EFFECTIVENESS OF CONTEXT-BASED APPROACH THROUGH 5E LEARNING CYCLE MODEL ON STUDENTS' UNDERSTANDING OF CHEMICAL REACTIONS AND ENERGY CONCEPTS, AND THEIR MOTIVATION TO LEARN CHEMISTRY

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ABSTRACT

EFFECTIVENESS OF CONTEXT-BASED APPROACH THROUGH 5E LEARNING CYCLE MODEL ON STUDENTS' UNDERSTANDING OF CHEMICAL REACTIONS AND ENERGY CONCEPTS, AND THEIR MOTIVATION TO LEARN CHEMISTRY

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The aim of study was to investigate the effect of context-based approach (CBA) through 5E learning cycle (LC) model over traditional instruction on students' understanding, achievement, and chemical literacy on chemical reactions and energy concepts. The effect of instruction on students' motivation to learn chemistry and the factors of motivation questionnaire were also explored. Additionally, the effect of gender difference was investigated. Six eleventh grade classes with 187 students taught by three teachers from two public Anatolian high schools of Ankara in 2011-2012 fall semester were enrolled in this study. Each teacher had experimental and control group. These classes were assigned randomly as experimental and control groups. The experimental groups were treated with CBA through 5E LC model, control groups were treated with traditional instruction. Chemical reactions and energy concept test and chemistry motivation questionnaire were administered as pre- and post-tests to groups. Achievement test and open-ended chemical literacy items on chemical reactions and energy were administered as post-tests to all groups. Science process skill test was administered to all groups at the beginning of the instruction. Multivariate Analysis of Covariance (MANCOVA) was used for the analysis of data. The results revealed that CBA through 5E LC model was superior to traditional instruction on students' understanding, achievement, and chemical literacy in the chemical reactions and energy unit. Although, students' overall motivation scores did not changed across the groups, experimental groups intrinsic motivation and relevance of learning chemistry to personal goals was superior than control groups. No gender difference was found.

Keywords: Context-based approach, 5E learning cycle model, chemical reactions and energy, understanding, achievement, motivation, chemical literacy, gender, and 11th grade science major students.

ÖZ

BAĞLAM TEMELLİ YAKLAŞIMLA DESTEKLENMİŞ 5E ÖĞRENME DÖNGÜSÜ MODELİNİN ÖĞRENCİLERİN KİMYASAL REAKSİYONLAR VE ENERJİ KONULARINI ANLAMALARINA, VE KİMYA ÖĞRENMEYE KARŞI MOTİVASYONLARINA ETKİSİNİN ARAŞTIRILMASI

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Bu çalışmanın amacı bağlam temelli yaklaşım ile desteklenen 5E öğrenme döngüsü modelinin ve geleneksel öğretimin öğrencilerinin kimyasal reaksiyonlar ve enerji konularını anlamalarına, başarılarına ve kimya okuryazarlıklarına etkisini araştırmaktır. Ayrıca uygulamanın deney ve kontrol grubu öğrencilerinin kimya öğrenmeye karşı motivasyonları ve motivasyon anketinin boyutları üzerine etkisi de araştırılmıştır. İlaveten cinsiyet etkisi de araştırılmıştır. Bu çalışmaya, 2011-2012 öğretim yılının güz döneminde Ankara'daki iki devlet okulunda üç kimya öğretmenine ait altı on birinci sınıftan toplam 187 öğrenci katılmıştır. Her öğretmenin bir deney bir de kontrol grubu mevcuttur. Bu sınıflar deney ve kontrol grubu olarak rastgele seçilmiştir. Deney grupları, bağlam temelli yaklaşım ile desteklenmiş 5E öğrenme döngüsü modeline göre öğretim alırken, kontrol grupları ise kimyayı geleneksel öğretimle almıştır. Kimyasal reaksiyonlar ve enerji kavram testi ve kimya motivasyon anketi hem deney hem kontrol grubuna ön ve son test olarak verilmiştir. Başarı testi ve açık uçlu kimya okuryazarlığı soruları da son test olarak tüm gruplara dağıtılmıştır. Bilimsel süreç işlem beceri testi uygulamadan önce tüm gruplara dağıtılmıştır. Çok değişkenli kovaryans analizi (MANCOVA) verilerin analizi için kullanılmıştır. Çalışmanın sonuçları bağlam temelli yaklaşımla desteklenmiş 5E öğrenme döngüsü modelinin geleneksel öğretime göre kimyasal reaksiyonlar ve enerji konularını anlamayı ve başarıyı cinsiyet farkı gözetmeksizin artırdığını ortaya koymuştur. Farklı gruplardaki öğrencilerin kimya öğrenmeye karşı motivasyonları anlamlı farka sahip olmasa da, deney grubunun iç motivasyonları ve kimya öğrenmeyi kişisel amaçlara uygun bulmaları kontrol grubuna göre artmıştır. İlaveten, açık uçlu kimya okuryazarlık sorularına verilen cevaplar, deney grubundaki öğrencilerin, geleneksel öğretimdeki öğrencilere göre kimya okuryazarlık bakımından daha iyi olduğunu gösteriyor.

Anahtar Kelimeler: Bağlam temelli yaklaşım, 5E öğrenme döngüsü modeli, kimyasal reaksiyonlar ve enerji, anlama, başarı, motivasyon, kimya okuryazarlığı, cinsiyet, ve 11. sınıf fen öğrencileri

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LIST OF ABBREVIATIONS

CBA: Context-Based Approach

ChemCom: Chemistry in the Community

CiC**:** Chemistry in Context

USA: United States of America

UK: United Kingdom

CL: Contextual Learning

ChiK: Chemie in Kontext

PBL: Problem-Based Learning

PJBL: Project-based Learning

REACT: Relating, Experiencing, Applying, Cooperating, Transferring

STS: Science Technology and Society

PLON: Dutch Physics Curriculum Development Project

LORST: Logical Reasoning in Science and Technology

ACS: American Chemical Society

NFS: National Science Foundation

LC: Learning Cycle

BSCS: Biological Sciences Curriculum Study

PISA: Programme for International Student Assessment

TIMSS: Trends in Mathematics and Science Studies

OECD: Organization for Economic Co-operation and Development

SL: Scientific Literacy

5E: Engage, Explore, Explain, Elaborate, and Evaluate

EG: Experimental Groups

CG: Control Groups

CRECT: Chemical Reactions Energy Concept Test

CMQ: Chemistry Motivation Questionnaire

SPST: Science Process Skill Test

TI: Traditional Instruction

CREAT: Chemical Reactions and Energy Achievement Test

CLI: Chemical Literacy Items

CFA: Confirmatory Factor Analysis

CHAPTER 1

INTRODUCTION

"The student who can begin early in life to see things as connected has begun the life of learning. The connectedness of things is what the educator contemplates to the limit of his (or her) capacity"

Mark Van Doren

"Why do I need to learn this topic?" is the foremost popular question which students ask their teachers throughout teaching learning process in their school years. Having been directed to be overloaded by curriculum and being unable to relate theoretical knowledge with real-world they live, students could not organize their knowledge into a coherent-cognitive-structure of transferable knowledge which in turns makes them to question "why to learn" a particular topic. Students' need for -why they learn any particular topic- brought about researchers and policy makers to reorganize curriculum by making extensive reforms in a need-to-know basis by embedding concepts to contexts.

Contextual learning is the process of teaching and learning that focuses on the importance of context for incorporation of concepts. Ingram (2003) states that; although studies indicated how students' learning was put in order by contextual learning approaches, schools go on with contemplating on fragmented instruction which is not suitable to connect real world issues. Reforming curriculums implemented in schools necessitates critical reconstructing efforts constituted with active student engagement. According to Bern and Erikson (2001), contextualized teaching and learning method feeds the pedagogical guide lines for reconstructing efforts. Therefore, in order to construct meaningful learning in schools, the concentration should be loaded on restructuring traditional instruction with contextualized curriculum reforms.

The last two decades have witnessed many curricular activities in science education field which mainly centers the attention on usage of real-world contexts through contextual teaching. Therefore, a renewed interest has emerged to investigate "why to use / how to use" a real world contextualized instruction (Belt, Leisvik, Hyde & Overton, 2005; Bennett & Lubben, 2006; Bulte, Westbroek, De Jong & Pilot, 2006; Campbell & Lubben, 2000; Fensham, 2009; King, Bellocchi & Ritchie, 2008; Newting, Demuth, Parchmann, Gräsel & Ralle, 2007; Pilot & Bulte, 2006; Schwartz, 2006). In late 1980s, designing concepts through real and meaningful contexts initiated extensively in a number of countries with innovative projects. These initiatives take its roots: in USA by National Science Foundation since 1983, in Canada by Science Council of Canada since 1984, in UK by Royal Society since1985. The most and the well-known projects are, CHEMCOM in USA, SALTERs in England and Wales, LORST in Canada, and PLON in Netherlands. All these curriculum projects tried to find research-based evidence for impact of contextualized teaching and learning in chemistry, physics, and biology by using real world contexts while explaining concepts. Kortland describes context-based curriculum as "practical applications and/or socioscientific issues act as a starter for the teaching-learning of science in an attempt to bridge the gap between the often abstract and difficult science concepts and the world the students live in" (2007, p.1). The common point of above-mentioned projects is, contextual learning is accomplished by "context-based" approaches in which activities are students-centered and concepts are introduced on a need-to-know basis.

Context-based learning approaches, sometimes called as "context-led approach" (Holman and Pilling, 2004), or "contextualized approach" or "contextual approach", or "context-based approach" (De Jong, 2005; Bennett and Lubben, 2006), or "context based instruction" (Taasoobshirazi and Carr, 2008) or "context based learning" (Acar and Yaman, 2011; Whitelegg and Parry, 1999) all utilizes "contexts" in teaching learning process and are used synonymy. These approaches to teach science started in early 1970s and have become increasingly popular in current research area. Bennett and Lubben (2006) point out usage of contexts at the beginning of construction of scientific understanding in context-based approaches as a major development in science education. These approaches are expected to overcome the deficiencies of students in; connecting concepts to the real-world they live, associating scientific knowledge to societal issues. Pilot and Bulte (2006) explain context-based approaches as; focusing on inquiry and relating the science-technology to socio-scientific problems. Additionally, Bulte et al. (2006) states that many context-based approaches propose, as an instructional framework, contexts as raising questions in students and making students to see the motive for extending their knowledge. They also mention such an instructional framework should incorporate in a need-to-know principle thus constructs students learning intrinsically meaningful. In this study, context-based approach (CBA) is preferred to use rather than others.

Context-based approaches are rooted in varying methodological concerns such as problem/project-based learning (PBL), science-technology-society approaches (STS), and inquiry-based science teaching which make learning more meaningful for students. As King (2010) stated these methodological concerns are aroused from sociocultural perspective on learning that is described by Vygotsky (1978, as cited in King, 2010) as discourses and communities are centre for knowledge construction. In the same study, King (2010) mentions that according Vygotsky, a persons' intellectual functioning takes its roots from his/her surroundings and interactions with others. Therefore, students should have learning environment in which a continuous relation between conceptual knowledge is constructed through students' experiences, application of knowledge, cooperation on societal issues and real world problems. So that, a well designed lesson integrating these issues is expected to develop students intellectual functioning.

Recent initiatives like inquiry-based and context-based approaches are both devoted to constructivist curricular developments by using real-world issues in science education. Anderson (2007) mentions on inquiry as being quite prominent theme for science curriculum reform initiatives in terms of content, learning, and teaching since 1950s. Hofstein and Kesner (2006) describes inquiry-based science activities as promoting the interest of students in the field of science education and they also states that such inquiry activities, makes students to ask better questions, also it gives students to have a good feeling of ownership on the scientific problems. Similarly, contextual learning is seen as a means to motivate and encourage students in developing more positive attitudes towards science by connecting knowledge to the real-world situation (Bennett, Campbell, Hogarth & Lubben, 2007). On this basis, both inquiry-based and context-based instructions promote students' interest in science learning therefore these instructions have a great potential to be integrated in designing real-world curriculum materials for meaningful learning.

Learning cycle (LC) finds its place among inquiry-based teaching approaches. Abraham (1997) describes LC as being appropriate for teachers in developing; well-designed curriculum materials and instructional strategies in science education field. He also explains the model as "is derived from constructivist ideas of the nature of science, and the developmental theory of Jean Piaget" (p.1). At the same time, Bybee, Taylor, Gardner, Scotter, Powell, Westbrook, and Landes (2006), mark the continuous effort of science teachers in developing instructional patterns in order to improve their students' learning. Bybee et al. (2006) also mentions, for fulfilling science teachers' aims, the systematic attempt of curriculum reformers to reveal research findings incorporating the materials which enhance the connection through curriculum, teachers, and students. Additionally, they states that "Recently, the use of coordinated and coherent sequencing of lessons -learning cycles and instructional models- has gained popularity in the science education community" (p.1). Therefore, designing materials incorporating LC with context-based instruction have latent capacity to reconstruct science curricula around real-world problems so that students will construct knowledge and develop skills required for a science and technology rich world; teachers will improve their instructional practices.

5E instructional model of LC was used widespread while developing new curriculum materials for Biological Sciences Curriculum Study (BSCS) (Bybee, et al. 2006). According to Bybee et al. (2006), 5E instructional model takes its roots from constructivist philosophy of education and it supports inquiry-based science learning. In constructivism, the aim is making students to feel conflict with their existing thinking so that to think in a different way. Bybee et al. (2006), states that 5E model has been used in widely in curriculum development. There are five phases in a 5E model of instruction which are engagement, exploration, explanation, elaboration and evaluation. Based on the Bybee et al. (2006) description, each "E" of 5E is a phase which functions differently to support teachers' instruction and students understanding, attitudes, and skills.

A great deal of research on CBA focused on positive influence of context-based instruction on students' interest, motivation, attitudes, problem solving, understanding, achievement, and/or scientific literacy (Acar & Yaman, 2011, Barker & Millar 1999, 2000; Bennett, Lubben & Hogarth, 2007; Demircioğlu, Demircioğlu & Çalık, 2009; Ilhan, 2010; Ingram, 2003; Kelly, 2007; Ramsden, 1997). Murphy's (1994) and Hennessy's (1993) (as cited in Whitelegg & Parry, 1999) suggest that context-based instruction has the possibility of enhancing students' interest provided that an appropriate context was used. The meta-analysis of Bennett, Hogarth and Lubben (2003) indicates that there are evidences to conclude CBA increases students' motivation in science courses and these approaches develop positive attitude towards science. Additionally, their study has also evidence to support no adverse affect of context-based approaches on students' understanding of scientific concepts. Moreover, in their review study in 2005, Lubben, Bennett, Hogarth, and Robinson states that courses using context-based and STS approaches took attention both nationally and internationally since these approaches are seen to have a serious role in improvement of students' scientific literacy.

CBAs have a widespread application especially in Chemical Education field in which active debates and reforms are proceeding for improvements of teaching and learning. As De Jong, (2005) stated, an important reason for debates and reform for improvement of chemistry teaching is the dissatisfaction with the chemistry curricula. He described the curricula as being “quite isolated from students’ personal interest, from current society and technology issues, and from modern chemistry” (p.1). A critical effort for healing current curriculum isolation is the use of meaningful real-life contexts in teaching and learning process of chemistry by means of CBAs. Therefore, from the late 1980s, context-based curriculum projects were implemented particularly in chemistry courses, for instance, ChemCom: the USA project of “Chemistry in the Community”, CiC: the USA project of ‘Chemistry in Contexts: Applying Chemistry to Society’, and Salters: the UK project of ‘Salters Chemistry’, and ChiK: the German project of ‘Chemie im Kontext’. Bulte et al. (2006) considered context-based chemistry curricula as a way of remedying deficient outcomes (i.e.: being abstract, difficult to learn, and irrelevance of concepts to the world students live) of current school chemistry, specifically in the affective domain.

A considerable number of studies have investigated the effectiveness of CBAs in chemistry education. Bennett and Lubben (2006) found research-based evidence to positive responses of students to context-based approach used in Salters Advanced Chemistry; they also concluded a comparable level of understanding with respect to conventional course. Several studies tried to explore the impact of approaches on different chemistry topics. For instance, Belt et al. (2005) studied thermodynamics, kinetics, and electrochemistry for undergraduate physical chemistry. Barker and Millar (1999) investigated students’ reasoning on chemical reactions in a context-based post-16 chemistry course. Ilhan (2010) explored the effect of context-based approach on 11^{th} grade high school students’ learning of chemical equilibrium and the change in students’ motivation and attitude level across the experimental and control groups. Demircioğlu et al. (2009) studied with 9^{th} grade students’ conceptions on Periodic Table and compared attitudes of students in context-based course with traditional course. Ünal (2008) conducted an experimental study with secondary-level students on the concept of heat and matter by implementing a context-based approach across traditional approach. Most of the studies investigating the effects of CBAs in chemical education focus on students’ learning outcomes, students’ motivation and their attitudes towards chemistry. Studies conducted in

Turkey particularly concentrate on one chapter from the chemistry curriculum rather than a whole course.

Recent reforms and innovative curriculum projects have direct impacts on Turkish national curriculum system. Although, Ültay and Çalık (2011) states that secondary science curricula, particularly chemistry and physics, are reorganized according to context-based approach, chemistry curriculum do not clearly mentions on context-based teaching as well as the physics. Objectives about: relating concepts to contexts, introducing the knowledge on a need-to-know basis, relating science-technology-society, science process skills are commonly used in science and technology curriculum for elementary level, even these objectives are established for physics and chemistry. However, only physics curricula clearly explain that the changes made in physics curricula are affected by CBAs. Moreover, several context-based activities and contexts as initiation of concepts are provided by physics curriculum for teachers' use. Thus new chemistry curricula may not be evaluated as a context-based curricula as much as the physics curricula; so, studies conducted in chemistry education field will probably bring about the needs, deficiencies, or any other demands related with the program, students, and teachers.

Chemical reactions and energy concepts have been studied widespread since understanding the basic ideas of the topic has some difficulties because of its abstractness, popularity in society (Barker & Millar, 1999; 2000; De Vos & Verdonk, 1985a; Goedhart & Kaper, 2002). These concepts are introduced to students gradually from elementary school years. The chemical reactions and energy chapter has also been in previous 10th grade curriculum, although the name of the chapter is the same as it was in the previous curriculum, the content and the concepts included in this chapter have changed radically. Concepts of thermochemistry and thermodynamics are introduced together in this new chapter of eleventh grade recently changed curriculum. Despite introducing students the main concepts of thermochemistry, the topic of thermodynamics is given in high school level in this new curriculum first time and the design of chapter is different from internationals'. The concepts of energy is currently quite popular in society and since recently changed no studies on methodological concern or any other have been reported on this chapter in spite of many research has been conducted abroad. For these particular reasons, this study purposes to reveal the effect of context-based approach through 5E learning model on students' achievement, motivational constructs, chemical literacy on chemical reactions and energy concepts of eleventh grade students.

1.1 The Purpose of the Study

Having been reported some advances of context-based approaches on chemistry education field, studies focusing on effectiveness of CBA on chemical reactions and energy for Turkish context is relatively untouched. Although, contextual teaching has been remained implicit for national chemistry curriculum, it is claimed to not only support understanding concepts by connecting real-life situations but also enhance chemical literacy, and increase motivation. In spite of extensive literature for these claims, there have been quite few studies testing those claims on current national chemistry curriculum in Turkey. For this reason, this study aimed to investigate the effectiveness of CBA through 5E learning cycle model on students' understanding, achievement, and chemical literacy on chemical reactions and energy unit and students motivation to learn chemistry.

1.2 Significance of the Study

Despite the innovative changes in Turkish national science curriculum, the approach to teach chemistry primarily has remained unchanged. The lack of enthusiasm to learn chemistry at high school level stems from traditional chemistry has been taught in which the focus is covering an overloaded curriculum with rote learning of a body of knowledge. Therefore, students cannot realize the relation of content of such curriculum to their everyday lives which later result in many students not to interest in chemistry since it is seen as irrelevant to their concerns. There is a growing need to improve the way of chemistry is taught in schools thus the students will see the connectedness concepts to the real world they live. Context-based learning activities are supposed to satisfy the needs to improve chemistry teaching by broadening students' knowledge base, interest, and scientific literacy through a context relevant to students. Thus, developing lessons which are claimed to improve quality of teaching becomes quite important for a recently reformed Turkish national chemistry curriculum.

Many studies reported how effectively context-based approaches could be implemented in class settings (Campbell & Lubben, 2000; Bulte et al., 2006; De Jong, 2006; Pilot & Bulte, 2006). Bennett et al. (2003) carried a systematic review on CBA and STS approaches, the study revealed that quality of the studies allow confidence in findings. Their conclusions were to benefit from systematic maps for implementations regarding a full STS course, attitudes/understanding/gender/ and pupils with different ability range. Therefore, designing the lessons incorporating learning cycle with context based approach, investigating their effectiveness for Turkish national chemistry curriculum is an area of interest for researchers. Despite the differences in international and national chemistry curriculum, embedding the concepts into contexts is the same for both but the nature of context is expected to be different. Testing the materials developed for this study is another significant point for teachers who want to utilize lesson plans which are not as usual as they are accustomed to use.

Recently a few studies from Turkey reported the effectiveness of context-based lessons over conventional lessons; most of these studies are dissertation studies. For instance, Ilhan (2010) investigated the effectiveness of CBA on 11th grade high school students' learning of chemical equilibrium and the change in students' motivation and attitude level across the experimental and control groups. He found that context-based activities have positive impact on affective domain of students in experimental group. Similarly, Demircioğlu (2008) studied with 9th grade students'; she focused on students' conceptions on Periodic Table and compared attitudes of students in context-based course with traditional course. She explored that students from context-based course are more engaged in the lessons. Chemical reactions and energy unit has not been studied neither as a dissertation nor a research study yet, therefore, findings will contribute to policy makers in chemistry education field and prospective chemistry teachers.

Although, many international studies have reported the advantages or critiques of context-based courses in terms of varying aspects, very limited number of studies from Turkey reported as such if any. Değirmenci (2009) prepared a dissertation in physics education field for the unit of "waves"; he discussed improving, applying and investigating new materials based on the context-based learning approach for the 9^{th} grade. If exists any, this study will also report problems associated with course design and implementation.

Even though studies on teaching chemical reactions and thermodynamics through CBA exist, the concepts covered in the chapter are different across the countries because of their curriculum structures. For example, Barker and Millar (2000) conducted a research with high school students to compare students' responses to chemical reactions through context-based course and traditional course. The content of chemistry they covered was chemical reactions, thermodynamics, and chemical bonds; they found a slight advantage in developing understanding of students in the context-based course. The main focus of the study was students' reasoning more qualitatively. Another group of studies investigated the effects of CBAs on students' motivation and attitude (affective variables) in chemistry. Ramsden (1997) conducted a research with high school students in UK; the content in her study was elements-mixtures-compounds and conservation of mass in chemical reactions-chemical change and periodic table as a unifying theme. She found out those students from CBA interested in chemistry more than conventional class students. Therefore, investigating the effect of CBA on chemical reactions and energy chapter which mainly cover thermochemistry and thermodynamics concepts from varying aspects is worth to study.

In Turkey, CBA in chemistry field has just become popular, even if it is widely studied in the other countries especially England, Germany, Netherlands, USA, and Australia. There are several studies which are not published or ended yet. The pool of such studies on CBAs in Turkey is expected to contribute chemistry teaching. Studying context-based chemistry is worth to deal with because it is claimed to improve students' chemical literacy level too, which was not investigated previously for this topic in Turkey.

To sum up, the developed course design is expected to help students to increase their motivation, to increase their interest in dealing with chemistry course, to have an achievement better than traditional course, raise students' awareness of the connections between chemistry and real-life issues. Additionally students in context-based course are expected to have more chemical literacy that traditional course. Moreover, the study will contribute teachers as it added some materials to their teaching repertoire. Besides, it will contribute to national policy makers. Finally, not only this study, but also others conducted in Turkey will bring a platform on which deficiencies, problems, advantages will be discussed not only in national borders but also in international borders.

1.3 Definition of Important Terms

The constitutive and operational definitions of important terms are given as follow;

Traditional instruction: It is a kind of instruction in which students are introduced to topics primarily with lecturing method. Taasoobshirazi and Carr (2008) explain traditional instruction as "business as usual" in the classroom. They also describe traditional instruction as a lecturing with no intervention such as inquiry-based. It is a teacher-centered instruction.

Context-based approach (CBA): In this approach real-life contexts are used to introduce concepts. Glynn and Koballa describe it as "using concepts and process skills in real-world contexts that are relevant to students from diverse backgrounds" (2005, p.75). Additionally, CBA is described by Lubben, Bennett, Hogarth, and Robinson (2005) as an approach adopted "in science teaching, in which contexts and applications of science are used as the *starting point* for the development of scientific ideas. This contrasts with more traditional approaches, which cover scientific ideas first and conclude with a brief mention of applications" (p.10)

5E Learning cycle model: An inquiry-based model of teaching having five different phases which are: engagement, exploration, explanation, elaboration, and evaluation.

Motivation: According to Glynn, Aultman, and Owens motivation is an internal state that arouses, directs, and sustains human behavior (p.1, 2005).

Achievement: A task that is accomplished successfully, especially by means of effort, skill, practice, or constancy.

Chemical Literacy: The definition of this term is quite similar to definition of scientific literacy. Witte and Beers (2003) explain chemical literacy as (1) being able to use and deal with given information related with a chemical problem (2) being able to use knowledge of chemistry and skills in order to understand information associated with everyday problems.

Context: A cultural psychologist, Cole (1996) explains context as; it comes from the Latin verb "contexere" meaning as "to weave together". It can also be defined as collection of parts and the connection between them.

1.4 Problems and Hypotheses

The main problems, sub-problems and hypotheses of the study will be stated in this section.

1.4.1 The Main Problems and Sub-problems

1.4.1.1 The Main Problems

1. What is the effect of context-based approach (CBA) through 5E learning cycle (LC) model and gender on eleventh grade public Anatolian high schools science major students' understanding and achievement in chemical reactions and energy concepts, and their motivation to learn chemistry when compared to traditional chemistry instruction?

2. What is the effect of CBA through 5E LC model and gender on eleventh grade science major students' motivational factors (Intrinsic motivation to learn chemistry, Extrinsically motivated chemistry learning, Relevance of learning chemistry to personal goals, Responsibility or Self-determination for learning chemistry, Confidence or Self-efficacy in learning chemistry, and Anxiety about chemistry assessment)?

3. What is the effect of CBA through 5E LC model on eleventh grade science major students' chemical literacy level on the concepts of chemical reactions and energy?

1.4.1.2 The Sub-problems

Sub-Problem 1

Is there a significant population mean difference between the groups exposed to CBA through 5E LC and traditionally designed chemistry instruction on eleventh grade science major students' understanding of chemical reactions and energy concepts when students' science process skills test scores are controlled?

Sub-Problem 2

Is there a significant population mean difference between the groups exposed to CBA through 5E LC and traditionally designed chemistry instruction on eleventh grade science major students' achievement of chemical reactions and energy concepts when students' science process skills test scores are controlled?

Sub-Problem 3

Is there a significant population mean difference between the groups exposed to CBA through 5E LC and traditionally designed chemistry instruction on eleventh grade science major students' collective chemistry motivation when students' science process skills test scores are controlled?

Sub-Problem 4

Is there a significant mean difference between males and females with respect to students' understanding of chemical reactions and energy concepts when students' science process skills test scores are controlled?

Sub-Problem 5

Is there a significant mean difference between males and females with respect to students' achievement of chemical reactions and energy concepts when students' science process skills test scores are controlled?

Sub-Problem 6

Is there a significant mean difference between males and females with respect to students' collective chemistry motivation when students' science process skills test scores are controlled?

Sub-Problem 7

Is there a significant effect of interaction between gender and treatment with respect to students' mean scores of collective dependent variables in chemical reactions and energy concepts when science process skills test scores are controlled?

Sub-Problem 8

Is there a significant mean difference between the groups exposed to CBA through 5E LC model and traditional designed chemistry instruction with respect to students' motivational factors scores (Intrinsic motivation to learn chemistry, Extrinsically motivated chemistry learning, Relevance of learning chemistry to personal goals, Responsibility or Self-determination for learning chemistry, Confidence or Self-efficacy in learning chemistry, and Anxiety about chemistry assessment)?

Sub-Problem 9

Is there a significant mean difference between males and females with respect to students' motivational factors scores (Intrinsic motivation to learn chemistry, Extrinsically motivated chemistry learning, Relevance of learning chemistry to personal goals, Responsibility or Self-determination for learning chemistry, Confidence or Self-efficacy in learning chemistry, and Anxiety about chemistry assessment)?

Sub-Problem 10

How students' chemical literacy level on chemical reactions and energy concepts differs across groups exposed to context-based approach through 5E learning cycle model and traditional designed chemistry instruction?

1.4.2 Hypotheses

The above-mentioned problems were stated as hypothesis in null form to be tested further.

Null Hypothesis 1

There is no significant population mean difference between the groups exposed to context-based approach through 5E learning cycle model and traditionally designed chemistry instruction on eleventh grade science major students' understanding of chemical reactions and energy concepts when students' science process skills test scores are controlled.

Null Hypothesis 2

There is no significant population mean difference between the groups exposed to CBA through 5E LC model and traditionally designed chemistry instruction on eleventh grade science major students' achievement of chemical reactions and energy concepts when students' science process skills test scores are controlled.

Null Hypothesis 3

There is no significant population mean difference between the groups exposed to CBA through 5E LC model and traditionally designed chemistry instruction on eleventh grade science major students' collective chemistry motivation when students' science process skills test scores are controlled.

Null Hypothesis 4

There is no significant mean difference between males and females with respect to students' understanding of chemical reactions and energy concepts when students' science process skills test scores are controlled.

Null Hypothesis 5

There is no significant mean difference between males and females with respect to students' achievement of chemical reactions and energy concepts when students' science process skills test scores are controlled.

Null Hypothesis 6

There is no significant mean difference between males and females with respect to students' collective chemistry motivation when students' science process skills test scores are controlled.

Null Hypothesis 7

There is no significant effect of interaction between gender and treatment with respect to students' mean scores of collective dependent variables in chemical reactions and energy concepts when science process skills test scores are controlled.

Null Hypothesis 8

There is no significant mean difference between the groups exposed to CBA through 5E LC model and traditional designed chemistry instruction with respect to students' motivational factors scores (Intrinsic motivation to learn chemistry, Extrinsically motivated chemistry learning, Relevance of learning chemistry to personal goals, Responsibility or Self-determination for learning chemistry, Confidence or Self-efficacy in learning chemistry, and Anxiety about chemistry assessment).

Null Hypothesis 9

There is no significant mean difference between males and females with respect to students' motivational factors scores (Intrinsic motivation to learn chemistry, Extrinsically motivated chemistry learning, Relevance of learning chemistry to personal goals, Responsibility or Self-determination for learning chemistry, Confidence or Self-efficacy in learning chemistry, and Anxiety about chemistry assessment).

Null Hypothesis 10

How students' chemical literacy on chemical reactions and energy concepts differs across groups exposed to context-based approach through 5E learning cycle model and traditional designed chemistry instruction

CHAPTER 2

LITERATURE REVIEW

Chemistry education in secondary level has not enough popularity among students in many western industrialized countries and in any other non-industrialized countries. Osborne and Dillion (2008) explained the reason for this situation as; students find it difficult to learn and they consider it will add little value to their lives and profession. The research concerning problems of many chemistry curricula revealed some critical issues associated with varying aspects. Gilbert (2006) categorized these problematic issues and clarified them in detail. A substantial research proposed that chemistry curricula if designed in the framework of context-based approach (CBA) will overcome the problems of conventional chemistry curricula (Bennett et al. 2003; Bennett et al. 2007; Bulte et al. 2006; Pilot and Bulte 2006). In the light of these international findings, investigating effectiveness of CBA has become a popular trend among national researchers as well. In this section firstly, contextual learning, projects promoting context-based approach, methodologies of context-based approach, variables affected by context-based approach, international-national studies, and studies conducted on chemical reactions and energy will be reviewed.

2.1 Contextual Learning

Parnell (1995) explains the term "contextual learning" (CL) as an educational philosophy and an educational strategy that focuses on enabling students to acquire *meaningfulness* in their education. CL endeavors to help students connect knowing (knowledge) with doing (application). In CL the major role of the teacher is to develop students' perceptions in a way that meaning becomes clear and the aim of learning becomes understandable immediately. Parnell (1995) additionally, add that helping students to follow the specific objectives of a course is not enough, instead, teachers have better to make students to understand the widespread meaning of a specific task – how this specific task is related to real-life issues and actual life roles.

"*The striving to find a meaning in one's life is the primary motivational force in humankind".*

Viktor Frankl

The contextual approach to education is intentionally adapted from the study of Viktor Frankl, who established the psychological practice named as "legotherapy". He worked on the importance of meaning for human experience. Frankl mentions that for an individual the importance of struggling to catch a concrete meaning or aiming to find personal existence is the primary motivational for living. This principle is expected to be applicable for education as well, since revealing the "why" of concrete world is quite essential motivational drive in learning. In line with Frankl view, Parnell (1995) states that if students are motivated to learn something, they will understand the relatedness and meaning of concepts in their educational practices. Moreover, he describes the best teachers of all times were trying to teach the meaning of concepts to their students consciously or simply instinct.

Table 2. 1 Description of contextual learning from Parnell 1995

Contextual learning is...	Contextual learning is not...
...a relentless search for meaning in the process of teaching-learning.	...just another gimmick in education under a new name.
...an avenue to education reform with emphasis upon the integration of content with context.	...emphasis only upon knowing or only upon doing.
...an emphasis upon continuity in learning.	...an unconnected series of school or college courses.
...a way of helping every student experience success in learning.	...a tracking system that separates the “dumb” students from the “smart” ones.
...a means of helping students learn to use resources, information, technology, and systems, and to work as effective team members.	...a system in which students works alone with little understanding of how their learning connects with real-world applications.

Frankl (as cited in Parnell 1995), briefly summarizes what CL is and what it is not in table 2.1. The table 2.1 clearly emphasizes on certain aspects of CL specifically describing it as an avenue for focusing on integration of content with context. Connecting content with context has almost become a slogan for context-based approaches which constitutes the main framework for recent curriculum innovations.

> *“The beginning of teaching should be made by dealing with actual things. The object must be a real, useful thing, capable of making an impression upon the senses… if visible, with the eyes; if audible, with the ears; if tangible, with the touch; if odorous, with the nose; if sapid, with the taste. First the presentation of the thing itself … then the real explanation for the further elucidation of it”*
>
> J.A. Comenius, 1592-1670

As statement of Comenius in 1592-1670, contextual teaching also suggests teaching/learning environment should be prepared in a way that students' attention was taken by their sensations, their experiences through actual things around them. The way to accomplish such learning can be done by using contexts aroused from daily-life activities, such as breathing, eating, drinking, and using medicines. The usage of natural and/or technical phenomena as context can be enriched with relevant questions and discussions which students engage in and hoped to be more motivated to deal with these activities. Cultural and societal issues are also authentic contexts for scientific investigations.

2.2 Problems Associated with Chemistry Education

Conventional instruction has been leaned on the active teachers and inactive students. However, an increasing awareness about the passive roles of students in traditional instruction has emerged since being inactive is not expected to advance varying aspects of students' development. Thus, an initiative in chemistry curricula has sustained to change classroom environment toward a frame which centres students as active agents of learning process. The problems of chemistry education are not restricted to students and teachers' role, Gilbert (2006) states that chemical education field has some inter-related problems. He summarizes these five problems in his study on "on the nature of context in chemical education". Additionally, Pilot and Bulte (2006) mention these problems too. In this section, the problems associated with current chemistry education based on Gilbert's 2006 study will be elaborated. These problems have to be addressed while designing effective lessons which make concepts more meaningful to students.

Overload. The accumulation of scientific knowledge has a great acceleration in this rapidly evolving technological environment. Millar and Osborne (2000) states that as a consequence of this knowledge accumulation, curricula have turned out to be over-loaded with content. This situation is interpreted by De Vos, Bulte and Pilot (2002) as gathering of isolated facts that are from their scientific sources.

Isolated Facts. Gilbert (2006) stresses that the content of the curricula are instructed to students regardless of whether they know how to connect within and between the isolated facts. He additionally states that the achieving great number of isolated facts is not meant to formation of mental schema. Similarly, Pilot and Bulte (2006) emphasizes that students do not understand the meaning of concepts they have learned.

Lack of transfer. The way students solve problems is possibly the way that their teacher taught them. Therefore, unfortunately, students usually fail to solve problems related with the same concepts when the presentations of the problems have changed. Osborne and Collins (2000) stated that students fail to perceive the relevance of problems to their everyday lives at the moment or in the future. Gilbert (2006) interprets this finding as lack of transfer of chemistry learning to everyday situations.

Lack of relevance. Gilbert (2006) states that if chemistry were not a compulsory course, a majority of the students would not select it as an elective course since many of the students do not find chemistry relevant to them. He also mentions that students perceive chemistry a tool, rather than seeing it worth to study. They also do not sense why they are required to learn a specific subject.

Inadequate emphasis. According to Gilbert (2006), chemistry curriculum has some traditional emphases on three bases which are "solid foundation", "correct explanation", and "scientific skill development". These bases are not considered as adequate for more progressive study of chemistry. Additionally, these emphases are not appropriate to students who will not prefer chemistry or chemistry-related-profession as a career.

2.3 Potential Solutions and Three Characteristics of Meaningful Chemistry

The challenges associated with these five problems revealed by Gilbert (2006) are different, so each requires different way of solution. Gilbert (2006) states that using "context" as a base for chemistry curricula has potential to address these challenges.

He also explains that the educational design which embodies the *context* should support sufficient answer to the problems associated with curricula and society. There are some ways to address each of these problems; first, the context should be used to both simplify and reduce the content overload. The concepts having widespread usage in chemistry should be identified and the focus on learning should be given to them. The contexts could be used to lighten the content load of chemical curriculum, to exemplify the concepts. Secondly, Gilbert (2006) states that the series of used contexts must be able to support the basis for students' improvement of coherent mental structures of relatedness between concepts. Subsequently, the collection of contexts utilized should provide likelihood of transferring concepts to other contexts as well. This solution is interpreted by Pilot and Bulte (2006) as "enabling transfer", they clarified this as important characteristics which have potential to improve students in making connections between the knowledge they had learnt and other situations. The fourth issue to address is the participation of the students to the activities at hand; some students should become very interested in these activities too. The collection of contexts utilized should have potential to make chemistry relevant to students, and these contexts should enhance the development of a personal relevance to chemistry content knowledge. Thus, students will be more willing to and engage in chemistry education. The last issue is selection of well-balanced curriculum emphases. Gilbert (2006) states that the collection of contexts utilized should be flexible enough to give permission to the design of curricula for a group of students with varying range of prior achievement and for students having future ambitions in chemistry.

As we explained the potential solutions based on Gilbert (2006) study, there are some more attempts to reduce the problematic characteristics of chemistry education by designing meaningful lessons (e.g. Bennett & Holman, 2002; Campbell, Lazonby, Millar, Nicolson, Ramsden & Wadding, 1994). As mentioned above, these range from: isolated-facts, adding some more content to the existing curriculum. Based on Westbroek (2005), there are three intertwined features of meaningful chemistry education. These three features are obtained from reviewing the literature, especially projects on improving chemistry education. How these features are considered as a solution to above-mentioned problems, and how they make chemistry learning more meaningful is described below.

Context. It is the use of a well defined group of related situations which are recognizable by students. The real world context is described by Yam (2005) as a way of allowing students to connect concepts to their applications from their lives as a member of society and family, student and worker. Westbroek (2005) states that contexts make students to utilize concepts meaningful and motivate them.

According to De Jong (2006), contexts are situations in which students are helped to make meaning about concepts, rules, laws, and so on. He describes that contexts have four different domains. These domains are clarified in below table.

Table 2. 2 Origins of contexts

Origin of a context	Example of a context
Personal domain	Personal health care
Social and society domain	Acid rain effects on the environment
Professional practice domain	Practices of chemical engineers
Scientific and technological domain	Historical models and theories

These domains are considered to give more precise information to enhance the clarity of discussions on contexts and how to use them in chemistry education. According to De Jong, there are four points which a context is required to: be well-known and relevant for both boys and girls, take attention of students, lack of complexity and confusion for students.

Need-to-know. Constructing a base for students to need knowledge is a requirement for meaningful chemistry instruction. Addressing the questions on a need-to-know platform implies that students will properly build new concepts on their pre-existing knowledge thus they will be more involved in teaching-learning activities. Westbroek (2005) mentions that establishing a need-to-know base along with a well-defined context contributes the improvement of coherent emphasis. The questions such as "why do I have to learn this topic" mentioned earlier will be clarified if a strong need-to-know base is established.

Attention for student input. This is quite related with need-to-know base. Westbroek (2005) states that if students are truly engaged in a need-to-know base, that is clearly an indication of real attention for student input. When the need-to-know base was established successfully, students will carefully follow the course, they will feel the functionality upcoming concepts. Therefore, teachers will easily continue on progression of content, and they will be able to pay attention to students' input.

2.4 The Use of "Context" in Chemistry Education

The term context, perceived as a tool to promote chemistry education, requires some clarifications. As previously mentioned the word originates from the Latin verb "contexere", in its noun form "contextus" means coherence, connection and relationship. Gilbert (2006) describes a context as tool to provide a rationale structural comprehension of something newly introduced in a broader perspective. In, chemistry education field, the use of context means ensuring a base for learning chemistry through introducing some relevant-experienced aspects from students lives. Duranti and Goodwin (1992), perceived the exact definition of context as impossible; however, they have some clues about the definition of the term. Based on their clues, Gilbert (2006) describes context as a non-verbal behavior, using a diagram, an animation, or a photograph have potential to be a context over which a talk or a discussion will start. Duranti and Goodwin call this as a "focal event", they describes context a focal event which embeds in cultural settings of society. Their educational context description requires four attributes:

a. a context requires a platform on which a social-spatial, framework is established for mental encounters to be settled with focal events.
b. It is a behavioural environment for encounters, the way that the concepts are associated with the focal event, addressed, is used to make a frame for the talk that then will take place.

c. It is the use of language, as the conversation related with the focal event will occur.
d. It is the relationship to extra-situational attained knowledge.

The clarification of attributes is given by Gilbert (2006) from science and technology field. He exemplifies an earthquake occurring in place on planet, a platform or a setting is the devastated place requiring rebuilding. Considering the societal issues of the country, population density-distribution, and weather conditions are determinants of rebuilding (attribute a). Then, the behavioural environment assign the activities in which architects, materials scientists, and city planners engage in to decide resources, methods for construction (attribute b). The language used constitutes discussion around houses resistant to earthquakes, usage of materials, and the types of structures (attribute c). The background knowledge is dialled when the action of forces on buildings is involved (attribute d).

According to Gilbert (2006), the four attributes of a focal event have potential to address his pre-mentioned five curricular challenges. If a context contributes a coherent-structural-framework for students by amplifying each of the four attributes then it is expected that students' personal relevance to concepts will be associated with their understanding of why they learn a particular topic of chemistry. Gilbert (2006) critiques that classification is limited on how learning will take place, therefore, the need for investigation of which educational psychology seems to reveal the way the attributes' of "context" can be carried out in context-based chemistry instruction. The relation of educational psychology with four attributes of context is clarified in following section.

2.4.1 Approaches of Making Meaning

According to Gilbert (2006), among many approaches, constructivism, situated learning and activity theory seems to have particular importance in usage of contexts. Based on Gilbert's description, while designing context-based learning environments, any of these approaches could be utilized.

Constructivism. According to Gilbert, this approach supports how to address attributes c and d. Ogborn (1997, as cited in Gilbert, 2006) states the importance of expressions and background knowledge in learning a chemistry concept related to task, in active construction of knowledge (attribute c, d). Ogborn describes that constructivism insist on four points: students' active involvement; respecting for both students and for their ideas; the notion of creation of science by human beings; designing teaching which makes sense by students, capitalizing students prior knowledge, and answering difficulties of students about images of things to be.

Situated Learning. According to Gilbert, how attributes a-d are connected to context-based education are explained by ideas of situated learning. First idea is participation in a group of activities which means students and teachers must accept themselves as engaging together in "community of learners". The next idea is the effective involvement of students and teachers to develop their identities by means of constructive interactions. Participation of students in productive interactions could be assisted by teachers and students to improving students' identities as learners. Thirdly, Greeno (1998, as cited in Gilbert, 2006) states that learning is situated however the outcomes of this situation should be carried over the situations since knowledge transfer is most important outcome of learning and it must be investigated actively. Finally, Gilbert (2006) mentions the quality of task as a requirement for involvement in community of practice. Students' engagement in activities related with learning and knowledge construction consists of affiliations and identity of communities of practices (Greeno, 1998 as cited in Gilbert, 2006). Greeno associates attribute a, b, c and d (setting-behavioural environment-talk-background knowledge, respectively) by stating participation in activities require students reasoning in subject domain and reasoning in concepts and methods of subject domain.

Activity Theory. According to Vygotsky (1978, as cited in Gilbert, 2006), learner and subject being studied are not dissociated objects; they are mutually defined by human activity. A person's interpretations from his life on a subject, makes meaning of subject. In this approach, the focal event or context is the object that is studied. Gilbert (2006) describes Vygotsky perspective of cognitive apprenticeship a place where learner and teacher, who have experience in interpreting the context, interact.

