz.
- Termometrelerin çalışma prensibinden bahsediniz.
- Aşağıdaki şekle benzer bir şekli tahtaya çiziniz ve dereceleri birbirine dönüştürmeyi sağlayan eşitlikleri veriniz.



$K = {}^0C + 273$

$F = \frac{9}{5}{}^0C + 32$

- Öğrenci metninde yer alan aşağıdaki örneği öğrencilere yöneltiniz:

Örnek: Hava Tahmini

Japonya'da hava durumunu sunan spiker Tokyo şehri için sıcaklığın 30^{0}C, yağış ihtimalinin ise %60 olduğunu söylerken, Amerika'daki bir spiker Washington için sıcaklığın 50F, yağış ihtimalinin ise %70 olduğunu söylemektedir.

a. Hangi şehir daha ılık olacaktır? Sıcaklığı aynı ölçeğe çevirerek karar veriniz.

b. İki şehirde de yağışın gerçekleştiğini kabul edersek, yağış türü yağmur mu olur kar mı?

- ❖ Öğrencilere çalışma yapraklarını dağıtınız. Öğrencilerden ikili gruplar halinde çalışmalarını isteyiniz.

Açıklama ve Derinleştirme (10 dk)

Aşağıdaki sorular üzerinden ve öğrenci metninden yararlanarak gerekli açıklamaları yapınız.

- Bir maddenin hacmi eksi değer alabilir mi?
- Sizce Celsius derecesinde ulaşılabilecek en düşük sıcaklık nedir?
- Sizce bir maddenin mutlak sıcaklığa ulaşması mümkün müdür?
- Isıtılan bir maddenin tanecikleri nasıl hareket eder?

Araştırmacılar hacmin sıfır olduğu noktaya karşılık gelen sıcaklığı -273.15^{0}C olarak bulmuşlardır. Bilim insanları bu değerin gelinebilecek en soğuk derece olduğunu varsaymışlardır ve bu sıcaklığa "**mutlak sıcaklık**" ya da "**mutlak sıfır noktası**" denmektedir. Kelvin ölçeği başlangıç noktası olarak bu noktayı almıştır. Bu sıcaklıkta tanecik hareketlerinin bittiği düşünülmektedir. Gerçekte, sıcaklık düştükçe, bu sıcaklığa gelmeden çok önce herhangi bir gaz önce sıvı hale geçer sonra katılaşır, aslında sıfır hacim tamamen varsayımsal bir noktadır. Şimdiye kadar her hangi bir madde mutlak sıcaklık noktasına kadar soğutulamamıştır ama en son 2003'te MIT araştırmacıları 0.0000000005 (500picokelvin) değerine laboratuvar şartlarında ulaşmışlardır.

- ❖ Gazların kinetik teorisini öğrenci metninden yararlanarak açıklayınız.

Değerlendirme

1. Bir madde en fazla ne kadar soğuk olabilir?
2. Gaz taneciklerinin hareketlerini 3 maddeyle açıklayınız.

Ödev:

Öğrenci metnindeki ***Öğrendiklerimizi pekiştirelim*** kısmındaki 7 soru ödev olarak verilir.

APPENDIX M

SAMPLE STUDENT TEXT-I

Hava Olayları

Yeryüzünde var olan her şey hava durumundan etkilenir. Televizyonda hava durumunu mutlaka izlemişsinizdir. Alçak basınç, yüksek basınç, Balkanlar'dan gelen soğuk hava, nem oranı; bunların bizim için ne ifade ettiğini hiç düşündünüz mü? Peki;

Uzaydan bakıldığında Dünyamızın üzerindeki bulutlar görülebilmektedir. Uzaydan çekilmiş bu fotoğraf ise gezegenimizin çoğunlukla sudan oluştuğunu göstermektedir.

Hava olaylarına ne sebep olur?

Bu soruya cevap verebilmek için,

- Yeryüzü, Hava, Su, Güneş
- Su Döngüsü

kavramlarını inceleyelim.

Konuyu Keşfetme

❶Yeryüzü, Hava, Su, Güneş

Bu ders kimya ve hava durumu arasındaki bağlantıyı araştırmayı amaçlamaktadır. **Hava olayları** bir bölgede belli bir zamandaki bulutlar, rüzgârlar, sıcaklık ve yağış ile ilgilidir. Bu yönüyle iklimden ayrılır çünkü **iklim** uzun dönem kayıtları (yaklaşık 30 yıl), ortalamaları ve değerleri gösterir, hava ise günlük tecrübelerdir. Aşağıdaki tanımlar, ikisi arasındaki farkı anlamanızda size yardımcı olacaktır:

'İklim sizin umduğunuz, hava ise bulduğunuzdur'
'İklim hangi elbiseyi alacağınızı, hava ise hangi elbiseyi giyeceğinizi söyler'
'Hava saat ise, iklim takvimdir'

Hava olayları; yeryüzü, atmosfer, su ve güneşin etkileşimi ile oluşur. Yani aslında tamamen maddenin hareketi ile ilgilidir.

Bir gezegende hava olaylarının gerçekleşebilmesi için o gezegenin **atmosfer**inin olması gerekir. Atmosfer gezegeni çevreleyen gaz tabakasıdır. Ay'da hava olayları görülmez çünkü atmosferi yoktur. Biz atmosfere günlük konuşmalarımızda *hava* diyoruz. Hava bir gaz karışımıdır. %78 Azot, % 21 Oksijen, %1 Argon, % 0.04 karbondioksit ve diğer gazlardan oluşur. Atmosferde su buharı da mevcuttur ama miktarı bölgeden bölgeye, günden güne, hatta saatten saate bile değişmektedir. Ortalama olarak, su buharı atmosferin %1'ini oluşturur diyebiliriz.

Maddeyi ısıtmak ve onu şekilendirmek fiziksel değişime örnektir. Yeni bir madde elde etmek için kimyasalları karıştırmak ise kimyasal değişimdir.