In other words, the teacher has the mission of bringing together the socially admitted attributes of focal event and the attributes of a focal event recognized by students.

Finkelstein (2005) also accepts the attributes of context described by Duranti and Goodwin (1992) as framework of context-based learning and effective learning. Attribute b (task), situation and idioculture are differentiated by Finkelstein from a wide conceptualization of situation (attribute a). The above-mentioned approaches to learning along with four attributes of a context constitute the framework for successive context-based chemistry instruction. The discussion around the attainment of context-based learning of chemistry makes Gilbert (2006) to propose four models of context. Below these models are explained in detail.

2.4.2 Four Models of "Context"

Gilbert (2006) describes four models of "context" which can be used in chemistry education. These models implicitly or explicitly support context and successful context-based instruction. Each of these is explained in detail in following sections.

***Model 1: Context as the direct application of concepts*:** The word context is generally used to mean the application of concepts or the significance of these applications. Gilbert (2006) describes that if a curriculum is based on the context that means curriculum provides some situations or circumstance from students' personal-social life and from the industrial perspective in which applications of chemistry concepts are presented. The approach refers to one-way rigid association among concepts and their applications: which totally means how chemistry concepts are employed in applications. These kinds of courses are fixed to application at the end of the instructing theoretical parts of the concepts. The application of context contains some situations which are considered as objects and usually omits the cultural importance of it. In this model of context, the focus is to concentrate on abstract learning of concepts without reorganizing the educational setting and the behavioral environment of teaching-learning process. Gilbert (2006) states that it is a post-hoc illustration to attempt to make a concept meaningful after its learning process. According to Gilbert (2006) the model of context does not satisfy the features of context-based curriculum since:

- Introduction of community of practice does not include social-spatial-temporal framework for students.
- A qualified learning task is not provided since insufficiency of behavioural environment.
- It is not a tool for students to acquire meaningful use of specific language.
- It does not appeal background knowledge of students.

Because of limitations for an effective context-based learning of chemistry, some more models are described by Gilbert.

***Model 2: Context as reciprocity between concepts and applications*:** According to Gilbert, this model does not only relate concepts with applications of but also applications impact on meaning attributed to the concepts. The position of context is alongside of the concepts and their applications in students' cognition. In this model, many subgroups associated with chemical context have potential to be mentioned. For biochemistry as a context; the knowledge of chemistry technology, ethical social-scientific issues are all sub-contexts. The change between sub-contexts explicitly or implicitly has potential to infer different meaning of concepts. This situation can cause confusion among students and teachers.

Based on the Gilbert's (2006) description, the degree of reciprocity within the coherence of concepts and their applications means as in the extensive definition of content used the Science-Technology-Society (STS) movement. The content in this movement contains interaction of science-technology, or science-society, and any one or below combinations:

- A technological product, process, or competence
- Interaction among technology and society
- Societal issues of science or technology

- The content of social science which enlighten the societal issues of science and technology
- In the community of science and technology, it is a philosophical, historical, or social issue.

According to De Vos et al. (2002), the existing chemistry curriculum includes sedimentary structures with sequential layers of contexts given in varying historical periods. Gilbert (2006) evaluates this model as having potential to cause students to perceive subjects confusing. When compared to first model of context, this model seems to have a sounder base for context-based chemistry learning; however, it still has a missing parameter for effective context-based instruction. The missing part in this model is establishment of need-to-know base for introducing the concepts of chemistry. According to Gilbert (2006), similar to Vygotsky view, teachers must introduce contexts which have the attribute of socially accepted contexts and the attributes of a context recognized by students. A teacher can perceive a context clear and having the ability of addressing certain issues of the focal event, but this does not mean that the context will function for students in the same way. Students need to understand the connection between an issue and the reason they should learn some concepts of chemistry. In brief, Gilbert (2006) states that context of teacher does not always mean the context of students. Therefore a new model is described.

Model 3: Context as provided by personal mental activity: Based on Gilbert description, this model has different terminologies with three elements contributing the keys of successful chemistry education. Stocklmayer and Gilbert (2002) used some terms from Duranti and Goodwin's work (1992) while explaining keys of successful chemistry education

- Situations: are the *settings* for *focal events*
- Contexts: product of transformation of situations from mental process. Existing mental models are used to make meaning on the settings

- Narratives: are described as the links between contexts and some aspects from students' lives. The links constitutes the transfer of learning from one setting to the other.

Mendeleyev was given as example, was fixed in time and space while investigating periodic trends of elements. In this example the representation of narrative, context and situation is successful. Using a book as medium, the parameters of effective chemistry education are:

I. Provided that student could empathize in the activities, and value the narrative, the criterion of model will be satisfied.
II. Provided that activities and talk are prepared effectively, the teacher must guide students extensively.
III. The language must be developed and used influentially.
IV. A significant amount of background knowledge is required.

When this model is interpreted, it seems the model has a serious value when implemented in major events of chemistry field. To value the description of a context, students need to empathize with the context. Unfortunately, this does not mean students will be engaged in actively. The missing part in this model is involvement of students in community of the practice. Therefore, Gilbert (2006) describes one more model of context.

Model 4: Context as the social circumstances: This model reveals the necessity of social aspect of a context which is situated as cultural stuff in the society. Chemical topics and students' activities which are significant for communities within the society are related to each other. According to Gilbert, a context can be some popular recent discussions about global climate, healthy food and obesity and the hydrogen economy. There are two ways of meaning making in this model: one views context as social surrounding, the other views it as social activity. The setting (attribute a) determines the talk which will be conducted in a context as social surrounding. Gilbert states that experiencing a setting result in learning however students' meaning making about the "talk" in context as a way of social activity is identified from involvement in the actions of community (attribute b). Briefly, context as the social situations is established on situated learning and activity theory. According to Gilbert, if a course is designed according to this model, the following will occur:

- Both students and teachers are involved in "community of practices" through effective interactions. The interactions will enable relevant zones students' of proximal developments.
- This will be satisfied when the course is based continuous enquiry in an existing setting.
- Based on Finkelstein (2005) task form, the task is required to contain clearly illustrated problems about important chemistry concepts so that students will develop a comprehensive use of chemistry language.
- Learners will combine what they have learnt from a focal event to other focal event.
- Developing such a course in not frequently found, possibly because this makes resources demand for teachers.

According to Gilbert (2006), the field of education generally has a gap between a new theoretical idea and initiations on implications of the idea in practice. He also states that although situated learning and activity theory are known for 20 years, designing curricula on this base and implementations of it are now emerging.

To sum up, Gilbert described four models context from Duranti and Goodwin's perspective of language. Extend and the ways of four models of context in answering the challenges that chemistry education faces has been said already. There are distinct differences among the models identified. The brief introduction of these models causes a high proportion of oversimplification. The transitions from model 1 to model 4 obviously have a steady progression in terms of their impact on how they satisfied the criteria for effective context-based courses.

In line with Gilbert emphasis on dissatisfying aspects of chemistry curricula, many educational committees concluded that chemistry curricula are outdated, overloaded, have isolated facts, and unable to lead knowledge transfer. To avoid using chemistry curricula which are not successful: in taking attention of students, motivating students, relating concepts to students personal lives many context-based chemistry curricula are developed and implemented internationally. Although these reforms are substantial internationally, the impact of these innovations on national chemistry curriculum is limited. Such studies have potential to contribute curriculum improvement projects.

Based on Gilberts' descriptions of models of context, in this study the model four is utilized since it is expected to satisfy criteria of successful context-based chemistry more than the other models. Substantial literature focused on how to use context-based learning approaches (Bulte et al. 2006; Campbell & Lubben, 2000; Fensham, 2009; King et al. 2008; Newting et al. 2007; Pilot & Bulte, 2006; Schwartz, 2006). In late 1980s, concepts were introduced through real-world meaningful contexts. Recently, many innovative projects in chemistry education focused on designing course materials based on context-based approaches. The first initiative started with Salters project in England and Wales then spread other countries like USA as ChemCom, ChiK in Germany. In the following sections the well-known context-based chemistry projects will be described.

2.5 Context-Based Curriculum Projects

Context-based approaches (CBA) to teach science are continuously gaining popularity among curriculum reformers, educational researchers and organizations since 1980s. Many curriculum projects utilized CBA as a framework for reconstruction of chemistry, physics, biology, and science curricula and courses. All these courses and projects aim to increase students' interest by presenting theoretical knowledge in everyday situations. Examples of projects in chemistry field include: Salters in England and Wales, ChemCom in USA, ChiK in Germany, LORST in Canada, and PLON in Netherlands. Each will be clarified in detail.

2.5.1 The Salters Approach

The story of Salters has started almost 30 years ago and has not ended yet. A group of teachers and educators from science education field gathered in a meeting in 1983 at York to make a discourse on how to teach chemistry in a better way so that students' interests should be increased to learn chemistry. At the end of the meeting, the group decided on developing five context-based chemistry chapters for students. More Salters courses were developed and these courses were spread out biology and physics for the age range of 11-18 (high school) in England and Wales. Additionally, these courses attracted the attention of other countries such as; China, New Zealand, Belgium, Spain, and USA, they benefited from Salters' courses in their science courses.

Rationale: The framework behind the Salters courses was to design a new kind of science teaching which is expected to be more appealing to students. The approach was to find a context which is relevant to students' everyday lives and their interests and this context is expected to make students to engage in varying classroom activities. Campbell et al. (1994) states that the concepts and contexts should be selected in way that they will enhance students' appreciation of the contribution of chemistry to their lives and they should improve students' understandings of the natural environment. Presenting scientific concepts through students' lives is common for context-based approaches.

The Design Characteristics: The Salters approach has three characteristics in designing courses. Campbell et al. (1994) states that the units of the course have better to begin with some parts of students' lives, students could experience it either personally or from the media, and the ideas-concepts should be introduced in a way they need it. First, the contexts are presented through the storylines which are prepared in a way that increase students' interests and make them to involve in learning process. Then, the need-to-know base was established by unfolding the storylines to obtain deeper insights from students' scientific concepts. The story will ensure a context with concepts and ideas are presented together. These concepts and ideas have an obvious function which makes learning meaningful. That means, throughout the storylines students will feel a need for related scientific concepts in order to follow the storyline. Finally, to provide transfer of content knowledge, the course should have varying learning activities which require active students' engagement. The usage of activities in lessons will promote student discussions. In their study, Bennett and Holman (2002) stated that usage of active-learning approaches is a significant characteristic of the Salters' courses. Additionally, they emphasized that students are more in action in activities like presentation, discussions, and decision making than conventional courses.

Evaluation: Many studies were conducted to evaluate the effectiveness of context-based Salters' courses. Barker and Millar (1996) conducted a research on students' reasoning about chemical reactions and they revealed what changes have occurred in a context-based chemistry course. Additionally, Ramsden (1997) conducted a research with high school students in UK; the content of Salters' course in was; elements, mixtures, compounds, conservation of mass in chemical reactions, chemical change, and periodic table. She found out that students from context-based Salters course were interested in chemistry more than conventional class students. Westbroek (2005) stresses that studies are not addressed; -whether students experienced a need to know through stories, -did students experience content as relevant and useful, though, they focused on how and to what extend the design contributed to characteristics of meaningful learning in detail.

2.5.2 ChemCom: Chemistry in the Community

One of the important curricula innovation movements is ChemCom: Chemistry in the Community prepared in USA. The American Chemical Society (ACS) with National Science Foundation (NFS) was the sponsors of development of secondary school text. ACS, as a leader in reforming chemistry curricula, made many efforts to improve educational changes in United States. Professors from universities and teachers from high schools were worked together to write ChemCom. They prepared this book on a need-to-know base, used students-centred activities and a context-based approach, and then they tested it extensively. The first version of ChemCom was introduced in 1988, and the fifth edition was printed in 2005. Up to now, there are approximately 500,000 sold copies and more than 2,000,000 students learned chemistry from it. In between years 1982 and 2000, the percentage of students who enrolled a formal chemistry course has increased from 32% to 62%. This book is translated to other languages too.

Rationale: The problems leading emergence of this project is in line with the problematic characteristics as mentioned before. ChemCom similar to other projects changed its emphasis from solid foundations towards applications of concepts to real life and social-environmental connections of scientific and technological innovations. The book aims to prepare students as effective elements of society by involving them in decision-making activities.

The Design Characteristic: The units of ChemCom begin with a societal or technological issue which is usually introduced as a problem for students to be interested in (first characteristic). These issues are designed on a need-to-know basis; students are expected to relate such societal or technological issues to concepts of chemistry so that they could catch the need to comprehend relevant chemistry to their lives. This experience is expected to motivate students by making them to feel themselves as owners of the new knowledge (second characteristic). The learning process in ChemCom is framed through group discussions, cooperative learning methods as problem solving. This can be stated as attention of students input (third characteristic).

Evaluation: The evaluation of this project lacks in depth studies related with the process and how the methodology used supported three characteristics (Westbrook, 2005). According to Schwartz (2006) studies focusing on assessment of ChemCom revealed that students from ChemCom have succeeded at least as well as the students using conventional texts. He emphasizes that ChemCom proved itself as successful in instruction and commercial issues, and also the book has the role of being model for other context-based curriculum studies in chemistry; Chemistry in Context is an example. Throughout five years, Sutman and Bruce (1992) evaluated ChemCom and they reported that students' responses to context-based course materials were positive and they were enthused to involve in. The feedbacks obtained from teachers caused the revision. Whether the students really find the materials relevant to their life? Whether the materials were designed on a need-to-know characteristic? If students used chemistry in decision making proves or not? Whether the design provided the sharing of experiences or not? were not addressed in the studies evaluating the project.

2.5.3 Chemistry in Context (CiC)

Due to late specialization in American educational system, students usually do not have commitment to a specific field of study (Schwartz, 2006). Students in the first two years of a four year undergraduate program generally enrol in varying courses even if students are certain about their career goals. Students are required to enrol in courses of science, humanities, fine arts, and social sciences since the aim is develop and deepen their knowledge base. For that reason, there are some students enrolled in chemistry courses with little or no intention to continue their careers in chemistry or any other natural science field. Some students may have taken a chemistry course in high school, some may have not. There is a significant difference in these two group students' interests, goals preparations, so it is not useful to prepare the same courses for these groups. Some universities offer an introductory chemistry course designed especially for nonscience major students. According to Schwartz, although, some of nonscience courses are innovative and effective in design, many of these courses are not. The Chemistry in Context (CiC) was designed to address the needs for meaningful chemistry instruction.

Rationale: The aim of developing CiC was consistent with development of ChemCom: it was to enhance students' chemical literacy, and also the aim was to prepare an effective text book rather than to carry out a research on teaching-learning. According to Schwartz, thanks to this book, poets, philosophers, painters, and politicians of near future would see the beauty and utility of the chemistry. University level chemistry professors and chemistry education professors prepared the texts for curriculum. Based on the discussions of this team, six goals are emerged to empower students in many aspects of technological age. These goals are:

- To affect students to learn chemistry and its impact on society with motivation.
- To make an instruction of basic chemistry concepts.
- To make students to feel the theoretical and practical importance of chemistry.
- To equip students to construct information and question technical issues.
- To improve students to have analytical skills, critically judge the situations, to evaluate risks and benefits.
- To provide students to participate in activities related with chemical phenomena.

Schwartz (2006) states that the course they developed may specifically attract some groups like women, ethnic minorities, African-Americans, Hispanics and native-Americans who are underrepresented in science. Schwartz concluded that the integration of below themes would increase the success of CiC. These themes are: interaction of science and society, vocabulary and concepts of chemistry, nature and methodology of science, analysis risks and benefits, evaluating information, importance of scale, science as a human endeavour, finally, putting chemistry in perspective. They spread through the all texts, however were not stated directly.

The Design Characteristics: As in the ChemCom, CiC project utilized context-based approach to motivate students for chemistry learning. The followings are design characteristics

- The chemistry curriculum is loaded with real world societal issues and with important chemistry content.
- The facts, principles of chemistry are given on a need to know base to create a context for core problems.
- Significant connections with other disciplines are made through the curriculum.

- As much as possible, chemistry is instructed through the way it is practiced.
- The chemistry curriculum contains methodology, theory as well as the laboratory-library-class activities.
- Emphasize on student centred discussions and group work.
- Problem solving and critical thinking are stressed considerably.

Schwartz mentions that many of students have interests in their majors, so CiC provides these students opportunities to combine their expertise on the themes of the course. The course is designed in a way that supports high student participation and class contribution. The activities are concentrated on responsibility to society more than students' self interests. The organization of the textbook is quite different than other chemistry textbooks. The concepts are put in order in a way that one is built on the other logically. Here, Schwartz describes his popular metaphor of ladder.

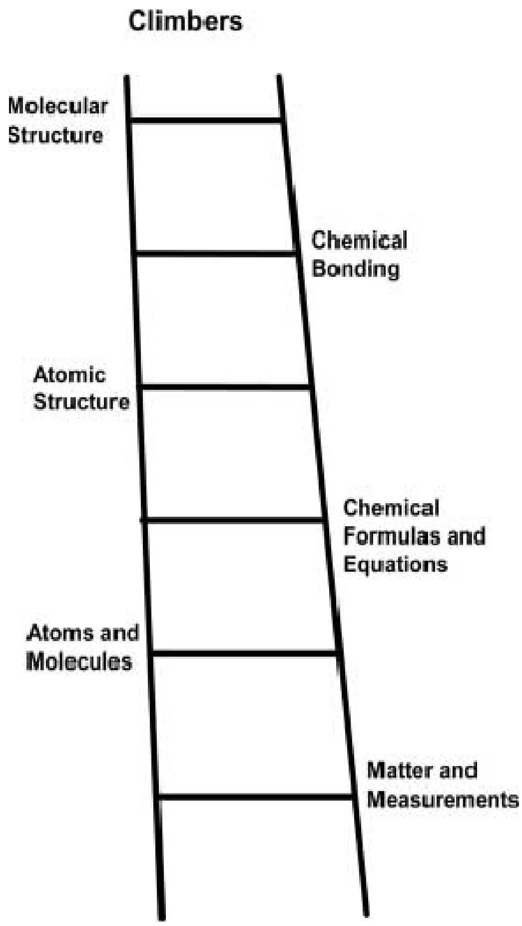

Figure 2. 1 The ladder metaphor ("climbers") Schwartz (2006)

Schwartz states that "some students enjoy climbing this ladder as part of their education. Others do not see the connection between the successive rungs, and before long they may develop vertigo" (2006, p.982). According to Schwartz, although most of us liked to climb the ladder, unfortunately, most of the students do not have an overview of connecting the steps of ladder. Students are not able to see how to climb and why to climb so they usually fall off which later cause them to distaste for science.

Evaluation: During the 1990-91 academic year, nearly 200 students were chosen to focus on the evaluation of the project. The achievement of students through exams and assignments along with the philosophy and pedagogy of the book was assessed. The students were interviewed about their conceptions on the course and curriculum. Students' responses revealed many useful suggestions, corrections and revisions. A broad class testing was conducted to detect the strength and weakness of the text. Many institutions and universities had interested in CiC, to use it so they were trained for three days in a workshop by engaging in experiments and activities. Time was limited for testing instruction or practice, thus, many ways were used in utilizing materials. The instructors evaluated many aspects of CiC, they have positive experiences about assignments and examinations. About 2000 students were enrolled for testing of the projects, students attitudes towards chemistry was addressed but a significant difference was not found even the positive responses of instructors. Schwartz stated that, the same research problems should have better to be tested with a larger sample of students and the fifth version of the book.

2.5.4 ChiK: Chemie im Kontext

The aim of the project is to improve secondary level chemistry instruction and learning along with the support of connecting teachers and science educators for cooperation. It is a German project initiated in 1999 by universities like Dortmund, Oldenburg. ChiK is inspired from other context-based projects such as Salters Advanced Chemistry, ChemCom or CiC. According to Newting at al. (2007), this program supports teachers through guidelines, examples, advices, and collections of materials which can be used to construct lessons based on the provided framework. The purpose of ChiK is to improve students the decontextualize fundamental concepts that they could apply to varying situations relevant to them.

Rationale: The roots of project are emerged by the studies revealing low performances and attitudes of German students in science education. Studies indicated that German students are not different from other students and they are good at reproducing the facts but they have difficulty in applying their knowledge to the real world around. The problems of chemistry curricula all around the world are also diagnosed in Germany; therefore, development of new curricular frameworks has become essential. ChiK is a context oriented project, according to Westbroek (2005) this project is slightly different from other projects described previously in drawing attention to knowledge transfer. The philosophy underlying in development of project was obviously affected by three theoretical constituents:

1. The concept of scientific literacy
2. Theories of motivation
3. Approaches of situated learning

Each theoretical component is addressed with questions: what students will learn in chemistry course, how students' motivation to learn chemistry can be increased, how situated learning environments can be formed respectively.

The Design Characteristics: The units of ChiK begin with a problem or a question which can be considered as relevant to students' lives (first characteristic). Then, chemical knowledge is introduced to students in detail to address the problems raised at the beginning which embodies learning process into authentic problems. So that students get the knowledge and ability in handling with interesting and relevant issues, students can solve problems stated at the beginning effectively (second characteristic). Newting et al. (2007) states that the context is red topic through which the search for the issue stated in question is addressed. They also describes context: beginning with students prior knowledge and experiences, being guided with students interests, and having linkage with as many real world situations as possible. According to Westbroek, multiple contexts are used for creation of situated knowledge, which means that learners will expand on new information in a sequence of different themes in which the knowledge is established on a need to know base. Self-directed and cooperative frameworks as teaching methodology is expected to increase students 'input (third characteristic).

Evaluation: According to Newting et al. (2007) the evaluation of Project focused of two areas: the teaching learning process in the classroom and the Professional development of teachers involved. First initiatives to evaluate Project showed positive impacts on both areas. Pre-post studies are conducted to reveal students' perceptions, students made a sense of learning chemistry. Doctoral studies are also conducted to evaluate ChiK, one study is focusing on learning outcomes at the end of the unit, and the other one is investigating use of real world contexts, the third one is seeking transfer of basic concepts in contextualized questions, and the fourth one investigates usage of scientific knowledge on decision making processes. Newting at al revealed that teachers' development is indication of perceived relevance of cooperation in school as strongest predictor of success. They also states that possibly other aspects such as instructional methodologies, teachers' perceptions on feasibility and effectiveness of ChiK will be elaborated in one year.

Above mentioned projects commonly use context-based approaches in designing chemistry lessons. The methodologies which can be integrated with CBA generally satisfy the required characteristics of meaningful chemistry instruction. Below these methodologies will be described.

2.6 Methodologies to Integrate with Context-Based Approach

Introducing contexts and concepts have different orders among teaching approaches. Based on De Jong (2006) description, in traditional approaches, context follows concepts and the function of context is an illustration or/and application. Secondly, he states that in more modern approaches, context precedes concept in which it functions as orientation or/and motivation. Finally, De Jong describes that in recent teaching approaches contexts precede concepts and other contexts follow them. The function of context in these approaches covers illustration, application, orientation, and motivation. Although, the order of presentation of contexts and concepts are described by De Jong, how to introduce concepts through contexts have some ambiguity. Possible solution to this ambiguity is embodied in the use of methodology or strategy in implementing context-based approach (CBA).

CBA has potential to be integrated with variety of methodologies for implementation. These varying methodologies are required to consider: a context as a critical component and students as active agents of teaching-learning environment. As long as the main characteristics of CBA is satisfied, these methodologies or strategies can be used individually or integrated with one or more of the others. Below each of these methodologies and strategies will be elaborated for readers.

2.6.1 Problem-Based Learning

Problem-based learning (PBL), as an inquiry-based methodology has great popularity especially in medical education, gained popularity in science art and humanities as well. PBL appeal a scenario, a case, a simulation or a real life problem at the beginning of teaching-learning process. These scenario, case or simulation is required to have a problem situation to be solved and it serves as a context and triggering force for learning. The learning of concepts is carried out within the context of the problem situations. Students need to use their critical thinking skills as well as a systematic approach while investigating the problem that need a solution. Real life problems that are relevant to students' own lives, families, experiences from society-school have greater potential to attract students. The same aspects are also stressed in CBA thus PBL and CBA have close similarities in some characteristics.

Serin (2009) compares PBL with constructivism and he states that PBL has compatible characteristics with constructivism in many aspects. The elaboration of these characteristics revealed that many of these are also embedded in CBA, thus integration of CBA with PBL is attainable for effective teaching-learning process.

First, both claim that education should have capability not only on cognitive domain but also on affective domain. PBL classes offer students to engage in real life problems more than traditional classes thus lead to: an increase in motivation to learning and promotion in affective domain. This characteristic is in line with CBA since both PBL and CBA tend toward the meaning orientation. Parnell (1995) states that rather than focusing on memorization (main aspect of medical education in the past), students in PBL endeavour to understand the applications of the acquired knowledge. Additionally, Parnell (1995) mentions that medical students practicing teaching in the context of application have more potential to transfer their knowledge to solve new problems than students in more conventional classes. Secondly, Serin (2009) states that PBL utilizes real-life and ill-structured issues that are related to students' experiences as a context for promotion of learning. Such characteristic directly stresses the use of real-life context as described by CBA. Thirdly, students in PBL environment are faced with a problem and try to resolve this problem at the initial step of learning process; therefore, it makes them to investigate why they are learning such a particular topic. Similar to PBL, CBA establishes a need-to-know base for students to question why they need to learn a particular subject. Finally, both PBL and CBA aim to provide learning process which is selected deliberately through real-world problems from students' life. These problems are supposed to be relevant to students' life and so to increase students' interest.

CBA and PBL commonly claim that students will be more motivated and could develop transferable skills as outcome. They both support independent and collaborative learning environments in which students can communicate effectively on the task. Therefore, they both contribute students' judgments and decision making since students critically address the problem situation or contexts. In a curriculum which is designed based on the CBA, contexts are selected carefully according to content and learning outcomes, similarly in PBL problems are chosen with regard to content and learning outcomes. CBA does not put a limitation on methods to be integrated; however, some of the strategies or methodologies satisfy the requirements of this approach. In PBL, students usually work in groups, lectures are not held, they involve in self-directed learning. If CBA is integrated with PBL, three characteristics; -relevant context, need-to-know base, and students' interest – of CBA will be supported and the processing of the lesson will be structured.

2.6.2 Cooperative Learning

Cooperative learning is another teaching methodology which supports some aspects of context-based approach (CBA). One common point which both CBA and cooperative learning poses is that they support students' motivation to learn. Johnson, Johnson and Stanne (2000) describe cooperative learning as the use of small groups in teaching leaning process through which students cooperate to work in order to increase their own and group members' learning. They also states that compared with other methodologies, cooperative learning has more positive impact on: students' achievement, relationship among class members, and psychological health. Although, CBA does not claim to enhance these characteristics, the interaction of students on the context is expected to contribute learning.

Framed from social interdependence theory, cooperative learning increases students' communication and cooperation in a CBA lesson. When integrated with CBA, cooperative learning will support teaching-learning process since context is a social situation in which students will work in teams or interdependent groups. The integration of CBA with cooperative learning should provide opportunities for small group work rather than individualistic learning. The role of teacher is moderator, that is s/he guides students by directions, encourages students to investigate, cooperate and communicate to solve problems or to understand the context. Cooperative learning serves social interactions to context-based approach, which in turn leads students to set the same goals. Thus, they seek meaningful outcomes not only personally beneficial but also beneficial for their groups.

The meta-analysis study of Johnson et al. (2000) revealed that cooperative learning method provides higher achievement when compared to individualistic methods. This claim produces a potential to CBA in increasing achievement as well as the affective issues. A context-based approach through cooperative learning method should accommodate certain characteristics of the approach along with the definite steps of methodology. Such a learning environment has opportunity to enhance students both in affective and cognitive domain. Experimental studies might be conducted to reveal the effect of this integration.

2.6.3 Project-Based Learning

Another method of learning which can be integrated with context-based approach is project-based learning (PJBL). The integration of this approach with the method has some application as well. “The Evolution of Water” is a project which is based on contextualized teaching through PJBL science. Rivet (2003) states that the project purposes to assist students to learn the content while also helping students to make meaning of context through inquiry.

Context-based approach (CBA) aims that through inquiry students involve in addressing scientific process, as well as the way new knowledge is constructed. According to Rivet (2003), PJBL integrated with real life context stimulates active engagement of students in the process of knowledge construction and give potentiality for students’ enthusiasm. Westbrook (2005) interpret this as an underlined change from rhetoric of conclusions to process orientation. Rivet describes features of contextual instruction in her thesis; she claims that contextual instruction will support more emphasis on the process of orientation of science as human activity. The followings are her claims;

- Using meaningful problems, situations for students will make sense of implications of these problems and situations in their life out of the school.
- Such kind of real life problems will provide a need-to-know base in which students will learn scientific concepts.

Rivet clarifies the difference between introducing application at the end of the lecture or at the beginning of it. She states that although need-to-know base is introduced in similar way with introduction of application at the end of a unit, contextual learning reveal the need for learning so rather than simply introducing the application knowledge following an abstract setting. According to Rivet, “These instructional models are similar in that there is a single overarching problem or setting that drives the instruction and provides a purpose for learning"(2003, p.22). Rivet describes the concepts as learning needs and these concepts constitutes reasons for students to involve in tasks actively. The integration of this method with the approach will make students involve in the task, which is not different for the requirement of method or approach.

2.6.4 Relating Experiencing Applying Cooperating Transferring

An important design strategy for context-based approach (CBA) is Relating-Experiencing-Applying-Cooperating-Transferring (REACT) strategy. This strategy has emerged as contextual teaching strategy especially in USA by the center for occupational research and development (CORD). Ingram (2003) described REACT as grounding on the bases of the constructivism, in which student involve in critical thinking and problems solving activities in order to improve students' understanding of concepts.

Relating: In which the concept to be learned is linked with students' life experiences which are something they already knows. In this step students will construct new knowledge based on their prior experiences. It is expected that students having high experiences will probably assimilate new information with existing knowledge higher than the other students. Ingram (2003) states that students sometimes cannot connect new information with existing ones, therefore, it is required to activates students' existing knowledge, reorganize related knowledge. She also states that classroom environments should be settled in a way that student percept the relevance of learning to their experiences. Ingram also states that usually students lack meaningful experiences before instruction. Additionally, she compares males with females and she states that boys engages in building games, disassemble toys more than girls therefore, boys are in a more advantageous place than girls in especially physics and chemistry classes.

Experiencing: According to Kolb, (1994 as cited in Ingram 2003), experiencing in learning by doing something is important in construction of new introduced concepts. In the case of irrelevant experiences and lacks in prior knowledge, students could not relate new information. Ingram states that a classroom which utilizes active learning environments, discovery and interaction leads students to relevant experiences which are contributor in constructions of newly introduced concepts. According to Ingram, in step, some experiences or hand-on activities that require problems solving situations, laboratories are provided by teacher explanations to allow students to discover new knowledge.

Applying: In this step students apply their new knowledge to real-world situations which they have experienced as a citizen, family member or other life roles. It is expected from students to engage in activities possessing problem solving situations from their own lives so that to be more motivated to learn science. If students could apply concepts to their context which are relevant and interesting for them, possibly they will be intrinsically motivated to learn. Ingram (2003) mentions that if this step is satisfied successfully, students will understand the "why" in their learning. As described by Gilbert (2006) CBA is application oriented within the cases, scenarios from students on going lives outside of the classroom, thus application strategy helps students to construct knowledge rather than memorization of knowledge.

Cooperating: This strategy provides students to learn in the context of interaction and sharing. According to Johnson et al. (2000), cooperative learning uses small groups in teaching learning process through which students cooperate to work on a task in order to increase their own and group members' learning. They also revealed that the achievement of students is higher in cooperative learning than individualistic learning strategies. In CBA contexts are generally real world complex issues in which team work is preferred than traditional instruction. Students working in groups socially interact to solve complex problems without an outside intervention so, Ingram (2003) sates that they are expected to gain greater understanding from group members. She also states that cooperation not only supports learning, it also supports collaborative skills as well as the critical thinking skills. CBA emphasizes on incorporation of laboratory experiments, if conducted with collaboration these activities are expected to increase students learning.

Transferring: One of the main curricular problems in chemistry is lack of transfer. Students generally have problems when they encounter an issue represented in another way. The reason of this is possibly about being unable to transfer their existing knowledge into other contexts or situations. Therefore, Ingram (2003) sates that activities which simply contribute rote memorization and low level thinking should not be used since they fail in transferring knowledge. She also states that in conventional classrooms, teachers just obey the facts and procedures, however, in CBA classroom teachers usually expand the knowledge into other learning contexts by focusing on understanding rather than memorization.

2.6.5 Learning Cycle

Learning cycle, as an inquiry base design, proposes to improve students' scientific understanding (Abraham, 1997; Marek and Cavallo, 1995; Marek, Laubach & Pedersen, 2003; Marek, 2008). Marek (2008) describes LC as "a way to structure inquiry and occurs in several sequential phases". According to Marek et al. (2003), cycles of this design move students through a scientific inquiry by fostering them first to explore materials, and then construct new knowledge, and finally apply or extend the newly acquired knowledge into other situations. There are three phases in LC: exploration, concept development and expansion. Marek et al. (2003) also states that the phases of LC lean on Piaget's frame of mental functioning. Based on their description, the first phase is exploration; students are allowed to assimilate the need for science concept. To improve understanding of concepts, students are exposed to information from their experiences until they live a disequilibrium situation. The second step of LC is concept introduction phase in which students are guided to interpret information they exposed up to a new equilibrium and accommodation of concepts is established. The last phase is called as concept application phase. In this step, students have opportunities to make connection between new acquired science concepts and their applications along with other concepts. According to Marek et al. (2003) Piaget names this cognitive process as organization.

There are some different statements on whether LC is a method or model or strategy. According to Marek, Gerber and Cavallo (1999), LC is not a method or a model for teaching instead it is a procedure to teach science. They stress that LC, an extensive approach, includes phases with integrity of full and the connection between phases for experiencing science through inquiry. Additionally, Marek et al. (2003) explains that LC design hold all tools and methods of teaching such as: questioning, group work, demonstrations, laboratory experiments, lectures, field trips, technology as well as other models of teaching as: cooperative learning, direct instruction.

Based on Marek et al. (2003) description, LC's nature directs students to scientific inquiry through asking questions, formulating problems, making reflections on information, constructing knowledge from acquired data, collaborating in investigating solutions, and developing connection among concepts and experiences. Substantial research indicates the effectiveness of LC on students' outcomes (Abraham, 1997; Cavallo, McNeely, and Marek., 2003; Ceylan, 2008; Odom and Kelly, 2001; Papuççu, 2008). Cavallo et al. (2003) examined ninth grade students' explanations regarding the concepts of chemical reactions by using open-ended essay questions in LC classroom. The findings of their study indicated students instructed with LC have significant positive understanding.

The contemporary research findings associated with science education through learning cycle have indicated that LC has positive effects on students' creative and critical thinking, understanding of scientific concepts, and attitudes to science learning, reasoning skills and science process skills (Anderson, 2007; Ceylan, 2008; Çakıroğlu, 2006; Papuççu, 2008). Papuççu (2008) conducted a study with eleventh grades on their conceptions about acids and bases; they revealed that students instructed with LC have better understanding than students in conventional classrooms. They also indicated the contribution of science process skills to students understanding of acids and base concepts. Similarly, Ceylan and Geban (2009) compared LC with traditional instruction on tenth grade students understanding of matter and solubility concepts along with their attitudes and motivation. They had revealed that instruction based on LC significantly resulted in better acquisition of science concepts than conventional instruction. Additionally, they concluded that LC improved students' attitudes toward chemistry and motivational constructs such as intrinsic/extrinsic goal orientation, task value, and elaboration /organization strategy.

Recent studies continue to reveal the positive gains related with learning cycle strategy. 5E instructional model/procedure was integrated with CBA in this study. The 5E model will be clarified in the following section.

2.6.5.15E Instructional Model

This model of instruction was used widespread while developing new curriculum materials for Biological Sciences Curriculum Study (BSCS) (Bybee et al. 2006). According to Bybee et al. (2006), 5E instructional model takes its roots from constructivist philosophy of education and it supports inquiry-based science learning. In constructivism, the aim is making students to feel conflict with their existing thinking so that to think in a different way.

Bybee et al. (2006), states that 5E model has been used in widely in curriculum development. There are five phases in a 5E model of instruction which are engagement, exploration, explanation, elaboration and evaluation. Based on the Bybee et al. description, each "E" of 5E is a phase which functions differently to support teachers' instruction and students understanding, attitudes, and skills.

Engagement, as a first step, aims to create a disequilibrium situation in students mind or to relate something to students experiences from their lives so that to motivate students. To achieve this aim, some activities such as demonstrations, stories, or cases can be used to take students' attention and the relatedness of new information with students existing lives should be established. The engagement activities -either physical or mental- can also be some questions or problem situations. The role of teacher is to ask questions or to create some interesting situations in which students' curiosity will increase. If this step is not attained satisfactorily, the next steps will become meaningless.

Exploration phase begins when students engaged in activities. Bybee et al. (2006) states that the disequilibrium which was formed in engagement phase, start to reach equilibrium in this phase. Activities of phase are developed in way that students will share common and concrete experiences in constructing concepts and skills. The role of the instructor is to facilitate a guided or open inquiry through experiences and questions to detect students' misconceptions. In this phase students can also work in groups without a direct instruction so that they can test their predictions and hypotheses by discussing with group members. Teacher should support cooperation and group discussion through probing questions and serving as a resource for them. Papuççu (2008) states that although verbal methods are used frequently, teachers can use videos, books, presentations from multimedia and computer courseware.

Explanation, the third phase, provides students to be focused on specific aspect of their experiences in engagement and in exploration along with providing them to reveal their conceptual understanding. Here, teacher has opportunity to introduce concepts or process directly. This phase is perceived as the step for lecturing or discussion with students. Bybee et al. (2006) emphasize that students are encouraged to state their explanations regarding the situation in exploration step at early stage of explanation phase. Students are also encouraged to fallow their peers and teachers critically. The teacher should help students comprehend explanations and terminology of scientific concepts as well as providing a common language for students regarding the content. The evidences from exploration and engagement phases are connected with scientific explanations and it was related to students' explanations. Once again, videos, multimedia and as such can be used as verbal methods. This step goes on with mental ordering and provides students some terms for explaining their experiences in exploratory and engagement phases.

Elaboration, the fourth phase, provides students to extend previously understood science concepts and students experiences in first three phases. Students are required to apply their knowledge and skills to new, but acquainted cases as well as employ definitions and labels. According to Bybee (1997), the main aim of this phase is to make generalizations about concepts, processes and skills. He states that some more questions or problems should be provided for students to make them to: apply their newly acquired knowledge, give solutions, decide on and/or draw acceptable conclusions, and use scientific terms in explaining concepts. To sum up, this phase establishes a base for students to apply newly acquired knowledge to new situations in order to expand conceptual understanding.

Evaluation, the fifth phase, provides students to assess what they have learnt, and provides teachers to evaluate the progress of students to attain objectives. According to Bybee et al. (2006), even this stage is proposed to be last stage of the model; the evaluation should be addressed at the end of each phase. The main focus of evaluation is students' conceptual understanding as well as their developments regarding learning outcomes. No matter the evaluation is formal or informal, reasonable assessment tools such as performance assessments, interviews, creative writing with scientific terms, concept maps, portfolios, laboratory notebooks can used for assessing students performances. In brief, by means of this phase, correct conceptual understanding of students and the generality of these scientific conceptions to other contexts are addressed.

Most recently, Bektaş (2011), investigated effectiveness of 5E LC model over conventional instruction. The topic was particulate nature of matter, and they investigated students' understanding and gender differences. Students treated with 5E LC model indicated significant mean difference on conceptual understanding and epistemological beliefs regarded with chemistry. They found no interaction with gender and treatment, gender and epistemological beliefs, and gender and conceptual understanding. They also collected some qualitative data, and the data supported students' responses to tests. Similarly, 5E model was also studied by Demircioğlu, Özmen and Demircioğlu in 2004. They investigated the impact of the model on solubility equilibrium after a six week period of instruction. They revealed that students in experimental group indicated better performance on relating events to daily life and misconceptions are remedied better.

Chemistry education has a number of learning and teaching approaches, methodologies, and strategies which have been propounded as a guide to practice. Many of these approaches, methods, strategies, procedures, and models are used chemistry curricula today. While designing a lesson based on CBA, many activities such as team teaching, cooperative learning as such explained above can be utilized. This methods or strategies usually support CBA in many aspects. Their similarities and differences are mentioned in above sections. These activities are used in classrooms to support inquiry, problem solving as well as helping students construct knowledge meaningfully. Kortland (2007) states that in CBA applications of concepts or socioscientific issues bridge abstract concepts to world students live in. Kortland also emphasize that relating science to everyday situation have potential to make teaching more interesting and this will make large proportion of students more motivated to learn so that students will better understand concepts.

To design an effective course based on CBA, all above-mentioned strategies can be presented in the teaching/learning environment. Implementation of CBA through these methods or strategies requires specific designs. While integrating context-base approach with any strategy the requirements of both approach and method should be satisfied. In this study, the CBA was integrated with 5E model to broaden and deepen students' conceptual understanding, achievement and chemical literacy.

Kortland (2007) states that studies on developing didactical structures for enhancement of teaching learning of concepts uses sequences in designing lessons. This didactical structure has four subsequent phases; each with specific function requires satisfying the conditions to relate activities of students. Kortland developed a contextual lesson on traffic situations. The aim of the lesson was to increase students' awareness, and responsibility in real life traffic situation. When he reorganized subsequent phases of didactical structure with theoretical framework, the below four phases are emerged:

1. Orientation and association of a global interest and motivation on traffic safety and measurement for its enhancement.
2. To narrow down this specific interest on traffic safety measures which need content knowledge about force and motion so that students will understand the necessity of knowledge.
3. To extend students' pre-knowledge on physics regarding force and motion concept
4. To apply the acquired knowledge into situations where knowledge is extended. That means, teachers extends force and motion knowledge will make students to fill necessity of traffic-safety measures.

As clarified in detail in previous sections, the phases described by Kortland have quite similarity with learning cycles as described by Bybee (1997). Kortland states that only the second phase is not presented in the LC as described by literature. Kortland (2007) also mentions that LC almost considers cognitive learning of students, the integration of these cycles with contextual learning will also consider students motivation.

The integration of CBA with 5E LC model has common characteristics for improvement of teaching and learning. As constructed for contextual learning by Kortland, the phases (cycles of learning) and CBA was embodied in this study to improve both cognitive learning, and motivational factors.

2.7 Chemical Literacy

The reasons of reconsiderations in chemistry curricula are described based on Gilbert's (2006) descriptions. These reconsiderations are mainly surrounded by the question of -how to involve students in teaching-learning process- since chemistry curricula are seen as insufficient to attain students engagement (Westbroek, 2005). She emphasizes on two main reasons for such insufficiency of current chemistry education. Firstly, students could not get accurate view of function of chemistry in society and in scientific developments. Secondly, the connectedness problem, which means, students could not acquire sufficient qualifications regarding chemistry as a member of modern and democratic society. This second issue is frequently addressed as “scientific literacy” (Laugksch, 2000).

Assessment is an essential ingredient of teaching learning process. According to Shwartz, Ben-Zvi and Hofstein (2006) assessment is also important when achievement of scientific literacy (SL) is considered as fundamental learning goal. There are two very well-known survey programs which aim to investigate students’ scientific literacy: International Student Assessment (PISA) of the Organization for Economic Co-operation and Development (OECD), and Trends in Mathematics and Science Studies (TIMSS). TIMSS generally focuses on the ability of remembering the content knowledge, however, PISA usually concentrates on use of practical knowledge in action. Based on the study of Shwartz, Ben-Zvi and Hofstein (2006), there are different philosophies, theoretical frameworks, and research guided the design of tools which aim to assess an aspect of SL by focusing on the followings:

- The measurement of recall of science knowledge. According to Laugksch and Spargo (1996a, 1996b), content knowledge is critical element of SL, thus teachers and researchers usually assess this aspect while measuring SL.
- The measurement of the students’ ability of using scientific principles in authentic context. The performance of students is assessed through tools designed in authentic tasks. The information on a gas or electricity bill can be an example for authentic task. In this framework, the assessment is mainly focused on distinctly appearing skills rather than content knowledge.
- The measurement of literacy skills in scientific situations, evaluating students’ abilities in reading, writing, reasoning, and asking for more information. According to Norris and Philips (2003), this approach also assesses students’ abilities to utilize media news and reports about science.
- The measurement of students’ understanding of science, nature of science, and their attitudes towards STS concepts. An instrument measuring these aspects is also developed by researchers.

OECD investigates students' literacy in science and other domains through Programme for International Students Assessment's (PISA) world-wide. PISA defines SL as the capacity to benefit from scientific knowledge, to diagnose problems and to make evidence-based conclusions in order to understand and make decisions on natural world and the changes caused by human activities.