Bizim gün içinde karşılaştığımız hava atmosferdeki fiziksel değişikliklerin sonucudur. Fiziksel değişim maddenin şeklini değiştirebilir ama kimliğini değiştirmez. Hacim, sıcaklık, şekil, büyüklük ve basınçtaki değişiklikler fiziksel değişime örnektir. Bunlar kimyasal değişimlerden farklıdır çünkü kimyasal değişim sonucu yeni bir madde ortaya çıkar. Güneşin dünyayı ısıtması atmosferde gerçekleşen birçok fiziksel değişimin kaynağıdır.

1

Soldaki resimde maddenin katı, sıvı, gaz hallerini ve bu hallerde atom veya moleküllerin yerleşim düzenini görüyorsunuz.

Atom ve moleküller maddenin katı, sıvı ve gaz halinde neden farklı yerleşim düzenine sahiptir? Yerleşim düzenindeki bu farklılık nasıl gerçekleşmiştir? Genellikle katılarda atom, iyon veya moleküller arasındaki boşluklar çok az olduğundan tanecikler arasındaki yer değiştirme hareketleri yok denecek kadar azdır ve bulundukları yerde titreşim hareketi yaparlar. Ancak tanecikler arasındaki etkileşimler de oldukça kuvvetlidir.

Katı halin en önemli özelliği düzenli yapıya sahip olmasıdır. Katılarda tanecikler **kristal** denilen belirli geometrik yapıları meydana getirir.

Bir buz parçasını kapalı bir kabın içine koyduğumuzu düşünelim. Başlangıçta buz kendi şeklini korur. Bu durum katı haldeki maddelerin davranışıdır. İçinde bulunduğu kabın şekli ne olursa olsun hal değiştirme sıcaklığına ulaşmadığı sürece katılar bulunduğu kabın şeklini almaz.

Sıvı tanecikler arasındaki boşluklar, katılara göre daha fazla; tanecikler arası etkileşim ise daha zayıftır. Sıvı tanecikleri birbiri ile temas halindedir. Birbirleri üzerinden kayarak yer değiştirebilirler.

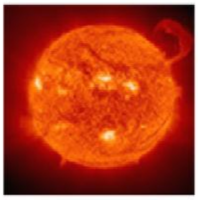
Sıvıların, belirli hacimleri vardır; fakat belirli şekilleri yoktur. Sıvılar bulundukları kabın şeklini alır ve akışkandır.

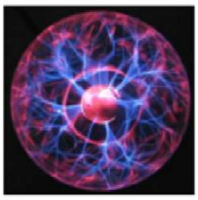
Katı ve sıvı tanecikleri arasında boşluklar çok azdır ve birbirleriyle temas halinde olduklarından fazla sıkıştırılamazlar. Sıvılar, normal koşullarda gazlara göre daha yoğundur. Maddenin katı ve sıvı hali ile gaz hali arasındaki en önemli fark tanecikler arasındaki boşluktur.

Gaz tanecikleri arasındaki boşluk katı ve sıvılara göre daha fazladır. Gaz tanecikleri düzensiz ve sürekli hareket halindedir. Bu hareketler sırasında gaz tanecikleri bulundukları kabın çeperlerine ve birbirlerine çarparlar. Çarpışmalarda taneciklerin yönü ve hızı değişebilir. Gazlar basınç uygulandığında sıkıştırılabilir. Bu nedenle belirli hacimleri ve şekilleri yoktur. Gaz tanecikleri bulundukları kaba yayılarak kabın şeklini alır.

Katı	Sıvı	Gaz
Katı hali, maddenin en düzenli halidir. Katıları oluşturan tanecikler arasındaki boşluklar yok denecek kadar azdır. Katı tanecikleri arasındaki çekim kuvveti çok fazladır. Katıların belirli bir şekli ve belirli bir hacmi vardır. Katılar sıkıştırılamaz.	• Sıvılar, katılara göre daha düzensizdir. • Sıvıları oluşturan tanecikler arasındaki boşluklar, katılara göre daha fazladır. • Sıvı tanecikleri arasındaki çekim kuvveti, katılardakine göre daha azdır. • Sıvıların belirli bir şekli yoktur. Bulundukları kabın şeklini alırlar. • Sıvıların belirli bir hacmi vardır. • Sıvılar, akışkandır. • Sıvılar çok az sıkıştırılabilir	• Gaz hali, maddenin en düzensiz halidir. • Gazları oluşturan tanecikler arasındaki boşluklar çok fazladır. • Gazları oluşturan tanecikler arasındaki çekim kuvveti çok azdır. • Gazların belirli bir şekli yoktur. Bulundukları kabın şeklini alırlar. • Gazların belirli bir hacmi yoktur. Bulundukları kabın hacmini alırlar. • Gazlar, uçucudur. • Gazlar rahatlıkla sıkıştırılabilir.

2





Maddenin 4. Hali: Plazma Hali

Plazma

Şiddetli gök gürültülerinin eşliğinde bardaktan boşanırcasına yağan yağmuru yüksekçe bir evin penceresinden seyretme fırsatını yakaladıysanız, hele bir de üst üste çakan şimşekler karşınızdaki bulutların arasında meydana geliyorsa, en pahalı havai fişek gösterilerinin yanında sönük kaldığı muhteşem bir ışık gösterisine şahit olursunuz. Bulutların sürtünme ile elektriklenmesinden kaynaklanan bir elektrik boşalması olduğu herkesçe bilinen şimşek ve yıldırım, yüz milyonlarca voltluk potansiyel farkı sıfırlanana kadar yaklaşık 20.000 Amperlik bir akım şiddetinde ve aktığı kanalda 30.000 Kelvin'lik bir sıcaklık meydana getirerek akar ve bu olay bir saniyeden daha kısa sürer. Bu yüzden yıldırımın ürkütücü yanının küçümsenmemesi ve gereken yerlerde tedbir alınması yerinde bir harekettir.

Gaz hâline gelen bir maddeyi çok yüksek sıcaklıklara ısıtırsanız; enerji alan elektronlar çekirdeklerinden kurtulur. Geriye iyon halinde gaz kalır. Bu olay sonucunda serbest elektron ve iyon bulutları oluşabilir, bazı atomlar nötr kalmaya devam eder. Yıldırımın yeryüzüne doğru aktığı yol da; iyon, elektron ve nötr atomlardan oluşan çok sıcak bir gaz çorbası hâlindedir. Bu oluşum, gaz hâlinden çok farklı özellikler taşıdığından, maddenin dördüncü hâli olarak kabul edilir ve "**plazma**" hâli olarak bilinir.

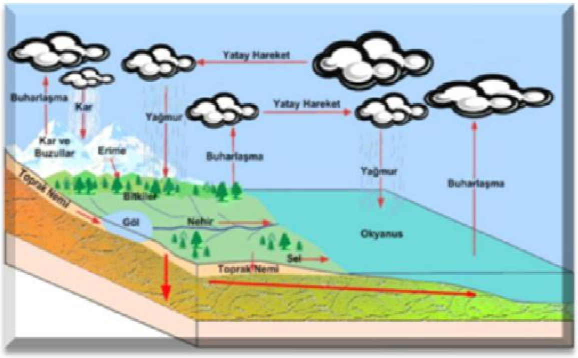
Yıldırım örneğine bakarak plazma hâlini gaz hâlinden ayıran önemli özellikleri hemen görebiliriz. Bunlar çok yüksek sıcaklık ve elektrik iletkenliğidir. Bütün maddelerin gaz hâli yalıtkan olduğu hâlde, plazma hâli elektriği son derece iyi iletir. Hatta bu iletkenlik katı iletkenlerden de daha iyidir, çünkü plazma hâli tamamen serbest elektronlara sahiptir. Yıldırım, bu olağanüstü özellikleri ile günlük hayatımızda kullandığımız floresan ve neon lâmbalarına ve metallerin kaynak edilmesinde kullandığımız elektrik arkına ilham kaynağı olmuştur.

Bunları biliyor muydunuz?

- "Ben plazmaya daha yakından bakmak istiyorum" diyorsanız, yapmanız gereken çok basit. Kibriti elinize alın ve çakın. İşte pırıl pırıl alevi ile plazma karşınızda duruyor. Evet; alev de bir plazma hâlidir.
- Alev bir plazma hâli olduğundan elektriği iletir. Bu özelliğinden faydalanarak gaz emniyetli sobalar yapılmıştır. Bu sobalar yanarken alevin içerisinden elektrik akımı geçirilir. Bu elektrik akımı sobanın gaz pompasını çalıştırır. Alev herhangi bir sebeple sönerse akım geçmeyeceğinden gaz otomatik olarak kesilmiş olur.
- Evrende en çok bulunan hal plazma halidir ve evrenin %99'undan fazlası plazma halindedir. Evrendeki tüm yıldızlar, Güneş, Gezegenler ve gezegenler arası boşluklar plazma hâlindeki maddeden oluşur.

❷Suyun Serüveni

Yeryüzündeki sular yerle gök arasında durmadan devam eden bir döngü içindedir. Bunun nedeni suyun halden hale geçmesidir. Güneşin etkisiyle buharlaşan sular gökyüzünde bulutları oluşturur. **Bulutlar** çok küçük su damlacıklarından oluşur. Soğuk bir hava tabakasına rastlayınca *ısı kaybettikleri için* bulutlarda yoğunlaşma gerçekleşir. Yoğunlaşmayla ağırlaşan su damlacıkları yeryüzüne doğru düşmeye başlar. Buna **yağmur** denir. Bazen soğuk hava tabakası buluttaki su damlacıklarını dondurur. Bu durum **kar** yağmasına neden olur. Yeryüzüne yağışlarla tekrar dönen su yine Güneşin etkisiyle buharlaşarak gökyüzüne yükselir. Böylece yeryüzündeki su dengesi sürekli olarak korunmuş olur.



Şekil 1. Doğadaki Su Döngüsü

Akılımızda bulunsun.

Katı maddeler erirken ısı alır.

Sıvı maddeler donarken ısı verir.

Bir maddenin erime noktası ile donma noktasının sıcaklık değeri aynıdır.

Maddenin hal değişimlerine **ısı** eşlik eder. Bir katıyı ısıttığımız zaman katının tanecikleri gittikçe daha hızlı hareket eder ve diğer tanecikler ile arasındaki mesafe arttıkça etkileşim azalır. Aynı şekilde gaz halindeki bir maddeden ısı alındığı zaman (soğutulduğu zaman) tanecikler daha yavaş hareket eder ve birbirlerinin etkileşim alanına girerler. Bu da maddenin hal değiştirmesiyle sonuçlanır. Hal değişimi ile ilgili kavramları yakından tanıyalım:

Erime ve Donma

Katı haldeki bir madde yeterince ısı alırsa tanecikler arasındaki etkileşimler zayıflar, katı özelliğini kaybeder ve sıvıya dönüşür. Bu olaya **erime**, erimenin olduğu sıcaklığa da **erime noktası** denir.

Sıvılar soğutulduğu zaman tanecikleri daha yavaş hareket eder. Soğutma işleminin devamında öyle bir sıcaklığa gelinir ki tanecikler arası çekim kuvvetleri onların bir kristal içinde istiflenmesine sebep olur. Bir sıvının katıya dönüşmesine **donma**, donmanın olduğu sıcaklığa da **donma noktası** denir.