A comprehensive theoretical framework is proposed by Bybee (1997) and the BSCS (1993) to assess students SL in science courses. There are some levels of SL in the framework they provided. First, *scientific illiteracy:* students who lack in relating to or responding to a reasonable question related with science knowledge means that they do not have sufficient terms, contexts, concepts, or cognitive potential in order to perceive given question as scientific. Secondly, *nominal scientific literacy:* in this level, students diagnose a given concept as related to science; however their understanding level obviously shows misconceptions. Thirdly, *functional scientific literacy:* in this situation, the description of a concept is given correctly by students; however, students don't have enough understanding of concepts. Fourthly, c*onceptual scientific literacy:* students have some understanding related to most of conceptual knowledge of a domain and relate that knowledge to their general science understanding. This level of literacy also includes students' procedural abilities and understanding regarding the processes in scientific inquiry and technology. Based on Shwartz et al. (2006) study, the finally level is m*ultidimensional scientific literacy.* According to this perspective, SL embodies comprehension of science which goes beyond the concepts of scientific domains and procedures of scientific inquiry including many aspects of science and technology. Students understand and appreciate science and technology and its impact on their daily lives through making connections between science concepts, scientific disciplines, science- technology, and other issues challenging society. According to Bybee (1997), the framework of SL has unique view in directing people who are corresponding of curriculum, assessment, professional development, research, and teaching science to large number of students. Shwartz et al. (2006) make comments on Bybee (1997) statements regarding multidimensional SL; they stated the achievement of this goal is not seen as possible since it is a lifelong task. A person can have high level of literacy about a specific topic, however a low level of literacy o another topic.

Shwartz et al. (2006) states that taxonomy of SL level is not for proposing a teaching sequence, but rather, it suggests a horizontal perspective and vertical development for students. Students’ functional literacy can be developed by increasing their vocabulary in a way that will also improve their conceptual literacy through making them to connect concepts with basic ideas serving for details. The material developers should determine and improve all literacy levels according to students’ personal concerns. In assessment procedure of SL, it should be considered that SL is a life-long process, so it has varying degrees and forms in different duration of students’ lives. Students’ attitudes and values towards science in early ages will prepare a base for them for high SL level in his adult years. According to Shwartz et al. (2006), assessment of SL at a certain grade level does not mean students’ final literacy level. They additionally mention that assessment of SL in school years is direct indication of whether the seeds of literacy are sprinkled in students’ minds.

The study of Shwartz et al. (2006) was designed in line with two theoretical bases, the first was about different levels for SL proposed by Bybee (1997) and the BSCS (1993), and the second was about the unique characteristics of chemical literacy. By consulting chemistry professionals, educators, and chemistry teachers a comprehensive definition for chemical literacy was stated by Shwartz and others. Table 2.3 gives an overview of chemical literacy described by Shwartz et al. (2006).

1. Chemical content knowledge

A person who is chemically literate understands the following:

A. General chemical ideas

- Being an experimental discipline, chemists carry out scientific investigations, generalize findings, propose theories to explain world.
- Chemistry serves knowledge to other fields in order to explain phenomena

B. *Characteristics (key ideas) of chemistry*

- It tries to explain macroscopic level by means of molecular structure of matter
- It seeks the dynamics of processes and reactions
- Investigate the energy changes accompanied in a reaction
- Aims to understand/explain life by chemical processes and structures of living systems
- A chemically literate student should appreciate the contribution of scientific language to this discipline

2. Chemistry in context

Chemically literate students are able to:

- Admit the significance of knowledge of chemistry in explaining everyday situations
- Utilize their understandings regarding daily life chemistry, such as being user of new products/technology, decision process, and involving in social argumentation on chemistry-related issues.
- See the relatedness of innovations in chemistry and sociology.

3. Higher-order learning skills

Students who are chemically literate, ask question, investigate relevant information when required. Additionally, he/she can evaluate pros/cons of and debates.

4. Affective aspects

Students who are literate have fair and rationale perspective of chemistry and its applications. Furthermore, literate students show interest in issues of chemistry, specifically in non-formal environment like mass media.

Figure 2. 2 Chemical literacy: an overview from Shwartz et al. (2006)

In line discussions on SL and chemical literacy have been continued by other researchers. Witte and Beers (2003) stated that in a symposium conducted at Utrecht, PISA definition guided to identify below scientific processes.

- To recognize questions which are scientifically investigable
- To identify evidence required through scientific investigation

- To make or to evaluate conclusions
- To have valid conclusions
- To reflect understanding of science concepts

The items assessing students' SL in PISA have real life situations to challenge students to use their scientific knowledge, to comprehend a given situation, to solve related problems, to have judgement and to share findings and opinions. Witte and Beers (2003) stated that in the same symposium Osborne critiqued curriculum reforms as being unable to teach scientific literacy effectively since knowledge of how to assess literacy skills does not exist. To prevent this, Witte and Beers explained that in chemistry exams they used the idea and they would assess chemical literacy when they assessed students' ability in using and dealing with given information in a chemistry problem and students' ability in using chemistry knowledge/skills in order to comprehend information regarding a everyday problem as well.

Based on Witte and Beers (2003) description, if students have following skills on using and dealing with given information along with the skills in argumentation that means students have high chemical literacy levels. These skills are;

- Understanding given information
- Being able to select needed information from text
- Being able to alter given information to another form
- The ability of assessing information from acceptability or plausibility aspects.

Witte and Beers (2003) additionally states that in argumentation and in deciding on an issue, the following skills are also required for high chemical literacy.

- Being able to manage valid arguments pro or con a given idea.
- Being able to have a standpoint during arguments.

Having contexts with real-life situations give students the possibility of showing their literacy skills. According to Witte and Beers, the chemistry examinations assessing these skills may be presented in the form of: a newspaper article, information on a product or drug, print from web, a comic book chapter, story or advertisement. A context in these forms can be industrial process, an environmental issue, everyday life problem from school or science. Witte and Beers described questions constructed by OECD and they stated that when questions are presented in this form, they propose to assess students': chemistry knowledge, chemical skills, and several other skills. The questions are context-based and they mainly try to assess students' chemical knowledge and skills (75%) and other skills in (25%).

In line with PISA statement about literacy, Westbroek stated that the aim of chemistry education should be qualifying students in a way that they could use scientific knowledge, to solve problems, to show evidence-based results, to evaluate the changes in nature made through human activities. It is possible to see such kind of expressions in majority of curriculum related studies, as well as Turkish national science and chemistry curriculum. The common point in these studies is to increase students 'chemical literacy skills. Whitelegg and Parry (1999) stated that context-based learning has a meaning of presenting students real world controversial and social issues in order to make argumentations. They also stated that context-based learning means integrating social or civic lessons to increase social awareness. In this study we can improve students conceptual understanding of chemistry while increasing their environmental awareness by using an appropriate context which meets both society' and students' needs.

Assessment of students' chemistry knowledge, chemical literacy skills and ability of using scientific terms in their explanations or argumentations could be carried through contextual questions, problems or situations from students' everyday lives and potential experiences. Taber (2003) states that standardized examinations with multiple-choice and open-ended questions are altered to more structured questions that are embedded into real life contexts. Therefore, a considerable effort has been put into the integration of real life contexts into context-based activities conducted in classroom and assessment tools since these activities and assessment tools are perceived as relevant for students (Kelly, 2007).

According to Cavallo et al. (2003) the use of open-ended structured questions through authentic contexts in eliciting students' understanding is an effective tool for assessment since students' answers represent their mental models regarding the concepts that are inquired. Students' mental models indicate their conceptual understanding which in turn indicate their chemical content knowledge which is an aspect of chemical literacy. Real-life contexts are proposed to establish a base for explaining the everyday issues by chemical concepts and make discussions around chemistry related social events. Eliciting higher orders thinking skills and affective domain, open-ended structured questions can be used to assess students' chemical literacy on specific knowledge domain. Therefore, in this study, some structured open-ended questions are offered to students through real-life contexts.

2.8 Chemical Reactions and Energy

In this section the place and the role of the chemical reactions and energy concepts in chemistry education will be clarified through research-based practices. Goedhart and Kaper (2002) states that there are some reasons of why the concepts related with energy are critical not only in secondary level, but also in university level. Goedhart and Kaper order these reasons as following: first, students experience these concepts in classroom or outside the school. The chemical reactions which students face with sometimes indicate a dramatic change which is referred as "energetic" such as flames and drastic temperature changes. Secondly, it is related with theory. The comprehension of reaction energy and relevant concepts provides students to predict some parameters regarding the chemical processes. The third reason is related with scientific literacy. Because energy is a popular societal discussion platform, students as educated citizens are expected to have certain understanding of this concept.

Students in secondary school level are taught different forms of energy and energy changes, in physics they learn sound, light, heat, and movement, in biology they learn adenosine three phosphates as energy source, and in chemistry they learn energy change accompanied by a chemical change. The energy change of chemical reaction can be in the form of electricity (electrochemistry), but it is usually in the form of heat which also most evident for students since they can usually feel the change by their senses.

The role of energy accompanied in a chemical reaction is an area of investigation for chemical thermodynamics. The concept of thermodynamics provides chemists to predict the progress of reactions under specific conditions. According to Goedhart and Kaper (2002), this property makes thermodynamics to have an important role for professional chemist and chemistry industry. Therefore, studying thermodynamics effectively in secondary level as well as college level is critical for students and teachers because understanding, using concepts of thermodynamics is seen as difficult. The question of how much thermodynamics should be taught in high schools has an importance too.

Heat and Energy in Chemical Change, students are introduced to these concepts in elementary school years. First they learn chemical changes like burning of a candle or magnesium, decomposition of sugar or ammonium dichromate, combustion of hydrogen gas, etc. According to Goedhart and Kaper (2002) these illustrations indicates fantastic visual effects like light effect, colour change, temperature change so that they are chosen to discriminate a chemical change from a physical change as well as indicating a dramatic start to lesson so that students will be motivated to lesson. Starting to lesson with combustion plays significant role because students are familiar and hear about the importance of these reactions in society as combustion of fuels.

De Vos and Verdonk (1985a) states that the energy effects are quite noticeable and consequently students express the heat and energy as absorbed or released related with a chemical reaction. Boo and Watson as cited in Goedhart and Kaper (2002), students generally see heat as the reason for chemical reactions, although it cannot be refuted, in combustion reactions generally heat is required to trigger the reaction.

This the indication of confusion in discriminating activation energy and the heat effect of a process. Similarly, some students also think that cold is required for rusting of nail. Barker and Millar (2000) revealed that some students consider the weight of products is less than the weight of reactant if the products are gases. An example for this conception is that the gases exhausted from a car engine are considered to weigh less than the petrol used. Barker and Millar (1999) studied students' reasoning regarding chemical reactions, and they found many students begin post-16 studies with substantial misconceptions regarding the concepts of the topic. Some students in their study stated that when phosphorus was burned, the mass is loosed in the form of energy.

Endothermic or Exothermic? Many students have also problems in discriminating whether a reaction is exothermic or endothermic. De Vos and Verdonk (1985b) reported that in their study students had difficulties in classifying reactions as endothermic or exothermic. The burning of candle is conceptualized as an endothermic reaction since without heat this reaction cannot proceed. Similarly, in their study some students classified the oxidation reaction of copper as endothermic because to initiate reaction the copper sheet should be heated in the flame.

Energy and Chemical Bond the relation of energy effect and making/breaking of bonds in chemical reactions is also a problematic area for students. In their study, Boo and Watson (2001) revealed that students categorize bond formation as energy needed reactions and bond breaking as energy releasing reactions. According to Boo and Watson this is about students' ideas from macroscopic world in which energy is usually required to do something. Additionally, they stated that such kind of conceptualization might be related with students' everyday lives or biology lessons in which they learn degradation of food is energy source for livings. Barker and Millar (2000) revealed that some students aging 16-18 have the idea that energy is released from fossil fuels. Students consider that when bonds are broken energy is released. Goedhart and Kaper (2002) state that students conceptualization may be aroused from their biochemistry knowledge since in this lesson they learn ATP contains energy-rich bond.

Heat and Temperature are two important terms used in both chemistry and physics. The literature about heat and temperature is closely associated with literature of energy and thermodynamics concepts. According to Goedhart and Kaper (2002), these two terms are used in synonym way in people' daily lives thus may cause an incorrect conceptualization. Both chemistry and physics education aim to improve students' understanding about these concepts which are connected in equation of heat capacity ($Q = C\ \Delta T$). Goedhart and Kaper (2002) states that this equation is essential to solve problems of students regarding non-additive of temperatures since this equation discriminate heat from temperature. They also mention that students consider temperature as measurement of heat or effect of heat thus no difference exist between them.

Energy and thermodynamics are important terms in this topic. Students' ideas regarding energy are affected both by physics and chemistry instruction. Goedhart and Kaper (2002) states that there are some proposals to alter the way energy is taught and they are based on students' prior ideas. First, the decrease in energy should be given in line with conservation of energy. Then, conceptual change can be used to persuade students on conservation of energy. According to Goedhart and Kaper, the concepts of heat and energy mentioned so far are different from heat or energy in thermodynamic. In the teaching and learning of thermodynamics, the concerns can be 'system', 'surroundings', and 'state/process quantities'. They explain that the literature on energy in chemistry is divided into two: one is stated previously, the other uses thermodynamic framework.
Although, the introduction of thermodynamic concepts in secondary school level is new for Turkish National Chemistry Educational program, it is under study for nearly 30 years in other countries. Even if the chapter name is the same with previous chemistry curriculum, the content of the chapter has almost changed. In both curricula the energy effects of chemical reactions are introduced to student in a quantitative way. For example the 'heat reaction', 'enthalpy of reaction' are given in new curriculum, and they had been given in the previous one as well, but the concepts like 'free energy' or 'entropy', 'laws of thermodynamics' are totally new for students. Ceylan (2004) studied with tenth grade students about students

understanding of chemical reactions and energy concepts through a conceptual change oriented instruction. Even, the concepts introduced in that curriculum was different from current one, they revealed conceptual change instruction was significantly superior to acquisition of concepts of chemical reactions and energy. Additionally, their results showed that science process skill was a strong predictor in understanding these concepts.

Johnstone, MacDonald and Webb (as cited in Goedhart and Kaper 2002) collected data from 98 students who are firstly introduced to chemical thermodynamics since the change in curriculum. Their study aimed to support the curriculum reform by evaluating it. The followings are misconceptions they reported:

- Endothermic reactions cannot proceed spontaneously.
- The amount of free energy change is associated with rate of reaction.
- Heat and work are not related in a chemical reaction.
- The term 'reversible' is confusing because of having different meanings in chemical: kinetics, equilibrium and thermodynamics
- The terms 'reversible' and 'infinitely small' are understood in a way that provides a base for considering the reaction of oxygen and hydrogen at standard conditions as reversible.

- System and surroundings are not different.
- The term 'disorder' has potential to be considered as its use in real life although redefinition is made through accessible microstates.

The authors mention the use of some terms in everyday life interferes with their meanings in chemistry. According to Goedhart and Kaper (2002), the concepts of thermodynamics should not be given in way that describes reaction energetic in secondary level since students do not have opportunity to meet such circumstances. They think that -form of energy- framework is sufficient for secondary level students. Moreover, Goedhart and Kaper (2002) stress that the concepts of thermodynamics should be introduced by questioning why a chemical reaction takes place in observed direction and why equilibrium occurs provided that the concepts of reaction direction and equilibrium are introduced prior to this topic.

Holman and Pilling (2004) tested Salter approach with 95 undergraduate students in university of York and 125 from university of Leeds. In York, the researchers evaluated the progress of course with a questionnaire of 1-5 scale at the end of the course. They compared the previous approach and new approach since an identical questionnaire was administered to students of same instructor in previous term. Even students' initial grades are only 2 % different, their findings are not quite strong since students participated in new and old approaches were not the same. Findings indicated that students from new approach found thermodynamics more interesting and they see the principles more clearly. Since new course required more time for contextual materials, students evaluated this course as more challenging. The authors also held small group discussions with seven students just completing the course. Students have stated that the course was interesting and relevant through popular demonstrations. Oppositely, some stated tutorial questions were difficult and they required a high pre-knowledge level from high school. The researches attributed the difficulty of problems to introducing problems through unfamiliar context to students.

Greenbowe and Meltzer (2003) focused on students' learning of thermochemical concepts through solution calorimetry. They analyzed a student's performance regarding the problems of these concepts in a freshman level general chemistry course. They collected data from 207 students' exam sheets with written responses as well as extensive longitudinal interviews with a member of this large class. They found out that considerable number of problems about learning, most of these are aroused from lack of understanding about net increases/decreases in energy of bonds in aqueous reactions resulted from energy absorption or releases. They developed tutorial worksheets and animations to overcome difficulties students have. Greenbowe and Meltzer (2003) concluded that significant curricular reforms or enhancements, much more time for instructional time is seriously required for better understanding of thermochemical concepts.

Marechal and Bilani (2008) investigated students' fundamental understanding in chemical thermodynamics. They hypothesized that better representation of concepts will help pre-university students to conceptualize bonding energy, reaction heat and changes in states of matter. The authors designed an innovative sequence with four tasks for teaching of these concepts. The originality of their design was creating suitable conditions for students to engage in convenient model when they encounter conflicting situations. Their model helped participant in confusion about energy/temperature, exothermic/endothermic reactions, energy of breaking/making bonds, and chain energy model. Although students still have difficulties, the evaluation of design is promising.

Studies integrating both chemical reactions and thermodynamic concepts are relatively untouched area for researchers in Turkey since chemistry curricula for 11th grade level is currently reorganized. International studies generally focused on these concepts separately. Chemical reactions and heat related energy concepts are studied both in Turkey and abroad with primary and secondary level students however they concepts of thermodynamics are usually studied at university level. This study will explore the effect of context-based chemistry through learning cycle on students' achievement and motivation in concepts of chemical reactions, energy, and thermodynamics all together. The topic of thermodynamics is firstly introduced in high school level with recently reformed curriculum therefore; no studies on methodological concern or any other have been reported on this chapter in Turkey even though researchers have conducted studies about chemical reactions and thermodynamics separately in international literature. The curriculum design, the order of concepts in Turkish curriculum is different from international design.

2.9 Motivation

Affective issues such as motivation and attitudes are closely linked to science learning (Koballa and Glynn, 2007). Koballa and Glynn state that attitude and motivation are constructs which are used to explain and figure out the patterns of students' thinking of science concepts, their emotions and actions regarding science. These constructs have potential to be relatively permanent for a person; however, if conditions are satisfied they can be changed.

Motivation has varying definitions, one of which is given by Schunk (2000) as process of seditious and maintenance on goal-directed behavior. Schunk states that this definition is cognitive since motivation hypotheses that learners determine their goals, they employ cognitive processing (such as planning) and behaviors (such as efforts) to reach their goals. Furthermore, Schunk likens motivation with learning in a way that they both are not directly seen but rather inferred from some of learners' indexes like verbalizations, preferences on tasks, and activities that direct to goals. Schunk perceive motivation as an explanatory concept because it provides information to understand reasons of learners' behaviors.

According to Schunk (2000), although some kind of learning can take place without motivation, the role of motivation is undeniable. Students who are motivated to learn participate in teaching-learning and they engage in process through practicing information, relating it to their previous knowledge, and asking questions. Additionally, according to Schunk (2000), motivated students do not leave a task when they confronted with a difficulty, rather they put greater effort. Furthermore, motivated students deal with different tasks when they don't have to work on; they engages in activities such as reading books related with their interest, solving problems, analyzing puzzles, and working on computer projects in their free time. Motivation is driving force for student to engage in teaching activities which facilitate learning. Schunk states that some variables like instruction, context, and personal variables come to contact in learning. Teachers, the feedbacks given, materials used are considered as instructional variables, contextual variables can be social and environmental; the temperature of classroom, time of the day, personal variables are related with learning such as self regulation and motivational indexes. According to Schunk (2000), these variables have effect on motivation of students for continues learning.

In line with Schunk definition, Glynn et al. (2005) define motivation as “an internal state that arouses, directs and sustains human behavior” (p.150). They state that currently motivation has a serious role in learning more than the past. The motivation of students is under discussion for researchers since this area always require innovative approaches due to a changing pattern in societal issues which have important role in motivation. According to Glynn et al. (2005), to foster students’ level of motivation effectively, the reason of why students strive for a specific goal, how concentrated are they in striving, how long they strive, and which emotions distinct them in such a process is required to be understood clearly.

The definition of Koballa and Glynn (2007) about motivation is the same as the others. Researchers in science education field try to explain the reasons behind why students endeavour for specific goals in science learning, and their force and time effort to strive. They also state that if science concepts are instructed effectively, it has the possibility to improve students’ attitudes toward science and increase their motivation to learn science. They mention the importance of hands-on activities, laboratory experiments, and inquiry-based lessons in improving attitudes and motivation. Additionally, these constructs can be used for comparisons of science programs as well as the evaluation of the programs.

What motivates students to learn science? The answer of this question can be given through integrating evaluations of Schunk (2000), methods and instruments of the constructs, and from findings. Koballa and Glynn (2007) described these constructs as arousal, interest, curiosity, and anxiety. They have significant role on intrinsic motivation of the students. And also intrinsic motivation is affected by how self-determined students are, how goal-directed behaviour they show, how self-regulated they are, how is their self-efficacy, and the expectations of their teachers about them. Below are general constructs described by Koballa and Glynn about motivation.

Arousal and Anxiety. Koballa and Glynn (2007) relate arousal to students' alertness and activation level. Arousal is associated with students' physical and psychological state of being ready for acting on a task. If it is limited in students, that means students can be inactive, bored, daydreaming, and sometimes even sleeping during the lessons. If it is quite high in students that means students have anxiety. Anxiety is described as feeling of tension, and the level of anxiety is important. Cassady and Johnson (2002) states that students sometimes experience anxiety in different extends, if it is not extreme, it helps students to be more motivated to learn science, but if it is very small, it slows down the performance.

Interest and Curiosity. These two terms are generally used interchangeably in the literature. Koballa and Glynn (2007) states that if students are interested or curious about something that means they are ready to learn it. These terms have significant role in students' achievement. Pintrich and Schunk (1996) stress that both interest and curiosity are obtained from activities that provide students information or ideas which are different from their current knowledge or belief, provided with moderately novel and complex phenomena. According to Koballa and Glynn (2007) the use of analogies in science instruction makes concepts relevant to students.
Intrinsic and Extrinsic Motivation. If students perform an activity for their own sake that means they are intrinsically motivated, if they do that for an external effect that means they are extrinsically motivated. Arousals, interests and curiosity contribute to intrinsic motivation that is they learn science concepts for their own sake not for physical rewards. Koballa and Glynn (2007) state that extrinsically motivated students learn concepts for earning grades or avoiding punishments. Usually, students accomplish tasks with intrinsic and extrinsic motivation. For example, is a student participate in a science fair can enjoy the process and also can enjoy for being awarded with a prize other external factor.

Self-Determination. It is described in Koballa and Glynn (2007) as the ability of possessing choices and definite amount of control in the process. People are responsible for their behaviours which explained by Koballa and Glynn as being captain of our own ships. According to Deci (1996), in self-determination students should be competent and free, intrinsically motivated activities enhance these emotions, but extrinsically motivated activities disable these emotions. Additionally, students who are self-determined have more potential to achieve higher and more adjusted emotionally.

Goal-Directed Behaviour. Pintrich and Schunk (1996) describe goal as an objective that students try to attain, and goal-directed behaviour is the process of it. For example a student in laboratory try to reveal properties of a substance, the steps students followed are goal-directed behaviours. It is stated in Koballa and Glynn (2007), setting goal is very important for students since it directs students be focused on, to develop different strategies to attain they goals. Two types of goals; learning (mastery) goals and performance goals exist. They also mention some properties of students with learning goals; these students do not consider the mistakes during the process or how they are appearing to others, rather they master the activities and related strategies. In short students with learning goals take responsibility for learning, have self-confidence and interest for learning. Contrast to this, student with performance goals focuses on gaining social status, making their teachers pleased with them and they don't want to take extra work.

Self-regulation. Koballa and Glynn (2007) states that self-regulation is a construct helping students to know they want to achieve in their science learning process. Self-regulated students use appropriate strategies; always control their progress in getting through their goals. Neber and Schommer-Aikins (2002) describes self-regulated learning as a cognitive process having two parts, use of regulator strategy (planning and monitoring) and use of cognitive strategy (organizing elaborating). The Motivated Learning Strategies Questionnaire measures these subscales of motivation Koballa and Glynn (2007) states that students controlling their learning process use challenging tasks and spend effort on assignments. Additionally, Students who feel control in their learning, easily overcome this situation when they fail, attributes the reason of failure to controllable and internal causes. They use appropriate strategies to learn science in order to increase their future success. Based on Koballa and Glynn description, contrarily, students not feeling in control attribute it to their limitations and they are not concerned about science learning.

Self-Efficacy. Bandura (as cited in Koballa and Glynn, 2007) defines this term as beliefs of a person on his/her capabilities in arranging and performing the courses of actions that are needed to given attainments. Koballa and Glynn (2007) states that self-efficacy is used by science educators to refer students evaluations' of their competence to achieve in a science domain. That means a student may poses high level of self-efficacy of knowledge and skills in chemistry, but low self-efficacy in physics. That is the indication of domain specific characteristic of self-efficacy. They also states that domain specific characteristic of self- efficacy makes questionnaires which are on a particular area of science useful than questionnaires addressing since in general.

Context-based approaches (CBA) to teach science specifically aims to influence students' affective issues in a positive manner (Acar & Yaman, 2011, Barker & Millar 1999; Bennett et al. 2007; Demircioğlu et al. 2009; Ilhan, 2010; Ingram, 2003; Kelly, 2007; Ramsden, 1997). Bulte et al. (2006) states that CBA have potential to increase affective issues provided relevant context are chosen. As stated earlier the meta-analysis of Bennett et al. (2003) indicated that evidences to conclude context-based approaches increases students' motivation in science courses and these approaches develop positive attitude towards science. Additionally, their study reveals no adverse affect of context-based approaches on students' understanding of scientific concepts.

Many researchers involved in studies regarding enhancement of teaching and learning believe that considerable benefits associated with context-based approaches exist. Therefore, this study also focuses on students the effect of CBA through 5E learning cycle on different constructs of motivation across experimental and control groups.

2.10 Gender

The gender issues in science related fields have been concern of research studies for a long time. Scantlebury and Baker (2007) stated that Trends in International Mathematics and Science Studies (TIMSS) data indicates that gender differences starts at fourth grade level and goes on through the final year of secondary school in favor of males, and this gap widens at each level in European countries. The gender difference may exist in cognitive or affective domain; Taasoobshirazi and Carr (2008) stated that a large gender difference is found in students' achievement level specifically in physics education. According to Glynn and Koballa (2007) physiological and sociological functions have direct effect on the reason of why attitude toward science is low in females than males. Thus, avoiding situations or contexts which will favor males or females becomes important in using specific methodologies in classrooms. Taasoobshirazi (2007) stated that gender differences in achievement as well as the motivation to learn physics may be minimized by context-based instruction by making the lesson more relevant to students. The selection of context in context-based approach becomes also critical in order to avoid superiority for males or females. According to Gilbert (2006) a context should be designed in a way to engage all students, the collection of contexts should have better to make chemistry more relevant to all students. Therefore, this study found it necessary to explore the role of treatments on gender as well.

2.11 Review of International and National Studies

In this section the studies focused on implication of context-based approach and investigated varying impacts of the approach will be summarized. Because CBA is already popular for international researchers, first studies conducted abroad will be reviewed, then national studies particularly, focused on chemistry will be reviewed.

Belt et al. (2005) have used CBA in undergraduate introductory physical chemistry course through a case study. The case was designed to teach students' thermodynamics, concepts of kinetics and electrochemistry through eight sessions consisting of 1-2 hours. The authors have chosen the generation of energy as a context, their case contained a city which they named as Los Verdes and it is in south-west region of USA. Students worked in groups to solve familiar and novel problems using principles of physical chemistry course regarded with fossil fuel combustion, hydrogen combustion, and fuel cells with hydrogen, solar power and energy of geothermal source. The study aimed to develop a case study which would enhance students understanding of different aspects of an early level physical chemistry course. They expected students to see the relevance of CBA thus would be more motivated. They also evolved storylines for their case, expecting it would provide students opportunity of working of different kind of problems. Their findings revealed some progress has been achieved for the aim of the study. Students were pleased to study chemistry through an application based context, it lead enhancement of knowledge and relevance. Furthermore, the implementation increased confidence of some students in their approach to solve problems in future.

Ramsden (1997) investigated the effect of context-based approach on students' understanding of key chemical ideas for 16+ levels. Her study aimed to compare the performance of students on some diagnostic questions instructed with a CBA and traditional approach in a high school chemistry course. She used a questionnaire with eight structured questions related with elements-compounds-mixtures, mass conservation in chemical reactions, chemical change and periodic table. The questionnaire was administered to 216 students, of which 124 were from Salters' course and the rest from other courses. The findings indicated positive and negative conclusions for chemistry teachers. Students learning and understanding in a context-based course seems to be more effective than conventional course about chemical ideas. However, whatever the approach used in the course, some key ideas of the chemistry are not conceptualized by students. Majority of students stated that further study of the course is not worth to study regardless of the type of chemistry course they followed. Such statement indicated that students do not prefer to chemistry as career choices even they do not prefer any science related field. High achievers' statements of about the process; as doing too much science rapidly is perceived by Ramsden as worrying. Ramsden recommended a more explicit implementation for these basic concepts, would improve students understanding. Furthermore, students treated with CBA stated that they had enjoyed in the course and the course increased their interest in the concepts they studied. In brief, the difference between students understanding level of chemical ideas across context-based instruction and conventional instruction was very small. Also, it is evident to propose that CBA is better in terms of supporting students to be aware of what is worthwhile in their science course.

Barker and Millar (1999) is in line with Ramsden (1997) study, they explored students' reasoning through a context-based Salters Advanced Chemistry (SAC) course. Their study was a longitudinal work including 250 participants; they investigated students reasoning on chemical reactions. The course was designed in a way to emphasize especially chemistry used in industry and the applications of chemistry aiming to keep students motivated to learn chemistry in order to study it. There were 36 schools complementing 23 diagnostic questions at the beginning, after 7 and 16 months over 20 month course schedule. The questions were related with mass conservation in chemical reactions proceeding in open-closed systems. The focuses of questions were about students understanding phosphorus, precipitation and solution aspects of chemical reactions. The responses of students indicated that high proportion of students start post-16 level with many misunderstandings associated with chemical reactions. By the time the course has progressed, students' conceptualization improved slowly. Although Salters' advanced course did not address some of students' misunderstandings, they have decreased in a noticeable proportion since the students become familiar to concepts and their chemical ideas developed. Barker and Millar (1999) stated that if teaching could be more directly, that could accelerate remedying the misunderstandings. Some misunderstandings seem to have resistance to change regardless of the type of the intervention used in the classroom. They stated that the approach should be reviewed continuously.

Campbell and Lubben (2000) studied with junior secondary school students to investigate the impact of science through contexts in order to support students to make sense of everyday situations. The way students deal with everyday situations used in a context-based science classroom was the focus of the study. Students' written responses, their explanations about social and economic applications of science, students' skills in proceeding an experiment for solving everyday dilemma, and students abilities on using their knowledge of science in relevant real-life problems was collected in this study. Four secondary schools participated in this study, the students were ninth grade, and nine probes were administered to 118 students. Students were allowed to use the knowledge provided in the materials developed by a curriculum project according to contextual teaching. While giving their responses, students provided information about the source of knowledge they used. The results indicated that less than half of the participants lack in displaying the proposed abilities. A considerable number of students showed experimental design skills implying to gain these skills from science they learnt in classroom; however, very limited number of students had related social-economic appreciation and problem solving to the school science. Campbell and Lubben (2000) suggested teachers to dilemmas about everyday contexts since they are assumed to show students implications of science around them. Such kind of dilemmas can be use of nuclear energy, generation of electricity or hybrid crops. They also suggest that using science knowledge to solve everyday problems through contexts is not enough only; rather students should work on projects about real-life problems. The situations students encounter in their everyday routines can be used both at the beginning and at the end of a science course. Campbell and Lubben (2000) concluded that if such and education is constructed in meaningful way, which means students will experience a two-way interaction of knowledge and understanding between what they have learned in schools and their experiences of everyday life.

Parchmann et al. (2007) and the ChiK Project Group worked on ChiK project to improve students understanding in chemistry at secondary level. The developed framework obtained from theoretical and empirical data of process, researchers-teachers focused on transforming the theory into practice. The founding communities developed and implemented nearly all topics for secondary education in upper and lower levels and they revealed the different effects on the motivation of students. The units used in ChiK indicated the relevance aspect of chemistry for students, however the approach of student centred teaching made students to feel they have lost in the context. Parchmann et al. think that the reason of this situation is about teachers' high emphasis on realization of an effective context than the development fundamental concepts. The evaluation of data obtained from communities indicated that teachers are supported to alter their current teaching with context-based and active student engagement process. They progressed to work on enhance student learning with better guideline and assessment of varying competencies of science.

Lubben et al. (2005) reviewed systematically the studies on CBA and STS approaches in terms of gender, low ability students, understanding, and attitude. They stated that these approaches took attention of both nationally and internationally since they have important role to develop students' scientific literacy. In their review, they examined 61 studies from different aspects. The studies they reviewed ranged across the approaches; 25 were context-based course, 13 were context-based unit, 11 were full STS course, and 12 were STS enrichment. The 44 of studies found the relation between intervention and attitudes, 41 had reported about effect on understanding, 24 of these studies explored both understanding and attitudes. 21 studies focused on skill development, 17 investigated effect of gender, and 7 focused on low ability students. Low ability and gender are especially investigated in age ranges of 11-16 since science courses are must-courses for these grade levels. Table 2.3 briefly summarize some of the studies included in review process.

Table 2. 3 Summary of some of the reviewed studies

Study	Age Range	Intervention	Discipline	Outcomes		
				Attitude	Gender	Ability
Banks (1997)	17-18	Salters course	Chemistry		√	
Barber (2000)	17-18	Salters course	Chemistry	√	√	
Barker and Millar (1996)	17-18	Salters course	Chemistry		√	
Key (1998)	17-18	Salters course	Chemistry	√		
Ramsden (1997)	11-16	Salters course	Science	√	√	√
Smith and Bitner (1993)	11-16	ChemCom course	Chemistry		√	√
Ben Zvi (1999)	11-16	STS course	Science	√	√	
Yager and Weld (1999)	11-16	STS course	Science	√	√	
Tsai (2000)	11-16	STS course	Science		√	
Zoller et al. (1990)	11-16	STS course	Science	√	√	
Zoller et al. (1991)	17-18	STS course	Science	√		

Note: The table is adapted from Lubben et al. (2005) Review study; some more studies are added as well. The implementations of all above-mentioned studies continued throughout the course rather than a unit.

In addition to studies summarized in table 2.4, some studies were conducted to report effectiveness of projects, to assess these projects. Sutman and Bruce (1992) have conducted a study for assessments of ChemCom through five years. They assessed the 3700 students and reported that students' responses to context-based course materials were positive and they were enthused to involve in course materials. The in-depth review of Lubben et al. (2005) has shown that the qualified studies have been carried out to reveal the effect of the interventions to provide reasonable confidence on the findings.

Demircioğlu et al. (2009) explored the impact of CBA on ninth grade students' conceptions about periodic table. They developed storylines by embedding them in CBA. The design of the study was non-equivalent pre-test-post-test control group design, with two intact classes; the participants were 80 students with and age range of 15-16. The experimental group was treated with materials developed based on CBA; control group was treated with traditional approach in which the teacher was active to explain concepts. The implementation took six teaching sessions utilizing six different lesson plans. The researchers administered an achievement test, attitude questionnaire, and retention test to participants. The findings indicated that CBA was more effective in construction of knowledge in long-term memory than traditional approach. Furthermore, results showed that students treated with CBA have developed more positive attitudes towards chemistry than other students. They suggested that such kind of activities should have better to be integrated with students textbooks and teachers guide book.

Demircioğlu (2008) studied CBA on the topic of states of matter in her dissertation. She developed instructional materials for pre-service teachers enrolled in general chemistry course. The effectiveness of materials was investigated through bringing out alternative ideas and participants' achievement. The design of the study was case study. The data was collected both quantitatively and qualitatively through a concept achievement test by 35 pre-service teachers and semi-structured interviews with 12 pre-service teachers and attitude test as well as classroom observations. The findings indicated that the context-based course materials have effect on replacement of pre-service teachers' alternative conceptions with scientific ones as well as providing high retention period. Contrast to substantial literature, Demircioğlu found that CBA also increased pre-service teachers' academic achievements. In line with other studies, participants' attitudes towards chemistry changed in positive manner.

Students enrolled in the study stated that lesson designed according to CBA were more enjoyable and interesting.

İlhan (2010) developed context-based materials for chemical equilibrium concept in eleventh grade chemistry curriculum. The study was a dissertation completed in 2010. It was a mixed method design with qualitative and quantitative data. Additionally, to reveal students and teachers responses on contextual learning some more data was collected. Four distinct classes of a state high school having totally 104 students constituted the sample of the study. An achievement test was constructed for the study. Quantitative data was collected from achievement test, questionnaire of chemistry motivation, and survey of constructivist learning environment. Appropriate quantitative data analysis producers were carried out to reveal if any differences exist across the groups. Qualitative data was analyzed through content analysis. Findings indicated that students in CBA have better in terms of achievement and motivation when compared to conventional instruction. Students treated with CBA were more satisfied with the instruction. Furthermore, CBA contributed constructivist learning environment more than the conventional instruction.

Currently, significant numbers of studies believing curriculum enrichment with context-based and science-technology-society approaches are on progress in Turkey in science, physics, and biology domains as well as the chemistry. These studies generally focus on whether this approach will help students to learn concepts better, whether students affective domain will be affected in positive way, whether the effect of implementation changes across the gender or not, and if the implantation differently affect low ability or high ability students.

Although there are some more studies than above mentioned national studies, we generally tried to focus on studies concentrated on CBA on chemistry education. It is clear that studies conducted in Turkey generally has chosen to focus on a unit for implementation new designed curriculum materials based on CBA, however, international studies are more organized in the duration of the implementation. The studies reviewed in the table 2.4 were all carried out throughout the course. The possible reason for Turkish researchers to focus on only one unit is possibly related with the organization of Turkish national curricula in any subject domain. Although the distributions of chapters are spiral across the grade levels, the concepts given in a grade level are usually difficult to make connections. Therefore, national researchers usually prefer to focus on a unit which has almost 5-8 weeks for implementation. They try to explore the effect of the instruction on student's achievement, understanding, attitudes, motivation, problem solving skills and gender issues.

In the light of findings of related literature, this study aim to compare groups on the issues of, conceptual understanding, achievement, and chemical literacy in chemical reactions and energy concepts in which experimental groups were instructed with context based approach through 5E learning cycle instruction and traditional instruction. Additionally students' motivation to learn chemistry and the factors of motivation questionnaire were compared for groups instructed with the context-based approach through 5E learning cycle model and traditional instruction. The materials designed for implementation primary tried to make students to involve students in learning chemistry, its application in industry so on society. Therefore, this study investigated the effect of CBA through 5E learning cycle on 11th grade students' understanding, achievement, motivation, motivational constructs, and chemical literacy level.

CHAPTER 3

DESIGN OF THE STUDY

In the previous chapters, the rationale of the study is given through the justifications from related literature; the problems and hypothesis are stated in the framework of the purpose of the study. This chapter briefly describes the research design, population and subjects, variables, instruments used to collect data, treatments, data analyses, treatment fidelity and verification, power analysis, unit of analysis, and assumptions of the study in detail.

3.1 Experimental Design of the Study

Frankel and Wallen (2000) describe experimental research as the best way of building cause-effect relationship between variables among other types of research designs. They additionally state that experimental research is unique in two significant aspects: “it is the only type of research that directly attempts to influence a particular variable, and, when properly applied, it is the best type of testing hypothesis about cause effect relationships” (p.283, 2000). In line with the purpose of the present study, experimental research methodology is used.

The quasi-experimental design as a type of experimental research was utilized for the study. In order to compare the effect of context-based approach through 5E learning cycle model versus traditional instruction on students’ understanding and motivational constructs in chemical reactions and energy concepts, the already formed classes were randomly assigned as experimental or control groups. Conducting the research with intact classes avoids disruption of students and school administrative rules. Therefore, the intact classes were randomly assigned to treatments rather than assigning students to treatments. The research design of the study is given in table 3.1.

Table 3. 1 Research design of the study

Groups	Pre-tests	Treatments	Post-tests
EG	CRECT CMQ SPST	CBALC	CRECT CREAT CMQ CLI
CG	CRECT CMQ SPST	TI	CRECT CREAT CMQ CLI

Note. EG: Experimental Group, CG: Control Group, CRECT: Chemical Reactions Energy Concept Test, CMQ: Chemistry Motivation Questionnaire, SPST: Science Process Skill Test, CBALC: Context Based Approach through 5E Learning Cycle Model, TI: Traditional Instruction, CREAT: Chemical Reactions and Energy Achievement Test, CLI: Chemical Literacy Items

Chemical reactions and energy is the topic for investigation of treatment effect. As seen from the Table 4.1, students in experimental group (EG) were treated with CBALC while to students in control group (CG) with traditional instruction (TI). Chemical Reactions and Energy Concept Test (CRECT), Chemistry Motivation Questionnaire (CMQ), and Science Process Skill Test (SPST) were administered to both experimental and control groups before the treatments. The post tests were, Chemical Reactions and Energy Concept Test (CRECT), Chemical Reactions and Energy Achievement Test (CREAT) and Chemistry Motivation Questionnaire (CMQ). CLI had been also distributed to all groups after treatments, but having higher percentages of missing data; the scores of these items had not been taken in main analysis. All groups took these tests after six weeks of treatment period.

3.2 Population and Subjects

Eleventh grade science major students in public high schools of Ankara - capital city of Turkey - were identified as target population of the study. Having the difficulty to reach all target population, accessible population was determined. All science major eleventh grade high school students in Çankaya district constituted as accessible population of the study. Nonscience majors of 11th grade do not have a chemistry course, so they were taken neither as target nor as accessible population. The results of this particular study will be generalized to accessible population.

There are 15 public Anatolian high schools in Çankaya district with almost 1500 11^{th} grade students in science major. Two Anatolian high schools which are well-equipped with technology and laboratory were selected from these schools conveniently. The level of students in high school entrance exam for two schools was close to each other. Four intact classes of two different teachers from the first school and two intact classes of one teacher from the second school were selected for implementation. These three teachers were volunteers for participating in the study. Each teacher had an experimental group and control group, that is, there are three experimental groups and three control groups. The subjects consisted of 187 eleventh grade science major students. Of these, 98 were females and 89 were males. 96 of the participants (45 male, 51 females) were in experimental groups and 91 of them (44 males 47 females) were in control groups. The age range of the students was between 16-18 years.

The study was conducted in the fall semester of 2011-2012 academic years. The topic of chemical reactions and energy was the first unit of eleventh grade chemistry curriculum, for that reason, during the early September the researchers and teachers met to discuss the contexts and lesson plans that will be covered in that unit. Also they had consensus on each activity related with the unit. The teachers obtained all materials to study before the implementation had started.

3.3 Variables

Fraenkel and Wallen (2000) state a variable as a concept that stands for variation within a class of objects. The classification of variables as dependent and independent is one way which is the most frequently used in the literature. This study had six variables, three of which were dependent variables and the three were independent variables, of which science process skills was covariate. Below, these variables are described in detail.

3.3.1 Dependent Variables

The dependent variables of the study were students' conceptual understanding scores obtained from chemical reactions and energy concept test (CRECT), chemistry achievement scores which was measured by chemical reactions and energy achievement test (CREAT) and students' motivation scores to learn chemistry which was measured by chemistry motivation questionnaire (CMQ). Each construct of CMQ; intrinsically motivated chemistry learning (Int), extrinsically motivated chemistry learning (Ext), relevance of learning chemistry to personal goals (Rel), responsibility or self-determination for learning chemistry (Sdet), confidence or self-efficacy in learning chemistry (Seff), anxiety about chemistry assessment (Anx) constituted a different dependent variable. All of these variables were in interval scale and continuous.

3.3.2 Independent Variables

The independent variables included in this study were type of instructional method (context-based approach through 5E learning cycle model and traditional instruction), gender of students, and science process skills test scores of students. The type of instruction and gender were considered as categorical variables and measured on nominal scale. Science process skills test scores of students was considered as continuous variable and measured on interval scale. Among these variables; science process skills test (SPST) scores were used as covariate. The summary on categorization of variables is given Table 3.2.

Table 3. 2 Description of variables

Name of the Variable	**Type of the Variable**	**Nature of the Variable**	**Type of the Data**
CRECT	Dependent	Continuous	Interval
CMQ	Dependent	Continuous	Interval
CREAT	Dependent	Continuous	Interval
CLI	Dependent	Continuous	Interval
SPST	Independent	Continuous	Interval
Gender	Independent	Categorical	Nominal
Treatment	Independent	Categorical	Nominal

CRECT: Chemical Reactions Energy Concept Test, CMQ: Chemistry Motivation Questionnaire, CREAT: Chemical Reactions and Energy Achievement Test, CLI: Chemical Literacy Items, and SPST: Science Process Skill Test.

3.4 Instruments

Five instruments were used in this study, they were; Chemical Reactions and Energy Conceptions Test (CRECT), Chemistry Motivation Questionnaire (CMQ), Science Process Skill Test (SPST), Chemical Reactions and Energy Achievement Test (CREAT), and Chemical Literacy Items (CLI). CLI was an open-ended questionnaire with real life contextual problems, it was administered to students in order to see the differences in chemical literacy of experimental and control groups. The researcher also carried out non-systematic classroom observations in the experimental and control groups to verify the treatments.