Buharlaşma ve Yoğunlaşma

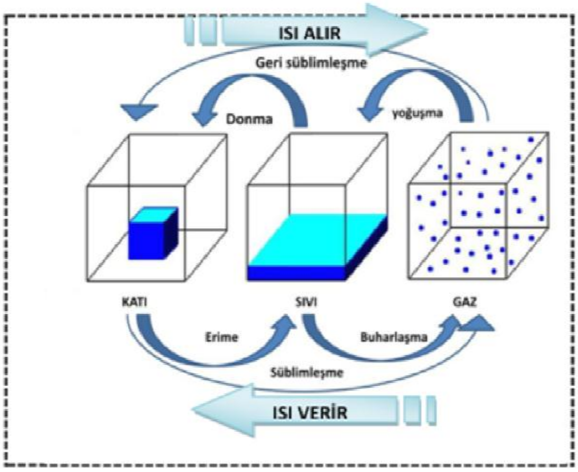
Sıvıları oluşturan tanecikler katılara oranla birbirlerine daha uzak ve taneciklerinin arasındaki çekim kuvvetleri daha zayıftır. Sıvıları buharlaştırmak yani gaz haline getirmek için tanecikleri arasındaki çekim kuvvetlerini yenmek amacıyla enerji yani ısı vermek gerekir. Yeterli enerji ile tanecikler sıvı yüzeyinden kurtularak gaz hale geçerler. Bu olaya **buharlaşma** denir. *Sıvı madde buharlaşırken dışarıdan ısı alır.*

Sıcaklık düşürülürse gaz taneciklerinin kinetik enerjileri azalır ve daha yavaş hareket etmeye başlarlar. Bu nedenle bir gaz yeteri kadar soğutulursa tanecikleri arasındaki etkileşim artar ve sıvı hale geçer. Gaz maddelerin *ısı vererek* sıvı duruma geçmelerine **yoğunlaşma** (yoğuşma) denir.

Süblimleşme

Sıvılarda olduğu gibi yeterli enerji verilirse katılar da buharlaşır. Ancak sıvılara göre katı moleküller arası etkileşimler daha güçlü olduğundan sıvılar kadar uçucu değildirler.

Maddenin katı halden sıvı hale dönüşmeden gaz hale dönüşmesine **süblimleşme** denir. Katıdan gaz hale geçerken madde ısı alır. Süblimleşmenin tersine, maddenin gaz halden doğrudan katı hale geçmesine **geri süblimleşme** denir. Gaz haldeki su moleküllerinin katı hale geçmesine ise **kırağılaşma** denir. Naftalin ve tuvaletlerde kullanılan katı koku gidericiler süblimleşen katılara örnektir.



Şekil 2. Hal değişimleri

Öğrendiklerimizi Pekiştirelim

1.Buzdolabından çıkardığımız şişe ve kavanozların dış yüzeyinde neden su damlacıkları oluşur?

2.Tüm canlılar su kullandığı halde yeryüzündeki sular neden tükenmez?

3.Yağmur yağınca caddeler ve sokaklar ıslanır. Fakat bir süre sonra bu ıslaklık kaybolur. Bunun sebebi nedir?

4.Ocağın üzerindeki çorba kaynadıkça neden kıvamı artar?

Sıcaklık düşürülürse gaz taneciklerinin kinetik enerjileri azalır ve daha yavaş hareket etmeye başlarlar. Bu nedenle bir gaz yeteri kadar soğutulursa tanecikleri arasındaki etkileşim artar ve sıvı hale geçer. Gaz maddelerin *ısı vererek* sıvı duruma geçmelerine **yoğunlaşma** (yoğuşma) denir.

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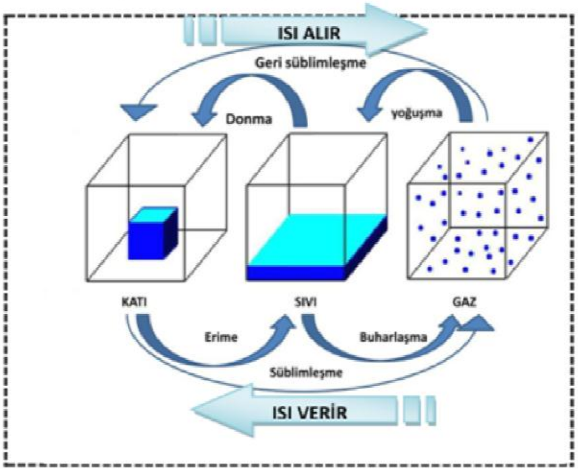

Şekil 2. Hal değişimleri

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4.Ocağın üzerindeki çorba kaynadıkça neden kıvamı artar?

Öğrendiklerimizi Pekiştirelim

1.Haydi Bulut yapalım!

Amaç: Maddenin hal değişimlerinden buharlaşmayı gözlemek

Malzemeler: Cam bardak ya da kavanoz, sıcak su, buz dolu metal tepsi

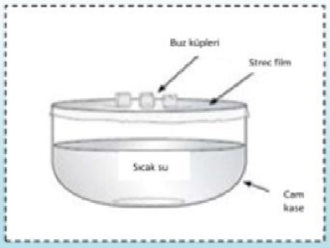
Önce bardağımızın yarısını sıcak suyla dolduruyoruz, tepsimizi de buzla dolduruyoruz. Tepsi iyice soğuyunca bardağın üzerine içi buzla dolu tepsiyi yerleştiriyoruz. Tepsi ile sıcak su arasında ne oluştuğunu görebiliyor musunuz?

Denizler gibi su kaynakları havanın ısınması ile buharlaşırken su damlacıkları gökyüzüne doğru çıkmaya başlarlar. Yüksek katmanlarda soğuk havayla karşılaşabilirler. Bizim bulut deneyimizde tabiattaki bu olaya benzer.

1. Haydi Yağmur Yağdıralım!

Amaç: Maddenin hal değişimlerinden yoğunlaşmayı gözlemek

Malzemeler: Cam kase, sıcak su, buz parçaları, streç film



Şekildeki düzeneği hazırlayalım. Buharlaşan sıcak su soğuk yüzeye çarpıp damlalar halinde yoğunlaşır. Böylece doğadaki yağmurun nasıl oluştuğunu gözlemlemiş oluruz.

❸ISI'nın Ettikleri

Bizim yaşadığımız gezegenin ısı kaynağı Güneş'tir. Güneş'ten gelen enerji uzay ve atmosferi geçerek yeryüzüne ulaşır. Yeryüzüne ulaşan enerji yeryüzünü, su kaynaklarını ve atmosferi ısıtır. Bu ısı günlük hayatımızdaki hal değişimlerinin başlıca kaynağıdır. Onun sayesinde su halden hale geçer ve doğadaki su dengesi korunur. Suyun hal değişimi ise meteorolojik olayların yani gün içinde karşılaştığımız hava olaylarının temel sebebidir. Peki;

Isının hal değişimindeki rolü nedir?

Kartopu oynarken elinizde tutuğunuz karın bir süre sonra eridiğini hissedersiniz. Çünkü elinizden kartopuna ısı geçişi olmuştur ve bu ısı kartopunu eritmiştir. Kartopunu eriten bu ısının miktarı hesaplanabilir mi?

Bu sorulara cevap verebilmek için;

*Isı alış-verişi

*Isınma eğrileri

Kavramlarını yakından inceleyelim.

Konuyu Keşfetme

Hal değiştirme ısısının hesaplanabilmesi için bazı kavramları anlamamız gerekir:

Hal değişim ısısı (L) : 1gram maddeyi bir halden başka bir hale geçirmek için ona verilmesi veya ondan alınması gereken ısıdır.

Aklımızda Bulunsun

Hal değiştiren bir maddenin sıcaklığı sabit kalır. Çünkü bu sırada maddeye verilen ısı, maddenin taneciklerinin birbirinden uzaklaştırılması için kullanılır.

Birimi joule/gram (j/g ya da j.g^{-1}) olarak ifade edilir.

Eğer madde eriyorsa erime ısısı (Le), buharlaşıyorsa buharlaşma ısısı (Lb), donuyorsa donma ısısı (Ld), yoğunlaşıyorsa yoğunlaşma ısısı (Ly) adını alır.

Hal değiştiren bir maddenin aldığı ısı enerjisi, maddenin tanecikleri arasındaki mesafeyi artırarak moleküller arasındaki çekim kuvvetinin azalmasını sağlar. Her maddenin tanecikleri arasındaki çekim kuvveti aynı değildir. Bu nedenle çekim kuvvetinin zayıflatılması için maddelere verilmesi gereken ısı miktarları da aynı olmayacaktır. Yani her maddenin hal değişim ısısı birbirinden farklıdır. Bu nedenle hal değişim ısısı maddeler için **ayırt edici bir özellik**tir.

Erime ısısı: Erime sıcaklığına ulaşmış 1 gram saf katı maddenin tamamen erimesi için gerekli ısı miktarıdır.

Erime ısısı sadece erime sıcaklığındaki maddeler için söz konusudur. Örneğin buzun erime ısısı 334,4 J/g'dır. Bu ısı -20 ºC'deki bir buza verildiğinde buzun sıcaklığı artar ama buz erimez. Ancak aynı ısı 0 ºC'deki buza verildiğinde buzun sıcaklığı artmaz ama erir. Buradan şöyle bir sonuç çıkıyor:

➢ **Hal değiştiren bir maddenin sıcaklığı sabit kalır. Çünkü bu sırada maddeye verilen ısı, maddenin taneciklerinin birbirinden uzaklaştırılması için kullanılır.**

Bir miktar maddenin erimesi için gerekli ısıyı şu bağıntı ile hesaplayabiliriz:

Q= m x Le

Q= Erime için gerekli ısı enerjisi
m =kütle
Le =erime ısısı

Bir maddenin donma ve erime ısıları birbirine eşittir.
Le=Ld

Donma ısısı: Donma sıcaklığında bulunan 1 gram saf sıvı maddenin tamamen katı hale geçmesi için gerekli ısı miktarıdır.

Bir maddenin katı halden sıvı hale geçmesi için ısı alması gerekir. Sıvı halden katı hale geçen madde ise çevresine ısı verir. Donan maddenin çevresine verdiği ısı miktarı, erirken aldığı ısı miktarına eşittir. Yani bir maddenin donma ve erime ısıları birbirine eşittir.

Not: Farklı maddelerin erime ve donma ısıları birbirlerinden farklıdır. (örn: suyun erime ve donma ısısı birbirine eşittir ancak demir ve suyun erime(donma) ısıları birbirinden farklıdır.)

Bir miktar maddenin donması için gerekli ısıyı şu bağıntı ile hesaplayabiliriz:

Q= m x Ld

Buharlaşma ısısı: Kaynama sıcaklığındaki 1 gram saf sıvıyı aynı sıcaklıktaki 1 gram buhar haline getirmek için gerekli ısı miktarıdır.

Bir maddenin yoğunlaşma ve buharlaşma ısıları birbirine eşittir.
Lb=Ly

Sıvı halde bulunan bir maddenin gaz haline geçmesi olayına **buharlaşma** denir. Buharlaşma olayının gerçekleşmesi için maddenin ısıya ihtiyacı vardır. Maddenin aldığı bu ısı, tanecikler arasındaki bağların yok olacak kadar zayıflamasına neden olur ve tanecikler birbirinden bağımsız hale gelir. Bu sırada maddenin sıcaklığı değişmez. Sıvı buharlaşırken çevresinden ısı aldığı için çevresini soğutur.

Q = m x Lb

Yoğunlaşma ısısı: Kaynama sıcaklığında ve gaz halinde bulunan 1 gram maddenin, aynı sıcaklıkta tamamen sıvı hale geçerken çevresine verdiği ısı miktarıdır.

Sıvılar buharlaşırken aldıkları ısıyı yoğunlaşırken geri verirler. Kaynama sıcaklığındaki buhar yoğunlaşma ısısı kadar ısı kaybettiğinde sıvı haline geçer. Bu yüzden buharlaşma ısısı yoğunlaşma ısısına eşittir. **Buharlaşma ve yoğunlaşma ısıları maddeler için ayırt edici özelliktir.**

Q = m x Ly

Özısı (c): Yalnız sıcaklık değişimine bakılarak bir maddenin aldığı ya da verdiği ısı miktarı bulunamaz. Çünkü sıcaklık değişimi maddenin cinsine ve miktarına bağlıdır. Bir maddenin 1 gramının sıcaklığını 1^{0}C değiştirmek için gerekli ısı miktarıdır. Birimi Joule/gram.derece^{0}C (J g^{-1} ^{0}C^{-1}) dir.