3.4.1 Chemical Reactions and Energy Concept Test (CRECT)

This test was used to reveal students' pre-conceptions about chemical reactions and energy concepts. Having some objectives in common with previous chemical reactions and energy unit, CRECT was adopted from Ceylan (2004) dissertation study. In its original form CRECT had 20 multiple choice items. This test was constructed for the previous chemistry curriculum so some of the items were suitable to objectives (see appendix A for objectives) of recently changed curriculum. In its original form CRECT had 15 questions developed by Ceylan (2004), and five items had been taken from the study of Yeo and Zadnik (2001). Each item of the test has a correct answer and four distracters.

The first five questions (Q1, Q2, Q3, Q4, and Q5) of CRECT were taken from Ceylan (2004); these questions were related to heat-temperature and energy. Students' prior knowledge on these concepts establishes a base for construction of new knowledge so these questions were retained in CRECT. All the other items except for these first five were totally related to objectives of recent chemistry curriculum. The questions; Q6, Q7, Q17, and Q18 were again taken from Ceylan (2004), these questions were serving objectives of recent curriculum. Additionally, questions; Q8, Q9, and Q16 were taken from Ceylan (2004) but small revision had done on these items. The rest of the instrument, questions; Q11, Q12, Q13, Q14, Q15, Q19, and Q20 were developed by researchers.

The questions were classified into categories as; heat-temperature and energy, energy release/absorption of bond dissociation and bond formation, endothermic and exothermic changes, heat of reactions; enthalpy, spontaneous changes, systems and energy, entropy changes, Gibbs free energy. The last version of CRECT had again 20 items (see Appendix C). 13 items were taken from the original version of the test and based on the objectives of the unit; the rest was developed by researchers. This version of the test was piloted with 12^{th} grade high school students just at the beginning of the 2011-2012 fall terms. The item difficulties and discrimination indexes were checked with ITEMAN; item analysis program. The results of the item analysis revealed that some questions needed revisions, and one question should be dropped from the test. Instated of not-functioning item, a new one was generated. The table 3.3 explains the details about the items of the test based on the pilot study scores.

Table 3. 3 Description of items in CRECT

Question number	Content domain of questions	Item difficulty	Discrimination index
1	Heat flow	0.756	0.296
2	Temperature and heat	0.585	0.433
3	Heat as a form of energy	0.648	0.219
4	Heat and temperature	0.261	0.539
5	Heat, thermal conductivity	0.767	0.339
6	Bond formation-dissociation	0.472	0.381
7	Endo/exothermic reactions	0.563	0.406
8	Exothermic reactions	0.563	0.372
9	Endo/exothermic reactions	0.697	0.387
10	System and surroundings	0.790	0.339
11	Absolute temperature, 3rd law	0.500	0.316
12	Spontaneity and exceptions	0.625	0.394
13	Spontaneity and entropy	0.608	0.441
14	Enthalpy change	0.605	0.523
15	Entropy of systems/universe	0.533	0.325
16	Oxidation reactions	0.352	0373
17	Bond Energies	0.403	0.456
18	Temperature, heat flow	0.159	0.258
19	Gibbs free energy	0.542	0.338
20	Entropy, order	0.382	0.422

Students correct responses were coded as 1 and incorrect responses as 0, therefore the maximum score that a student can get from CRECT was 20 and the minimum was 0. The reliability of the instrument was computed from students' responses to Pilot study. There were 168 students from 12th grade in the pilot study. The Cronbach alpha reliability of the pilot study' test scores were found to be .72. Validity of the test was established by three experts from chemistry education field, and a chemistry teacher. Feedbacks of one Turkish language expert and a chemistry teacher were used for both understandability and face validity of the instrument. Final version of the test was administered to experimental and control groups both as a pre-test and as post-test. The pre-test scores were used to compare whether both groups have equal conceptions regarding the topic they would be treated. The administration process took approximately half an hour in each classroom.

3.4.2 Chemical Reactions and Energy Achievement Test (CREAT)

The test, CREAT, was developed by the researchers in order to assess students' achievement in both conceptual and algorithmic problems of chemical reactions and energy unit. Based on the objectives of the 11^{th} grade chemistry curriculum, the items of the test were constructed by researchers utilizing textbooks, available question banks, University Entrance Exam (YGS). There were 25 multiple choice questions in CREAT, each question had five alternatives, of which one was the correct answer. And each question at least met one of the objectives of the unit. The overall test is provided in Appendix D.

The first version of the test was piloted in state high school with 85 12^{th} grade students before the treatment. According to the results obtained from item analysis (item difficulty and discrimination indexes were checked), some of the questions were revised, some were dropped, and instead new ones were constructed. The Cronbach alpha reliability of the final version of the test scores was found to be .74. The appropriateness and content validity of the test was established by chemistry teachers, chemistry education experts. Students correct responses were graded as 1 and incorrect responses as 0. Thus, the maximum score that a student can obtain from the test was 25, the minimum score was 0. The distributions of items according to objectives of the unit are described in Table 3.4

Table 3. 4 Distribution of questions of CREAT based on the objectives

1.Systems and types of energy		2.Enthalpy change		3.Changes and spontaneity	
Obj1.1	Q1, Q2	Obj2.1	Q6, Q8	Obj3.1	Q11,Q12
Obj1.2	Q2, Q1	Obj2.2	Q7, Q9	Obj3.2	Q13,Q14
Obj1.3	Q3	Obj2.3	Q9	Obj3.3	Q13
Obj1.4	Q4,Q6,Q8,Q22	Obj2.4	Q10,Q24	Obj3.4	Q19, Q20
Obj1.5	Q5,Q25			Obj3.5	Q11, 14
Obj1.6	Q2			Obj3.6	Q18,Q25
				Obj3.7	Q16, Q17
				Obj3.8	Q15,Q23

Note: Obj: Objective, Q: Question number in CREAT. As seen from the numbers, the unit has totally 18 objectives. See appendix B for overall objectives.

The test was administered o both experimental and control groups after the treatment in regular class hours as a post-test to determine effect of treatments on students' achievement on chemical reactions and energy concepts. The administration took approximately 30 minutes.

3.4.3 Science Process Skill Test (SPST)

Okey, Wise and Burns developed the instrument: Science Process Skill Test (SPST) in 1982. Later, Geban, Askar, and Ozkan translated and adopted this test into Turkish in 1992. The instrument was constructed to measure intellectual abilities of students about identifying variables, stating and identifying hypotheses, defining and designing investigations operationally, graphing and interpreting data. There are 36 items in this test and each question is in multiple choice forms with four alternatives. The Cronbach alpha reliability of the test scores was found to be .88. Experimental and control groups took this test before the instruction. Students' correct responses to items were scored as 1 and wrong responses are scored as 0, thus, possible maximum score that a student could obtain from the test was 36 (see Appendix F for the entire instrument).

3.4.4 Chemistry Motivation Questionnaire (CMQ)

Science Motivation Questionnaire (SMQ) developed by Glynn and Koballa, in 2006 was used to gather information about students' motivation to learn chemistry. In their study they gave permission to researchers to extend the usage of SMQ to different versions such as the Biology Motivation Questionnaire (BMQ), Chemistry Motivation Questionnaire (CMQ), and Physics Motivation Questionnaire (PMQ). Glynn and Koballa (2006) reported that the SMQ as reliable in terms of its internal consistency, they measured reliability from coefficient alpha as .93. In the version used in this study, only the word "science" was replaced with the word "chemistry".

According to Glyn and Koballa (2006), the items 1, 16, 22, 27, 30 ask students to report on intrinsically motivated chemistry learning (Int). The items 3, 7, 10, 15, and 17 are demonstrating extrinsically motivated chemistry learning (Ext). Items 2, 11, 19, 23, and 25, are showing relevance of learning chemistry to personal goals (Rel). Items 5, 8, 9, 20, and 26 are related to responsibility or self-determination for learning chemistry (Sdet). Confidence or Self-efficacy in learning chemistry (Seff) are represented by the items 12, 21, 24, 28, and 29, and finally Anxiety about chemistry assessment (Anx) are investigated with the items 4, 6, 13, 14, and 18. Students respond to each of the 30 randomly ordered items on a 5-point Likert type scale ranging from 1 (never) to 5 (always). The anxiety about chemistry assessment items are negative, which means, a higher score on this construct means less anxiety thus these items were reversed in PAWS Statistics 18 through recode procedure for necessary computations.

Ranging from 1 to 5 the questionnaire included 30 items. The maximum score was 150 and minimum score was 30. According to Glynn and Koballa (2006) a score in the range of 30–59 is relatively low, 60–89 is moderate, 90–119 is high, and 120–150 is very high. The entire instrument is available in appendix E. The total score on the CMQ served as a comprehensive measure of the students' motivation.

In order to establish an evidence to whether CMQ assess six constructs proposed by Glynn and Koballa (2006), the confirmatory factor analysis (CFA) was conducted for pre-test scores of CMQ and post-test scores on CMQ, having similar results, CFA from pre-test was reported. In order to perform CFA, the reliability of the scores must be at least .70 (Pallant, 2007). The Cronbach alpha coefficient of reliability was computed for both students' scores obtained from preCMQ results and postCMQ results, the values were; .89, .88 respectively. Additionally, the reliability coefficients of factors were found as .72 for Int, .67 for Ext, .77 for Rel, .67 for Sdet, .82 for Seff, and .75 for Anx for pre-test scores. According to Barrett (2007) the sample size to make structural equation modeling should be at least 200. The sample in this study was 177, although the value is below 200, Tabachnick and Fidell (2007, p.683) explained that the sample size could be less if the variable was reliable. They stated that 16:1 ratio is enough for CFA. In this study, the ratio was 177:6 which gives 29.6. The descriptive of the CMQ and related dependent variables were controlled for assumptions of CFA, skewness, kurtosis, linearity, outliers were all checked, and assumptions of CFA were not violated.

CFA as conducted to verify the factor structures of proposed constructs for pretest scores of CMQ. CFA let researchers to see the relationship among the observed variables and the underlying latent construct existed or not. Chemistry motivation score was latent variable and it predicts six constructs: Int, Ext, Rel, Sdet, Seff, and Anx. At the beginning the model and the observed data did not indicated good fit according to pretest scores. To obtain a good fit, some modifications had to be done based on modification indices suggested by the LISREL program and covariance were added to the model. Four modifications had to be done in order to obtain a good fit value. Firstly a covariance had to be added between Ext and Anx, then another was added between Seff and Anx, thirdly, between Int and Ext, and finally between Rel and Anx. The last version of the model which has good fit values ($\chi^2 = 9.30$, $p = 0.09$, GFI= 0.98; AGFI= 0.93; RMSEA= 0,070; SRMR= 0.040) is given in the figure 3.1.

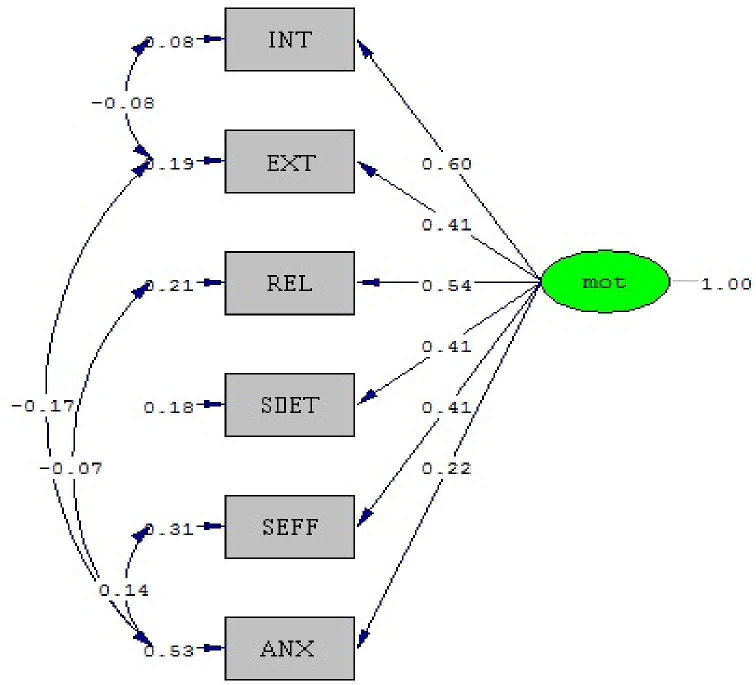

Figure 3. 1 The model with good fit indices through modifications.

In order to see whether CMQ assess six motivational constructs, the researchers conducted confirmatory factor analysis. The first model obtained from pretest scores had not given good fit values so modifications required. Modifications suggest correlation between the constructs, when four modifications have performed, good fit values were obtained. Although, the correlations among four constructs, CMQ assess the six constructs since goodness of fit values were acceptable for pretest scores. In addition to pretest scores, CFA had been performed also for posttest scores similar results were obtained.

In this study, the instrument Chemistry Motivation Questionnaire (CMQ) was used for overall motivation score and for six factors (Int, Ext, Rel, Sdet, Seff, Anx). The questionnaire was administered to students of experimental and control groups both before the treatment and after the treatment since the effect of intervention on students' motivation was investigated. Each of the construct of CMQ served as a separate dependent variable in this study.

3.4.5 Chemical Literacy Items

Problems through everyday contexts were developed by researchers to assess students' chemical literacy skills on chemical reactions and energy unit. Based on the objectives of the unit, everyday contexts which have applications of concepts are investigated. The questions assessing students' scientific literacy skills in PISA 2009 and the questions developed Witte and Beers (2003) to reveal students' chemical literacy skills were inspired the researchers to develop these open-ended questions. Some science related news which has covered by media was perceived to make students to be interested in the tasks. The everyday contexts used in these problems not only ask knowledge base questions to students but also investigate students discourse abilities, interpretations by using pro and con ideas from the given data. The problem contexts were constructed in a way to reveal students' understanding of given information, their ability to select needed information from text, their ability to alter given information to another form, and their abilities to make interpretations on the information provided (see appendix G for the entire items).

There are four different themes for questions. The first theme was related with the combi boiler which approximately every house in Çankaya distinct poses one. Student are familiar this context since each of them has it in their houses. Additionally they are accustomed to problems associated with use of combi boiler from the media. A piece of newspaper along with a fundamental knowledge about two kinds of combi boiler is provided for students to reveal their chemical literacy skills on heat, exothermic reactions, and related calculations. Students were also expected to mention molar heats of some chemical species. The second theme was about energy concepts in biological systems. To avoid mentioning only the application of energy on technological aspects, the researchers needed to construct questions through biological aspects. The energy required for teenagers was provided for students as problems task. They were expected to connect their chemistry knowledge to both biology and physics. Bond dissociation energies and bond formation energies were investigated in biological systems; they were expected to connect this conceptual knowledge to putting on weight and the role of activities for healthy body. The third theme was about the elastics bands which have widespread usage in daily life, students were expected to connect their pure conceptual knowledge of order of molecules to entropy of system and entropy of surroundings. The formulas were given to students in order to provide evidence for their conclusions. The final theme was related with the volcanoes, types of systems and changes, the sign of basic quantities such as ΔG, ΔH, and ΔS were investigated through this context. The first and second laws of thermodynamics were provided in the text, and students were expected to draw this information from the text provided. In each theme some questions are knowledge based; simply asking comprehension, some questions are interpretive. For the first theme, the options; "a", "b", and "c" were knowledge based, the rest were interpretive. For the second theme "a" and "b" were knowledge based, "c" and "d" were interpretive. For the third theme, option "a" was knowledge based, b was interpretive. Finally, for the last theme, "a" was knowledge based, "b" was interpretive.

The evaluation of these problem contexts were carried through a rubric prepared according to correct answers of the questions. For the first theme, the options "a", "b", "c", "d", and "e" has maximum score of 3, partial score of 2 or 1 and minimum score of 0; the options "f" had maximum score of 1; the option "g" and "h" had maximum score of 2, partial score of 1 and minimum score of 0. For the second theme, option "a" had maximum score of 1; option "b" had maximum score of 3, partial score of 2 and 1; option "c" had maximum score of 4, partial score of 2; the option "d" had maximum score of 2 and partial score of 1. For the third theme, option "a" had maximum score of 2, partial score of 1; option "b" had maximum score of 3, partial score of 2 and 1. For the fourth theme, the option "a" had maximum point of 7, that is, each blank (totally seven blanks) in this task had one point for correct answer; the option "b" had maximum score of 3 and partial grades as 2 or 1. The problem contexts and rubric were controlled by another researcher too. Students' responses were categorized according to content domains of the questions. The qualitative data given in the responses was transformed to quantitative data by means of the answer key rubric. Students' correct answer responses were given in percentages. The percentages were divided into categories of point intervals. The answers obtained by experimental groups and control groups were compared to reveal whether any change exist across the groups or not.

3.5 Procedure

This study aimed to investigate the effect CBA through 5E learning cycle model on students' understanding and achievement on chemical reactions and energy unit, and their motivation to learn chemistry as well as the students' chemical literacy on this topic. The initiation of this study begins with to popularity of the topic to propose attractive outcomes for meaningful learning. First a detailed search for related literature started. The key terms such as "context-based approach", "learning cycle", "5E learning cycle model", "motivation", "chemical literacy", and "chemical reactions and energy" were searched through academic data bases, libraries and goggle scholar. The thesis studies conducted nationally-internationally and books related with effective chemistry-science teaching through real-life contexts were examined. The most struggling process was to develop materials which the implementation was established over. A serious time were spent on connecting the objectives of the unit with the real life contexts. When the main framework was drawn, the instruments required to measure the related aspects of students which were proposed to be affected by the implementation were started to construct. The concept tests used in the literature were investigated and some questions were adapted from them, some new questions were constructed based on the misconceptions widely stated in the literature concerning chemical reactions and energy concepts. The item analyses were conducted to see the discrimination and difficulty indexes based on the pilot study scores of the students. Then achievement test were constructed by researchers, the same computation were also carried for this test too. The chemical literacy items through real-life problems of everyday contexts were also developed by researchers. The tests developed by the researchers were piloted in order to reveal the item analysis; the validity of the constructs was established by chemical education experts. Based on the pilot study, some items were revised, some dropped, and some more were added. The science process skill test and the chemistry motivation questionnaire were used from the literature.

After the material and test development process, the permission was taken from the related organizations. Schools participating in the study were selected conveniently. The schools were visited and informed about the process at late summer of 2011. The teachers were in the schools because of seminars prior to new education year. The administrative units of the schools informed the teachers, some teachers were volunteers to participate in the study but some were not. Classes of these teachers were randomly assigned to experimental and control groups. The volunteer teachers were firstly informed on experimental research design and CBA through 5E learning cycle model to teach chemistry and the possible effects of it. The teachers were specifically informed on steps of 5E LC model, and the main requirements of CBA. The teachers and researcher discussed on the materials and some parts of the materials were revised according to feedbacks of the teachers. All lesson plans were given to teachers before the implementation started. The technological tools were checked before the lessons, the student handouts, laboratory materials for performing experiments were provided by the researcher at the beginning of the term. The unit of the chemical reactions and energy were the first unit of the eleventh grade chemistry curriculum. Just before the lessons started, the pre-tests CRECT, CMQ, and SPST were administered to students of both experimental and control groups in order to reveal if any significant difference across the groups exist or not. The handout related to historical development of cars, their engines from past to today was distributed to students before the first lesson has started. The context used in this study had been prepared according to the attributes of an educational context which were reported by Duranti and Goodwin (1992). The details of an educational context had been reported by Gilbert (2006) in literature review part of this study. Table 3.5 briefly describes the attributes of context used in this study in the framework of Gilbert (2006) description.

Table 3. 5 Attributes of the context for car engines

Attributes	Focal event: development of car engines	
a	Where, when, how is the focal event situated?	Historical development of cars, from steam engines to 4 stroke engines
b	What do people do in the situation, what actions do they take?	Production of more efficient cars, more efficient fuels, bio-fuels, high octane ratings, reduction of environmental hazards
c	In what language do people speak about their actions?	Related to efficiency of car engines, 1.4 – 1.6 – 2.0 capacity, different energy types, energy related discussion in society
d	What is the background knowledge of those who act?	Chemical reactions and energy terms in car engines; system, surrounding, heat, work, internal energy

The discussion on which the concepts would be introduced on the context had been distributed to teachers before the treatments. The figure 3.2 briefly gave the concepts of the unit around the context of the study, the researcher and teachers had discussed on the spider web metaphor for learning chemical reactions and energy concepts. It was designed according to Schwartz (2006). The teachers had perceived that they could make interconnectivity among the concepts of the unit.

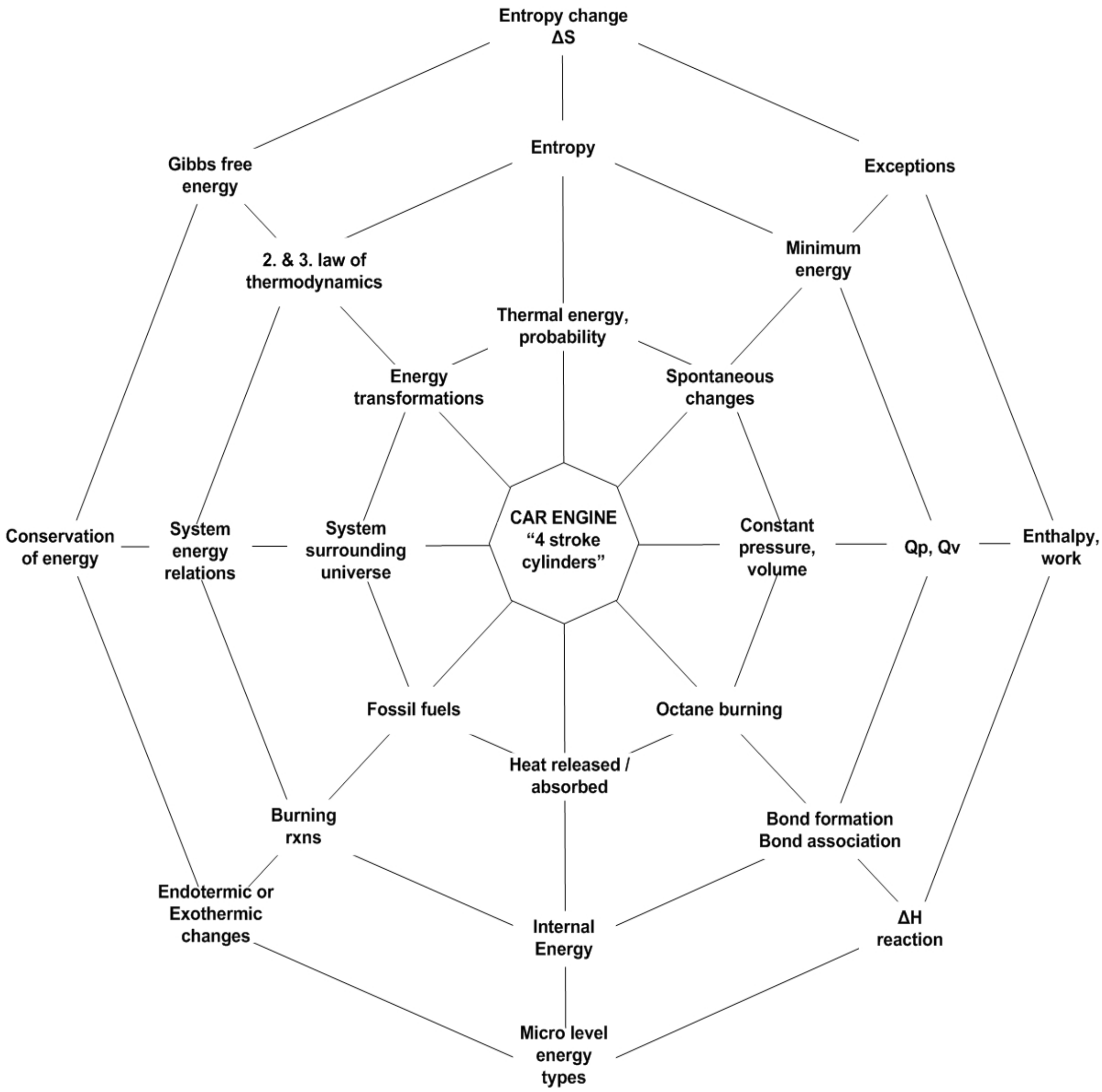

Figure 3. 2 The spider web metaphor for learning chemical reactions and energy

The researcher participated each class hour to observe the teacher and class by taking notes on the classroom observation checklist (see appendix K) when the implementation has started. The checklists were adopted from Peşman (2012). There were six classes in the study; a few hours of the lectures were at the same time, thus the researcher attended to classes for one week and attended to the other for the next week. Although, a research assistant from secondary science and mathematics department had also observed the class hours, some of them had been missed during the implementation. To verify the implementations of CBA through 5E learning cycle model and traditional approach, the researcher observed the classrooms both experimental and control groups. The researcher was a non-participant observer. The classroom observation checklist given in the appendix L was filled by researcher and sometimes by a colleague for almost all class hours. Sometimes some additional notes had been taken by the researcher. Based on the notes and classroom observation checklist results, it can be concluded that the teachers treated their classrooms as proposed by the researcher, students engaged in activities, teachers connected the concepts to the context in each class hour, and in traditional classes they gave the applications of concepts after introducing concepts. The researcher and the other observer had consensus on the requirements given in the classroom observation checklists.

After each class hour, the teacher and researcher evaluated the implementation of a context based course through learning cycle model. The same procure continued with other teachers too. Researcher always supported the teachers in any problem about the implementations, as well as giving feedbacks and suggestion to make intervention more proper. Additionally, the teachers were informed to teach in their control groups in the way that they were accustomed to. Control groups were also observed but not as much as the experimental groups because of having six different classes for the study.

At the beginning of the first lesson the teachers informed their students about the implementation they will be treated through this unit. They told students that the concepts would be taught through their application around them, and should ask questions whenever they wondered a concept. Then the teacher asked students about historical development process of cars, their engines, he tried to make students to remember the handout they have read. The teacher directed many questions given in the lesson plan to students and waited them to think and give answer. The aim was to establish a need to know base for students to acquire this novel concepts. Students in experimental groups watched the animation movie about how car engines works, and then the teacher again directed the questions to students. The students discussed and give some correct and incorrect answers. The teacher informed them they would learn the answers throughout the lesson. The experimental setup was always prepared by researcher. The teacher followed the guide lines given in the lesson plan, and made students to engage in the process properly. The experiments were carried in normal class hours, students are not taken to laboratory to perform experiments and these experiments were carried out as demonstrations on a table of middle line in the classroom. Students and teachers usually discussed on the issues and new discussion topics were emerged for the next lesson. The teachers always took attention on connecting the concepts to the contexts provided for students at the beginning of the course. In some parts of the lesson, the teacher connected his or her notes to the appropriate part of the lesson plan. When the introduction of concepts ended, the teacher repeated to ask the same question to the students, and students discussed to find some more files of applications for these concepts. The each class session the teacher followed the lesson plan. At the end of each class session the teachers distributed the hand outs to relate to next lesson plan.

In control groups the teachers did whatever they were doing in their usual class hours. The lessons were mainly teacher centred, and the approach was traditional. The teacher used lecturing and questioning and sometimes discussion methods to solve problems to teach concepts of chemical reactions and energy. The real-life contexts were not served to students to see the connection of concepts through real-life context. Instead after introducing main concepts the teacher generally focused on the question banks, they selected question and solved them for university entrance examination. At the end of the lesson the teacher usually distributed some questions to students as homework, these homework were given to both experimental and control groups.

The implementation took totally six weeks. In each week, students had three chemistry lecture hours, that is, they had overall 18 hours to study the chemical reactions and energy concepts. The post tests were distributed to the students at the end of the implementation, both experimental and control groups took these tests. The first midterm examination was just after the implementations.

3.6 Treatments

Two types of treatments were implemented in this study: The first was context-based approach with 5E learning cycle model, and the second was traditional instruction.

3.6.1 Context-Based Approach through 5E Learning Cycle Model

Based on the descriptions of main characteristics of the context- based approach, 5E learning cycle was enriched. Gilbert (2006) stated some actions to overcome problems related to chemistry instruction, these problems and actions to resolve them are given in related literature. According to those descriptions, context based approach must have some requirements. Westbroek (2005) examined context-based curriculum projects and concluded that the requirements for meaningful chemistry are, use of (a) ***context,*** (b) ***need-to-know,*** and (c) ***attention for students input.*** Briefly, the collection of contexts utilized should provide likelihood of transferring concepts to other contexts to improve students in making connections between the knowledge they had learnt and other situations. The context should provide a need to know base for knowledge construction and it should enable the participation of the students, that is, the activities at hand should take students' attention.

5E learning cycle model has five phases; (1) engagement, (2) exploration, (3) explanation, (4) elaboration, and (5) evaluation. In the *engagement* phase, students' curiosity had been taken by asking questions related to context followed in lesson plans "Cars". That means, at the beginning of the lesson, the context was presented to students as a form of discussion; teachers took students' responses, and asked further questions to deepen the discussion as much as possible. For example, in the first lesson plan, the teacher asked students about the handout delivered; teachers asked the applications of chemistry in cars (see appendix H). The simulation video of "how car engines work" had been shown to students and further questions were again asked to deepen to create a need to know base for new knowledge construction. Related to systems and energy types, students had guessed a 4-stroke engine cylinder as an open system and further discussed was carried for other system types. The energy transformations in a cylinder the teacher asked more questions and students made some guesses. The discussion was taken to matter-energy transformations, heat-mechanical energy-internal energy changes and first law of thermodynamics by context-related questions.

Then, from contextual questions and discussions the teacher continued with experimental activity. The next steps of learning cycle model as described by Marek and Cavallo (1997) were fallowed. In *exploration* phase, the activity given in the related lesson plan had been prepared by the teacher in class, on the desk of teacher and teacher asked questions related to the activity to increase students' curiosity. For example, when setting the experimental apparatus, the teacher asked students how the reaction of zinc with hydrochloric acid will move the piston, why the piston moved up, is the work done by the system or by the surroundings. Students are asked to write their hypothesis regarding to questions, then students performed experiment and tested their hypothesis by working in groups. The next step was *explanation* phase, the teacher wanted students to answer the questions given in previous phases. Teacher always guided, asked additional questions to students explain their ideas, observations. For example the teacher asked which parameters were important in work, heat and internal energy. Along with waiting answers from students, the teacher made some explanations when needed. The teachers briefly explained, clarified students' ideas and observation related to work-heat-energy transitions. The teacher gave the formula related to internal energy and parameters that contributes internal energy. In, *elaboration* phase, students have watched another video (a closed system); the teacher asked some more questions for elaborateness. For example, asked how heat of the system has changed (enthalpy change), how this change is related to internal energy of the system. Teacher wanted students to give some more examples from daily-life to teach type of systems; open-closed-isolated-isothermal, energy transformations and heat-work-and energy relation in systems. The final step of learning cycle was *evaluation.* In this phase the context-related questions were directed to students and main concepts were clarified in detail. The knowledge constructed was transferred to other contexts or problem situations.

To sum up, the CBA was integrated with steps of 5E LC model. Bybee et al. (2006) stated that the disequilibrium or with context-based approach the "need to know" base was formed in engagement phase. As done in the sample lesson plans given in the Turkish National Physics curriculum, the basics of CBA were specifically integrated with LC model in the engagement and evaluation phases. The table 3.5 briefly summarizes the whole framework of activities implemented CBA through 5E LC "model in experimental groups.

Table 3. 6 Overall activities of CBA through 5E LC treatment

The context for chemical reactions and energy unit: *"CARs"*			
Systems and energy types	Enthalpy change of a system	Spontaneity of changes	Entropy and Gibbs free energy
Lesson plan I: "4 stroke engines: how car engines work"	Lesson plan II: "Rxn of fossil fuels in engines" Exp: Heat of Rxn	Lesson plan III: "Air conditioners" -How refrigerators work? Liquid nitrogen	Lesson plan IV: Reading assignment: "What is free about Gibbs free energy"
Related objectives; 1.1, 1.2, 1.3, 1.4, 1.5, 1.6	Related objectives: 2.1, 2.2, 2.3, 2.4	Related objectives: 3.1, 3.2, 3.3, 3.4, 3.5	Related objectives: 3.7, 3.8

3.6.2 Traditional Instruction

The basic framework for traditional classroom was being teacher-centered. The teacher started to introduce basic concepts briefly, solved some simple exemplary problems then increased the difficulty level of questions and wanted students to solve these problems. For example just at the beginning of the lesson, the teacher wrote a title on the board and wrote the types of systems and clarified them in detail then s/he read the notes from the notebook and students followed the teacher to write the notes to their notebooks. The definitions, formulas related to heat and work, internal energy were directly presented by teacher, definitions were explained. Actually, the teachers were doing whatever they were doing in their routine class hours. The methods were mainly lecturing and questioning, sometimes discussions were also carried by students around the questions asked by the teachers. The real-life contexts were not introduced to students to see the connection of concepts through real-life contexts at the beginning of the course. Instead, after introducing main concepts the teacher generally focused on the question banks.

During the breaks, the students from different classrooms were in touch and this was unavoidable. Experimental group students were usually talking to each other about the activities they were following; some of the students from control groups might have been demoralized and such a situation may affect these students' performances in a positive or negative way. Hake (1998) describes this as attitude of subjects and it was called as John Henry effect. To reduce the impact of such variables, the demonstration used in context-based approach through learning cycle were shown to traditional classroom students at the end of concept introduction. The teachers only showed the movies or simulation and they gave them as applications of concepts.

3.7 Data Analysis

The study had quantitative data to reveal the effect of implementation. The quantitative data was collected by some instrument; Chemical reactions and energy concepts test (CRECT), Chemical reactions and energy achievement test, (CREAT), Chemical literacy items (CLI) on chemical reactions and energy, and chemistry motivation questionnaire (CMQ). Students background knowledge of gender, GPA, mother and father educational level were also taken. The data obtained from students was entered to Predictive Analytics Software (PASW) Statistics 18. The whole data gathered from students were typed to SPSS, the students were in the rows, and each of the variables was inserted to columns.

The independent variables were; treatment (experimental vs. control groups) and gender (males vs. females). The dependent variables are; understanding and achievement in chemical reactions and energy concepts (post-CRECT and CREAT scores) and motivation to learn chemistry scores (post-CMQ). Although, CLI was a dependent variable of the study, the percentages of missing for these open-ended items were higher than other missing percentages, therefore, students scores regarding these items were not taken in main analysis. Students' responses to these items were reported based on percentages of groups. Additionally, each construct of motivation questionnaire (Int, Ext, Rel, Sdet, Seff, and Anx) was dependent variable. Science process skill test (SPST) was a confounding variable, it constituted as a covariate. The variables were categorized as string or numeric. First, the string variables such as students' responses of "A" or "B" or others were transformed into numeric variables; the answers of pre-CRECT, SPST, post-CRECT, CREAT were dichotomized. The item analysis has been computed before the actual implementation, item descriptions were stated in previous parts. Responses to the negative items on the chemistry motivation questionnaire (CMQ) were reversed for pre-test and post-test scores then the confirmatory factor analysis was conducted for CMQ. Each of the factors was renamed to constitute a dependent variable for the study. These constructs were intrinsically motivated: items 1, 16, 22, 27, 30, extrinsic motivation: items 3, 7, 10, 15, 17, relevance of chemistry: items 2, 11, 19, 23, 25, self-determination: items 5, 8, 9, 20, 26, self-efficacy: items 12, 21, 24, 28, 29, and anxiety: items 4, 6, 13, 14, 18.

Then, missing data analysis was conducted by excluding students who were in the pre-test but were not in post-tests. This process has done before computing the descriptive and inferential statistics. The missing data of pre-CRECT and pre-CMQ were almost the same participants since they had administered to the students at the same day. The missing data of CREAT and post-CMQ were also almost the same since they have been administered to students at the same day. Numbers of missing cases were detected for pre-test and post-test scores. Cases 27, 63, 69, 73, 82, 83, 94, 98, 142, 161, 163, 168 were missing for the post-test scores, cases 30, 31, 42, 54, 61, 92, 93, 123, 185, 186, 187 were missing in pre-CMQ. The percentage of missing students on post-CMQ and CREACT was 6.4 % for both. 11 students were missing for pre-CRECT and pre-CMQ, 13 for SPST, and the percentages are 5.9 % and 7 %

respectively. Students who were missing in post test were excluded from the data set and the item missing in CRECT and CREAT were coded as "0", others were replaced with the mean for statistical analysis. The missing data was high in open-ended CLI, so students' scores could not be used in main analysis, rather, correct response percentages are given across the groups. The details regarding percentages of missing are given in result section.

Before descriptive and inferential statistics, reliability estimates have been computed. The values are given in the related parts. Statistical analyses of the study were categorized in two parts; descriptive statistics and inferential statistics. The PASW Statistics 18 were used for analysis, since the study had three dependent variables with a covariate, the statistical method of multivariate analysis of covariance (MANCOVA) was used to test the hypothesis of the study. This method makes it possible to equate the groups on more independent variables; it controls type 1 error. According to Pallant (2007), by reducing the error variances, analysis of covariate allows us a powerful comparison of groups' means. Subsequent to the MANCOVA, follow-up ANCOVAs were computed to test the effects of the independent variables on each dependent variable separately. Additionally, multivariate analysis of variance (MANOVA) was used to investigate the effect of treatment on each construct of motivation questionnaire.

The data obtained from the open-ended chemical literacy items were evaluated according to rubric prepared as answer key. The responses were used to compare experimental and control groups. Students' scores were categorized for each theme, the percentages of correct responses were given and some sample responses were reported for both experimental and control groups.

3.8 Treatment Fidelity and Verification

Treatment fidelity is required to ensure no other variable except for treatment to be responsible for the difference expected on dependent variable. The experimental and control groups were treated with pre-designed lesson plans which are developed according the requirements given in the literature and definitions of key terms. The lesson plans of experimental group were prepared based on the Gilbert's (2006) description of an effective context along with the sample lesson plan provided in Turkish National Physics curriculum which is developed based on context-based approach through learning cycle. Since the CBA is integrated with 5E LC, the requirements of LC were also established according to descriptions of Marek and Cavallo (1997). The activities that teachers should follow were determined prior to implementations, revised based on teachers' suggestions.

To verify the treatments, almost all lessons except for the one which was at the same time with another, were observed by the researcher and rarely observed by a research assistant of Secondary Science and Mathematics department of Middle East Technical University. A check list (provided in appendix K) is used by researcher and observer to verify the consistency of treatment with lesson plans developed. The observer and researcher has consensus on verification of treatments.

3.9 Power Analysis

Power of a study is described by Hinkle, Wiersma and Jurs (2003) as probability of rejecting a null hypothesis in the case of being false. The power of this study was established to .80 prior to implementation. Based on the formulation of Cohen, Cohen, West and Aiken (2003), the following equation was used to calculate the sample size which is necessary for obtaining the pre-established power value.

$$n = \frac{L}{f^2} + k_A + k_B + k_C + 1$$

In this equation, "n" means sample size, the L value is taken from the table given in Cohen et al. (2003, pp.650-651) according to alpha level. The f^2 constitutes effect size; k_A represents number of covariates used in the study, k_B means the number of independent variables, and k_C represent the number of interaction terms.

The alpha level (probability of making type 1 error) was set to .05 in this study. The covariate of the study is students' scores of SPST. The dependents variables are post-

CMQ, post-CRECT, and CREAT; the independents variables are the treatments and gender in main analysis. The independent variables are categorical and they were transformed to dummy variables. The k_A value is 1, the k_B is 2, and k_C is 2 (1x2). To find the L value the table given in Cohen' book on page 651 was used and L is found to be 9.64. According to Cohen et al. (2003), f^2 (the effect size) is proposed to be .15 for medium effect size. Since the effect size is considered to be medium for this study, the value of f^2 is used as .15. When all values are inserted into equation given, the minimum size of the sample is found to be 69.26. The inferential statistics used in this study was carried out with 175 subjects, that is, the effect size is determined as equal as or larger than medium effect size with power higher than .80 value.

3.10 Unit of Analysis

The unit of analysis is the major thing that we are trying to analyze in our study.The unit of analysis may be individuals, groups or any other things. In experimental studies, the independence of observation is satisfied when the unit of analysis is the same with experimental unit. In this particular study, the unit of analysis is student individually; experimental unit is intact classes, thus independence of observation was not met. Fortunately, it can be assumed that teachers avoided interactions of students in data collection process.

3.11 Assumptions

The study assumes the followings;

- Experimental group students were not interacted with control group students.
- Teachers are not biased about the implementation carried out in classrooms.
- The tests, questionnaires are distributed to the students in equal conditions
- Students respond the items seriously and independently.
- The teachers have equal enthusiasm to implement this novel methodology.
- Different schools do not influence results of the study.
- Different teachers do not affect the results of the study.

3.12 Limitations of the Study

- The results of the study are limited to units of chemical reactions and energy.
- The participants are restricted to 187 eleventh grade science major students, who are small proportion of accessible population.
- The classroom observations are restricted to researchers and only one colleague.
- The independent observation assumption for statistical analysis has the possibility of being improper.
- Students participating in this study may not be representative of the accessible population since all of them are from Anatolian High schools.
- The generalizability is restricted to Anatolian High schools.
- The multiple choice test items may also be a limitation because of its nature.
- The motivation questionnaire was broad, it could be limited to chemical reactions and energy concepts
- The implementation took only 6 weeks, majority of international studies focus on a course designed by CBA throughout a course.
- The misconceptions covered in the study could be obtained from the sample before study, and a diagnostic test could be used to reveal the misconceptions of that sample.

CHAPTER 4

RESULTS

The results of the study are categorized into five sections. Firstly, the missing data analysis was described. Secondly, statistical analysis based on pre and post tests were reported, and then inferential statistics regarding the hypothesis were carried out. Subsequently students' responses to open-ended chemical literacy items were given. Finally, the results of classroom observation checklist were reported.

4.1 Missing Data Analysis

Subjects who were not present in pre-tests/post-tests or students' background information of grades and gender are called as missing. The table 4.1 briefly summarizes the missing values for pre-test scores, post-test scores and other variables.

Table 4. 1 Missing values based on variables

Variable	Present (N)	Missing (N)	Missing (%)
Pre-CRECT	175	11	5.9
Pre-CMQ	175	11	5.9
SPST	170	13	7.1
Post-CMQ	175	12	6.4
CREAT	175	12	6.4
GPA	187	12	6.4
Gender	187	0	0

N: Number of participants

The pre-test and post-test scores indicated that 187 students took the instruments however; they all could not constitute the sample size of the study because of missing values. Students who took all the post-tests constituted the participants whose scores were taken for main analysis. 186 students had taken the all pre-tests, 11 students were missing for pre-tests thus their scores were replaced by the mean of the sample. Although, the overall number of participants of study was 187, 12 students did not take the post-CMQ and CREAT, having a percentage of higher than 5, these participants was excluded from the data set instead of replacing their scores with mean. Before removing these participants' scores from data set, a dummy variable was constructed to control if there was a pattern in missing values of post-CMQ and CREAT scores. Participants with missing values were coded as 1 and the rest as 0, having no evidence to claim a statistically significant difference between missing and present participants, dummy variable was not needed to use for further analysis.

All of the participants taking the post-tests were retained in data set thus the total number of participants included in inferential statistics was emerged as 175. Students who do not have pre-test scores retained and the missing values were replaced with series means.

4.2 Statistical Analysis of Pre-test Scores

Before the treatment, independent sample t-tests were used to determine if a statistically significant mean difference exist between experimental and control groups with respects to their; conceptual understanding scores through Chemical Reactions and Energy Concepts (CRECT), Test, Science Process Skills Test (SPST) scores and Chemistry Motivation Questionnaire (CMQ) scores. Then, a MANOVA statistics was conducted for six factors of motivation questionnaire. Statistical analyses were conducted at .05 significance level with SPSS 18 program. The descriptive statistics based on pre-tests and post-tests scores were reported as well.

4.2.1 Statistical Analysis of Pre-CRECT, SPST, and Pre-CMQ Scores

The descriptive statistics for the Pre-CRECT, SPST, and Pre-CMQ scores are given for both experimental and control groups. Table 4.2 summarizes these descriptions.

Table 4. 2 Descriptive statistics for Pre-CRECT, Pre-CMQ, and SPST scores

Test	N		Mean		Std Dev		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG
Pre-CRECT	84	91	11.30	11.45	2.63	2.50	-.199	.228	.005	.515
Pre-CMQ	84	91	100.3	103.9	12.88	14.8	.171	-.091	.141	-.208
SPST	84	91	18.33	22.41	6.56	7.33	-.149	-.674	-.526	-.127

EG: Experimental Group, CG: Control Group

Students' mean scores of pre-CRECT were 11.30 for control groups, 11.45 for experimental groups. A high score of chemical reactions and energy concepts test means having higher prior knowledge based on these concepts. The mean scores of experimental and control groups were close to each other, which means students in both groups have approximately close prior knowledge on chemical reactions and energy concepts.

Students' mean scores of pre-CMQ is slightly different for experimental and control groups; control group students have a mean score of 100.3 where as experimental groups have 103.9. The difference means that students in experimental groups have higher motivation to learn chemistry than the students in control groups before the treatment.