Her saf maddenin aynı şartlardaki öz ısısı farklıdır. Dolayısıyla öz ısı maddeler için ayırt edici bir özelliktir.

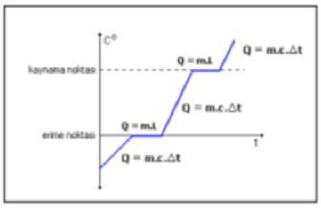
Sıcaklık farkı (Δt): Son sıcaklık ile ilk sıcaklık arasındaki farktır. Sıcaklık birimi Celcius'tur.

☺ ÖĞRENELİM ☺

Hal değişimi sırasında erime, donma, kaynama ve yoğunlaşma süresince **sıcaklık değişmez.** Alınan ya da verilen ısı, tanecikler arası bağlar için kullanılır. Bu durumlarda ısı miktarı yukarıda gördüğümüz Q=m x L bağıntılarından elde edilir.

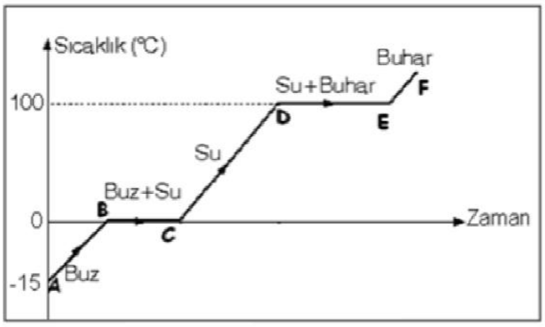
Sıcaklığın değiştiği durumlarda ise $\boxed{Q = m.\ c.\ \Delta t}$ bağıntısı kullanılır.

Özetle;



Öğrendiklerimizi Pekiştirelim

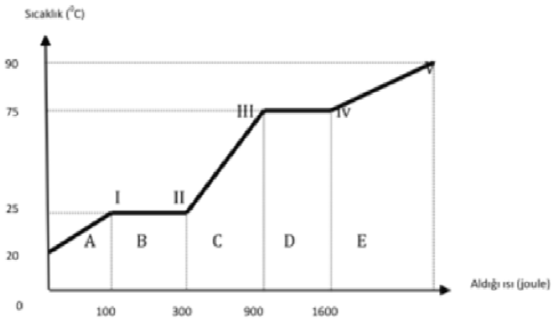
Maddelerin hal değişim ısıları farklı olduğu için her madde için farklı grafik elde edilir. Suyun sıcaklık-zaman grafiğini birlikte yorumlayalım:



Grafikte sıcaklık 0 °C ve 100 °C de sabit kalmıştır. Sıcaklığın sabit kaldığı bu durumlarda madde hal değiştirmiştir. Yani 0 °C bu maddenin **erime (donma)** sıcaklığı; 100 °C ise bu maddenin **buharlaşma (yoğunlaşma)** sıcaklığıdır.

A noktasında ısı alan buz taneciklerinin hareket enerjileri arttığından aralarındaki uzaklık artmıştır. A noktasından B noktasına doğru maddede sıcaklık artışı gözlenir. B noktasına yani, 0°C değerine gelindiği zaman erime başlar. Artık buz taneciklerinin aldığı ısı buzun erimesi için kullanılır. Burada B ve C noktaları arasında hal değişimi olduğu için maddenin sıcaklığı değişmeyecek, buzun aldığı ısı erimeye harcanacaktır. Ancak su sürekli ısı almaya devam ederse suyun aldığı bu ısı erime tamamlanınca suyun sıcaklığının yükselmesini sağlar. C ve D noktaları arasında suyun sıcaklığı hızla yükselir. Yükselen bu sıcaklık değeri 100 °C 'ye ulaştığında sıcaklık yine sabit kalır. Alınan ısı tanecikler arasındaki bağları daha da zayıflatarak suyun artık buhar haline gelmesini sağlar. D noktasında buharlaşmaya başlayan su, E noktasında tamamen buhar olur. E noktasından itibaren su buharına verilen ısı onun sıcaklığının sabit kalmadan artmasına neden olur.

Hal değişim grafikleri ve yorumlanması



Yukarıdaki kütlesi 50 g olan bir maddenin sıcaklık-ısı grafiği bulunmaktadır. Grafiği hep birlikte yorumlayalım:

1. Maddenin erime ve donma sıcaklıkları nedir?

2. Maddenin buharlaşma ve yoğunlaşma sıcaklıkları nedir?

3. Maddenin A, B, C, D ve E bölgelerindeki fiziksel halleri nedir?

4. Madde hangi bölgelerde homojen hangi bölgelerde heterojendir?

5. Erime hangi noktada başlar hangi noktada biter?

6. Kaynama hangi noktada başlar hangi noktada biter?

7. Madde hangi bölgede en düzensiz haldedir?
8. Madde hangi bölgede en düzenli haldedir?
9. Madde 40⁰C'de hangi haldedir?
10. Madde -5⁰C'de hangi haldedir?
11. Madde 10⁰C'den 100⁰C'ye yükseltilirse kaç kez hal değiştirir?
12. Maddenin erimesi için verilen ısı kaç joule'dür?
13. Maddenin kaynaması için verilen ısı kaç joule'dür?
14. Madenin erime ısısı kaç joule/gram'dır?
15. Madenin buhalaşma ısısı kaç joule/gram'dır?
16. Maddenin sıvı haldeyken özısısı nedir?

10

APPENDIX N

SAMPLE STUDENT WORKSHEET

Adı-Soyadı:__________________

Tarih__________ Sınıfı:________

Sıvılar ve Özellikleri

Amaç: Sıvılar ile ilgili durumları gözlemlemek ve araştırmak

Yönerge: Her deney için gözlemlerinizi ve açıklamalarınızı aşağıdaki tabloda ilgili kısımlara yazınız.

Deney	**Ne gözlemlediniz?**	**Açıklayınız.**
1. Su kabarıyor		
2. Su dökülmüyor		
3. Bardak ters dönünce..		
4. Yüzeyi bozalım		
5. Yüzen ataçlar		

1

Deneyler

1. Su kabarıyor

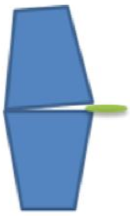
Bir bardağı ağzına kadar suyla doldurun. Sonra içine yavaşça madeni bir para bırakın. Suyun yüzeyini dikkatle gözleyin. Ne oluyor?

Su taşmadan önce kaç tane para bırakabildiniz?

Su neden kabarıyor?

Suyun molekülleri birbirlerini her yönde çekerler. Bu, suyun yüzeyinde, bardak düzeyinin üzerinde bir miktar su tutmaya yetecek kadar kuvvet yaratır. Su yüzeyindeki bu çekim kuvvetine yüzey gerilimi denir.

2. Su dökülmüyor



Bu deneyde bir tane madeni para, iki tane eşit büyüklükte bardak ve bir büyük kap kullanacaksınız.

1. Bardakları su ile dolu büyük kabın içinde yani suyun altında doldurun. Sonra da ağızlarını su dökülmeyecek bitiştirin ve sudan çıkarın.
2. Bardakları düz bir yüzey üzerine koyun, biri diğerinin üzerinde ters olarak dursun. Parayı bardakların arasına kaydırın. Bu aşamada biraz su dökülecektir.
3. Parayı yerleştirdikten sonra, su molekülleri iki bardak ağzı arasında birbirlerini çekecek ve suyun akmasını durduracaktır.

3. Bardak ters dönünce…

Bu şaşırtıcı deney su moleküllerinin bir mendilin kumaşındaki küçücük deliklerde çekim kuvveti uyguladığını gösteriyor. Bu deneyi kendiniz de yapabilirsiniz, bir arkadaşınıza oyun da oynayabilirsiniz.

1. Bir bardağa yarısına kadar su doldurun. Ağzına kumaş bir mendil kapatın ve mendili lastikle tutturun.
2. Şimdi bardağı ters çevirin. Su molekülleri birbirini çekecek ve suyun mendilin deliklerinden dökülmesini önleyecektir.
3. Moleküllerin çekimini zayıflatmak için mendile parmağınızla dokunun. Suya ne oldu?

4. Yüzeyi bozalım

Yukarıdaki deneyde, su yüzeyine parmağınızla dokunursanız, moleküllerin çekimini zayıflatırsınız. Su yüzeyini bozduğumuzda ne olacağını tam olarak görmek için, üzerine hafifçe karabiber serpilmiş bir kap suyla aşağıdaki deneyi yapın.

Bir kabı suyla doldurun, yüzeyine karabiber serpin. Ucuna sabun değdirilmiş kürdanı yüzeye dokundurun. Neler oluyor? Aynı işlemi en baştan kürdan yerine parmağınızı kullanarak deneyin. Ne gözlemlediniz?

Yüzeyde ne oluyor?

Derinizde ve sabunda yağ vardır. Yağ, suyla karıştığında su moleküllerinin birbirini çekme kuvveti azalır. Su yüzeyine parmağınızla ya da sabunla değdiğinizde olan işte budur. Tasın kenarlarındaki moleküller birbirlerini hala kuvvetle çekmeye devam ettikleri için karabiber taneleri tasın kenarlarına doğru sürüklenir.

5. Yüzen Ataçlar

Büyükçe bir kaba su doldurun. Bir çatal ya da kaşık yardımıyla ataçların suyun yüzeyinde yüzmesini sağlayın. Daha sonra suya bol miktarda sıvı deterjan ekleyiniz. Ne gözlemlediniz?

2

APPENDIX O

PERMISSION DOCUMENTS

T.C.
BURSA VALİLİĞİ
İl Milli Eğitim Müdürlüğü

Sayı : B.08.4.MEM.0.16.20.02-605 / 7885 — 15 Şubat 2012
Konu : Araştırma İzni

ORTADOĞU TEKNİK ÜNİVERSİTESİNE
(Öğrenci İşleri Daire Başkanlığı)

İlgi : a) M.E.B.na Bağlı Okul ve Kurumlarda Yapılacak Araştırma ve Araştırma Desteğine Yönelik İzin ve Uygulama Yönergesi.
b) 04/01/2012 tarih ve 400-62/187 sayılı yazınız.

Ortaöğretim Fen ve Matematik Alanları Eğitimi Anabilim Dalı Doktora öğrencilerinden Sabiha SUNAR'ın "Yaşam-Temelli Öğretim Yaklaşımının Öğrencilerin Kimya Başarısına, Kimyaya Karşı Tutuml[illegible]ırlama Oranları Üzerine Etkisi" konulu tez çalışmasına veri toplama aracını ekli onayda adı geçen ilimiz ortaöğretim kurumu öğrencilerine uygulanması ile ilgili onay ve mühürlü veri toplama aracı ilişikte gönderilmiştir.

Bilgilerinizi, ilgi (a) yönergenin 5.maddesinin (o) bendinde belirtildiği üzere; ilgilinin çalışmasının tamamlanmasından sonra en geç iki hafta içinde çalışmanın iki örneğinin CD'ye kayıtlı olarak EK-1 ile birlikte Müdürlüğümüze teslim edilmesini arz ederim.

Atilla GÜLSAR
Milli Eğitim Müdürü

EKLER:
1- Veri Toplama Aracı (7 Sayfa)
2- Onay Örneği (2 Sayfa)
3- Araştırma Değerlendirme Formu (1 Sayfa)

NOT: Onayın aslı ilgiliye elden teslim edilmiştir.