Experimental and control groups students' mean scores of SPST is 22.41 and 18.33 respectively. This numbers imply that students in experimental groups have higher abilities in solving problems related to science process than students in control groups before the treatments.

The differences between experimental and control groups' means on pre-CRECT, pre-CMQ, and SPST required to compare group means by t-test if there was a statistical significant mean difference across the groups. Before this computation, the assumptions of t-test; normality, independence of observations along with the equality of variances have been checked. The distribution was normal, the skewness and kurtosis were in the range of -2 and +2 that means the assumption of normality was not violated. The teachers were informed to make their students to answer the tests independently, thus it was assumed the assumption of independence of observation has been met. The table 4.3 indicates the population variances of experimental and control groups for pre-CRECT, pre-CMQ and SPST as equal.

Table 4. 3 Levene's test of equality of variances

	F	*p*
Pre-CRECT	.453	.502
Pre-CMQ	2.023	.157
SPST	.296	.587

After checking the assumptions, the output of independent samples t-tests were examined to control if experimental and control groups have statistically significant different means of pre-CRECT, pre-CMQ, and SPST. Table 4.4 indicates the t-test results.

Table 4. 4 Independent-samples t-tests for pre-CRECT, pre-CMQ, and SPST

	t	*df*	*P*
Pre-CRECT	-.382	173	.702
Pre-CMQ	-1.704	173	.090
SPST	-3.371	173	.000

As seen from table 4.4, the mean difference of experimental group (EG) (M= 11.45, SD= 2.50) and control groups (CG) (M= 11.30, SD= 2.63) was not statistically significant with respect to pre-CRECT scores, $t(173) = -.382$, $p > 0.05$. Additionally, when the results of pre-CMQ have been examined from table 4.4, it obvious to conclude there was no significant mean difference across the EG (M= 103.9, SD=

14.8) and CG (M= 100.3, SD= 12.88) with respect to students' motivation to learn chemistry prior to treatment which is addressed by pre-CMQ t (173) = -1.704, p > 0.05. Unlike the pre-CRECT and pre-CMQ scores, EG (M= 22.41, SD= 7.33) and CG (M= 18.33, SD= 6.56) have a statistically significant mean difference with respect to SPST scores; students of EG had better scores than CG t (173) = -3.371, p < 0.05. Such a pre-existing difference in SPST scores, requires it to be controlled for statistical analysis of post-CRECT, CREAT, and post-CMQ scores, thus it was assigned as a covariate.

4.2.2 Statistical Analysis of Pre-CMQ Scores Based on its Factors

As mentioned in method section, CMQ has six factors: intrinsic motivation to learn chemistry (Int), extrinsically motivated chemistry learning (Ext), relevance of learning chemistry to personal goals (Rel), responsibility or self-determination for learning chemistry (Sdet), confidence or self-efficacy (Seff) in learning chemistry, and anxiety about chemistry assessment (Anx). Before the treatment, in order to explore whether a significant mean difference between EG and CG exist in terms of collective dependent variable of motivation, multivariate analysis of variance (MANOVA) was computed. Table 4.5 shows the descriptive statistics for each of these dependent variables for both EG and CGs.

Table 4. 5 Descriptive statistics of Int, Ext, Rel, Sdet, Seff, and Anx for groups

	N		Mean		Std. Dev		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG
Int	84	91	17.13	17.94	3.40	3.19	-.367	-.394	-.179	-.384
Ext	84	91	18.97	19.59	2.79	3.12	-.209	-.707	.887	.277
Rel	84	91	15.13	16.57	3.48	3.46	.397	-.307	.544	.101
Sdet	84	91	17.86	18.61	2.89	2.94	-.566	-.094	.647	-.391
Seff	84	91	17.15	17.15	3.17	3.68	-.040	-.176	-.456	.100
Anx	84	91	14.09	14.05	3.34	4.42	-.008	.182	.560	-.363

Before the interpretation of MANOVA output of collective dependent variable of motivation, the sample size, normality and outliers, linearity, multicollinearity-singularity, and homogeneity of variance-covariance matrices assumptions were checked.

4.2.2.1 Assumptions of MANOVA

According to Pallant (2007), number of cases should be more than the dependent variables for each cell, thus the *sample size* of the study was large enough to met sample size assumption of MANOVA.

To check the *normality and outliers* assumptions, the values of skewness and kurtosis examined for dependent variables. These values are given in table 4.5. As seen from the table 4.5 the skewness and kurtosis values were in the range of -2 and +2 for both experimental and control groups which means that normality assumption was met.

To check the multivariate outliers, the Mahalanobis value was controlled from Mahalanobis distance output. Tabachnick and Fidell describes Mahalanobis distance as “the distance of a particular case from the centroid of the remaining cases” (1996, p.67). A Chi-square table is provided in Pallant (2007) for comparison of critical values based on the number of dependent variables. For six dependent variables the critical value is given as 22.46 from the table provided in Pallant (2007). The value for this study was found 19.79, which means no multivariate outliers exist in the data so the outliers’ assumption is not violated.

The *linearity* assumption controls the existence of a straight-line relationship among the each pair of dependent variables (Pallant, 2007, p.223). The scatter-plots between pairs of dependent variables indicated linearity which means the linearity assumption was satisfied.

The *multicollinearity and singularity* is related with the correlations between dependent variables. According to Pallant (2007), MANOVA function best if dependent variables are correlated moderately. A high correlation (.8 or .9) among dependent variables means multicollinearity while a low correlation implies singularity. To control these, correlations between Int, Ext, Rel, Sdet, Seff, and Anx were checked. Based on the correlations among the dependent variables, the table 4.6 was formed and as seen from the table, the assumption was met.

Table 4. 6 Correlations between dependent variables

	Int	Ext	Rel	Sdet	Seff	Anx
Int	---					
Ext	.411	---				
Rel	.673	.566	---			
Sdet	.617	.493	.516	---		
Seff	.595	.291	.456	.433	---	
Anx	.281	-.229	.067	-.210	.487	---

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

The next assumption of MANOVA was homogeneity of variance/covariance matrices and checked through Box’s M Test of Equality of Covariance Matrices and the Levene’s Test of Equality of Error Variances. Based on the Box’s test results table, the covariance matrices of the dependent variables were equal for EG and CGs $F(21, 108589) = 2.163$, $p = .002$. According to Tabachnick and Fidell (1996), if sig. value is larger than .001, then the assumption is not violated.

Table 4. 7 Box's test of equality of covariance matrices

Box's Test of Equality of Covariance Matrices	
Box’s M	47.160
F	2.163
df1	21
df2	108589
Sig.	.002

Homogeneity of variance was checked from Levene's test table; the results are indicated in table 4.8. According to results, each dependent variable of motivation questionnaire except for Anx has equal variances for EG and CGs. Having normal skewness and kurtosis values along with a not large F value implies that the assumption was not violated.

Table 4. 8 Levene's test of equality of error variances

	F	df1	df2	*p*
Int	.312	1	173	.577
Ext	2.875	1	173	.092
Rel	.150	1	173	.699
Sdet	.606	1	173	.437
Seff	1.122	1	173	.291
Anx	4.258	1	173	.041

Subsequently, the assumptions have been checked, MANOVA analysis was computed.

4.2.2.2 MANOVA for Pre-CMQ Scores Based on its Factors

Before the treatment, MANOVA was conducted to see if there was a significant mean difference across EG and CG based on scores of Int, Ext, Rel, Sdet, Seff, and Anx. The results are given in the table 4.9.

Table 4. 9 MANOVA results based on Int, Ext, Rel, Sdet, Seff, and Anx

Source	Wilk's Lambda	F	Sig. (p)
Treatment	.942	1.71	.121

The MANOVA output indicated that EG and CG have not statistical significant mean difference based on the collective motivation dependent variables of Int, Ext, Rel, Sdet, Seff, and Anx, F (6, 168) = 1.71, p = .121; Wilks' Lambda = .942. Such numbers implied that students in experimental and control groups had not significant difference with respect to chemistry motivation before the treatment.

4.3 Statistical Analysis of Post-test Scores

The hypotheses stated previously were tested using Multivariate Analysis of Covariance (MANCOVA) with post-CRECT, CREAT, and post-CMQ scores. MANCOVA was used because experimental and control groups have significant means difference with respect to SPST scores at the beginning of the study. In this analysis, post-CRECT, CREAT, and post-CMQ were dependent variables, SPST was covariate and treatment and gender were independent variables. The analyses were conducted at .05 significance level through PAWS Statistics 18.

The descriptive statistics of post-test scores are given for both experimental/control groups and males/females. Number of participants was; 84 from control groups, 91 students from experimental groups for post-tests. Table 4.10 gives these statistics for EG/CG, table 4.11 summarizes these statistics for males/females.

Table 4. 10 Descriptive statistics for Post-CRECT, CREAT, and Post-CMQ across the groups

	Mean		Std. Dev.		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG
Post-CRECT	11.92	13.22	2.35	2.38	.222	.435	-.247	.781
CREAT	14.88	18.34	3.80	2.94	-.583	-.295	1.125	.040
Post-CMQ	101.14	106.90	14.49	13.50	.033	.000	1.180	-.911

As seen from the table 4.10, EG's mean scores on post-CRECT, CREAT and post-CMQ were higher than the CGs. Whether these differences were significant or not were analysed later. The skewness and kurtosis values were in the range of -2 and +2 verifying the normal distribution. The descriptive statistics of dependent variables of post-CRECT, CREAT, and post-CMQ were given across gender in the table 4.11.

Table 4. 11 Descriptive statistics of Post-CRECT, CREAT, Post-CMQ for gender

	Mean		Std. Dev.		Skewness		Kurtosis	
	Male	Female	Male	Female	Male	Female	Male	Female
Post-CRECT	12.19	12.95	2.39	2.45	-.028	.576	.045	.285
CREAT	16.20	17.10	3.42	4.05	-.830	-.635	1.768	.670
Post-CMQ	103.2	104.92	15.53	13.05	-.223	.336	.441	-.586

Totally 175 participants took the post-tests, of which 81 were male and 94 were female. The mean scores of females on post-CRECT, CREAT and post-CMQ were slightly higher than males. Whether a statistical significant mean difference across males and females exists or not would be analyzed in the main analysis. The skewness and kurtosis values were also in between -2 and +2 which supports the normal distribution.

4.3.1 Assumptions of Multivariate Analysis of Covariance

Before computing the Multivariate Analysis of Covariance (MANCOVA), the assumptions of it were checked. First, the *sample size* should be large enough to conduct a MANCOVA. As mentioned previously and based on Pallant (2007) description, number of cases should be greater than dependent variables for each cell. Since the study satisfied this condition, this assumption was met.

Secondly, the *normality and outliers* assumption was controlled. The skewness and kurtosis values of all dependent variables were examined for the assumption of univariate normality. All values were in the range of -2 and +2 for EG and CG so we could conclude that the assumption was satisfied.

Whether there were some outliers in the data set or not, the Mahalanobis value was investigated for testing the multivariate outliers. The value was checked against the t-critical value given in Pallant (2007) for three dependent variables. This critical value for three dependent variables was given as 16.27 in the table, in this study the value was 16.62. Since the value was larger than the critical value, it was required to determine multivariate outliers. The related procedure was carried out as described by Pallant (2007) and extreme values were identified. Only one case was slightly higher than the critical value, so as suggested by Pallant (2007), the case was retained in the data set, and it assumed the assumption has met.

The *linearity* assumption requires a direct relationship among each pairs of dependent variables. According to Pallant (2007) drawing a scatter-plot matrix between each set of dependent variables make is possible to control this assumption. Having linearity in scatter-plots, it was concluded that the assumption of linearity was satisfied.

The next assumption of MANCOVA was *multicollinearity and singularity*. This assumption requires a moderate correlation between dependent variables. Based on Pallant (2007) description, in the case of a high correlation, the situation is called as multicollinearity, in low correlation situation, it is called as singularity. The values around .8 and .9 implies for multicollinearity. The table 4.12 indicated the correlations among dependent variables.

Table 4. 12 The correlations of dependent variables

	Post-CRECT	Post-CMQ	CREAT
Post-CRECT	---		
Post-CMQ	.361	---	
CREAT	.360	.200	---

Table 4.12 indicated that there were moderate correlations among the dependent variables to conclude that the assumption of multicollinearity and singularity was verified.

The assumption of *homogeneity of variances and covariance* matrices was also controlled from the Box's test output. Based on the Box's text results, it was concluded that the covariance matrices of dependent variables were not different across the groups F (18, 94904.78) = 1.136, p = .308. The numbers given in the table 4.13 mean that the assumption of variance/covariance matrices was verified.

Table 4. 13 Box's test of equality of covariance matrices

Box's Test of Equality of Covariance Matrices	
Box's M	21.125
F	1.136
df1	18
df2	94904.78
Sig.	.308

The *homogeneity of variance* was also checked to control if the groups have same variance or not. The Levene's test of equality of variances output (table 4.14) was examined. Based on the numbers given in that table 4.14, it can be concluded that dependent variables has equal variance for groups.

Table 4. 14 Levene's test of equality of error variances

	F	df1	df2	*p*
Post-CRECT	.174	3	171	.914
Post-CMQ	.160	3	171	.923
CREAT	2.917	3	171	.036

According to the results of Levene's test table, each dependent variable of except for CREAT has equal variances. Having normal skewness and kurtosis values along with a not large F value implies that the assumption was not violated.

The next assumption was *homogeneity of regression slopes* for MANCOVA and follow up ANCOVAs. According to Pallant (2007), in this assumption we were checking if there was interaction between the covariate and the treatment. A syntax based on the descriptions given in Tabachnick and Fidell (2007, pp.281-284) was written in SPSS. The figure 4.1 indicates the written syntax.

```
MANOVA SPST,PostCMQ, PostCRECT,CREAT by Treat,Gender(0,1)
/PRINT=SIGNIF(BRIEF)
/ANALYSIS=PostCMQ, PostCRECT,CREAT
/DESIGN=SPST,Treat,Gender,Treat by Gender,SPST by Treat by Gender
/ANALYSIS=PostCMQ
/DESIGN=SPST,Treat,Gender,Treat by Gender,SPST by Treat by Gender
/ANALYSIS=PostCRECT
/DESIGN=SPST,Treat,Gender,Treat by Gender,SPST by Treat by Gender
/ANALYSIS=CREAT
/DESIGN=SPST, Gender,Treat by Gender,SPST by Treat by Gender.
```

Figure 4. 1 SPSS syntax to check homogeneity of regression for MANCOVA

Based on the statements given in Tabachnick and Fidell (2007, p. 281), the alpha level was set to .01. The output obtained from running the syntax indicated that the assumption of regression slopes was satisfied to compute MANCOVA and the follow-up ANCOVAs. The related values for performing the analysis, the F (3,167) = 1. 806, p = .148, Wilks' Lambda = .968, and to perform the follow-up ANCOVAs F (1,56.57) = .31, p = .578, F (1,56.57) = 3.73, p = .055, and F (1,56.57) = 1.01, p = .480, respectively for post-CMQ, post-CRECT, and CREAT.

Additionally, a *linear relationship between dependent variables and covariates* required for MANCOVA analysis that is correlation of these variables is needed to be significant to verify the assumption. The correlation of; post-CMQ with SPST (p = .000), post-CRECT with SPST (p = .780), and CREAT and SPST (p = .000) were all significant. That means this assumption was also met.

Furthermore, the covariate must be a reliable instrument, Pallant (2007) states that the Cronbach alpha should be at least .70 for a covariate. As mentioned before, the reliability of SPST scores were .88 which is a good value for a covariate. MANCOVA was computed to test the related hypotheses given in the first chapter.

4.3.2 Multivariate Analysis of Covariance

Providing the assumptions of Multivariate Analysis of Covariance, the outputs obtained from MANCOVA were discussed.

Table 4. 15 MANCOVA results regarding the collective dependent variables.

Source	Wilks' Lambda	Multivariate F	Hypothesis df	Error df	Sig. (p)	Eta-Squared	Observed Power
Treatment	.770	16.731	3	168	.000	.230	1.000
Gender	.969	1.793	3	168	.151	.031	.461
SPST	.879	7.681	3	168	.000	.121	.987
Treatment* Gender	.991	.495	3	168	.686	.009	.149

Based on the results given in the table 4.15, it clear to conclude that the experimental and control groups had significant mean difference with respect to their understanding of chemical reactions and energy topic when their SPST scores were controlled ($F (3, 168) = 16.731$, Wilks' Lambda = .770, $p < 0.05$)). This difference between groups was obtained from the effect of treatment, and it is possible to state that the effect size was large since the value of eta-squared is found to be .230. An eta-squared value larger than .14 is said to large. That means, 23 % of the variance of dependent variables was aroused from independent variables.

In addition to effect size, the observed power (1.00) of the study indicated that the source of difference across the experimental and control groups was related to effect of treatment. Furthermore, such a value indicated that the effect of the treatment had practical importance too. Since the contexts chosen for the study were generally technological issues, it was quite necessary to investigate the effect of the treatment across the gender. The results revealed that there was no significant mean difference between males and females with respect to collective dependent variables of the study when their science process skills test scores were controlled ($F (3, 168) = 1.793$, Wilk's Lambda = . 969, $p > 0.05$). The difference among the males and females was calculated as .031 from the eta-squared value. The value means 3.1 % of multivariate variance on collective dependent variables was associated with gender. Table 4.15 showed the interaction values related to gender and treatment, based on these values, it was clear to state that no interaction existed between treatment and gender (F (3, 168) = .495 Wilk's Lambda = .991, $p > 0.05$).

Students' science process skills scores was a significant contributor of their collective dependent variables on chemical reactions and energy concepts; the related values are (F (3, 168) = 7.681 Wilk's Lambda = .879, $p < 0.05$). To differentiate the effect of treatment and gender separately on each dependent variable, the multiple univariate ANCOVAs were performed. The univariate or follow up ANCOVA results are given in the table 4.16.

Table 4. 16 Univariate ANCOVA results based on each dependent variable.

	Dependent Variable	df1	F	Sig. (p)	Eta Squared	Power
Treatment	Post-CMQ	1	2.710	.102	.016	.373
	Post-CRECT	1	13.269	.000	.072	.952
	CREAT	1	31.584	.000	.157	1.000
Gender	Post-CMQ	1	.126	.723	.001	.064
	Post-CRECT	1	3.811	.053	.022	.493
	CREAT	1	1.069	.303	.006	.177
Treatment* Gender	Post-CMQ	1	.843	.360	.005	.150
	Post-CRECT	1	.065	.799	.000	.057
	CREAT	1	.466	.496	.003	.104

According to table 4.16, the hypothesiss H_o1, H_o2, H_o3, H_o4, H_o5, H_o6 and H_o7 were answered. H_o1 was stating no significant population mean difference between the groups exposed to context-based approach through learning cycle and traditionally designed chemistry instruction on eleventh grade science major students' understanding of chemical reactions and energy concepts when students' science process skills test scores were controlled. The results related to post-CRECT given in table 4.16 indicated that a statistically significant mean difference across EG and CG exists, and this difference was in favor of EG when SPST was controlled (F =13.296 p = .000). That result is indication of rejecting the null hypothesis. The power of the results indicated the treatment had also practical significance.

The hypothesis of number two (H_o2) was about no significant population mean difference between the groups exposed to context-based approach through learning cycle and traditionally designed chemistry instruction on eleventh grade science major students' achievement of chemical reactions and energy concepts when students' science process skills test scores were controlled. The values given in table 4.16 indicated that null hypothesis is rejected since EG and CG's mean differences on CREAT were statistically significant (F = 31.584, p = .000) in favor of EG when SPST was controlled. The power of the results indicated the treatment had also practical significance.

The third hypothesis (H_o3) were stating no significant population mean difference between the groups exposed to CBA through 5E LC and traditionally designed chemistry instruction on eleventh grade science major students' collective chemistry motivation when students' science process skills test score was controlled. Based on the related values of post-CMQ in table 4.16, we could not reject the null hypothesis, that means EG and CG students did not have statistically significant mean differences (F = 2.710, p = .102) when their SPST scores were controlled.

The fourth hypothesis (H_o4) were claiming no significant mean difference between males and females with respect to students' understanding of chemical reactions and energy concepts when students' science process skills test score is controlled. According to table 4.16, we failed to reject the null hypothesis, which means males and females mean scores on post-CRECT were not statistically significantly different (F = 3.811, p =.053) when their SPST scores were controlled. Such result implied that the contexts that followed in lessons did not differently affected males and females.

The next hypothesis (H_o5) was stating; there is no significant mean difference between males and females with respect to students' achievement of chemical reactions and energy concepts when students' science process skills test scores were controlled. The values given in table 4.16 about CREAT revealed that there was no statistical significant mean difference between males and females with respect to their achievement on chemical reactions and energy concepts when their SPST scores are controlled ($F = 1.069$, $p = .303$). The results means that we fail to reject the null hypothesis by stating males and females mean achievement mean scores are not statistically different.

The six hypothesis (H_o6) was claiming that there is no significant mean difference between males and females with respect to students' collective chemistry motivation when students' science process skills test scores were controlled. When we examined the related values from table 4.16, it obvious to conclude that male and females do not have statistically significant differences on mean scores of post-CMQ ($F=.126$ $p= .723$). That means we failed to reject the null hypothesis. As mentioned previously, results implied that students' collective motivation score are not different across the males and females when SPST scores are controlled.

Subsequently, the seventh hypothesis (H_o7) was also checked based on the MANCOVA results. It was stating no significant effect of interaction between gender and treatment with respect to students' mean scores of collective dependent variables in chemical reactions and energy concepts when science process skills test scores were controlled. The interaction cell of MANCOVA table (table 4.16) showed that gender and treatment did not interacted for post-CRECT, CREAT and post-CMQ, we again failed to reject null hypothesis regarding the interaction effect. The results regarding this hypothesis means that the treatment did not significantly changed for females or males. Such a result is desired for an effective context, since context should not favor females or males.

Students' responses to post-CRECT had been examined for each item separately through SPSS program. The proportions of correct responses had been computed for both experimental and control groups. There were 84 students in control groups and 91 students in experimental groups. The findings indicated that in some questions the proportion of correct responses were almost the same for both groups. For example, the percentage of correct responses to 4th item of post-CRECT was almost the same experimental group (36 %) and control group (37 %). This misconception was related to heat-temperature-thermal equilibrium and it was taken from the literature. Similarly, the item 6 had the same proportion of correct responses for both groups; 46 % for experimental and control groups. This question was related to energy release or absorption associated with bond formation and bond dissociation and again the question had been taken from the literature with small revision. The question number 10 had again close proportion of correct response for both groups, the experimental had 80 %, and the control had 79 %. This item was about the definitions of the terms; system, surroundings and energy transfer regarding these issues and it was taken from the literature. Although the experimental group slightly had higher proportion, the treatment of CBA through 5E LC model was almost effective as the traditional instruction. The item 11 was about the terms absolute temperature, 3rd law of thermodynamics it was written by the researchers. The proportion of correct responses was 58 % for control group and 60 % for experimental groups. The treatment slightly increased students' conceptions regarding these issues in favor of experimental groups.

Students' responses to some items were distinctly higher in favor of experimental groups. After the treatment, for example the second item which was about the terms heat and temperature, was answered in 65 % correctly by experimental groups and 57 % by control groups. This means experimental group students better catch the difference between heat and temperature and they perceived that temperature is not the amount of heat which a substance poses. Another question regarding the heat and temperature were the same thing was assessed by item 5, and it was again taken from the study of Ceylan (2004). The percentage of correct response to this item was 84 % for experimental group, 71 % for control groups. Such numbers indicated that the treatment remedy better students' misconceptions regarding heat and temperature when compared to traditional instruction. There was a striking difference between the proportions of correct responses of two groups on the item regarding the endothermic and exothermic properties of bond formation and bond dissociation (item 7). Experimental group responded the item correctly in a 75 %, control group has percentage of 49 %. The item 12 was about spontaneity of phase changes and spontaneity and exceptions to minimum energy trend in changes at specific temperatures and experimental group percentage of correct response was 74 % and the percentage of control group was 55 %. The treatment of CBA through 5E learning cycle favored experimental groups especially on items 16, item 17 and item 18. The percentage for item 16 was 64 % for experimental group, 35 % for control group students. This item was about oxidation reactions. The treatment remedies misconception about the oxidation reactions in experimental groups better than improvement in control groups. The item 17 which was again related to endothermic and exothermic properties of bond formation and bond dissociation, experimental group responded the item 68 % correctly; control groups answered the item 45 % correctly. The item 18 was about the relation of size and temperature; experimental group had 43 % correctly, whereas control group had answered correctly in 29 %. The item 19 was about the term Gibbs free energy, students generally think that the ΔG^o, ΔG_f, ΔG, ΔG^o_f, G^o are all the same things. Experimental group had percentage of correct response slightly higher than control groups; 71 % and 68 % respectively. Although the difference is not sharp, the treatment of CBA through 5E learning cycle remedies students' misconception about donation of Gibbs free energy. Finally, students' percentages of correct responses on item 20 were obviously different for both experimental and control groups; they are 81 % and 69 % respectively. This item was related to misconception regarding the term "disorder" and entropy of the substance. The treatment of CBA through 5E LC again favored experimental group more than the improvement effect of traditional instruction which control groups were exposed. Students in control groups had perception of entropy as synonymous of the terms "disorder" more than the experimental groups.

4.3.3 Statistical Analysis of the Post-CMQ Based on its Factors

As mentioned previously, Chemistry Motivation Questionnaire (CMQ) had six factors: Intrinsic motivation to learn chemistry (Int), Extrinsically motivated chemistry learning (Ext), Relevance of learning chemistry to personal goals (Rel), Responsibility or Self-determination for learning chemistry (Sdet), Confidence or Self-efficacy in learning chemistry (Seff), and Anxiety about chemistry assessment (Anx).

Each factor of CMQ was taken as a dependent variable (Int, Ext, Rel, Sdet, Seff and Anx), treatment and gender were taken as independent variables to test the null hypothesis of number 8 and hypothesis 9. After the treatment, a two way MANOVA was computed to test these hypotheses. Table 4.17 shows the descriptive statistics regarding Int, Ext, Rel, Sdet, Seff and Anx across the treatment groups.

Table 4. 17 Descriptive statistics of Int, Ext, Rel, Sdet, Seff, Anx for groups

	N		Mean		Std. Dev		Skewness		Kurtosis	
	CG	EG	CG	EG	CG	EG	CG	EG	CG	EG
Int	84	91	17.38	18.87	3.88	3.10	-.300	-.221	.431	-.503
Ext	84	91	19.12	19.60	3.51	3.07	-.877	-.347	2.163	-.588
Rel	84	91	15.86	18.01	3.84	3.60	.094	-.433	.000	-.181
Sdet	84	91	17.87	18.62	3.64	2.86	-.883	-.191	1.297	.018
Seff	84	91	17.37	17.67	3.80	3.77	-.038	-.302	.637	.129
Anx	84	91	13.54	14.13	3.74	4.24	.149	-.049	.209	-.165

Table 4.17 indicated that experimental group students had higher mean score of Int, Ext, Rel, Sdet, Seff, and Anx. The skewness and kurtosis values are almost in the range of -2 and +2, which supported the normal distribution. Whether these differences of dependent variables across groups were significant or not had been

investigated by MANOVA. Table 4.18 described the statistics of Int, Ext, Rel, Sdet, Seff, and Anx for males and females.

Table 4. 18 Descriptive statistics of Int, Ext, Rel, Sdet, Seff, Anx for gender

	N		Mean		Std. Dev		Skewness		Kurtosis	
	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Int	81	94	17.99	18.30	3.70	3.45	-.426	-.381	.646	.017
Ext	81	94	18.83	19.83	3.48	3.07	-.944	-.277	1.981	-.435
Rel	81	94	16.78	17.15	3.98	3.77	-.378	.015	-.220	-.522
Sdet	81	94	17.23	19.14	3.86	2.35	-.475	.087	.382	-.346
Seff	81	94	18.85	17.25	4.25	3.31	-.389	.055	.316	.091
Anx	81	94	14.54	13.24	4.21	3.74	-.087	.103	-.322	.454

As seen from the table 4.18, the mean score of females for Int, Ext, Rel, and Sdet were higher than the males, whereas males mean scores of Seff and Anx were higher than the females. The skewness and kurtosis values were in the range of -2 and +2.

Before the interpretation of MANOVA output of collective dependent variables of motivation, the sample size, normality and outliers, linearity, multicollinearity and singularity, and homogeneity of variance/covariance matrices assumptions were checked.

4.3.3.1 Assumptions of MANOVA

As stated previously, Pallant (2007) proposes that number of cases should be more than the dependent variables for each cell, thus the *sample size* of the study was large enough to met sample size assumption of MANOVA.

To check the *normality and outliers* assumptions, the values of skewness and kurtosis examined for all dependent variables. These values are given in table 4.17 and 4.18. As seen from the both tables the skewness and kurtosis values are in the range of -2 and +2 for both experimental and control groups and males and females which mean that normality assumption is met.

To check the *multivariate outliers*, the Mahalanobis value was controlled from Mahalanobis distance output. Tabachnick and Fidell describes Mahalanobis distance as “the distance of a particular case from the centroid of the remaining cases” (1996, p.67). A Chi-square table is provided in Pallant (2007) for comparison of critical values based on the number of dependent variables. For six dependent variables the critical value is given as 22.46 from the table provided in Pallant (2007). The value of maximum distance for this study was found 33.07, which meant multivariate outliers existed in the data so the outliers were investigated from extreme value table. Based on the extreme value table, only one case had the value of 33.07 and two cases had value of 23.06. Then, these extreme cases were dropped from the data set and new Mahalanobis distance value was found as 22.33 therefore we could conclude that the assumption of outliers was met.

The *linearity* assumption controls the existence of a straight-line relationship among the each pair of dependent variables (Pallant, 2007, p.223). The scatter-plots between pairs of dependent variables indicated linearity which means the linearity assumption for six dependent variables was satisfied.

As followed for pre-test analysis of factors of motivation, the *multicollinearity and singularity* was again checked. This assumption is related with the correlations between dependent variables. According to Pallant (2007), MANOVA function best if dependent variables are correlated moderately. A high correlation (.8 or .9) among dependent variables means multicollinearity while a low correlation implies singularity. To control these, correlations between Int, Ext, Rel, Sdet, Seff, and Anx are checked. Based on the correlations among the dependent variables, the table 4.19 was formed and as seen from the table, the assumption was met.

Table 4. 19 Correlations between dependent variables

	Int	Ext	Rel	Sdet	Seff	Anx
Int	---					
Ext	.404**	---				
Rel	.607**	.570**	---			
Sdet	.569**	.462**	.391**	---		
Seff	.545**	.342**	.339**	.491**	---	
Anx	.221**	-.299**	-.037	.017	.389**	---

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

The next assumption of MANOVA was *homogeneity of variance/covariance* matrices and checked through Box's M Test of Equality of Covariance Matrices and the Levene's Test of Equality of Error Variances. Based on the Box's test results, table 4.20 was formed, the covariance matrices of the dependent variables were equal for EG and CGs F (63, 60572.68) = 1.127, p = .229. According to Tabachnick and Fidell (1996), if sig. value is larger than .001, then the assumption was not violated.

Table 4. 20 Box's Test of Equality of Covariance Matrices

Box's Test of Equality of Covariance Matrices	
Box's M	75.928
F	1.127
df1	63
df2	60572.68
Sig.	.229

Homogeneity of variance was checked from Levene's test table; the results are indicated in table 4.21. According to results, each dependent variable of motivation questionnaire except for Sdet has equal variances for EG and CGs. Having normal skewness and kurtosis values along with a not large F value implies that the assumption was not violated.

Table 4. 21 Levene's test of equality of error variances

	F	df1	df2	*p*
Int	.529	3	168	.663
Ext	.333	3	168	.801
Rel	.268	3	168	.848
Sdet	3.785	3	168	.012
Seff	1.287	3	168	.281
Anx	1.124	3	168	.341

After verifying the assumptions of MANOVA, the analysis have been conducted to see the differences if exist.

4.3.3.2 MANOVA of Post-CMQ Scores Based on its Factors

After the treatment, MANOVA was conducted to see if there was a significant mean difference across experimental/control groups and males/females based on scores of Int, Ext, Rel, Sdet, Seff, and Anx. The results are given in the table 4.22.

Table 4. 22 MANOVA results based on Int, Ext, Rel, Sdet, Seff, and Anx

Source	Wilk's Lambda	F	Sig. (p)
Treatment	.900	3.023	.008
Gender	.855	4.617	.000

According to MANOVA output H_o8 and H_o9 were answered. The results given in table 4.22 indicated that EG and CG have statistical significant mean difference based on the collective motivation dependent variables of Int, Ext, Rel, Sdet, Seff, and Anx, $F(3, 168) = 3.023$, $p = .008$; Wilks' Lambda = .900. Such numbers implied that students in experimental and control groups had significant difference with respect to factors of chemistry motivation questionnaire after the treatment. The hypothesis 8 (H_o8) which were stating no significant mean difference between the groups exposed to context-based approach through 5E learning cycle model and traditional designed chemistry instruction with respect to students' motivational factors scores was clarified based on the table 4. 22. We rejected null hypothesis because there was statistical significant mean difference between experimental and control groups with respect to factors of motivation. Additionally, table 4.22 clarified the null hypothesis 9 (H_o9) which was about no significant mean difference between males and females with respect to students' motivational factor. We rejected null hypothesis because there was statistical significant mean difference between males and females with respect to factors of motivation $F (3, 168) = 4.617$, $p = .000$; Wilks' Lambda = .855.

To reveal which dependent variable of motivation had significant difference, fallow up ANOVAs were performed. Table 4.23 shows the details regarding each dependent variable.

Table 4. 23 Fallow-up ANOVAs for pairwise comparisons

	Dependent Variable	df1	F	Sig. (p)	Eta Squared	Power
Treatment	Int	1	6.193	.014	.036	.696
	Ext	1	.323	.570	.002	.087
	Rel	1	12.114	.001	.067	.933
	Sdet	1	.638	.426	.004	.125
	Seff	1	.454	.501	.003	.103
	Anx	1	2.481	.117	.015	.347
Gender	Int	1	.001	.972	.000	.050
	Ext	1	3.140	.078	.018	.422
	Rel	1	.004	.951	.000	.050
	Sdet	1	12.488	.001	.069	.940
	Seff	1	1.149	.285	.007	.187
	Anx	1	3.496	.063	.020	.460
Treatment* Gender	Int	1	1.413	.236	.008	.219
	Ext	1	.613	.435	.004	.122
	Rel	1	.121	.729	.001	.064
	Sdet	1	2.520	.114	.015	.352
	Seff	1	.008	.928	.000	.051
	Anx	1	1.272	.261	.008	.202

The results of fallow-up ANOVAs revealed that the treatment had effect on Intrinsic motivation to learn chemistry (Int) on chemical reactions and energy unit F= 6.193, p= .014. When we checked the mean scores of experimental and control groups, they are 18.87, 17.38 respectively. The experimental group students' intrinsic motivation to learn chemistry had positively affected. Additionally, the findings also indicated that Relevance of learning chemistry to personal goals (Rel) had also changed across the groups F= 12.114, p= .001. Comparing the mean scores of experimental (18.01) and control groups (15.86) from table 4.17, it can be concluded that students is experimental groups found learning chemistry relevant to their personal goals. The other dependent variables of Extrinsically motivated chemistry learning (Ext), Responsibility or Self-determination for learning chemistry (Sdet), Confidence or Self-efficacy in learning chemistry (Seff), and Anxiety about chemistry assessment (Anx) had not statistically different across the experimental and control groups even experimental group has slightly higher mean scores on these variables.

When males and females mean scores regarding the Int, Ext, Rel, Sdet, Seff, and Anx had examined at significance level, it was obvious to conclude that only Responsibility or Self-determination for learning chemistry (Sdet) had differed across the gender. The mean of males was 17.23, the mean of females was 19.14 (see table 4.18), that result indicated that female student's responsibility or self determination for learning chemistry had positively affected by the treatment F= 12.488, p= .001 with a high power value of .940. The other factor of motivation; Int, Ext, Rel, Seff, and Anx had not changed across the males and females in statistically significant ranges by the effect of treatment.

4.4 Analysis of Students' Responses to Chemical Literacy Items

The items included in this section had been designed based on the sample questions of PISA measuring students' scientific literacy. Students' responses were categorized according to themes of the questions. In each theme, questions were categorized into knowledge-based and interpretive questions and the percentages of students' correct responses were divided into score intervals to avoid overestimate of each response. These percentages are given across experimental and control groups for each of the theme. The first theme was related to Combi Boiler, which almost each student has it in their house in order to heat their house and to have hot water every time. The second one was related chemistry of healthy life, the third one was about order and entropy terms which were tried to be assessed by elastic polymers and their entropies and the last one was about volcanoes and related chemical terms. A rubric was prepared as an answer key to score students responses. Based on the rubric, each student' responses were evaluated and graded thus each student had scores obtained from the themes. The maximum score of each theme was different, and the distribution of total score to each question was not equal. The percentages of correct responses specifically in each interval had been summarized across experimental and control groups in related tables.

The combi boiler theme had 8 questions; of which first three was knowledge based questions (9 points) and the rest were interpretive questions (11 points). The percentages of students' correct responses were given according to their score ranges and comparatively across the experimental and the control groups. Students' scores obtained from their responses were categorized as scores of knowledge based questions and scores of interpretive questions, and they are reported for both experimental and control groups. Table 4.24 briefly summarizes these percentages for first theme which was about combi boiler and maximum scores 20, minimum of 0 of these.

Table 4. 24 The percentages of correct responses to combi boiler

	Combi boiler (20 point)						
	Knowledge score intervals			Interpretation score intervals			
	0-3	4-6	7-9	0-2	3-5	6-8	9-11
Experimental Group	3,70	22,22	74,07	0,00	7,41	22,22	70,37
Control Group	17,39	60,87	21,74	21,74	30,43	30,43	17,39

As from the table 4.24, knowledge-based scores were ranged from 0 to 9 and interpretive questions are ranged from 0 to 11. The scores obtained from knowledge-based questions were divided into three intervals, and interpretive scores are divided into 4 intervals for both experimental and control groups. The percentage of correct response to knowledge-based questions of combi boiler was 74.1 % in 7-9 point intervals for experimental group, whereas, it was 21.7 % for control group. Majority of control group students had taken point in the interval of 4-6 for knowledge based questions. Students interpretive scores changes across the groups sharply; majority of experimental group students took point in the ranges of 9-11, whereas, majority of students in control group took scores in ranges of 3-5 and 6-8.

The first item of combi boiler was related to balancing chemical reaction occurring in combi, experimental and control groups students' responses were not differentiated on this question. The second item in combi boiler theme was asking what type of a system is the combi boiler. Experimental group students generally correctly answered which kind of system was combi boiler, but they generally lacked to state both matter and energy exchange in combi systems. A sample response from experimental group is as follow;

- *Combi boiler is an open system since natural gas is entering to combi*

For example a student in experimental group answered the question related to "what can be the main advantages of CH_4 to be used in combi boiler" as follows;

- *When CH_4 burned in combi boiler, more energy can be released, or since it has only one Carbon atom, it will produces less CO_2, thus is less harmful to natural environment, or additionally it may be cheaper than other kinds of hydrocarbons*

Although, these statements were the ones which covered in the answer key, majority of students in experimental groups could gave generally two possible reasons as advantage of CH_4. Contrarily, responses of students in control group indicated that they generally could propose only one reason as an advantage, for example a student in control group stated that "*having only one C atom, CH_4 is more efficient than other types of hydrocarbons*".

The results of combi boiler theme indicated that whether the questions were knowledge based or interpretive, experimental group students had high points than control group students. Moreover, 65 students in control groups, 76 students in experimental groups responded to this theme; these numbers of students was highest when compared to responses given to other themes. The possible reason for this much involvement may be aroused from being familiar this news from media in recently, and the event had happened in Ankara.

When students responses to the item asking more scientific explanation of reason of dead, had examined it is seen that they could gave the reason of that more scientifically by stating the damages of carbon monoxide (CO) on human health. One of the students from experimental group stated that,

- *Possible there was problem with the combi boiler system in that house, so the products of burning reactions were entering into the house, instead of going out. That means the concentration of oxygen in house was decreasing so both people and burning reaction has affected from. The product of reaction had become carbon monoxide instead of carbon dioxide, which is seriously harmful to other body. Since this gas was leaked in to house, the people had died because it poisoned them.*

Surprisingly, a few students from both experimental and control groups stated that,

- *CO_2 molecule cannot combine with the complex molecule of hemoglobin. When the concentration of gases had changed in the room, CO concentration increased and CO molecule combine with hemoglobin with a coordinated covalent bond thus the nature of blood, its pH will be destroyed to result in dead.*

The next theme of open-ended chemical literacy items in chemical reactions and energy concepts was about the chemistry of the healthy life. 64 experimental group students and 59 control group students responded this theme. As done for the first theme, students' responses were scored according to knowledge-based questions and interpretive questions. The maximum score of this theme was 10, and 4 of this was knowledge-based, and 6 was interpretive. Again the scores are divided in to intervals to elaborate percentages of responses more detail. The knowledge-based questions were requiring students to make simple calculations. Especially the second item of theme was about converting units, combining energy knowledge to physics knowledge which is indication of interdisciplinary point of chemical literacy. The table 4.25 elaborates the percentages of correct responses obtained from second theme.

Table 4. 25 The percentages of correct responses to chemistry of healthy life

	Chemistry of healthy life (10 point)			
	Knowledge score intervals		Interpretation score intervals	
	0-2	3-4	0-3	4-6
Experimental Group	44,4%	55,6%	55,6%	44,4%
Control Group	41.2%	58.8%	82,6%	17,4%

As seen from the table, experimental group students slightly differed on their score intervals on knowledge-based questions. Surprisingly control group students had higher correct response percentage on knowledge-based questions specifically, 3-4 score intervals (58.8). The items in knowledge-based question were requiring simple algorithmic calculations, and converting the units thus regardless of the treatments, groups had close percentages.

When percentages of responses to interpretive questions had been examined, the striking difference among experimental and control groups had emerged. Although, both groups' scores are in 0-3 score interval, experimental group had higher percentage (44.4 %) than control group (17.4 %) in 4-6 score ranges. That means experimental group students had better responded interpretive items regarding the healthy life chemistry.

The third item of chemistry of health life theme was about biological reactions of metabolism occurring in cells. A small information text was provided for students about the coupling reactions occurring in human body. This information says that “the energy produced from oxidation of glucose in human body is used to initiate many reactions as well as converting ADP to ATP”. Then it was reminded to students that in chemistry course they had learned bond formation produces energy and bond dissociation requires energy. In the light of this information, students were expected to write their ideas in an argumentative discourse to decide on classification of the conversion of ADP to ATP and ATP to ADP as endothermic or exothermic reactions and to state whether bonds associate or dissociate in these reactions. Students’ responses indicated that a vast majority of them had dilemmas about whether bonds formation and dissociation requires energy or releases energy. They had misconception about energy release or energy absorption of reaction occurring in metabolism. Although some students in experimental and control groups correctly classified the relationship of energy with ADP and ATP molecules, critical number of students lacked to explain their reasons to make this classification.

One important misconception that many students hold was “when ATP is converted to ADP, bonds are broken and bond breaking releases energy”. Although, some students could successfully classified these conversions as endergonic or exergonic, almost all experimental and control group students failed to explain the concepts correctly. Many students stated that they had dilemmas and could not decide on which one was correct. A student from experimental group responded to the question as follows:

- *ADP + P → ATP + Energy,*
  ATP → ADP: Requires Energy, Endothermic
  ADP → ATP: Energy Releases, Exothermic

A student from experimental group explained the issues as following;

- *Energy + ATP → ADP + P, the free phosphate obtained from this reaction is released to cytoplasm (Breaking of phosphate bonds)*
  ADP + P → ATP + Energy (phosporilization reaction)

Another student from experimental group explained the terms as follows:

- *When ATP is converted to ADP the diphosho ether bond is broken in nucleotides and energy is released. I think we have also learned in chemistry that bond formation requires energy, bond dissociation produces energy.*

Regardless of their groups, vast majority of the students failed to explain correct conceptualization. Below are some more sample explanations from control group students;

- *ADP + P + Energy → ATP , endothermic*
- *ATP → ADP + P +Energy, exothermic*

One student from control group wrote that;

- *Converting ATP to ADP requires more energy because in order to break the bonds in ATP we have to give energy.*

Another stated that;

- *ATP → ADP in this conversion we get one phosphate so this means bond breaking occurs in this reaction, thus energy is released. When ADP → ATP conversion occurs, energy is required for this reaction.*

Although, experimental group students had higher percentage of correct responses in 4-6 interval (44, 4 %) than control group students (17,4 %), both groups lacked to explain the terms correctly. The reason of these high scores was that experimental group could classify more correctly than control groups but failed in their explanations.

Interestingly, when responses were examined, researchers noticed that many of the females explained the concepts according to the information they had that learned in biology lesson, contrarily, males explained concepts based on their knowledge from chemistry course. Furthermore, the students having high total score from all themes had better explained energy relation of bond formation and bond breaking.

The third theme in questions of chemical literacy on chemical reactions and energy concepts was related to the terms order and disorder.