Adres: Yeni Hükümet Konağı A-Blok
Osmangazi / 16050 BURSA
Tel: (0 224)25670 00/116 **Faks:** (0 224)256 66 80
Web: www.bursameb.gov.tr / www.arge16.com
Müdür Yardımcısı: Omuhammet ATAKLI

EĞİTİME %100 DESTEK — DANIŞMA 444 0 632 HATTI — Ulusal Kalite Hareketi

T.C.
BURSA VALİLİĞİ
İl Milli Eğitim Müdürlüğü

13 Şubat 201

Sayı : B.08.4.MEM.0.16.20.02-605 / 7516
Konu : Araştırma İzni

VALİLİK MAKAMINA

İlgi : M.E.B.na Bağlı Okul ve Kurumlarda Yapılacak Araştırma ve Araştırma Desteğine Yönelik İzin ve Uygulama Yönergesi

Orta Doğu Teknik Üniversitesi Ortaöğretim Fen ve Matematik Alanları Eğitimi Anabilim Dalı Doktora öğrencilerinden Sabiha SUNAR'ın "Yaşam-Temelli Öğretim Yaklaşımının Öğrencilerin Kimya Başarısına, Kimyaya Karşı Tutumlarına ve Hatırlama Oranları Üzerine Etkisi" konulu tez çalışmasını ekte yer alan İnegöl, Yenişehir, İznik ve Yıldırım ilçelerindeki toplam 12 ortaöğretim kurumu öğrencilerine uygulamak istediği, Orta Doğu Teknik Üniversitesi Rektörlüğü Öğrenci İşleri Daire Başkanlığı'nın 04 Ocak 2012 tarihli ve 400-62/187 sayılı yazısı ile bildirilmektedir.

Milli Eğitim Bakanlığına bağlı her tür ve her derecedeki okul ve kurumlarda yapılacak lisans, yüksek lisans, doktora veya doktora üstü araştırma-geliştirme çalışmaları ile Bakanlığın destek verdiği araştırmalar kapsamındaki anket, uygulama, gözlem gibi faaliyetler; bir ili kapsıyorsa izin başvurularının İl Milli Eğitim Müdürlüğü'ne yapılacağı ilgi yönergede belirtildiğinden Orta Doğu Teknik Üniversitesi Ortaöğretim Fen ve Matematik Alanları Eğitimi Anabilim Dalı Doktora öğrencilerinden Sabiha SUNAR'ın "Yaşam-Temelli Öğretim Yaklaşımının Öğrencilerin Kimya Başarısına, Kimyaya Karşı Tutumlarına ve Hatırlama Oranları Üzerine Etkisi" konulu tez çalışması ile ilgili öneri ve veri toplama araçlarının, ilgi Yönerge gereği ilimizde oluşturulan "Araştırma Değerlendirme Komisyonu" tarafından incelenerek değerlendirilmesi sonucunda, araştırma ile ilgili anketlerin okullardaki eğitim öğretim faaliyetleri aksatılmadan, mühürlü ve imzalı anketlerin aslı okul müdürlüklerince görülerek, gönüllülük esası ve veli izni ile okul müdürlüklerinin gözetim ve sorumluluğunda ekte yer alan İnegöl, Yenişehir, İznik ve Yıldırım ilçelerindeki toplam 12 ortaöğretim kurumu öğrencilerine ilgi Yönerge çerçevesinde uygulanması Müdürlüğümüzce uygun görülmektedir.

Makamlarınızca da uygun görüldüğü takdirde gereğini olurlarınıza arz ederim.

Atilla GÜLSAR
Milli Eğitim Müdürü

OLUR
10./02/2012
İsmail DEMİRHAN
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EĞİTİME %100 DESTEK   DANIŞMA 444 0 632 HATTI   Ulusal Kalite Hareketi

CURRICULUM VITAE

PERSONAL INFORMATION

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Nationality: Turkish (TC)

Date and Place of Birth: 07.08.1984, Bursa

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EDUCATION

Degree	Institution	Year of Graduation
MS	METU, Secondary Science and Mathematics Education	2007
BS	METU, Secondary Science and Mathematics Education	2007
High School	Bursa Yenişehir Ertuğrul Gazi Anadolu Lisesi	2002

WORK EXPERIENCE

Year	Place	Enrollment
2007-2013	METU, Secondary Science and Mathematics Education	Research Assistant
2006-2007	METU, Computer Center	Student Assistant

PUBLICATIONS

Journal Articles

- Sunar, S. & Geban, Ö. (2010). Turkish Prospective Science Teachers' Perceptions on Socio-scientific and Technological Phenomena, Eurasian *Journal of Physics and Chemistry Education*, (Special Issue): 9-24.

Conference Papers

- Sunar, S. & Geban, Ö. (2012). *Etkili Öğretmen Nitelikleri Hakkında Öğretmen Görüşlerinin Belirlenmesi*, Applied Education Congress (APPED), Ankara, Turkey.
- Sunar, S. & Geban, Ö. (2012). *Students' Questions: A Potential Resource for Characterizing Students' Interest in Chemistry,* 11th European Conference on Research in Chemical Education (ECRICE), Rome, Italy.

- Sunar, S. & Geban, Ö. (2012). *Classroom Implementation of Context-based Chemistry: Learning Styles of Students and Their Achievement in Chemistry,* 11th European Conference on Research in Chemical Education (ECRICE), Rome, Italy.
- Sunar, S. & Geban, Ö. (2012). *Yaşam Temelli Öğretim Yaklaşımında Bağlamların ve Günlük Hayat Uygulamalarının Belirlenmesi,* 10. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi, Niğde, Turkey.
- Sunar, S. (2011). *Analysis of Science Textbooks for A-levels in the UK: Issues of Gender Representation.* European Science Education Research Association (ESERA), Lyon, France.
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- Sunar, S. & Geban, Ö. (2011). *Meaning of Doctoral Qualifying Examinations for PhD Students.* International Conference on Education and New Learning Technologies (EDULEARN11), (virtual), Barcelona, Spain.
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- Subaşı, S. & Geban, Ö. (2009). *An investigation of pre-service teachers' alternative conceptions of global warming*. Frontiers in Science Education (FISER), Cyprus.