Table 4. 26 The percentages of correct responses to order-disorder

	Ordered-disordered (5 points)			
	Knowledge score intervals		Interpretation score intervals	
	0	1-2	0	1-3
Experimental Group	22,2%	77,8%	33,3%	66,7%
Control Group	24,8%	75,2%	50,9%	40,1%

Totally 104 students responded this theme; 59 were from experimental groups, 45 were from control groups. When compared to other themes, the responses on this were least. There were two questions, one was knowledge based the other was more interpretive. The maximum score of this theme was five, 2 from knowledge question, 3 from interpretive question. The correct answer percentages were again categorized according to intervals.

When students responses to knowledge based question is examined, it is seen that the percentages of correct response were close to each other across the groups. Majority of the students from both groups could know that when we stretch an elastic polymer, the molecules of it become more ordered. Surprisingly, although some students could state molecules become more ordered, they could not relate how entropy will change. Furthermore, results revealed that some students still had misconceptions about entropy-order-disorder terms.

An experimental group student explained how entropy will change as follow;

- *When we stretch it, molecules become more disordered, and that means the entropy of the system will increase.*

Similar explanations were also given from control groups students, one of them stated that

- *Entropy (disorder) will increase since the molecules will become more ordered.*

Correct conceptualization was also given from students of both groups. A student from experimental group stated that "*the entropy of the system will decrease since entropy means probability of microstates that molecules exists that means when we stretch it molecules become more ordered, probability of alternative microstates decreases"*. A student from control group mentioned that "*stretching the elastic polymer will make the molecules of it to be more ordered, thus its entropy will decrease. Entropy means probability of alternative places that molecules could arrange"*. The percentages of correct responses for experimental group was 77,8 % for experimental group, 75, 2 % for control groups in 1-2 interval. This numbers imply that both groups have similar knowledge about these issues.

When students responses to interpretation question had been examined, as seen from the numbers given in the table 4.26, experimental group students had high percentages of correct responses (66, 7 %) than control group students (40,1 %). Although the related formula was given as a hint to predict how heat of the system will change for an isothermal compression, majority of the students lacked to explain the relationship among the terms correctly. Surprisingly, high majority of control group students stated the system should release heat to keep the temperature constant, but they usually failed to explain the reason. Sample response from a control group student is presented below;

- *Heat should be released by the system.* $\Delta S_{system} = q_{system} / T$, *that means to keep temperature constant we must take heat from the system.*

A few students from control group correctly elaborated the question, for example one stated that;

- *When we stretch the polymer, the heat of the system will increase, so we should take heat from the system to keep temperature constant. As seen from the formula,* $\Delta S_{system} = q_{system} / T$, *the entropy and the heat are directly proportional, entropy is decreasing, so we should decrease the heat in order to have constant temperature.*

Experimental group students had higher percentage of correct responses in 1-3 score intervals than control groups that mean more students in experimental groups correctly answered the question or made more correct comments that control group students. Regardless of their group, a large number of students could not state anything for the second question of order-disorder theme; this may imply that this theme was most difficult for students to answer.

The last theme was about volcanoes and related chemical terms. Totally, 134 students responded these items. Possibly because of being “fill in the blank” type, majority of the students responded the first question of the theme. Table 4.27 represent the percentages of correct responses according to intervals for the theme.

Table 4. 27 The percentages of correct responses to volcanoes and related chemical terms

	Volcanoes and related chemical terms (10 points)				
	Knowledge score intervals			Interpretation score intervals	
	0-2	3-4	5-7	0	1-3
Experimental Group	7,4%	18,5%	74,1%	48,1%	51,9%
Control Group	8,7%	17,4%	73,9%	52,2%	47,8%

There were two questions; one was knowledge-based, the other was interpretive. The maximum score of the theme was 10, of this 7 was from knowledge-based question, 3 was from interpretive questions. In this theme students were expected to connect their knowledge of thermochemical and thermodynamic chemical terms to an eruption of volcano. In the first question students would fill in the blanks on a text of information about eruption of a volcano. The second question was utilizing information from a given text; students were expected to connect their knowledge of laws of thermodynamics to give information text.

Students’ percentages of correct responses were almost the same in each interval, for both experimental and control group students. That means they did not differed on connecting thermochemical and thermodynamics terms to an eruption of volcano. Majority of the experimental and control groups students correctly filled the blanks related to *open-system, energy, heat, exothermic, decrease* correctly, but they had problems in filling the blanks related to *entropy* and *Gibbs free energy.* As seen from the table, both groups had high percentage of correct response on 5-7 score interval.

When students' responses to second questions were examined, results revealed that nearly half of students in both experimental and control groups had problems in relating the given information to laws of thermodynamics 48,1 %, 52,2 % respectively (0 score). Students correct response percentages are slightly higher for experimental groups (51, 9 %) than percentages of control group students (47,8 %).
A student from experimental group wrote the below statement,

- *The energy of the universe is conserved, this is about first law of thermodynamics and given 3rd sentence of the text, additionally, the entropy of the universe increases for spontaneous changes which is about second law of thermodynamics, again it is stated in 3rd sentence.*

Findings indicated that generally students, who could fill the sixth and seventh blank of the text, could successfully comprehend the related laws of thermodynamics stated in the text.

To sum up, in general, experimental group students had higher percentage of correct responses than control groups for all themes. Experimental group students had more concerned on the topics. Combi boiler theme was most answered by students; chemistry of healthy life theme had striking difference of correct response percentage on interpretive questions in 4-6 intervals. Majority of the students had difficulty in connecting chemistry knowledge and biology knowledge. Order-disorder theme was possibly most difficult for students; few students from experimental and control groups could answer the second question correctly. Volcanoes and chemical terms theme was also answered by majority of the students. Students of different groups were not different about their knowledge specifically related to thermochemistry concepts, however; experimental group students were better in connecting given information to the terms of thermodynamics than control group students.

4.5 Conclusion of Results

- CBA through 5E LC model caused a better conceptual understanding than traditional instruction on chemical reactions and energy concepts.
- CBA through 5E LC model better remedied students' misconceptions than traditional instruction on chemical reactions and energy concepts
- CBA through 5E LC model caused higher achievement than traditional instruction on chemical reactions and energy concepts.
- CBA through 5E LC model did not interact with gender, that is males and females were not affected by the treatment differently in chemical reactions and energy concepts both in understandings and achievement.
- CBA through 5E LC model did not contribute differently to students' overall motivation to learn chemistry than traditional instruction
- CBA through 5E LC model improved students' intrinsic motivation to learn chemistry better than traditional instruction
- CBA through 5E LC model improved students' relevance of learning chemistry to personal goals better than traditional instruction
- CBA through 5E LC model improved females self determination more than males
- CBA through 5E LC model contributed to students' chemical literacy on chemical reactions and energy concepts more than traditional instruction on chemical reactions and energy concepts.
- Experimental group students used more scientific terms in explaining the phenomena than control group students.

CHAPTER 5

DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

5.1 Discussion of the Results

This study aimed to investigate the relative effectiveness of context-based approach (CBA) through 5E learning cycle (LC) model and traditional instruction on 11^{th} grade students' understanding, achievement, and chemical literacy on chemical reactions and energy concepts, and their motivation to learn chemistry. In this study, both experimental and control groups were administered to pre-tests regarding students' conceptual understanding of chemical reactions and energy concepts (CRECT), students' motivation to learn chemistry (CMQ), and science process skills test (SPST). The t-tests were conducted to compare the groups before the treatments.

The analysis of the pre-tests indicated that students' prior knowledge on chemical reactions and energy concepts were not different across the experimental and control groups (11.45, 11.30 respectively). The maximum score of pre-CRECT was 20, thus, both groups had almost knew the half of the questions. Those mean scores refer to average prior knowledge in chemical reactions and energy concepts. Some items which were related with heat and temperature were specifically used to reveal comprehension of these concepts since they underlie a base for positive or negative construction of knowledge of chemical reactions and energy concepts. Since prior knowledge has critical importance in knowledge construction, it was good to study with groups having almost the same prior knowledge level. Gooding, Swift, Schell, Swift, and McCroskery (1990) stated that students' prior achievement and attitudes explain 70 % of the variation in their final scores. Therefore, in this study, it can be concluded that the variation in understanding of experimental and control groups are not aroused from the prior differences of the groups.

Students overall chemistry motivation scores obtained from pre-CMQ were not also statistically different for experimental (103.9) and control groups (100.3). According to Pintrich, Marx, and Boyle (1993), not only cognitive variables, but also affective variables are important to facilitate students' understanding. Therefore, analysis of students' prior CMQ scores is also necessary before the process of knowledge construction. It could be concluded that if a difference were observed in students' post motivation scores, the variation is not aroused from the prior differences of the groups. Glynn and Koballa (2006) stated that a score in the range of 30–59 is relatively low, 60–89 is moderate, 90–119 is high, and 120–150 is very high, thus in thus study the students of experimental (103.9) and control groups (100.3) had high chemistry motivation scores. Having high motivation score for both groups might be aroused from the season of the implementations since it was just at the beginning of the semester. The students had not seen any topic after the summer holiday and they had not any exam yet, thus at the beginning of the term they filled the questionnaire quite positively. Another reason of high motivation score might be aroused from studying with science major students of Anatolian high schools since their success is higher than many other majors and high schools.

Students scores of pre-CMQ factors has also been analysed before the treatment. MANOVA statistics was conducted to reveal whether experimental and control groups had different mean scores with respect to factors of motivation to learn chemistry questionnaire. Results indicated that students' mean scores based on intrinsically motivated to learn chemistry (Int), extrinsically motivated to learn chemistry (Ext), relevance of learning chemistry to personal goals (Rel), responsibility or self-determination for learning chemistry (Sdet), confidence or self-efficacy in learning chemistry (Seff), and anxiety about chemistry assessment (Anx) were not different between groups before the treatments. Again, it can be concluded that the variation in groups' motivational factor scores are not aroused from the prior differences of the groups.

When students mean scores on Science Process Skills Test (SPST) had been analysed by t-test before the treatment, it has seen that the groups had statistically significant mean differences. The experimental groups had higher mean scores (22.41) than the mean score of control group students (18.33). To avoid the effect of this score on post-tests scores, students' SPST scores were controlled since as mentioned by Papuççu (2008) SPST reflects students' intellectual ability of identifying variables, stating hypotheses, designing investigations and interpreting the data. Therefore, to avoid unwanted effect of SPST scores during the analysis of post-tests scores, MANCOVA statistics is used.

To reveal the effect of treatments on students' conceptual understanding, chemical reactions and energy concept test was distributed to groups as a post test (post-CRECT). To reveal the effect of treatments on students' achievement in chemical reactions and energy concepts, the CREAT, to reveal the effect of treatments on students' motivation to learn chemistry and, motivational factors on Int, Ext, Rel, Sdet, Seff, and Anx, the post-CMQ had been distributed to groups after the implementation. That means the dependent variables of the study were post-CRECT, CREAT and post-CMQ. SPST scores were different across the groups, thus it was used as a covariate. Treatments and the gender were independent variables of the study. Post-CRECT, CREAT and post-CMQ were all put in MANCOVA statistics together since the relationship among; post-CRECT and post-CMQ was .361, post-CRECT and CREAT was .361, and post-CMQ and CREAT was .200 that means variables have moderate correlations. The probability of having type I error is reduced by MANCOVA statistics.

Students' scores on post-CRECT indicated that experimental groups had higher mean score than control groups (13.22 and 11.92 respectively). Although, the mean scores of groups still seems to be low, statistical analysis indicated that experimental group had considerable improvement from the implementation. CBA through 5E LC model had better improved students' conceptual understanding from traditional instruction. The proportion of variance in students' conceptual understanding of chemical reactions and energy concepts explained by the treatment is 7.2 % which means medium effect size. The results of the study are consistent with findings of considerable number of national and international studies which had focused on the positive outcomes of LC model (Abraham, 1997; Balcı, Çakıroğlu & Tekkaya, 2005; Bektaş, 2011; Cavallo, McNeely, & Marek., 2003; Ceylan, 2008; Demircioğlu, Özmen & Demircioğlu, 2004; Odom & Kelly, 2001; Papuççu, 2008). The findings of studies indicated that students instructed with learning cycle have better understanding of concepts. CBA and LC both take their roots from constructivist philosophy of education and they support inquiry-based learning. Specifically, the engagement phase of 5E LC aimed to create a disequilibrium situation in students mind or to relate something to students' experiences from their lives so that to motivate them. Some activities utilized in this study, such as, demonstrations, reading stories, discussions may have taken students' attention and the relatedness of new information with students existing lives. The engagement activities -either physical or mental- could create some questions or problem situations in students' mind. The role of teacher was to ask questions or to create some interesting situations in which students' curiosity would increase. Similarly, CBA supports many activities such as; discussions and cooperative learning which had potential to increase students understanding. The activities used in classrooms had supported the connection of concepts to contexts, problem solving related to context and concepts as well as helping students construct knowledge meaningfully. Kortland (2007) states that in CBA, applications of concepts or socioscientific issues bridge abstract concepts to world students live in. Kortland also emphasize that relating science to everyday situation have potential to make teaching more interesting and this will make large proportion of students more motivated to learn so that students will better understand concepts. Therefore, the characteristics of CBA and 5E LC had been examined; it might be expected to have such results from integration of CBA with LC model. Inquiry-based activities, small and whole class discussions used in CBA through 5E LC model contributed to students' conceptual learning too. Discussion of concepts through real life experiences has possibility of affecting students' conceptual understanding in chemical reactions and energy concepts. Teacher-student and student-student interactions had also probability of increasing the conceptual understanding. Ramsden (1997) had reported little benefits of conceptual understanding of CBA but some benefits related to students' interests. Barker (1999) revealed that a course designed according to context-based approach steadily improved conceptual understanding when the course had progressed. This findings are consistent with findings of the study, thus it can be stated that both CBA and LC contribute students conceptual understandings. In line with the post-CRECT results, CBA through 5E LC model supported students' achievement more than traditional instruction. Chemical reactions and energy achievement test (CREAT) had been distributed to the groups only after the treatments. Students' scores on CREAT indicated that experimental groups had higher mean score than control groups (18.34 and 14.88 respectively). Statistical analysis indicated that experimental group had considerable higher achievement when compared to traditional instruction. Context-based approach through 5E LC model had better supported students' achievement on chemical reactions and energy concepts than traditional instruction. The proportion of variance in students' achievement on chemical reactions and energy concepts explained by the treatment is 18 % which means large effect size was observed. The finding also supported that CBA integrated with 5E LC model broadened and deepened students' conceptual understanding and achievement. Similar to the effects of treatment on conceptual understanding, the same effects; -discussion of concepts through real life experiences, teacher-student, and student-student interactions had also probability of increasing students' achievement. Toroslu (2011) have reported similar results about achievement of students through 7E learning cycle supported by CBA, she stated that the implementation favored experimental group on conceptual achievement.

Moreover, gender difference had been investigated; no significant mean difference between males and females with respect to students' conceptual understanding and achievement of chemical reactions and energy concepts was found when students' science process skills test score was controlled. Such result implied that the contexts that followed in lessons did not differently affected males and females. Selection of context is quite important in context-based approaches, since some concepts have probability of favoring males or females. For example, Fensham (2009) reported that when real life contexts used in PISA 2006 had been examined, results obtained from

Australia, had indicated that females outperformed males on health issues. The context used in this study did not favored males or females, that is, an important characteristic of good context has been satisfied. Additionally, Nieswandt (2005) revealed that males and females were differently affected from implementations; females usually work better when they are engaged in social activities, and small group works, contrarily, males usually prefer to work individually. Despite, the findings of Nieswandt (2005), in this study, females and males were engaged in group works, no significant interaction between treatment and gender had been observed. The possible reason behind such results may be attributed to the widespread use of cars, almost every family had a car and students were familiar to the context. Having no interaction effect with the treatment, it is possible to conclude that the context used did not favored males or females.

Student chemical literacy level on chemical reactions and energy concepts had been assessed by open-ended items generated from real-world contexts. Based on the description of Shwartz et al. (2006), a chemically literate person should; know content-knowledge of a particular topic, key characteristics of chemistry to explain phenomena of other fields; investigate the energy changes accompanied in a reaction; understand and explain life by chemical processes and structures of living systems. A chemically literate student should appreciate the contribution of scientific language to this discipline (see figure 2.2 in review of literature part for the rest of the description). Experimental group students had higher percentages of correct responses regarding four themes given through open-ended chemical literacy items. The first theme was related to combi boiler and it was mostly answered by students; the second theme; chemistry of healthy life, had striking difference of correct response percentage on interpretive questions in 4-6 intervals. Majority of the students had difficulty in connecting chemistry knowledge and biology knowledge; furthermore, many students had misconceptions regarding energy requirement or energy release of bond formation and bond dissociation. Students could not state that in ATP-ADP conversion both bond dissociation and bond formation occurs. Students possibly had lack of knowledge related to issues, thus they generally could not gave valid pro and con ideas related to information. Boo and Watson (2001) revealed that students categorize bond formation as energy requiring reactions and bond breaking as energy realizing reactions. According to Boo and Watson this was about students' ideas from macroscopic world in which energy is usually required to do something. Additionally, they stated that such kind of conceptualization might be related with students' everyday lives or biology lessons in which they learn degradation of food is energy source for livings. Barker and Millar (2000) revealed that some students aging 16-18 have the idea that energy was released from fossil fuels. Students consider that when bonds are broken energy is released. Goedhart and Kaper (2002) state that students conceptualization may be aroused from their biochemistry knowledge since in this lesson they learn ATP contains energy-rich bond. In this study, students' perceptions regarding these issues are consistent with the related literature.

Order-disorder theme was possibly most difficult for students; few students from experimental and control groups could answer the second question correctly. Analysis of open-ended items related to stretching of an elastic polymer indicated that students especially in control groups had misconceptions related to the terms; order-disorder-entropy. Sözbilir and Bennett (2007) revealed that students define entropy as "disorder", they considers these terms as synonymous. The same results were also obtained from these items. Volcanoes and chemical terms theme was also answered by majority of the students. Students of different groups were not different about their knowledge specifically related to thermochemistry concepts, however; experimental group students were better in connecting given information to the terms of thermodynamics than control group students. As Bennett et al. (2007) stated the courses designed according to CBA played important role in increasing students' chemical literacy levels. Having contexts with real-life situations gave students the possibility of showing their literacy skills. According to Witte and Beers (2003), the chemistry examinations assessing these skills may be presented in the form of: a newspaper article, information on a product or drug, print from web, a comic book chapter, story or advertisement. A context in these forms can be industrial process, an environmental issue, everyday life problem from school or science.

Although, there was no significant difference between experimental and control group with respect to students' motivation to learn chemistry (post-CMQ), substantial literature claim that context-based approaches to teach science specifically aims to influence students' affective issues in a positive manner (Acar & Yaman, 2011, Barker & Millar 1999; Bennett et al. 2007; Demircioğlu, Demircioğlu & Çalık, 2009; İlhan, 2010; Ingram, 2003; Kelly, 2007; Ramsden, 1997). Bulte et al. (2006) states that CBA have potential to increase affective issues provided relevant context chosen. The possible reason of steady state of overall motivation scores was related to students' high motivation scores before the treatments. The unit of chemical reactions and energy concepts was the first unit of eleventh grade chemistry program, the students had just returned from summer holiday and they have not any exam or lecture before administration of the questionnaire, thus they had high motivation scores before the treatment. Additionally, the questionnaire was not limited to the concepts of chemical reactions and energy, thus the implementation regarding the unit could not differentiated students overall motivation scores itself. Moreover, the implementation was restricted to six weeks; such a period of time might be regarded as a short duration to change students' motivation scores. Lubben et al. (2005) reviewed studies to reveal the effect of CBA on affective issues, they concluded that the approach result in more positive attitudes to science in both boys and girls, however, the majority of the studies they had reviewed were conducted throughout a term rather than a unit.

Chemistry Motivation Questionnaire (CMQ) had six factors: intrinsic motivation to learn chemistry (Int), extrinsically motivated chemistry learning (Ext), relevance of learning chemistry to personal goals (Rel), responsibility or self-determination for learning chemistry (Sdet), confidence or self-efficacy in learning chemistry (Seff), and anxiety about chemistry assessment (Anx). Each factor of post-CMQ was taken as a dependent variable (Int, Ext, Rel, Sdet, Seff and Anx), the MANOVA analysis of post-CMQ scores based on the factors revealed that there were differences across the groups and gender. The fallow-up ANOVAs indicated that experimental groups had statistically significant higher mean scores of intrinsically motivated chemistry learning than control groups ($X_{EG} = 18.87$ and $X_{CG} = 17.38$ respectively). As Deci and

Ryan (2000) stated, intrinsic motivation is related to students' activity level, curiosity and interest; it is the tendency of pursuing interest and exercises capabilities. Based on the results, we can claim that the treatment of CBA through 5E LC model intrinsically motivated students to learn chemistry, and required students' active participation. This situation may have increased students' curiosity and interest; experimental groups were inherently motivated to learn chemistry. Additionally, the discussions which were conducted on social and technological issues of context of cars (which students are familiar from their own lives) had increased students' interest and curiosity to learn chemistry intrinsically. King et al. (2008) revealed that the student, the case of their study, reported real-world connections of concepts and contexts increased her engagement and context-based tasks were interesting and productive for her. Such result supports the finding of this study and these outcomes are desirable since the aim of meaningful learning is to increase motivation inherently.

Additionally, students' Rel (relevance of learning chemistry to personal goals) scores were significantly different in favor of experimental groups (X_{EG} = 18.01 and X_{CG} = 15.86 respectively). Pintrich and Schunk (1996) describe goal as an objective that students try to attain, and goal-directed behaviour is the process of it. It is stated in Koballa and Glynn (2007), setting goal is very important for students since it directs students to be focused on, to develop different strategies to attain their goals. The results of this study had revealed that experimental group students found learning chemistry more relevant to their personal goals, thus they possibly interested in mastering the task and task related strategies (Pintrich & Schunk, 2002). When the effect of treatments on collective motivational constructs had been examined across the gender, findings indicated that only responsibility or self-determination for learning chemistry (Sdet) had differed across the gender. The mean of males was 17.23, the mean of females was 19.14 (see table 4.18), that result indicated that female student's responsibility or self-determination for learning chemistry had positively affected by the treatments. Such a gender difference can be explained by the statement of Smith (1998) as females generally value more intimacy and affiliation.

Lubben et al. (2005) reviewed systematically the studies on context-based and Science-Technology-Society approaches in terms of gender, understanding, and attitude. They stated that these approaches took attention of both nationally and internationally since they have important role to develop students' conceptual understanding and scientific literacy. In their review, they examined 61 studies from different aspects. The studies they reviewed ranged across the approaches; 25 were context-based course, 13 were context-based unit, 11 full STS course, and 12 STS enrichment. The 44 of studies found the relation between intervention and attitudes, 41 reported about effect on understanding, 24 of these studies explored both understanding and attitudes. 21 studies focused on skill development, 17 investigated effect of gender, and 7 focused on low ability students. In this study, the findings revealed that the integration of CBA with 5E LC model has common characteristics for improvement of conceptual understanding but contrary findings from the literature on overall motivation scores. As mentioned before, the possible reason of such a result was aroused from using a broad questionnaire rather than a questionnaire restricted to the unit.

5.2 Internal Validity

Threats to internal validity have potential to explain the outcomes of a particular study (Frankel and Wallen, 2000). Therefore, controlling these threats is required for preventing their effects on dependent variables. *Characteristics of subjects* is one of the threats that has effect on validity; age, gender, intelligence, prior knowledge constitute the characteristics of subjects. Students SPST scores, chemistry motivation scores, and concept test scores were obtained before the implementation; and SPST scores were used as a covariate to control their effects on observed difference of dependent variables. Students in experimental and control groups were in the same age ranges, same grades, same types of schools.

Loss of subjects' threat is common in many educational studies. Some of the subjects were absent while data collection process, students who were absent during the post-test were removed from the data. The percentages of these missing have been calculated and it was seen that it is below 10 percent. Additionally some of the subjects were absent during the pre-tests, for that, a dummy variable was constructed and the post-test scores were investigated whether a difference exist among them or not. No difference was observed between the scores, therefore, loss of subject threat (mortality) was not considered as a threatening issue. *Location* was another threat to internal validity. In school A, there were two experimental and two control groups, in school B, there was one experimental and one control group. The activities have been carried out in classrooms which students constantly use, the classrooms of each school had equal conditions so it could be concluded that location threat was controlled.

The way *instrumentation* was used has potential to be a threat to internal validity. Students and teachers were informed about data collection process, pre-post test were administered by the same teacher of each class. The teachers were informed about to follow standard procures of test administration in order to avoid data collector bias. The instruments of study; CRECT, CMQ, CREAT, SPST were all in multiple choice format, that means scoring of the constructs was not a problem for instrumentation decay. The chemical literacy items on chemical reactions and energy concepts were open-ended, and it was scored based on a rubric prepared as an answer key to control instrumentation decay. *Testing* was another threat to internal validity, the use of pre-test may affect the scores of post-tests. Since each group was influenced by this effect, we could conclude it was minimized. The events that might have impact on students' performances are defined as *history* effect. No such event was observed during the implementation so, it could be concluded that this threat was also controlled.

Maturation threat was not a serious issue in this study since the implementation took only six weeks, and the students age ranges were almost the same. *Attitude of subjects*, a threat which was related to students' views and participation in that study. Students of experimental and control groups shared the same schools, so they were in contact in breaks; they have possibility of mentioning the novel activities that are carried out in their classrooms. To avoid this threat, the teachers were permitted to demonstrate the same videos shared in experimental groups however not at the beginning of the lesson, rather at the end of lesson as an example to application of concepts. Therefore, it was assumed attitude of subjects was controlled. *Regression* was related to studying with a group of students who are extremely low or high in their performances. Since experimental and control groups were chosen from similar types of schools and scores which are different across the groups were chosen as covariate, this threat was also assumed to be controlled. *Implementation* threat was related to characteristics of teachers who will implement the treatments. Before the implementation, the researcher and teachers were met to discuss the importance of the process and how they will follow the implementation. The teachers accepted to implement the methods in their regular classes, so it was assumed the implementation threat was also controlled.

5.3 External Validity

Frankel and Wallen (2003) states that external validity is related to extend to which the results of a particular study can be generalized beyond the sample. The generalizability of result depends upon the environmental conditions as well as the nature of sample. Two Anatolian high schools which are well-equipped with technology and laboratory were selected from these schools conveniently. The convenient sampling was used since obtaining a sample through random selection of subjects is not generally possible in experimental studies. Four intact classes of two different teachers from the first school and two intact classes of one teacher from the second school were selected for implementation. The sample of the study was 187 students which correspond approximately 8 % of the accessible population. Because of low proportion sample to accessible population along with the convenience sampling, the generalizability of the study was limited. Additionally, the results might only be generalized to students of Anatolian high schools since their prior achievement level is higher than general high schools. Furthermore, two schools which are well equipped with technology participated in the study; to increase the generalizability, some more studies can also be conducted with other kind of schools.

5.4 Implications

- The findings of the study may contribute to our national chemistry education by integrating context-based approach through 5E learning cycle model. The studies integrating the approach and model are restricted on chemical reactions and energy unit. The materials developed and findings might serve teachers, textbook writers, curriculum development organization and researchers in designing effective courses.
- CBA through 5E LC seems to be more effective than traditional instruction on students understanding of chemical reactions and energy as well as the students' chemical literacy skills. CBA through 5E LC seems to support assessment of students with more context-based problems. Generally, students find it difficult to answer open-ended long problem situations, if such implementations could be widely used; students' responses to these kinds of items might be increased.
- The findings of the study also implies that CBA through 5E LC seems to be more effective than traditional instruction in increasing students intrinsic motivation to learn chemistry and relevance of learning chemistry to personal goals as well as increasing females responsibility or self-determination to learn chemistry. Rather than traditional instruction CBA through 5E LC may be used to increase students' interest and curiosity about chemistry learning.

5.5 Recommendations for Further Study

- As recommended by Peşman (2012), CBA may provide students with some other skills such as problem solving skills, scientific process skills. Some more studies may focus on these issues.
- Designing context-based lessons or courses, may improve students' abilities to solve context-based real-life problems as assessment tools.
- A motivation questionnaire which is more specific to content domain or implementation can be used.

- Implementations of longer durations can be carried out by researcher on different concepts.
- The sample size, school type can be enlarged by researchers to increase generalizability.
- CBA with 5E LC can be implemented to different grade levels, and units.
- Further studies can be conducted to explore the effect of CBA with 5E LC on retention of concepts.
- Further studies can collect qualitative data from students and teacher to support the results.
- Further studies can also investigate the discourse abilities of students in discussion carried out during the implementations.

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APPENDIX A

OBJECTIVES OF THE UNIT

1. Related to types of systems and energy, the students will;

   1.1 Be aware of importance of relationship among systems and surroundings.

   1.2 Classify systems according to heat exchange, temperature, pressure, and volume.

   1.3 Explain internal energy of a system based on its atoms/molecules

   1.4 Relate change in internal energy with heat exchange and mechanical energy for constant volume and constant pressure systems.

   1.5 State the first law of thermodynamics

   1.6 Give examples to applications of thermodynamics from daily life.

2. Related to enthalpy change of system, the students will;

   2.1 Explain enthalpy change (ΔH) with heat of reaction (Qp)

   2.2 Relate empathy change of a reaction with standard enthalpy of formation.

   2.3 Associate enthalpy change of a system with enthalpy change of intermediate steps

   2.4 Establish a relationship between enthalpy change of a chemical reaction and bond energies.

3. Related to spontaneity of changes, students will;

   3.1 Investigate spontaneous/nonspontaneous changes

   3.2 Give examples to tendency of minimum energy for spontaneous changes

   3.3 Give examples to spontaneous changes which do not obey the tendency of minimum energy.

3.4 Explain the term entropy as unused thermal energy and probability.

3.5 Establish a relationship between entropy change (ΔS) and spontaneity.

APPENDIX B

STUDENTS BACKGROUND QUESTIONNAIRE

Sevgili öğrenciler,

Bu çalışmanın amacı sizlerin kimyasal reaksiyonlar ve enerji ünitesindeki kavramları anlamanızı, bu üniteye ait başarınızı ve kimya öğrenmeye olan motivasyonunuzu ortaya çıkarmaktır. Bu doğrultuda, sizlere bazı anketler uygulanacaktır. Bu çalışmadan elde ettiğimiz veriler kimya derslerinin geliştirilmesine katkıda bulunacaktır. Şimdiden çok teşekkür ediyoruz.

1. Adınız, Soyadınız:
2. Sınıfınız:
3. Okulunuz:
4. Cinsiyetiniz:
5. Doğum tarihiniz:
6. Genel not ortalamanız:
7. Annenizin eğitim durumu:

Herhangi bir okul mezunu değil	İlkokul	Ortaokul	Lise	Üniversite	Lisansüstü (Y. Lisans, Doktora)
☐	☐	☐	☐	☐	☐

8. Babanızın eğitim durumu:

Herhangi bir okul mezunu değil	İlkokul	Ortaokul	Lise	Üniversite	Lisansüstü (Y. Lisans, Doktora)
☐	☐	☐	☐	☐	☐

APPENDIX C

CHEMICAL REACTIONS AND ENERGY CONCEPT TEST (CRECT)

1. Soğuk bir ortamda, metal bir cetvel ile odun bir cetveli elimizde tuttuğumuzda, metal cetvelin daha soğuk olduğunu hissederiz. Bu durumu sizce aşağıdaki cümlelerin hangisi daha iyi açıklamaktadır?

   A) Metal elimizdeki ısıyı oduna göre daha hızlı iletir.
   B) Odun doğal olarak daha sıcak bir nesnedir.
   C) Odun cetvel daha fazla ısı içermektedir.
   D) Soğuk metalde daha iyi hissedilir.
   E) Soğuk olmak metallerin özelliğidir.

2. Bir grup öğrenci radyodan hava durumunu dinliyor. Sunucu "Bu akşamki hava sıcaklığı dün akşam 10 ^{0}C olan hava sıcaklığından daha soğuk; yaklaşık 5 ^{0}C olacak" diyor. Bu durumda guruptaki insanlardan hangisinin yorumu sizce daha <u>doğrudur</u>?

   A) Ayşe "Bu akşam dün akşama göre 2 kat daha soğuk olacak" diyor.
   B) Doruk "Ayşe'nin bu yaklaşımı yanlış bir yaklaşım, 5 ^{0}C, 10 ^{0}C den iki kat daha soğuk anlamına gelmez" diyor.
   C) Tuna "Ayşe'nin yaklaşımı kısmen doğru ama 10 ^{0}C, 5 ^{0}C den iki kat daha sıcak demeliydi" diyor.
   D) Mehmet "Bana göre de Ayşe'nin yaklaşımı kısmen doğru, 5 ^{0}C, 10 ^{0}C'nin yarısı kadar soğuk" diyor.
   E) Simge " Hava sıcaklıklarını tam olarak kıyaslayabilmek için hissetmek gereklidir" diyor.

3. Bir bisiklet pompası ile tekerlek şişirilirken pompanın ısınmasını aşağıdakilerden hangisi açıklamaktadır?

   A) Sıcaklık pompaya transfer edilmiştir.
   B) Elimizden pompaya ısı akışı olmuştur
   C) Pompanın metal oluşu sıcaklığın artmasına neden olmuştur.
   D) Enerji pompaya transfer edilmiştir.
   E) Pompanın içindeki hava ısınmaya neden olmuştur.

4. İki şişe su düşünelim ve her birinin içerisinde 20 ^{0}C de su olduğunu varsayalım. İki şişeden birini ıslak diğerini kuru yün parçası ile saralım. 20 dakika sonra şişelerin içerisindeki suyun sıcaklığını ölçelim. Islak yün ile sarılan 18 ^{0}C, kuru yün ile sarılan 22 ^{0}C de olduğunu görmüş olalım. Sizce bu deney esnasında oda sıcaklığı kaç ^{0}C olabilir?

   A) 26 ^{0}C
   B) 21 ^{0}C
   C) 20 ^{0}C
   D) 18 ^{0}C
   E) 17 ^{0}C

5. İki kutu süt düşünelim; birisi dolapta diğeri de mutfak rafının üzerinde olsun. İkisine birden dokunalım. Buzdolabından çıkan sütü daha soğuk hissedersiniz. Bunun nedeni, soğuk kutu;

   A) Daha fazla soğuk içermektedir.
   B) Daha az ısı içermektedir.
   C) Daha zayıf bir ısı iletkenidir.
   D) Isıyı elimizden daha hızlı iletmektedir.
   E) Soğuğu elimize daha fazla iletmektedir.

6. Kimyasal bir reaksiyonda,
   I. Bağ kırılması sırasında enerji açığa çıkar
   II. Bağ oluşumu sırasında enerji tüketilir
   III. Hem bağ oluşumu hem bağ kopması için enerji gereklidir.

   Yargılarından hangisi veya hangileri <u>yanlıştır</u>?

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

7. Aşağıdaki olaylardan hangisi endotermiktir?

A) Suyun yoğunlaşması
B) Mumun yanması
C) Metalin yanması
D) Bağ kırılması
E) Bağ oluşumu

8. Isı veren (ekzotermik) tepkimelerde
I. Sabit basınçta sistemin toplam ısısı azalır.
II. Düşük sıcaklıklarda ürünler daha kararlıdır.
III. Ortamın sıcaklığı artmıştır.

Yargılarından hangisi veya hangileri doğrudur?
A) Yalnız I
B) Yalnız II
C) I ve II
D) II ve III
E) I, II ve III

9. Aşağıdaki yargılardan hangisi doğrudur?

A) Bir tepkimede bağ oluşumu sırasında enerji tüketilir.
B) Mumun yanması endotermik bir reaksiyondur.
C) Suyun yoğunlaşması ekzotermik bir değişimdir.
D) Endotermik reaksiyonlar kendiliğinden gerçekleşemez.
E) Demirin paslanması endotermik bir reaksiyondur.

10. Laboratuar şartlarında bir tüpün içerisinde bir tepkime gerçekleştirdiğimizi düşünürsek;
I. Tüpün içerisinde yürüttüğümüz tepkimeye ortam adı verilir.
II. Tüp, sistemi ortamdan ayıran sınırdır.
III. İçinde bulunduğumuz laboratuar ise sistemdir.

Yargılarından hangisi veya hangileri doğrudur?

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

11. Mutlak sıcaklık ile ilgili aşağıda verilenlerden hangisi doğrudur?

A) Mutlak sıcaklıkta tüm maddeler kristaldir.
B) Mutlak sıcaklıkta maddenin hacmi minimuma iner.
C) Mutlak sıcaklıkta maddeler minimum enerji halindedir.
D) Mutlak sıcaklıkta maddenin iç düzeni değişir, kristal olur.
E) Mutlak sıcaklıkta atomlar daha çok titreşim hareketi yaparlar.

12. Aşağıdaki değişimlerden hangisi kendiliğinden oluşmaz?

A) 150 C^0 ye ısıtılmış bir metal parçasının 40 C^0 deki suya atıldığında suyun ısınması
B) Oda sıcaklığında naftalinin süblimleşmesi
C) Su buharının oda koşullarına geldiğinde yoğunlaşması
D) Elimize aldığımız bir buz parçasının erimesi
E) Oda sıcaklığında metan gazının karbon ve hidrojene ayrışması.

13. İzole bir sistemde kendiliğinden gerçekleşen bir değişimin entropisi ile ilgili olarak aşağıdakilerden hangisi doğrudur?

A) Entropisi azalır
B) Entropisi değişmez
C) Entropisi artar ya da azalır
D) Entropisi artar
E) Yetersiz bilgi

14. Aşağıdaki yargılardan hangisi doğrudur?

A) Ekzotermik reaksiyonlar endotermik reaksiyonlardan daha hızlıdır.
B) Elementlerin en kararlı hallerinin standart entalpi değişimi "0" dır.
C) Endotermik değişimlerde entalpi değişimi negatiftir.
D) Ekzotermik değişimlerde entalpi değişimi pozitiftir.
E) Entalpi deki değişim sabit hacimdeki ısı değişimidir.

15. Oda sıcaklığında bir gün kalan günlük sütün ekşidiğini fark ettiniz. Bu değişimde sütün entropisi arttığına göre, aşağıdaki ifadelerden hangisi yanlıştır.

A) Sitemin düzensizliği artmıştır
B) İstemli değişime örnektir
C) Serbest enerji değişimi negatiftir
D) Sistemin enerjisi artmıştır.
E) Evrenin entropisi azalır.

16. Yanma reaksiyonları için;

I. Ateş ve alev içermeyen reaksiyonlar yanma reaksiyonu değildir.
II. Her zaman ekzotermik reaksiyonlardır.
III. Yanma reaksiyonları temel anlamda farklı nesneler için farklılık gösterir.

Yargılarından hangisi ya da hangileri <u>doğrudur?</u>

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

17. $X_2 \rightarrow 2X$ dönüşümü endotermiktir.
$2Y \rightarrow Y_2$ dönüşümü ise ekzotermiktir.

Buna göre, aşağıdaki yargılardan hangisi ya da hangileri doğrudur.

I. Bağ oluşumu sırasında enerji açığa çıkar.
II. Bağların kırılması enerji gerektirir.
III. Bağ oluşumu için reaksiyon ısısı sıfırdan büyüktür.

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

18. Ahmet buzdolabında bir gündür beklemekte olan bir kutu kolayı ve plastik şişe kolayı aynı anda dışarı çıkarıyor. Sonra hemen kutu kolanın içerisine bir termometre daldırıp sıcaklığının 7 ^{0}C olduğunu görüyor. Sizce plastik şişe ve içindeki kolanın sıcaklığı kaç derece olabilir?

A) Her ikisinin sıcaklığı 7 ^{0}C den azdır.
B) Her ikisinin sıcaklığı da 7 ^{0}C dır.
C) Her ikisinin sıcaklığı da 7 ^{0}C den fazladır
D) Kolanın sıcaklığı 7 ^{0}C, şişeninki 7 ^{0}C den fazladır
E) Kolanın miktarına ve şişenin büyüklüğüne bağlıdır.

19. Aşağıdakilerden hangisi bir maddenin "standart oluşum serbest enerji değişimini" gösterir.

A) ΔG^o
B) ΔG_f
C) ΔG
D) $\Delta G^o{}_f$
E) G^o

20. Birbiri ile tepkime vermeden karışabilen aynı sıcaklık ve hacimdeki iki ideal gaz hareketli bir pistonda karıştırılıyor, bu durumla ilgili aşağıdakilerden hangisi <u>yanlıştır?</u>

A) Entropi artar.
B) Kullanılamayan termal enerji artar.
C) Düzen artar.
D) Moleküllerin farklı konumlarda bulunma ihtimali artar.
E) Entropi değişimi pozitiftir.

APPENDIX D

CHEMICAL REACTIONS AND ENERGY ACHIEVEMENT TEST (CREAT)

1) Verilen sistem örneklerinden hangisinde sistem ve ortam arasındaki etkileşim en fazladır?

A) Yalıtılmış kaptaki çay
B) Yanan bir mum
C) Buz torbası
D) Termometredeki cıva
E) Ağzı kapalı beherdeki etanol

2) Kimyasal reaksiyonlar sonucu açığa çıkan ya da soğurulan enerjinin hesaplanabilmesi için enerji alış-verişini en aza indiren izole sistemler kullanılır. Aşağıda verilenlerden hangisi izole sisteme bir örnek değildir?

A) Buzdolabı
B) Termos
C) Kalorimetre
D) Düdüklü tencere
E) Derin dondurucu

3) Bir sistemde bulunan atomların/moleküllerin sahip olduğu farklı enerji türlerinin toplamı o sistemin iç enerjisini verir. Aşağıdakilerden hangisi Helyum (He) gibi tek atomlu gaz taneciklerinin iç enerjisine katkıda bulunmaz?

A) Titreşim hareketlerinden kaynaklanan enerji
B) İtme ve çekmeden kaynaklanan enerji
C) Çekirdek yükünden kaynaklanan enerji
D) Öteleme hareketlerinde kaynaklanan enerji
E) Elektronik hareketlerden kaynaklanan enerji

4) Sabit basınçlı ve sabit hacimli sistemler göz önünde bulundurulduğunda aşağıdaki önermelerden hangileri doğrudur?

I. Sabit basınçlı sistemlerde yapılan iş hesaplanabilir.
II. Sabit hacimli sistemlerde iş yapılamaz.
III. Sabit hacimli sistemlerde açığa çıkan ya da alınan ısı iç enerji değimine eşittir.

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

5) Aşağıdakilerden hangisi termodinamiğin birinci kanunu ifade eder?

A) Kütlenin korunumu
B) Minimum enerji
C) Enerjinin korunumu
D) Mutlak sıcaklık
E) Kimyasal denge

6) Sürtünmesiz hareketli bir pistonda gerçekleşen bir tepkimeden açığa çıkan ısı aşağıdakilerden hangisine <u>eşittir</u>?

A) ΔU
B) $\Delta U - w$
C) $\Delta U + w$
D) $\Delta U - q_p$
E) $\Delta U + q_p$

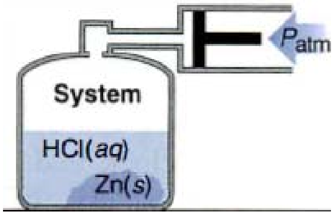
7) Besinlerden aldığımız glikozun vücudumuzdaki yanma reaksiyonu aşağıda verilmiştir.

$$C_6H_{12}O_6\,(k) \;+\; 6\,O_2(g) \;\rightarrow\; 6\,CO_2\,(g) \;+\; 6\,H_2O\,(s)$$

Bu reaksiyonun entalpi değişimini (ΔH) nedir? ($\Delta H_f^o\ C_6H_{12}O_{6(k)}$ = - 1273 kJ/mol, $\Delta H_f^o\ CO_{2(g)}$ = - 394 kJ/mol, $\Delta H_f^o\ H_2O_{(s)}$ = - 286 kJ/mol)

A) -2743 kJ/mol
B) 2743 kJ/mol
C) 2907 kJ/mol
D) 2807 kJ/mol
E) -2807 kJ/mol

8)



$Zn(k) + 2HCl\ (suda) \rightarrow ZnCl_2(suda) + H_2(g) \qquad \Delta Hr < 0$

Yukarıdaki reaksiyon sabit basınçta gerçekleşmektedir ve açığa çıkan gaz pistonu itmektedir. Bu sistemdeki; iç enerji değişiminin (ΔU), ısının (q_p) ve işin (w) işareti ile ilgili olarak aşağıda verilenlerden hangisi doğrudur?

	ΔU	q_p	w
A)	+	-	-
B)	+	-	+
C)	-	+	-
D)	-	-	-
E)	+	+	+

9) $C_3H_8\ (g) + 5\ O_2(g) \rightarrow 3\ CO_2\ (g) + 4\ H_2O\ (s) \qquad \Delta Hr = ?$

Yukarıdaki reaksiyonun entalpi değişimini (ΔHr) ara basamakların entalpi değişimleri cinsinden ifade edilişi hangi seçenekte **<u>doğru</u>** verilmiştir?

$C_3H_8\ (g) \rightarrow 3\ C\ (k) + 4\ H_2\ (g) \qquad \Delta H_1$
$3\ C\ (k) + 3\ O_2(g) \rightarrow 3\ CO_2\ (g) \qquad \Delta H_2$
$4\ H_2\ (g) + 2\ O_2(g) \rightarrow 4\ H_2O\ (s) \qquad \Delta H_3$

A) $\Delta Hr = \Delta H_1 + 3\ \Delta H_f^o\ (CO_2) - \Delta H_3$
B) $\Delta Hr = -\Delta H_1 + \Delta H_2 + 4\ \Delta H_f^o\ (H_2O_{(s)})$
C) $\Delta Hr = -\Delta H_f^o\ (C_3H_{8\,(g)}) + \Delta H_2 + \Delta H_3$
D) $\Delta Hr = \Delta H_f^o\ (C_3H_{8\,(g)}) - \Delta H_2 - \Delta H_3$
E) $\Delta Hr = -\Delta H_1 + \Delta H_2 - \Delta H_3$

10) Doğal gazın önemli bir bileşeni olan Metanın (CH_4), yanma tepkimesi aşağıda verilmiştir.

$$CH_4(g) + 2O_2(g) \rightarrow CO_2(g) + 2H_2O(g)$$

Standart şartlarda 1 mol Metanın (CH_4) yanma entalpisi nedir? (Bağ Kırılma Entalpileri; C □ C : 350 kJ/mol, C □ H : 410 kJ/mol, O □ H : 460 kJ/mol, C = O : 732 kJ/mol, O = O : 498 kJ/mol)

A) -3304 kJ/mol
B) 668 kJ/mol
C) -668 kJ/mol
D) -6040 kJ/mol
E) 6040 kJ/mol

11) Aşağıdakilerden hangisinde verilen olayların Entropi değişimi doğru olarak belirtilmiştir?

	-18 °C ye koyduğumuz Suyun Donması	Oda Sıcaklığında Suyun Buharlaşması
A)	Artar	Değişmez
B)	Artar	Artar
C)	Azalır	Azalır
D)	Değişmez	Azalır
E)	Azalır	Artar

12) 1 atm basınçta aşağıdakilerden hangisi ya da hangileri kendiliğinden gerçekleşir.

I. - 1 ^{0}C de buzun erimesi,
II. 0 ^{0}C de suyun donması,
III. +1 ^{0}C de buzun erimesi,

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

13) Kendiliğinden gerçekleşen tepkimeler çoğunlukla ekzotermiktir. Aşağıdaki olaylardan hangisi ya da hangileri bu kurala ters düşer?

I. Oda sıcaklığında buzun erimesi
II. Sıvı dietil eterin açık bir beherden buharlaşması
III. Amonyum nitratın suda çözünmesi

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

14) $2\ PCl_3(g) + O_2(g) \rightarrow 2\ POCl_3(s)$ $\Delta H° = -620.2$ kJ/mol

Aşağıdakilerden hangisinde 25 °C ve 1 atm basınçta yukarıda verilen tepkimenin standart serbest enerjisi ve sistemin istemlilik-istemsizlik-tersinirlik durumu doğru olarak belirtilmiştir? S° $PCl_3(g)$ = 311.7 J/K.mol, S° $O_2(g)$ = 205.0 J/K.mol, S° $POCl_3(s)$ = 222.4 J/K.mol

A) 505 kJ/mol, İstemli
B) -505 kJ/mol, İstemli
C) -0.5 kJ/mol, Tersinir
D) 5050 kJ/mol, İstemsiz
E) -5050 kJ/mol, İstemsiz

15) $NH_4CI\ (s) \rightarrow NH_3\ (g) + HCI\ (g)$

T = 25 ^{0}C, ΔS^0 = +285 J/ K.mol, ΔH^0 = +177 kJ/mol, ΔG^0 = +91.9 kJ

Yukarıdaki tepkimenin istemlilik durumu 25 ^{0}C de ve 500 K de nasıldır? (Sıcaklığı 500 K çıkardığımızda ΔH ve ΔS değerlerinin değişmediğini kabul ediyoruz)

	25 ^{0}C de	500 K de
A)	İstemli	İstemsiz
B)	İstemsiz	İstemli
C)	İstemli	İstemli
D)	İstemsiz	İstemsiz
E)	Dengede	Dengede

16) Gibbs Serbest Enerjisi ile ilgili olarak verilenlerden hangisi doğru değildir?

A) Serbest enerji iş yapmaya hazır enerjidir.
B) Bir olayın istemliliğini bulmakta yararlanılır.
C) Bir olayın istemliliği, ortamın özelliklerine göre anlaşılır.
D) Bir olayın istemliliği, sistemin özelliklerine göre anlaşılır.
E) Değişimlerin istemliliğini etkileyen faktörleri birleştirir.

17) $2\,NO(g) + O_2(g) \rightarrow 2\,NO_2(g)$

25 °C ve 1 atm basınçta tepkimenin kullanılamayan termal enerjisi – 146.2 J/K dir. Aşağıdakilerden hangisinde kullanılabilir standart serbest enerjiyi ve sistemin istemlilik-istemsizlik durumu doğru olarak belirtilmiştir? (Δ°H = - 114.1 kJ/mol)

	Kullanılabilir serbest enerji	İstemlilik durumu
A)	-70.5 kJ	İstemli
B)	157.26 kJ	İstemsiz
C)	-157.26 kJ	İstemli
D)	+70.5 kJ	İstemsiz
E)	- 157.26 kJ	istemsiz

18) Aşağıdakilerden hangisi termodinamiğin ikinci kanunu ifade eder?

A) Sistem düzenli bir yapıya yaklaşır.
B) Her istemli olayda evrenin toplam entropisi artar.
C) Evren zaman geçtikçe bir dengesizlik haline doğru yaklaşır.
D) Sistemdeki moleküllerin sahip oldukları konumlarının sayısı azalır.
E) Mutlak sıfır noktasında bütün saf maddelerin kristallerin entropisi sıfırdır.

19) Aşağıdakilerden hangisinin entropisi en yüksektir?

A) 0 ^{0}C ve 1 atm de $H_2O(k)$
B) 0 ^{0}C ve 1 atm de $H_2O(s)$
C) 25 ^{0}C ve 1 atm de $H_2O(s)$
D) 50 ^{0}C ve 1 atm de $H_2O(s)$
E) 50 ^{0}C ve 1 atm de $H_2O(g)$

20) 0 ^{0}C de 1 mol buzun erimesi olayında ($H_2O(k) \rightarrow H_2O(s)$) sistemin entropi değişimi (ΔS_{sistem}), ortamın entropi değişimi (ΔS_{ortam}), ve toplam entropi değişimi (ΔS_{toplam}), hangi seçenekte doğru verilmiştir?

	ΔS_{sis}	ΔS_{ort}	ΔS_{top}
A)	Pozitif	Negatif	Pozitif
B)	Pozitif	Negatif	Negatif
C)	Negatif	Negatif	Negatif
D)	Negatif	Pozitif	Pozitif
E)	Pozitif	Pozitif	Pozitif

21) Aşağıda verilen madde örneklerinin entropileri az ya da çok oluşuna göre sıralandığında hangi seçenekte verilen her iki sıralamada da ortada kalır?

	Madde	Entropisi
A)	10 ^{0}C ve 2 atm de 1 mol CO_2 (g)	S_1
B)	10 ^{0}C ve 1 atm de 1 mol CO_2 (g)	S_2
C)	10 ^{0}C ve 1 atm de 0.1 mol CO_2 (g)	S_3
D)	50 ^{0}C ve 1 atm de 1 mol CO_2 (g)	S_4
E)	50 ^{0}C ve 1 atm de 2 mol CO_2 (g)	S_5

22) Bir elektrik motoru mekanik iş olarak saniyede 15 kJ lük enerji üretip çevreye saniyede 2 kJ lük enerji verirse motorun 1 saniyedeki iç enerji değişmesi kaç kJ olur?

A) 17 kJ
B) 13 kJ
C) -13 kJ
D) -17 kJ
E) -34 kJ

23)

I.	N_2 (g)	+	3 H_2 (g)	$\rightarrow$	2 NH_3 (g)	ΔG^0 = -32.9 kJ
II.	1/2 N_2 (g)	+	O_2 (g)	$\rightarrow$	NO_2 (g)	ΔG^0 = +51.3 kJ
III.	H_2 (g)	+	1/2 O_2 (g)	$\rightarrow$	H_2O (g)	ΔG^0 = - 237.1kJ

Yukarıda denklemeleri ve standart serbest enerji değişimleri verilen reaksiyonlardan hangilerinde bileşiklerin elementlerinden oluşmasında entropi azalmış, değişim istemli gerçekleşmiştir.

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

24) N_2 (g) + 3 H_2 (g) → 2 NH_3 (g)

Standart koşullarda, yukarıda ki tepkimenin entalpi değişim değeri nedir? Gerekli bağ kırılma enerjileri; N ≡ N: 946 kJ/ mol, H−N: 389 kJ/ mol, H−H: 436 kJ/ mol dür.

A) -60 kJ/ mol
B) -40 kJ/ mol
C) -80 kJ/mol
D) 50 kJ/mol
E) 160 kJ/mol

25) Aşağıdaki temalardan hangisi termodinamiğin yasaları ile ilgili değildir?

A) Termal denge durumu
B) Enerjinin korunumu
C) İstemli olaylarda entropinin artması
D) Mutlak sıcaklıkta, saf mükemmel kristallerin entropisinin sıfıra inmesi
E) Sabit basınçta reaksiyon ısı değişimine entalpi denmesi

APPENDIX E

CHEMISTY MOTIVATION QUESTIONNAIRE (CMQ)

Kimya dersi hakkında ne düşündüğünüzü ve nasıl hissettiğinizi daha iyi anlamak için aşağıdaki ifadeleri şu perspektiften bakarak değerlendirin:

01. Kimya öğrenmekten hoşlanırım.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

02. Öğrendiğim kimya kişisel amaçlarımla bağlantılıdır.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

03. Kimya sınavlarında diğer öğrencilerden daha başarılı olmak isterim.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

04. Kimya testlerinin nasıl geçeceğimi düşünmek beni endişelendirir.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

05. Eğer kimyayı öğrenmekte zorluk çekersem sebebini bulmaya çalışırım.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

06. Kimya sınav zamanı geldiğinde endişelenirim.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

07. Kimyadan iyi bir not almak benim için önemlidir.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

08. Kimyayı öğrenebilmek için gerekli çabayı gösteririm.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

09. Kimyayı iyi öğrenmemi sağlayacak stratejiler kullanırım.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

10. Kimyayı öğrenmenin iyi bir iş bulmama nasıl yardımcı olacağını düşünürüm.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

11. Öğrendiğim kimyanın bana nasıl yararlı olacağını düşünürüm.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

12. Kimya dersi başarımın diğer öğrencilerle aynı seviyede ya da onlardan daha iyi olacağını düşünürüm.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

13. Kimya sınavlarında başarısız olmaktan endişelenirim.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

14. Diğer öğrencilerin kimyada daha başarılı olduğunu düşünmek beni endişelendirir.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

15. Kimya notumun genel not ortalamamı nasıl etkileyeceğini düşünürüm.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

16. Benim için kimyayı öğrenmek aldığım nottan daha önemlidir.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

17. Kimyayı öğrenmenin kariyerime nasıl katkısı olacağını düşünürüm.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

18. Kimya sınavlarına girmekten hoşlanmam.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

19. Öğrendiğim kimyayı nasıl kullanacağımı düşünürüm.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

20. Kimyayı anlamıyorsam bu benim hatamdır.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

21. Kimya laboratuarında ve projelerinde başarılı olacağım konusunda kendime güvenirim.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

22. Kimya öğrenmeyi ilginç bulurum.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

23. Öğrendiğim kimya yaşantımla alakalıdır.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

24. Kimya derslerindeki bilgi ve becerileri tam anlamıyla öğrenebileceğime inanırım.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

25. Öğrendiğim kimya benim için pratik önem taşır.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

26. Kimya sınavları ve laboratuarları için iyi hazırlanırım.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

27. Beni zorlayan kimya hoşuma gider.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

28. Kimya sınavlarında başarılı olacağım konusunda kendime güvenirim.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

29. Kimya dersinde en yüksek notu alabileceğime inanırım.

□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

30. Kimyayı anlamak bana başarı duygusu verir.
□Hiçbir zaman □Nadiren □Bazen □Genellikle □Her zaman

APPENDIX F

SCIENCE PROCESS SKILLS TEST (SPST)

AÇIKLAMA: Bu test içinde, problemdeki değişkenleri tanımlayabilme, hipotez kurma ve tanımlama, işlemsel açıklamalar getirebilme, problemin çözümü için gerekli incelemelerin tasarlanması, grafik çizme ve verileri yorumlayabilme kabiliyetlerini ölçebilen sorular bulunmaktadır. Her soruyu okuduktan sonra kendinizce uygun seçeneği işaretleyiniz.

1. Bir basketbol antrenörü, oyuncuların güçsüz olmasından dolayı maçları kaybettiklerini düşünmektedir. Güçlerini etkileyen faktörleri araştırmaya karar verir. Antrenör, oyuncuların gücünü etkileyip etkilemediğini ölçmek için aşağıdaki değişkenlerden hangisini incelemelidir?

a. Her oyuncunun almış olduğu günlük vitamin miktarını.
b. Günlük ağırlık kaldırma çalışmalarının miktarını.
c. Günlük antreman süresini.
d. Yukarıdakilerin hepsini.

2. Arabaların verimliliğini inceleyen bir araştırma yapılmaktadır. Sınanan hipotez, benzine katılan bir katkı maddesinin arabaların verimliliğini artıdığı yolundadır. Aynı tip beş arabaya aynı miktarda benzin fakat farklı miktarlarda katkı maddesi konur. Arabalar benzinleri bitinceye kadar aynı yol üzerinde giderler. Daha sonra her arabanın aldığı mesafe kaydedilir. Bu çalışmada arabaların verimliliği nasıl ölçülür?

a. Arabaların benzinleri bitinceye kadar geçen süre ile.
b. Her arabnın gittiği mesafe ile.
c. Kullanılan benzin miktarı ile.
d. Kullanılan katkı maddesinin miktarı ile.

3. Bir araba üreticisi daha ekonomik arabalar yapmak istemektedir. Araştırmacılar arabanın litre başına alabileceği mesafeyi etkileyebilecek değişkenleri araştımaktadırlar. Aşağıdaki değişkenlerden hangisi arabanın litre başına alabileceği mesafeyi etkileyebilir?

a. Arabanın ağırlığı.
b. Motorun hacmi.
c. Arabanın rengi
d. a ve b.

4. Ali Bey, evini ısıtmak için komşularından daha çok para ödemesinin sebeblerini merak etmektedir. Isınma giderlerini etkileyen faktörleri araştırmak için bir hipotez kurar. Aşağıdakilerden hangisi bu araştırmada sınanmaya uygun bir hipotez değildir?

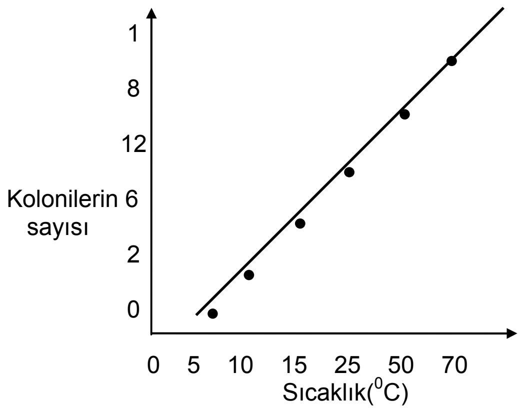
a. Evin çevresindeki ağaç sayısı ne kadar az ise ısınma gideri o kadar fazladır.
b. Evde ne kadar çok pencere ve kapı varsa, ısınma gideri de o kadar fazla olur.
c. Büyük evlerin ısınma giderleri fazladır.
d. Isınma giderleri arttıkça ailenin daha ucuza ısınma yolları araması gerekir.

5. Fen sınıfından bir öğrenci sıcaklığın bakterilerin gelişmesi üzerindeki etkilerini araştırmaktadır. Yaptığı deney sonucunda, öğrenci aşağıdaki verileri elde etmiştir:

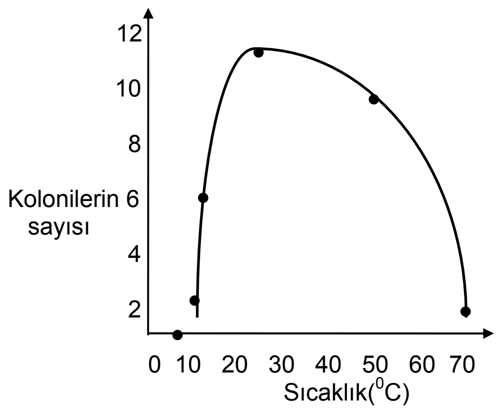
Deney odasının sıcaklığı (^{0}C)	Bakteri kolonilerinin sayısı
5	0
10	2
15	6
25	12
50	8
70	1

Aşağıdaki grafiklerden hangisi bu verileri doğru olarak göstermektedir?

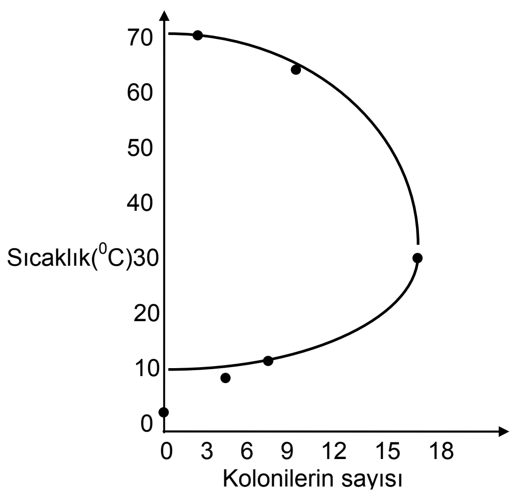
a.



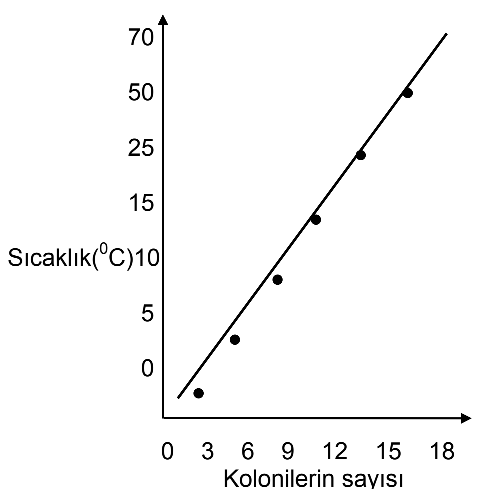
b.



c.



d.



6. Bir polis şefi, arabaların hızının azaltılması ile uğraşmaktadır. Arabaların hızını etkileyebilecek bazı faktörler olduğunu düşünmektedir. Sürücülerin ne kadar hızlı araba kullandıklarını aşağıdaki hipotezlerin hangisiyle sınayabilir?

a. Daha genç sürücülerin daha hızlı araba kullanma olasılığı yüksektir.
b. Kaza yapan arabalar ne kadar büyükse, içindeki insanların yaralanma olasılığı o kadar azdır.
c. Yollarde ne kadar çok polis ekibi olursa, kaza sayısı o kadar az olur.
d. Arabalar eskidikçe kaza yapma olasılıkları artar.

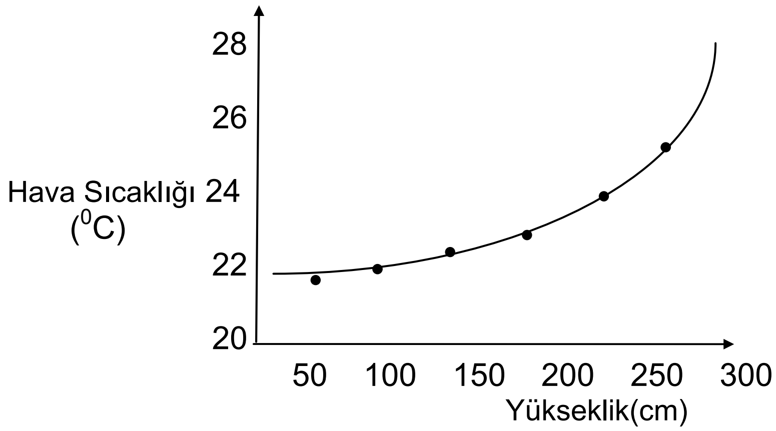
7. Bir fen sınıfında, tekerlek yüzeyi genişliğinin tekerleğin daha kolay yuvarlanması üzerine etkisi araştırılmaktadır. Bir oyuncak arabaya geniş yüzeyli tekerlekler takılır, önce bir rampadan (eğik düzlem) aşağı bırakılır ve daha sonra düz bir zemin üzerinde gitmesi sağlanır. Deney, aynı arabaya daha dar yüzeyli tekerlekler takılarak tekrarlanır. Hangi tip tekerleğin daha kolay yuvarlandığı nasıl ölçülür?

a. Her deneyde arabanın gittiği toplam mesafe ölçülür.
b. Rampanın (eğik düzlem) eğim açısı ölçülür.
c. Her iki deneyde kullanılan tekerlek tiplerinin yüzey genişlikleri ölçülür.
d. Her iki deneyin sonunda arabanın ağırlıkları ölçülür.

8. Bir çiftçi daha çok mısır üretebilmenin yollarını aramaktadır. Mısırların miktarını etkileyen faktörleri araştırmayı tasarlar. Bu amaçla aşağıdaki hipotezlerden hangisini sınayabilir?

a. Tarlaya ne kadar çok gübre atılırsa, o kadar çok mısır elde edilir.
b. Ne kadar çok mısır elde edilirse, kar o kadar fazla olur.
c. Yağmur ne kadar çok yağarsa , gübrenin etkisi o kadar çok olur.
d. Mısır üretimi arttıkça, üretim maliyeti de artar.

9. Bir odanın tabandan itibaren değişik yüzeylerdeki sıcaklıklarla ilgli bir çalışma yapılmış ve elde edilen veriler aşağıdaki grafikte gösterilmiştir. Değişkenler arasındaki ilişki nedir?

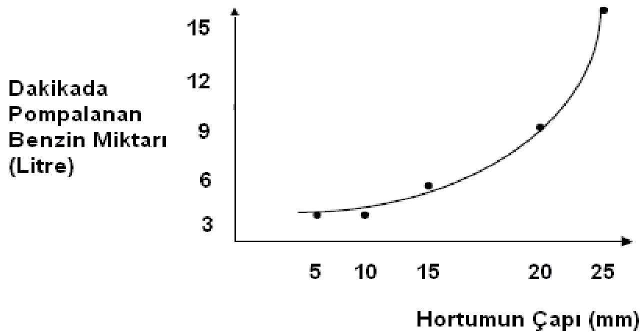


a. Yükseklik arttıkça sıcaklık azalır.
b. Yükseklik arttıkça sıcaklık artar.
c. Sıcaklık arttıkça yükseklik azalır.
d. Yükseklik ile sıcaklık artışı arasında bir ilşki yoktur.

10. Ahmet, basketbol topunun içindeki hava arttıkça, topun daha yükseğe sıçracağını düşünmektedir. Bu hipotezi araştırmak için, birkaç basketbol topu alır ve içlerine farklı miktarda hava pompalar. Ahmet hipotezini nasıl sınamalıdır?

a. Topları aynı yükseklikten fakat değişik hızlarla yere vurur.
b. İçlerinde farklı miktarlarda hava olan topları, aynı yükseklikten yere bırakır.
c. İçlerinde aynı miktarlarda hava olan topları, zeminle farklı açılardan yere vurur.
d. İçlerinde aynı miktarlarda hava olan topları, farklı yüksekliklerden yere bırakır.

11. Bir tankerden benzin almak için farklı genişlikte 5 hortum kullanılmaktadır. Her hortum için aynı pompa kullanılır. Yapılan çalışma sonunda elde edilen bulgular aşağıdaki grafikte gösterilmiştir.



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi açıklamaktadır?

a. Hortumun çapı genişledikçe dakikada pompalanan benzin miktarı da artar.
b. Dakikada pompalanan benzin miktarı arttıkça, daha fazla zaman gerekir.
c. Hortumun çapı küçüldükçe dakikada pompalanan benzin miktarı da artar.
d. Pompalanan benzin miktarı azaldıkça, hortumun çapı genişler.

Önce aşağıdaki açıklamayı okuyunuz ve daha sonra 12, 13, 14 ve 15 inci soruları açıklama kısmından sonra verilen paragrafı okuyarak cevaplayınız.

Açıklama: Bir araştırmada, bağımlı değişken birtakım faktörlere bağımlı olarak gelişim gösteren değişkendir. Bağımsız değişkenler ise bağımlı değişkene etki eden faktörlerdir. Örneğin, araştırmanın amacına göre kimya başarısı bağımlı bir değişken olarak alınabilir ve ona etki edebilecek faktör veya faktörler de bağımsız değişkenler olurlar.

Ayşe, güneşin karaları ve denizleri aynı derecede ısıtıp ısıtmadığını merak etmektedir. Bir araştırma yapmaya karar verir ve aynı büyüklükte iki kova alır. Bumlardan birini toprakla, diğerini de su ile doldurur ve aynı miktarda güneş ısısı alacak şekilde bir yere koyar. 8.00 - 18.00 saatleri arasında, her saat başı sıcaklıklarını ölçer.

12. Araştırmada aşağıdaki hipotezlerden hangisi sınanmıştır?

a. Toprak ve su ne kadar çok güneş ışığı alırlarsa, o kadar ısınırlar.
b. Toprak ve su güneş altında ne kadar fazla kalırlarsa, o kadar çok ısınırlar.
c. Güneş farklı maddelari farklı derecelerde ısıtır.
d. Günün farklı saatlerinde güneşin ısısı da farklı olur.

13. Araştırmada aşağıdaki değişkenlerden hangisi kontrol edilmiştir?

a. Kovadaki suyun cinsi.
b. Toprak ve suyun sıcaklığı.
c. Kovalara koyulan maddenin türü.
d. Herbir kovanın güneş altında kalma süresi.

14. Araştırmada bağımlı değişken hangisidir?

a. Kovadaki suyun cinsi.
b. Toprak ve suyun sıcaklığı.
c. Kovalara koyulan maddenin türü.
d. Herbir kovanın güneş altında kalma süresi.

15. Araştırmada bağımsız değişken hangisidir?

a. Kovadaki suyun cinsi.
b. Toprak ve suyun sıcaklığı.
c. Kovalara koyulan maddenin türü.
d. Herbir kovanın güneş altında kalma süresi.

16. Can, yedi ayrı bahçedeki çimenleri biçmektedir. Çim biçme makinasıyla her hafta bir bahçedeki çimenleri biçer. Çimenlerin boyu bahçelere göre farklı olup bazılarında uzun bazılarında kısadır. Çimenlerin boyları ile ilgili hipotezler kurmaya başlar. Aşağıdakilerden hangisi sınanmaya uygun bir hipotezdir?

a. Hava sıcakken çim biçmek zordur.
b. Bahçeye atılan gübrenin miktarı önemlidir.
c. Daha çok sulanan bahçedeki çimenler daha uzun olur.
d. Bahçe ne kadar engebeliyse çimenleri kesmekte o kadar zor olur.

17, 18, 19 ve 20 nci soruları aşağıda verilen paragrafı okuyarak cevaplayınız.

Murat, suyun sıcaklığının, su içinde çözünebilecek şeker miktarını etkileyip etkilemediğini araştırmak ister. Birbirinin aynı dört bardağın herbirine 50 şer mililitre su koyar. Bardaklardan birisine 0 ^{0}C de, diğerine de sırayla 50 ^{0}C, 75 ^{0}C ve 95 ^{0}C sıcaklıkta su koyar. Daha sonra herbir bardağa çözünebileceği kadar şeker koyar ve karıştırır.

17. Bu araştırmada sınanan hipotez hangisidir?
a. Şeker ne kadar çok suda karıştırılırsa o kadar çok çözünür.
b. Ne kadar çok şeker çözünürse, su o kadar tatlı olur.
c. Sıcaklık ne kadar yüksek olursa, çözünen şekerin miktarı o kadar fazla olur.
d. Kullanılan suyun miktarı arttıkça sıcaklığı da artar.

18. Bu araştırmada kontrol edilebilen değişken hangisidir?
a. Her bardakta çözünen şeker miktarı.
b. Her bardağa konulan su miktarı.
c. Bardakların sayısı.
d. Suyun sıcaklığı.

19. Araştımanın bağımlı değişkeni hangisidir?
a. Her bardakta çözünen şeker miktarı.
b. Her bardağa konulan su miktarı.
c. Bardakların sayısı.
d. Suyun sıcaklığı.

20. Araştırmadaki bağımsız değişken hangisidir?
a. Her bardakta çözünen şeker miktarı.
b. Her bardağa konulan su miktarı.
c. Bardakların sayısı.
d. Suyun sıcaklığı.

21. Bir bahçıvan domates üretimini artırmak istemektedir. Değişik birkaç alana domates tohumu eker. Hipotezi, tohumlar ne kadar çok sulanırsa, o kadar çabuk filizleneceğidir. Bu hipotezi nasıl sınar?
a. Farklı miktarlarda sulanan tohumların kaç günde filizleneceğine bakar.
b. Her sulamadan bir gün sonra domates bitkisinin boyunu ölçer.
c. Farklı alanlardaki bitkilere verilen su miktarını ölçer.
d. Her alana ektiği tohum sayısına bakar.

22. Bir bahçıvan tarlasındaki kabaklarda yaprak bitleri görür. Bu bitleri yok etmek gereklidir. Kardeşi "Kling" adlı tozun en iyi böcek ilacı olduğunu söyler. Tarım uzmanları ise "Acar" adlı spreyin daha etkili olduğunu söylemektedir. Bahçıvan altı tane kabak bitkisi seçer. Üç tanesini tozla, üç tanesini de spreyle ilaçlar. Bir hafta sonra her bitkinin üzerinde kalan canlı bitleri sayar. Bu çalışmada böcek ilaçlarının etkinliği nasıl ölçülür?
a. Kullanılan toz ya da spreyin miktarı ölçülür.
b. Toz ya da spreyle ilaçlandıktan sonra bitkilerin durumları tespit edilir.
c. Her fidede oluşan kabağın ağırlığı ölçülür.
d. Bitkilerin üzerinde kalan bitler sayılır.

23. Ebru, bir alevin belli bir zaman süresi içinde meydana getireceği ısı enerjisi miktarını ölçmek ister. Bir kabın içine bir litre soğuk su koyar ve 10 dakika süreyle ısıtır. Ebru, alevin meydana getirdiği ısı enerjisini nasıl ölçer?

a. 10 dakika sonra suyun sıcaklığında meydana gelen değişmeyi kayeder.

b. 10 dakika sonra suyun hacminde meydana gelen değişmeyi ölçer.

c. 10 dakika sonra alevin sıcaklığını ölçer.

d. Bir litre suyun kaynaması için geçen zamanı ölçer.

24. Ahmet, buz parçacıklarının erime süresini etkileyen faktörleri merak etmektedir. Buz parçalarının büyüklüğü, odanın sıcaklığı ve buz parçalarının şekli gibi faktörlerin erime süresini etkileyebileceğini düşünür. Daha sonra şu hipotezi sınamaya karar verir: Buz parçalarının şekli erime süresini etkiler. Ahmet bu hipotezi sınamak için aşağıdaki deney tasarımlarının hangisini uygulamalıdır?

a. Herbiri farklı şekil ve ağırlıkta beş buz parçası alınır. Bunlar aynı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

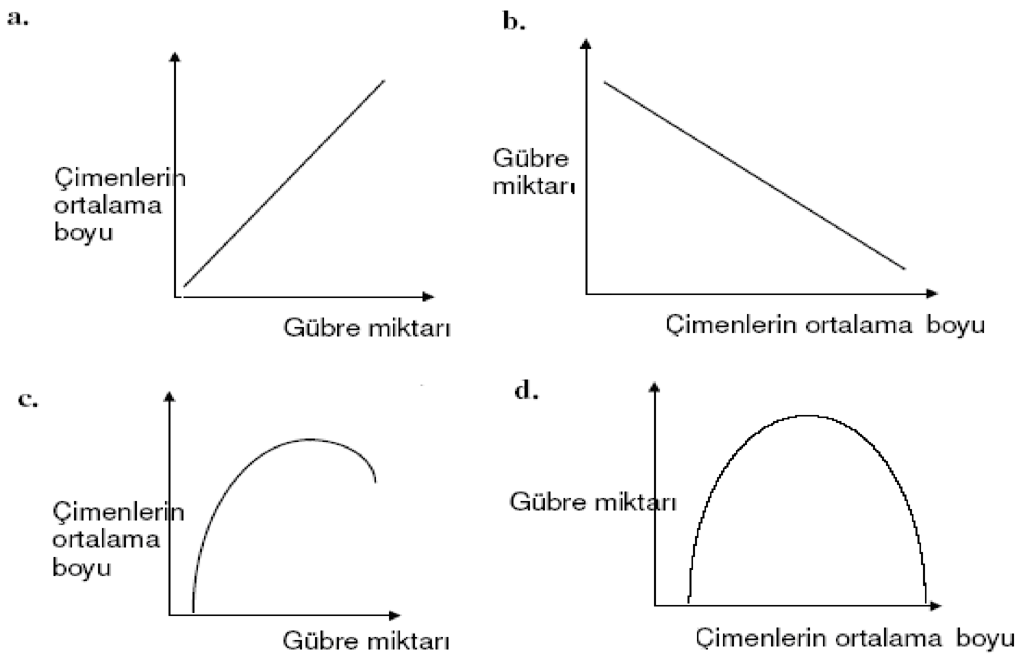
b. Herbiri aynı şekilde fakat farklı ağırlıkta beş buz parçası alınır. Bunlar aynı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

c. Herbiri aynı ağırlıkta fakat farklı şekillerde beş buz parçası alınır. Bunlar aynı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

d. Herbiri aynı ağırlıkta fakat farklı şekillerde beş buz parçası alınır. Bunlar farklı sıcaklıkta benzer beş kabın içine ayrı ayrı konur ve erime süreleri izlenir.

25. Bir araştırmacı yeni bir gübreyi denemektedir. Çalışmalarını aynı büyüklükte beş tarlada yapar. Her tarlaya yeni gübresinden değişik miktarlarda karıştırır. Bir ay sonra, her tarlada yetişen çimenin ortalama boyunu ölçer. Ölçüm sonuçları aşağıdaki tabloda verilmiştir.

Gübre miktarı (kg)	Çimenlerin ortalama boyu (cm)
10	7
30	10
50	12
80	14
100	12



26. Bir biyolog şu hipotezi test etmek ister: Farelere ne kadar çok vitamin verilirse o kadar hızlı büyürler. Biyolog farelerin büyüme hızını nasıl ölçebilir?

a. Farelerin hızını ölçer.

b. Farelerin, günlük uyumadan durabildikleri süreyi ölçer.

c. Hergün fareleri tartar.

d. Hergün farelerin yiyeceği vitaminleri tartar.

27. Öğrenciler, şekerin suda çözünme süresini etkileyebilecek değişkenleri düşünmektedirler. Suyun sıcaklığını, şekerin ve suyun miktarlarını değişken olarak saptarlar. Öğrenciler, şekerin suda çözünme süresini aşağıdaki hipotezlerden hangisiyle sınayabilir?

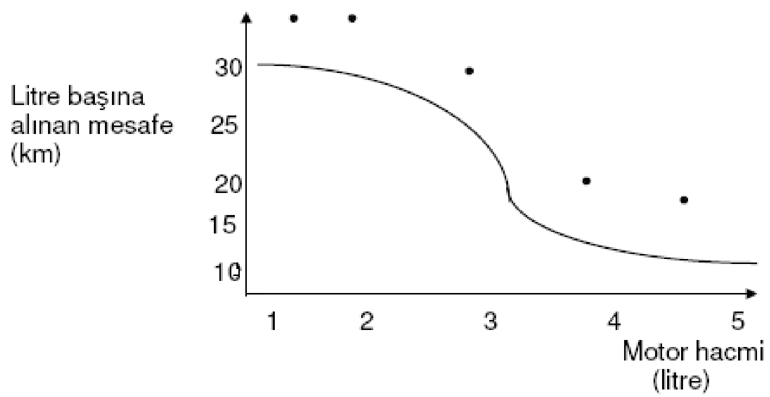
a. Daha fazla şekeri çözmek için daha fazla su gereklidir.

b. Su soğudukça, şekeri çözebilmek için daha fazla karıştırmak gerekir.

c. Su ne kadar sıcaksa, o kadar çok şeker çözünecektir.

d. Su ısındıkça şeker daha uzun sürede çözünür.

28. Bir araştıma grubu, değişik hacimli motorları olan arabaların randımanlarını ölçer. Elde edilen sonuçların grafiği aşağıdaki gibidir:



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi gösterir?

a. Motor ne kadar büyükse, bir litre benzinle gidilen mesafe de o kadar uzun olur.

b. Bir litre benzinle gidilen mesafe ne kadar az olursa, arabanın motoru o kadar küçük demektir.

c. Motor küçüldükçe, arabanın bir litre benzinle gidilen mesafe artar.

d. Bir litre benzinle gidilen mesafe ne kadar uzun olursa, arabanın motoru o kadar büyük demektir.

29, 30, 31 ve 32 nci soruları aşağıda verilen paragrafı okuyarak cevaplayınız.

Toprağa karıştırılan yaprakların domates üretimine etkisi araştırılmaktadır. Araştırmada dört büyük saksıya aynı miktarda ve tipte toprak konulmuştur. Fakat birinci saksıdaki toprağa 15 kg., ikinciye 10 kg., üçüncüye ise 5 kg. çürümüş yaprak karıştırılmıştır. Dördüncü saksıdaki toprağa ise hiç çürümüş yaprak karıştırılmamıştır. Daha sonra bu saksılara domates ekilmiştir. Bütün saksılar güneşe konmuş ve aynı miktarda sulanmıştır. Her saksıdan elde edilen domates tartılmış ve kaydedilmiştir.

29. Bu araştırmada sınanan hipotez hangisidir?

a. Bitkiler güneşten ne kadar çok ışık alırlarsa, o kadar fazla domates verirler.
b. Saksılar ne kadar büyük olursa, karıştırılan yaprak miktarı o kadar fazla olur.
c. Saksılar ne kadar çok sulanırsa, içlerindeki yapraklar o kadar çabuk çürür.
d. Toprağa ne kadar çok çürük yaprak karıştırılırsa, o kadar fazla domates elde edilir.

30. Bu araştırmada kontrol edilen değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı
b. Saksılara karıştırılan yaprak miktarı.
c. Saksılardaki toprak miktarı.
d. Çürümüş yapak karıştırılan saksı sayısı.

31. Araştırmadaki bağımlı değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı
b. Saksılara karıştırılan yaprak miktarı.
c. Saksılardaki toprak miktarı.
d. Çürümüş yapak karıştırılan saksı sayısı.

32. Araştırmadaki bağımsız değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

33. Bir öğrenci mınatısların kaldırma yeteneklerini araştırmaktadır. Çeşitli boylarda ve şekillerde birkaç mıknatıs alır ve her mıknatısın çektiği demir tozlarını tartar. Bu çalışmada mıknatısın kaldırma yeteneği nasıl tanımlanır?

a. Kullanılan mıknatısın büyüklüğü ile.

b. Demir tozlarını çeken mıknatısın ağırlığı ile.

c. Kullanılan mıknatısın şekli ile.

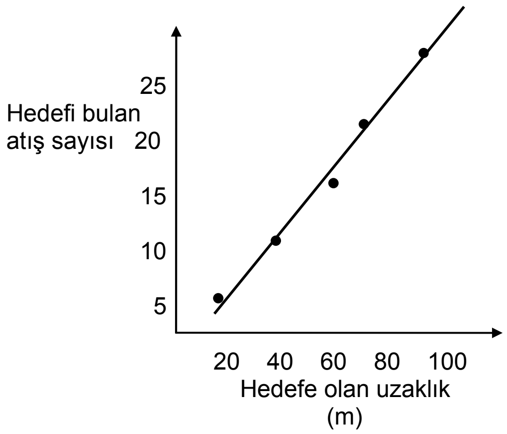
d. Çekilen demir tozlarının ağırlığı ile.

34. Bir hedefe çeşitli mesafelerden 25 er atış yapılır. Her mesafeden yapılan 25 atıştan hedefe isabet edenler aşağıdaki tabloda gösterilmiştir.

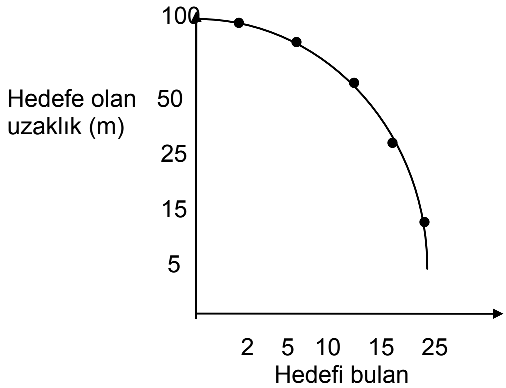
Mesafe (m)	Hedefe vuran atış sayısı
5	25
15	10
25	10
50	5
100	2

Aşağıdaki grafiklerden hangisi verilen bu verileri en iyi şekilde yansıtır?

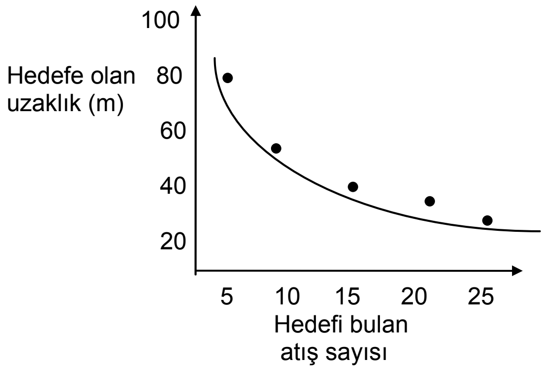
a.



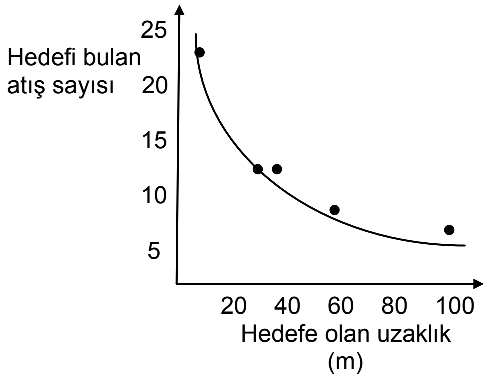
b.



c.



d.



35. Sibel, akvaryumdaki balıkların bazen çok haraketli bazen ise durgun olduklarını gözler. Balıkların hareketliliğini etkileyen faktörleri merak eder. Balıkların hareketliliğini etkileyen faktörleri hangi hipotezle sınayabilir?

a. Balıklara ne kadar çok yem verilirse, o kadar çok yeme ihtiyaçları vardır.
b. Balıklar ne kadar hareketli olursa o kadar çok yeme ihtiyaçları vardır.
c. Su da ne kadar çok oksijen varsa, balıklar o kadar iri olur.
d. Akvaryum ne kadar çok ışık alırsa, balıklar o kadar hareketli olur.

36. Murat Bey'in evinde birçok elektrikli alet vardır. Fazla gelen elektrik faturaları dikkatini çeker. Kullanılan elektrik miktarını etkileyen faktörleri araştırmaya karar verir. Aşağıdaki değişkenlerden hangisi kullanılan elektrik enerjisi miktarını etkileyebilir?

a. TV nin açık kaldığı süre.
b. Elektrik sayacının yeri.
c. Çamaşır makinesinin kullanma sıklığı.
d. a ve c.

APPENDIX G

CHEMICAL LITERCY ITEMS

KOMBİ KİMYASI

Yukarıda 3 Ocak 2009 tarihinde tirajı yüksek bir gazetenin manşeti verilmiştir. Ankara’da yılbaşı gecesi yedi gencin ölümüyle sonuçlanan olaya kombinin neden olduğu açıklandı.

Kombiler çalışma prensibine göre bacalı, hermetik ve yoğuşmalı olmak üzere üçe ayrılırlar.

Bacalı kombi ile hermetik kombi arasındaki fark nedir?

Bacalı kombilerde fan yoktur. Atık gaz, sıcaklığından dolayı genleşerek yükselir, *tabii bir çekim* ve baca vasıtasıyla dış ortama atılır. Bu nedenle bacalı kombi cihazları standartlara uygun yapılmış bir bina bacasına bağlanmalıdır. Aksi takdirde bacadan sızan atık gaz ortamdaki kişileri zehirler. Hermetik kombi ise fanlıdır. Atık gaz fan ile iç borudan dış ortama zorunlu olarak atılırken, dış borudan da yanma için gereken havayı yanma odasına çeker. Bu nedenle hermetik kombi cihazlarının bina bacasına ihtiyacı yoktur, evin dış ortama açılabilen herhangi bir mekânına monte edilebilirler. Ortamdaki havayı tüketmezler ve baca çekiş problemi olmadığı için ortamdaki havayı kirletmezler.

Kombiler doğal gazın yanmasından açığa çıkan ısıyı kullanırlar. Doğal gazın yaklaşık % 95 ini metan (CH_4) oluşturur; bunun dışında, etan (C_2H_6), propan (C_3H_8), bütan (C_4H_{10}) gibi diğer hidrokarbonlar da doğal gazın bileşenleridir.

Kombilerin ısı odasında gerçekleşen yanma tepkimesinin bir ürünü de su buharıdır ($H_2O_{(g)}$).

$$CH_{4\,(g)} + \ldots\ldots\ldots \rightarrow \ldots\ldots\ldots + 2\,H_2O_{(g)} \qquad \Delta H = \ldots\ldots$$

a) Yukarıdaki tepkimede eksik yerleri doldurunuz, reaksiyon ısısının işaretini yazınız.

b) Kombiler nasıl sistemlerdir? Sebebiyle açıklayınız (açık, kapalı, izole, vs.).

c) 1 mol CH_4 ün yanmasından 212 kcal ısı açığa çıkıyorsa 256 g oksijen kullanıldığında kaç kcal ısı açığa çıkar? Tepkime endotermik mi, ekzotermik midir? (O_2 = 32g/mol)

d) CH_4 kullanımının diğer hidrokarbonlara oranla daha avantajlı olduğu bilinmektedir. Sizce bu avantajlar neler olabilir?

e) Oksijenin yetersiz olduğu durumlarda yanma tepkimesi tam anlamıyla gerçekleşemez, yanma tepkimesi tam gerçekleşemediğinde ürünlerden biri olan karbon dioksit (CO_2) yerine daha çok karbon monoksit (CO) oluştuğu biliniyor. Karbon monoksit ise konsantrasyonu normalin üstüne çıktığında insanları zehirlemektedir. Bu ve parçada geçen bilgiler ışığında gazetede anlatılan ölüm nedenini daha bilimsel bir dille açıklayınız (Facianın yaşandığı evde bacalı kombi kullanılmaktaydı).

f) Parçada geçen " *tabii bir çekim*" ifadesini bilimsel bir dille açıklayınız.

g) Mersin' in Tarsus ilçesine bu sene ilk kez doğal gaz alt yapısı kullanıma hazır hale gelmiştir. Mustafa Bey evine kombi taktırmak istemektedir. Mustafa Bey'e hangi tip kombiyi neden önerirsiniz? Kanıtlarınızla açıklayınız.(Yoğuşmalı ve hermetik kombi benzer özelliklerdedir).

h) Arkadaşınız bacalı kombisi olan bir evde yaşamak zorundadır, böyle bir faciadan korunmak adına arkadaşınıza neler önerirsiniz?

SAĞLIKLI YAŞAM KİMYASI

11-K sınıfındaki Ahmet'in kilo problemi olduğu için diyetisyene gitmişti. Diyetisyen ergenlik dönemine ait enerji ihtiyacını saptamak için kullandığı tablodaki bilgileri Ahmet'le paylaştı.

Ergenlik çağındaki gençlerin enerji ihtiyacının hesaplanması

*Bazal Metabolizma Hızı, ** Vücut Ağırlığı ***Fiziksel aktivite standardı

YAŞ (Yıl)	ERKEK (kkal/gün)	KADIN (kkal/gün)
10-12	36.5* x A** x 1.75***	33.0* x A** x 1.64***
12-14	32.5x A x 1.78	28.5 x A x 1.55
14-16	29.5 x A x 1.60	26.5 x A x 1.55
16-18	27.5 x A x 1.60	25.5 x A x 1.53

Örneğin:
14 Yaşında 55 kg erkek bir ergenin günlük enerji ihtiyacı = 32,5 x 55 x 1,78 = 3182 kkal/gün

a) Ahmet'in günlük enerji ihtiyacı nedir? (Ahmet 17 yaşında, 80 kg ağırlığındadır)

b) Günlük ihtiyacından 2000 kkal fazla enerji tüketen Ahmet bu miktar enerjiyi 50 kg lık kütle kaldırarak harcamak istemektedir. Bu enerjiyi harcayabilmek için Ahmet bu kütleyi kaç defa kaldırmalıdır? (Her seferinde 2 m kaldırdığını ve ağırlığı aşağı indirirken iş yapılmadığını farz ediniz, g = 10 m/s^2 , 1 Kcal = 1000 cal, 1 cal = 4,18 J dür).

Biyolojik sistemler genellikle kendiliğinden gerçekleşen bir tepkimenin tetiklemesi ile kendiliğinden gerçekleşmeyen bir tepkimeyi tetikler. Bu reaksiyonlara birleştirilmiş (*coupled*) reaksiyonlar denir. Kendiliğinden gerçekleşmeyen çoğu tepkimeyi başlatmak için gereken enerji yiyeceklerin kimyasal değişimi (metabolizma) ile sağlanır. Örnek: şekerin oksitlenmesi

$$C_6H_{12}O_6(k) + 6O_2(g) \rightarrow 6CO_2(g) + 6H_2O(s) \qquad \Delta G = -2880 \text{ kJ.}$$

Açığa çıkan bu serbest enerji, adenozin iki fosfatın (ADP), bir fosfat daha bağlanarak adenozin üç fosfata (ATP) dönüşmesine katkıda bulunur.

Kimya dersinde bağ oluşumlarını ısı açığa çıkaran, bağ kırılmalarını ise ısıalan tepkimeler olarak sınıflandırdığımızı hatırlayalım.

c) Parçada anlatılanlar ve kimya bilgileriniz ışığında ATP → ADP, ADP → ATP dönüşümlerini bağ oluşumu, bağ kırılması şeklinde sınıflandırarak hangisinde enerji açığa çıktığını hangisinde enerji gerektiğini sebepleriyle açıklayınız?

d) Kilo almaması için Ahmet' e yukarıdaki bilgiler çerçevesinde kanıtlar bularak beslenme-aktivite konularında neler önerirsiniz?

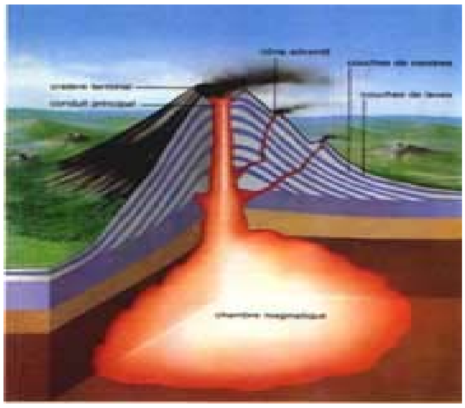
DÜZENLİ Mİ, DÜZENSİZ Mİ?

Çeşitli amaçlarla günlük hayatımızda kullandığımız paket lastikleri elastik polimerlerdir. Herhangi bir elastik paket lastiğini gerdirdiğimizde, şekilde görüldüğü gibi, moleküller ilk duruma göre daha düzenli duruma gelir. Bir paket lastiğini şekildeki gibi gerdirdiğinizi düşününüz,

a) Sistemin (paket lastiğinin) entropisi artar mı? Azalır mı? Nedeni ile açıklayınız.

b) Paket lastiğini izotermal olarak gerdirmek istiyorsunuz, sıcaklığın değişmemesi için sistemin ısı alması mı yoksa vermesi mi gerekiyor? Açıklayınız (İpucu: izotermal işlem için $\Delta S_{sistem} = q_{sistem} / T$ olduğunu hatırlayınız).

VOLKANİK PATLAMA ve KİMYA TERİMLERİ

2010 yılında İzlanda’daki yanardağ patlamasını hepimiz hatırlıyoruz. Bir yanardağ (ya da volkan), magmanın (Dünya'nın iç tabakalarında bulunan, yüksek basınç ve yüksek sıcaklıkta erimiş kayalar) yeryuvarlağının yüzeyinden dışarı püskürerek çıktığı coğrafi yer şekilleridir.

Aşağıdaki boşlukları uygun kelimelerle doldurunuz.

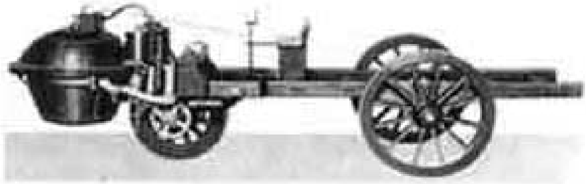
Yanar dağ ……………… sistemdir çünkü madde ve …………… çıkışı vardır. Sistemden çevreye ………….. akışı olduğundan bu değişim ………………….. tir. Sistemin iç enerjisinin ………………… nedeni sistemin iş yapıp, çevreye ısı vermesindendir. Evrenin toplam enerjisi sabit olsa da …………………. artmaktadır çünkü bu patlama istemlidir. İstemli olaylarda …………………………. enerjisinin işareti negatiftir. $\Delta G = \Delta H - T\Delta S$ formülü olaydaki enerji dönüşümlerini özetler.

Sizce parçada termodinamiğin değinilen ve değinilmeyen yasaları hangileridir? ……………………………………………………………………………………… ……………………………………………………………………………………… ………………

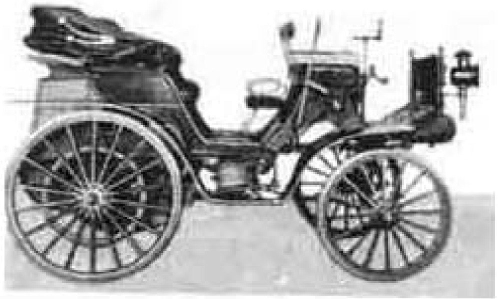
APPENDIX H

SAMPLE LESSON PLAN I

OTOMOTİV: GECMİSTEN GÜNÜMÜZE



1770. Cugnot'nun buharlı arabası



1895. Daimler

1962. Kabriyole Peugeot 404

Tarih boyunca her zaman ihtiyaçlar, yeni buluşları ortaya koydu. Binek hayvanlarının kullanımını kolaylaştıran at arabaları zamanla ihtiyaçları gidermede yetersiz kaldı ve daha iyiye ulaşma çabasıyla ilk bisiklet yapıldı. İki tekerlekli bisikletten sonra, hızla üçtekerliye geçildi. Sanayi Devrimi ile her alanda makine kullanımı yaygınlaştı, yeni buluşlar yapıldı.

Buhar gücü kullanılmaya başlandı ve ilk olarak buhar gücüyle kullanılan makineler yapıldı. Bu makineler, tekerli arabalara uygulandı. İlk buharlı araba, 1770 yılında Cugnot tarafından yapıldı. Böylece otomobilin icadında ilk adım atılmış oldu. Ardından da hızla motorlu taşıtlara geçildi. Böylece hız kazanan teknoloji, insanları da beraberinde götürmüş, artık onlara da hız kazandırmıştı. Hızlanan çalışmalar sonucu ilk motorlu taşıt 1885 yılında Alman Karl Benz tarafından yapıldı. Yaklaşık bir yıl sonra Gottlieb Daimler motoru atlı arabalara monte etti.

Ulaşılan bu sonuçlardan sonra çalışmalar hızlanmıştı ve klasik tip araba icadı fazla gecikmedi. 1891 yılında, Fransız Rene Levassor bilinen ilk klasik tip arabayı icat etti. Her an etrafımızda görebildiğimiz bu araçlara insanlar o dönemde o kadar yabancılardı ki, önden giden bir kişi elinde bayrak sallayarak taşıta yol açıyordu. 1908'de Henry Ford'un fazla para kazanamayanların bile otomobil satın alabilmesini sağladı. Ford'un başarısının gizi "zincirleme üretim" deydi. Çok sayıda otomobil yapmak için büyük insan ekiplerini sistemli biçimde çalıştırmaktaydı.

19. yüzyılın sonlarında insanların hayatına giren otomobil, 20.yy ile birlikte insan hayatının bir parçası olmuştu. 1900'lü yıllara gelindiğinde arabalar artık insanların zevklerine hitap etmeye başlamıştı. Genellikle siyah renkte üretilen otomobiller önce çeşitli renklere büründü, 1960'lı yıllarla birlikte ise adeta gücü simgeleyen büyük arabalar üretilmeye başlandı. İlk otomobillerin üretim aşamasında karşımıza çıkan modeller ile otomobil çeşitlerinin artmasıyla karşımıza çıkan modeller arasındaki fark, yapılan çalışmaların hızını ve verilen önemi anlatıyor.


Hayatımızın bir parçası haline gelmiş arabalardaki KİMYA uygulamalarını biliyor musunuz?

Referanslar:

1 http://www.teknoalem.org/otomobillerin-teknolojik-gelisimi-arabanin-tarihi.html

2. www.obitet.gazi.edu.tr/download/Otomotiv_Sekturu_io.doc

1. Merak Uyandırma Aşaması (Excite)

Öğretmen derse girer, elindeki araç gereci masanın üzerine koyarak, öğrencileri selamlar. Geçen dersi özetletir. Okuma parçası olarak dağıttığı metni okuyup okumadıklarını sorgular, birkaç öğrenciye sorular yönlendirerek metnin anlattıkları hatırlatılır. Öğretmen sınıf mevcuduna dikkat ederek öğrencilerden yanlarındaki arkadaşları ile 2-3 kişilik gruplar oluşturmasını ister.

Öğretmen öğrencilere benzinli araba motorlarının nasıl çalıştığını sorar, öğrencilerin fikirleri alındıktan sonra, araba motorunun çalışma sistemini gösteren bir animasyon videoyu öğrencilere izletir.

http://www.nasilbilgi.com/araba/araba-motoru-calisma-sistemi-animasyon-video/

Öğrencilerin varsa soruları yanıtlandıktan sonra öğretmen aşağıdaki şekli açar ve sınıftakilere sorular yönlendirir, kısaca cevaplarını alır ve bu dersin sonunda bu soruların cevaplarını bulacaklarını belirtir.

a. Sistem ve ortam kavramlarını tarif ediniz

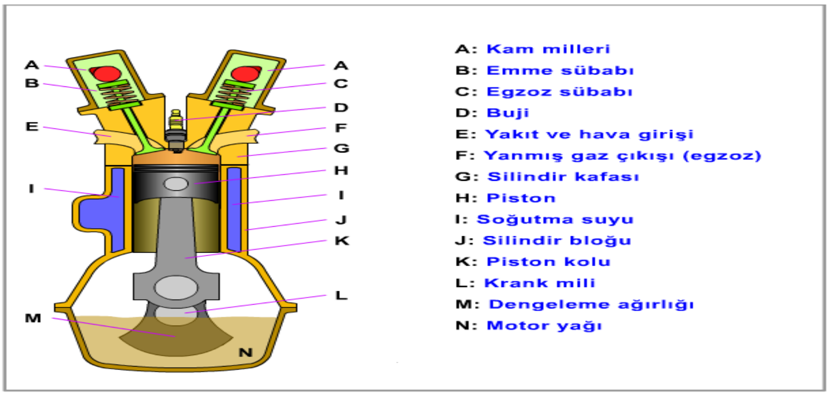
b. Araba motorları nasıl sistemlerdir? (Açık, Kapalı, İzole, Sabit basınçlı)

c. Motorda gerçekleşen enerji dönüşümleri nelerdir?

d. Motorda gerçekleşen olayları endotermik ve ekzotermik olması bakımından tartışınız

e. Sistem mi iş yapmaktadır, sistemin üstüne mi iş yapılmaktadır?

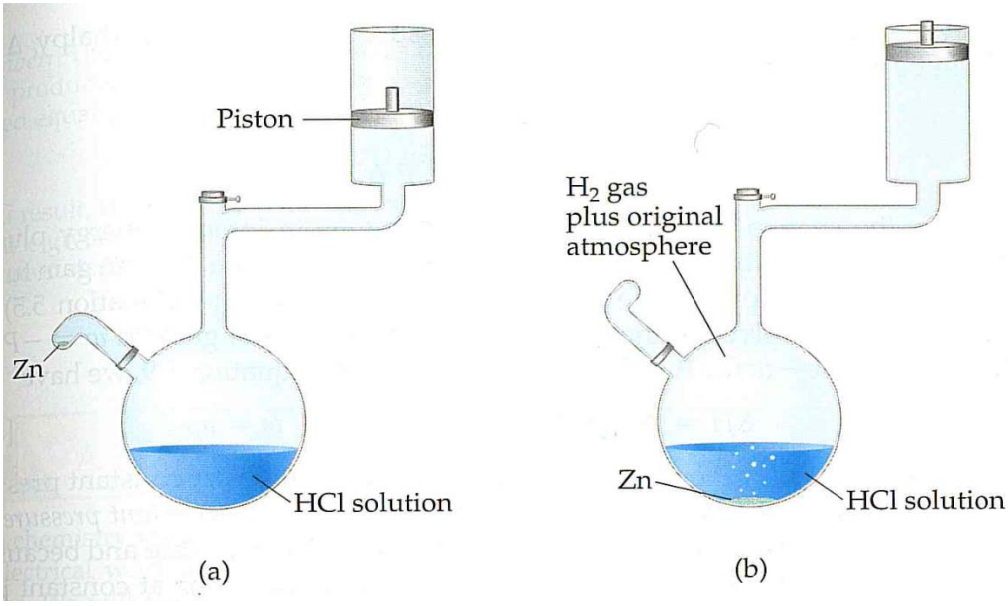
f. Motorun iç enerjisini, ısı enerjisini ve yaptığı işi artma ve azalma yönünden tartışınız



Bir benzinli araba motorunun kesiti ve çalışma prensibi

2. Araştırma Aşaması (Explore)

Öğretmen aşağıdaki deney düzeneklerini sırası ile en ön sıranın üzerine kurar.



Öğrencilerin yukarıdaki sorulara cevap bulabilmeleri için izlenilen animasyondan ve yukarıdaki deney düzeneğinden yola çıkılarak sorulara yanıt aramaları sağlanır.

a. Öncelikle (a) düzeneği kurulur. "Zn katısını HCl çözeltisine eklersek ne olur?" sorusunu öğrencilere yönlendirir. Öğrencilerin muhtemel cevapları dinlenir. ***(Zn katısı HCl çözeltisi ile ile reaksiyona girer ve H_2 gazı açığa çıkar, Oluşan gaz pistonun yukarı doğru hareket etmesine neden olur).***

b. Öğretmen katı Zn yi çözeltiye ekler ve değişimleri gözlemlemeleri istenir (b düzeneği kurulur). Daha sonra öğrencilere;

1. ***Piston neden yukarı doğru hareket etmektedir?***
2. ***Bu düzenekte Sistem mi Ortam mı iş yapmaktadır?***
3. ***Yapılan iş kime karşı yapılmaktadır?***

Sorularını yönlendirilir. Buna göre öğrencilerin muhtemel cevapları alınır. ***(Reaksiyon kabının basıncının sabit kalabilmesi için sistem yani H_2 ortam üzerine iş yapmaktadır. Bu iş açık hava basıncına karşı yapılmaktadır).***

Bunun üzerine öğretmen öğrencilere yapılan ***işin büyüklüğünün nelere bağlı*** olduğunu, ***piston daha yukarı hareket ederse yapılan iş nasıl etkilenir*** sorularını sorar. Öğrencilerin muhtemel hipotezler (tahminleri) şunlardır. ***Piston daha yukarı hareket ederse iş artar/azalır.*** Öğretmen ***reaksiyondan daha fazla H_2 gazı açığa çıkarsa yapılan iş nasıl değişir?*** diye sorar. Öğrencilerin muhtemel hipotezler (tahminleri) şunlardır. ***Daha fazla gaz çıkışı yapılan işi artırır/azaltır.***

Öğretmen Asit çözeltisine biraz daha Çinko parçacıkları ekleyerek, öğrencilerin hipotezlerine yanıt aramalarını ister.

3. Açıklama Aşaması (Explain)

Öğretmen her gruba "Reaksiyondan daha fazla H_2 gazı çıkmasının işi nasıl etkilediğini sorar?" ve "bu sonuç sizin kurduğunuz hipotezle aynı mıdır?" diye sorar. Öğrencilerden ***"Daha fazla H_2 gazı çıkması pistona daha çok basınç yapılması demektir, bu basınç pistonu daha fazla yukarı hareket ettirerek tepkime kabının basıncını sabit tutmaya çalışır"*** demeleri beklenir.

Öğretmen yapılan işin büyüklüğü pistonun hareket ettiği yüksekliğe ve pistona etkiyen kuvvete bağlı olduğunu doğrular aşağıdaki denklemleri kullanarak açıklamalarda bulunur.

Hareketli pistonun kesit alanını A ise, F büyüklüğünde aşağı doğru bir kuvvet pistona etki eder. Birim alana etki eden basınç , $P = F / A$ olduğu ifade edilir

Silindir içindeki H_2 gazının pistonu Δh kadar yukarı kaldırdığını kanaati ile,

İşin Büyüklüğü = Kuvvet X Yükseklik= F X Δh ve F yerine P X A ,Δh yerinede ΔV yazıldığında

İşin Büyüklüğü = F X Δh = P X A X Δh = P X ΔV olduğu öğrencilerce açıklanır.

Sistem ortamın üzerine iş yaptığı için işin işaretinin negatif ve büyüklüğünün

$w = - P \Delta V$ olduğu, Eğer sadece P-V işi yapılıyorsa, ΔU = Sistemin iç enerji değişiminin **= $q + w = q - P \Delta V$** olduğu konuşulur

Termodinamiğin birinci yasası iç enerji değişiminin ısı ve iş değişimi ile olan ilişkisini verir (Araba motorunda gerçekleşen dönüşümleri birinci yasa ile ilişkilendirerek değerlendirilir).

Reaksiyon sabit hacimde gerçekleşseydi, $\mathbf{\Delta U = q_v}$ (sabit basınç) olduğu

Çoğu reaksiyonun sabit hacimde gerçekleştiği, bu durumda $\mathbf{\Delta U = q_p - P \ \Delta V}$ **veya**

$\mathbf{q_p = \Delta E + P \ \Delta V}$ **(sabit basınç)** olduğu, sabit basınçtaki ısı değişimine ise ***Entalpi*** denildiği ve ***ΔH*** ile gösterildiği ($\mathbf{q_p = \Delta H}$) açıklanır.

Özetle, öğretmen **iç enerji** değişiminin sabit hacimdeki kazanılan ya da kaybedilen ısı ölçümü olduğunu, **entalpi** değişiminin ise sabit basınçtaki kazanılan ya da kaybedilen ısı ölçümü olduğunu açıklar. Sabit basınçtaki **ΔE** ve **ΔH** arasındaki fark yapılan P - ΔV işini verdiği, pek çok tepkimedeki hacim değişiminin sıfıra yakın olduğu bu nedenle **ΔU** ve **ΔH** arasındaki farkın küçük olduğu söylenir**.** Bu nedenle genellikle tepkimelerin enerji değişiminin **ΔH** kullanılarak ifade edildiği söylenir.

4. Genişletme Aşaması (Extend)

Bu aşamada öğrenciler kapalı- izotermal gibi başka sistem tipleri ile ilgili animasyon video izleyecekler ve araba gibi diğer motorlu araçların motorlarında gerçekleşen olayları **kimyasal reaksiyonlar ve enerji**, **iş, sistem, iç enerji, açık-kapalı-izole-izotermal sistem,** kavramları bakımından bu sistem üzerinde tartışırlar, benzeri farklı sistem türlerine örnekler bulurlar (Örnek; Jeneratörler). Öğretmen öğrencilere motorda benzin yerine başka bir madde kullanılması durumunu sorar, öğrenciler gruplar halinde kullanabilecek yakıtların özellikleri hakkında fikirlerini yazarlar. Öğretmen bir sonraki derste işlenecek olan kimyasal reaksiyonlarda entalpi değişimi, oluşum entalpileri, ara basamakların entalpi değişimleri, bağ oluşum ve kırılım enerjileri gibi konulara alt yapıyı hazırlamış olur.

5. Değerlendirme Aşaması (Evaluate)

1. Sistem ve Ortam kavramlarını tarif ediniz

2. Araba motorları nasıl sistemlerdir? (Açık, Kapalı, İzole, Sabit basınçlı)

3. Motorda gerçekleşen olayları endotermik ve ekzotermik olması bakımından tartışınız

4. Sistem mi iş yapmaktadır, sistemin üstüne mi iş yapılmaktadır?

5. Motorun iç enerjisini, ısı enerjisini ve yaptığı işi artma ve azalma yönünden tartışınız

6. Motorda gerçekleşen enerji dönüşümlerini söyleyiniz?

7. Pistonlar motorlu araçlarda araç yakıtını yakma ve hareketi sağlama görevini üstlenir. Bujilerin oluşturduğu kıvılcımların sebep olduğu patlama sonrası büyük bir enerji açığa çıkar ve bu enerji piston hareketi sağlar. Piston aşağıya doğru itilirken pistonun bağlantı çubukları ile bağlı olduğu krank şaftı döner. Bu dönme sonucu oluşan hareket tekerleklere iletilir. Benzindeki enerji hareket enerjisine çevrilmiş olur.

Benzer bir piston sisteminin içerisinde CO gazının yanma reaksiyonu aşağıdaki tepkimeye göre gerçekleştirilmektedir

$$2CO\ (g) + O_2(g) \rightarrow 2CO_2\ (g)$$

Oluşan bu reaksiyon sonucunda 563,5 kj kadar ısı açığa çıkarmaktadır ve sistem 194,3 kj iş yapmaktadır. Bu bilgiler ışığında, yanma reaksiyonunun sonucunda sistemde meydana gelen iç enerji değişimini hesaplayınız?

APPENDIX I

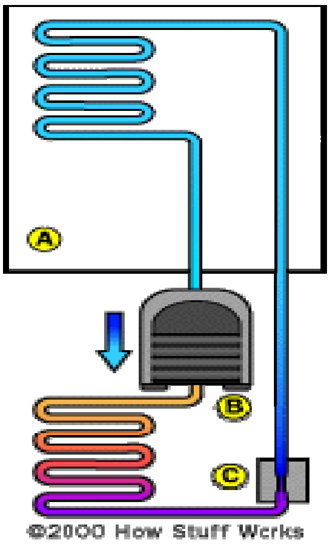
SAMPLE LESSON PLAN II

BUZDOLABI NASIL ÇALIŞIR?

Buzdolapları yiyeceklerin bozulmasını geciktirerek ömürlerini uzattığı için, yaşamımızı olumlu yönde değiştiren önemli icatlardandır.

Soğutma işlemi çevrelenmiş bir ortamdan veya maddeden ısının alınarak, sıcaklığının düşürülmesidir. Buzdolapları buharlaşan sıvıların ortamdan ısı alması prensibini kullanır. Bu sıvılar ya da soğutucular çok düşük sıcaklıklarda buharlaşarak buzdolabının içini dondurucu sıcaklıklarına düşürürler.

Genleşen gaz soğur ve yeterince soğuyan bazı gazlar sıvılaşır. Farklı sıcaklıktaki iki nesneyi birbirine yaklaştırırsanız ya da dokundurursanız sıcak olan soğur, soğuk olan ısınır. Bu iki yasa, bir buzdolabının nasıl soğuttuğunu açıklar. Bir buzdolabı, içinde dolasan gazı önce sıvılaştırır, sonra sıvının ısısını soğurur. Bu sayede de soğutur.



Buzdolabı, beş temel bölümden oluşur sıkıştırıcı (kompresör), buzdolabının dış arka bölümünde bulunan ve ısıyı değiştiren kıvrımlı borular, bir tarafında yüksek basınç alanı, diğer tarafında düşük basınç alanı bulunan bir delik olan genişletme valfı, buzdolabının içinde bulunan ve ısıyı değiştiren kıvrımlı borular, sıvı haldeyken buharlaşarak soğutmayı sağlayan gaz. Bu bölümlerin temel işleyişi şöyle,

Bir buzdolabının yapısı

A) Buzdolabının içi
B) Sıkıştırıcı
C) Genişletme valfı

Sıkıştırıcı (B), soğutucu gazı sıkıştırır. Bu sıkıştırma, gazın basıncını ve sıcaklığını artırır. Böylece buzdolabının dışındaki ısı değiştirme boruları, soğutucunun sıkışmasıyla oluşan ısının dışarıya bırakılmasını sağlar (turuncu bölge). Soğuyan gaz sıvılaşır ve genişletme valfına akar (C). Sıvı, genişletme valfına aktığında, yüksek basınç bölgesinden düşük basınç bölgesine doğru bir hareket oluşmasına neden olur. Böylece genişler ve buharlaşır. Buharlaşma sırasında sıvı ısıyı soğurur ve ortamı soğutur. Buzdolabının içindeki ısı değiştirme boruları, soğutma maddesinin ısıyı soğurmasını sağlayarak buzdolabının içini soğutur. Bu döngü böylece devam eder.

- ***Buzdolabı motorlarından ortalama 15 dakikada bir ses gelmesinin nedeni ne olabilir?***
- ***Buzdolabında gerçekleşen olayları kimya bilgilerinizi dikkate alarak yorumlayınız?***
- ***İstemli- istemsiz değişim kavramlarını tarif ediniz, buzdolabının çalışmasından örnekler veriniz.***
- ***Enerji-entropi gibi kavramları tarif ediniz.***

1. **Merak Uyandırma Aşaması (Excite)**

Öğretmen derse girer, elindeki araç gereci masanın üzerine koyarak, öğrencileri selamlar. Geçen dersi özetletir. Araba motorlarının nasıl çalıştığına kimya açısından baktıklarını hatırlarlar, arabaların soğutma sistemlerinin nasıl çalıştığından yola çıkarak buzdolaplarının çalışma prensipleri üzerinden kimya konuşacaklarını söyler. Daha sonra öğrencilere ***soğutma sistemlerinin*** sağlığımız açısından önemini sorar. Öğrencilerin cevapları alındıktan sonra, Buzdolaplarının bu soğutma sistemlerinden biri olduğu vurgulanır ve bu sistemlerin nasıl çalıştığı hakkında önceki dersin sonunda verdiği okuma parçasını hatırlatır. Bir öğrenciden buzdolabının nasıl çalıştığını anlatmasını ister.
Daha sonra aşağıdaki animasyon video izlenir.

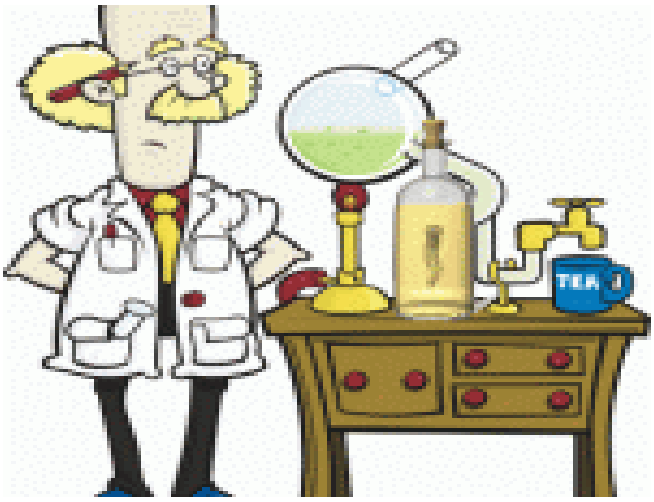
http://www.youtube.com/watch?v=mbCJ2Qy-how

Öğrencilerin varsa soruları yanıtlandıktan sonra öğretmen sınıftakilere sorular yönlendirir, kısaca cevaplarını alır ve bu dersin sonunda bu soruların cevaplarını bulacaklarını belirtir.

- Buzdolabındaki gazı kompresörde sıkıştırmak istemlimidir, istemsiz midir?
- Sıkıştırılmış gazın basıncının ve sıcaklığının artması istemlimidir istemsiz midir?
- Buzdolabının içinde ki borulardaki maddenin ısıyı soğurması istemlimidir, istemsiz midir?
- İstemli değişimde enerji artar mı azalır mı?
- İstemsiz bir değişimde enerji artar mı azalır mı?
- Oda sıcaklığında buz eridiğinde daha düzenli mi, daha düzensiz mi olur?

2. Araştırma Aşaması (Explore)

Öğretmen yanında getirdiği deney malzemelerini ön sıraya koyar ve öğrencilerin yaklaşmasını ister.



Bir miktar aseton ya da kolonya öğrencilerinin ellerine dökülür ve zamanla nasıl bir his yaşadıkları sorgulanır (ısınma, soğuma gibi). Öğrencilerin muhtemel cevapları "Soğuma hissi" dir.

Aseton (s) (**CH** $_3$COCH $_3$) → Aseton (g) (**CH** $_3$COCH $_3$)

Sıvı halden gaz haline geçiş olan bu fiziksel değişim ile ilgili olarak, öğretmen öğrencilere olayın kendiliğinden mi yoksa dışarıdan bir etki ile mi gerçekleştiğini sorar. Öğrencilerin muhtemel cevapları " ***Vücut sıcaklığında Aseton kendiliğinden buharlaştı***" dır.

Öğretmen yukarıdaki şekildeki gibi sıvı azotu beherin içerisindeki asetonun üzerine döker ve bu olay ile ilgili olarak,

a) *Oda sıcaklığında azot sıvıdan gaza geçince enerjisi nasıl değişir?*
b) *Oda sıcaklığında azotun sıvıdan gaza geçişi esnasında ortamın ısısı nasıl değişir?*
c) *Oda sıcaklığında azot sıvıdan gaza geçince moleküllerin farklı konumlarda bulunma ihtimalleri nasıl değişir?*
d) *Asetonun enerjisi nasıl değişir?*
e) *Aseton moleküllerinin farklı ortamlarda bulunma ihtimalleri nasıl değişir?*

Sorularını öğrencilere yönlendirir ve azotun normal donma noktasının -196 ^{0}C civarında olduğu hatırlatılır.

(a) İle ilgili olarak öğrencilerin muhtemel hipotezlerini (tahminleri) **"Azot sıvıdan gaza geçerken ortamdan ısısı artar/azalır"**

(b) İle ilgili olarak muhtemel hipotezler ***"Azot sıvıdan gaza geçince enerjisi artar/ azalır"***

(c) İle ilgili olarak muhtemel hipotezler ***"Azot sıvıdan gaza geçince enerjisi artar / azalır"***

(d) , (e) İle ilgili olarak ***"Asetonun enerji ve moleküllerin farklı ortamlarda bulunma ihtimali artar/ azalır"***

Öğrenciler behere hafifçe dokunarak ve deney sonucunda asetonun donduğunu gözlemleyerek, aşağıdaki sonuçlara;

- **Azot sıvıdan gaza geçerken ortamdan ısısı azalır**
- **Azot sıvıdan gaza geçince enerjisi artar**
- **Azot sıvıdan gaza geçince enerjisi artar**
- **Asetonun enerji azalır, düzensizliği artar**

Ulaşmaları beklenir.

3. Açıklama Aşaması (Explain)

Öğretmen istemlilik ve istemsizlik kavramları, tek yönlü basit tepkimelerde, (demirin paslanması gibi)

$$2\ Fe(s) \quad + \quad 3/2\ O_2\ (g) \quad \rightarrow \quad Fe_2O_3\ (s)$$

ok yönündeki olayın kendiliğinden yürümesi; ters yöndeki olayın özel önlemler alınmadıkça meydana gelmemesi şeklinde açıklamalara ulaşabilmeleri için öğrencilere sorular yönlendirir. İstemlilik ile minimum enerjiye yönelme eğilimi arasındaki paralelliği, incelenen örnek değişimlerle açıklamalarını ister

$$N_2\ (s) \quad \rightarrow \quad N_2\ (g)$$

Oda sıcaklığında yukarıdaki (sıvı azotun kaynaması) değişimin istemli olduğunu öğrenciler açıklar. Öğretmen öğrencilere buzdolabında benzeri (kaynama noktasının oldukça düşük) bir kimyasalın kullanıldığını hatırlatır, öğrencilerin sıvı azotun buharlaşmasını buzdolabında gerçekleşen olaya benzetmeleri sağlanır.

Öğretmen kuru bardağın içerisine bir parça buz koyar, başka bir bardağa biraz su koyar. Aşağıdaki değişim denklemlerini tahtaya yazar ve oda sıcaklığında bu değişimlerin yönünü sorar. Öğrencilerin istemliliğin sıcaklığa bağlı olduğunu fark etmelerini sağlar.

H_2O (k) → H_2O (s) $T > 0\ ^0C$ için **istemli**

H_2O (s) → H_2O (k) $T < 0\ ^0C$ için **istemli**

Öğretmen ayrıca istemli tepkimelerin/ değişimlerin çoğu zaman ekzotermik olduğunu ancak istemli olduğu deneyimlerle bilinen endotermik tepkimelerin/değişimlerin olduğunu örnekler vererek, örnekler isteyerek öğrencilerin bu sonuca ulaşmalarını sağlar.

Bu tepkimelerde iç enerjinin değişim yönünü irdelenir. Böyle olaylarda minimum enerji eğiliminden daha etkili bir başka eğilim olması gerektiği sonucuna götürecek yönlendirmelerde bulunur ve Entropi kavramını kullanılmayan termal enerji olarak açıklar.

İstemli olaylarda entropinin artacağını ($\Delta S > 0$) açıklar, Entropinin arttığı istemli olaylara örnekler verilir. Termodinamiğin 2. Kanununu açıklanmış olur.

H_2O (k) → H_2O (s) $T = 25\ ^0C$ de ki

Buzun erimesi olayında sistemin entropi değişiminin pozitif, ortamın entropi değişiminin negatif, toplam entropi değişiminin pozitif olduğunu sonuçlarına ulaşılır aşağıdaki eşitlik anlatılır.

$\mathbf{\Delta S_{evren} = \Delta S_{sistem} + \Delta S_{ortam} = 0}$ **Tersinir için**

$\mathbf{\Delta S_{evren} = \Delta S_{sistem} + \Delta S_{ortam} > 0}$ **Tersinmez için**

Benzer şekilde, sıcaklığı -30 ^oC olan bir odaya konmuş, 0 ^oC da 1 mol sıvı su için, evrenin toplam entropi değişiminin bu olayda pozitif olduğu sorgulanır.

4. Genişletme Aşaması (Extend)

Bu aşamada buzdolabında gerçekleşen değişimler ***istemlilik, enerji, düzensizlik*** gibi kavramlar bakımından yeniden tartışılır. Termodinamiğe güzel bir uygulama olanı olan buzdolapları dışında başka ne gibi soğutucu sistemler olduğu tartışılır. Hal değişiminin izotermal bir süreç olduğu hatırlatılarak,

H_2O (k) → H_2O (s) T = 0 ^0C, 1 atm basınç ta

Değişimin ısı değişimi sorulur. Öğrencilerin önceki bilgilerini hatırlayarak, bu değişimde sisteme $q = \mathbf{\Delta H_{erime}}$ kadar ısı vermemiz gerektiğini söyler söylemeleri beklenir. Öğretmen sistem ve ortamın entropi değişimlerini ilişkilendirmelerini ister, Sistemin entropi değişiminin;

$\mathbf{\Delta S = q_{rev} / T = q = \Delta H_{erime} / T}$ olduğu,

Sistemin entropi değişimi ΔS ve ortamın entropi değişimi (-ΔH/T) ile gösterilip, istemli olaylarda bu iki terim toplamının > 0 olması gerçeğinden, $\Delta H - T\Delta S < 0$ sonucuna ulaşılır. Buradan Gibbs serbest enerjisi (ΔG) tanımına geçilerek istemlilik, ΔG nin işareti ile ilişkilendirilir. Araba motorlarında gerçekleşen tepkimelerin istemliliği, entropi değişimleri, ΔG leri irdelenir.

Araç klimaları, ev klimaları gibi cihazlarında hal değişim ısıları sayesinde soğutma yaptıkları vurgulanır.

5. Değerlendirme Aşaması (Evaluate)

- Araba motorunda gerçekleşen yanma tepkimesinin; istemliliği, entropisi, ΔG değerleri nasıl değişir?
- Buzdolabındaki gazı kompresörde sıkıştırmak istemlimidir, istemsiz midir?
- Sıkıştırılmış gazın basıncının ve sıcaklığının artması istemlimidir istemsiz midir?
- Buzdolabının içinde ki borulardaki maddenin ısıyı soğurması istemli midir, istemsiz midir?
- İstemli değişimde enerji artar mı azalır mı?
- İstemsiz bir değişimde enerji artar mı azalır mı?
- Oda sıcaklığında buz eridiğinde daha moleküllerin bulunma farklı konumlarda bulunma ihtimallerinin nasıl değişir?
- "Bir fincandaki sıcak çayın oda koşullarında sıcaklığının zamanla düşmesi"
  Bu olayla ilgili olarak, aşağıdakilerden hangisi <u>yanlıştır?</u>

  a. İstemli değişime örnektir

  b. Minimum enerjiye yönelmiştir.

  c. Ekzotermik değişime örnektir

  d. Sistemin iç enerjisi artmıştır.

  e. Ortamın enerjisi yükselmiştir
- Oda sıcaklığında cıva sıvı halde bulunur. Civanın normal donma noktası -38.9 ^{0}C, molar erime ısısı 2.29kj/mol dür. Sistemin entropi değişimini 50 g cıva için hesaplayınız.(MA Cıva= 209.59 g/mol)
- -196°C ve 1 atm de 1 mol N_2 ----- -196°C ve 1 atm de 5 mol N_2
  25°C ve 1 atm de 2 mol O_2 ----- 25°C ve 5 atm de 2 mol O_2
  Standart şartlarda 1 mol H_2O(s) ----- Standart şartlarda 1 mol H_2O (g)

Yukarıdaki çiftlerin entropi büyüklüklerini kendi aralarında karşılaştırınız.

APPENDIX J

GIBBS SERBEST ENERJİSİNİN NESİ "SERBEST" TİR?

Gibbs serbest enerji termodinamiğin dikkate değer bir niceliğidir. Çoğu kimyasal tepkime yaklaşık olarak sabit basınç ve sıcaklıkta gerçekleştiği için kimyacılar, biyokimyacılar ve mühendisler ΔG nin işaret ve büyüklüğünü olağanüstü faydalı bularak tepkimelerini tasarlamada ve uygulamada bu değeri kullanırlar.

Gibbs Serbest Enerjisini ilk öğrenenler genellikle "*Gibbs Serbest Enerjisinin Nesi "Serbest" tir?"* sorusunu düşünürler. Önceden öğrendiğimiz bazı kavramları kullanarak bu soruyu tartışacağız. Termodinamiğin ikinci yasasının olayların kendiliğinde olup olamayacağı ile ilgili olduğunu öğrendik. İkinci yasa ile ilgili olarak

Tersinir Olaylarda ; $\mathbf{\Delta S - \Delta H / T = 0}$

Tersinmez Olaylarda ; $\mathbf{\Delta S - \Delta H / T > 0}$ (Sabit P,T) olduğunu hatırlayalım. Termodinamiğin ikinci yasasının **ΔG** ile arasındaki ilişkiyi her iki eşitliği –T ile çarparak görelim.

Tersinir Olaylarda ; $\mathbf{\Delta G = \Delta H - T \Delta S = 0}$

Tersinmez Olaylarda ; $\mathbf{\Delta G = \Delta H - T \Delta S < 0}$ (Sabit P,T)

Yukarıdaki eşitliklere bakarak, **ΔG** nin işaretinin bize tepkimelerin istemli, istemsiz veya dengede olduğu hakkında bilgi verdiği sonucuna ulaşabiliriz. **ΔG** nin büyüklüğü de ayrıca önemlidir. **ΔG** nin *büyük ve negatif* olduğu, petrolün yanması gibi, tepkimeler oda sıcaklığında buzun erimesi gibi **ΔG** nin *küçük negatif* olduğu durumlara kıyasla ortamın üzerine daha fazla iş yapma gücüne sahiptir. Aslında termodinamik bize ***serbest enerji değişiminin , ΔG nin, sabit basınç ve sıcaklıkta kendiliğinden gerçekleşen ve sistemin ortam üzerinde iş yaptığı bir olaydaki maksimim kullanılabilen işe eşit*** olduğunu açıklamaktadır.

$\Delta G = -w_{max}$

Bu ilişki bize **ΔG** ye neden serbest enerji dendiğini açıklamaktadır. **Yani kendiliğinden gerçekleşen bir tepkimenin enerji değişiminin iş yapmak için kullanılabilecek, serbest, olan kısmıdır**.

- ***Araba ve uçak motorlarında gerçekleşen yanma tepkimelerinin ΔG lerini işaret ve büyüklük bakımından karşılaştırınız.***

APPENDIX K

CLASSROOM OBSERVATION CHECKLISTS

GELENEKSEL YÖNTEM

Gözlemci :…………………………………… Süre :……………………….…………...
Okul/Sınıf :…………………………………… Konu :……………………….…………...

YARGILAR	H	K	E
Öğretmen bu sınıfta ders işledi			
Öğretmen öğrencilere konuyla ilgili sorular sordu			
Öğrenciler konuyla ilgili soru sordu			
Öğrencilerin soruları çözmelerine fırsat verildi			
Öğretmen konuyu diğer konularla ilişkilendirerek anlattı			
Öğretmen dersi geleneksel yöntemle anlattı			
Uygun yerlerde örnek videolar izlendi			

H: Hayır, K: Kısmen, E: Evet

BAĞLAMA DAYALI 5E ÖĞRENME DÖNGÜSÜ MODELİ

Gözlemci :…………………………………… Süre :……………………….…………...
Okul/Sınıf :…………………………………… Konu :……………………….…………...

		YARGILAR	H	K	E
5E ÖĞRENME DÖNGÜSÜ MODELİNİN AŞAMALARI	**Isındırma**	Ders ilgi çekici bir bağlamla başladı			
		Bağlam bu konuya uygundu			
		Öğrenciler bağlamla ilgilendi			
		Bağlamla ilgili sorular soruldu			
		Konuyla ilgili öğrenci görüşleri alındı			
		Öğrenciler bilgiye ihtiyaç duydu			
	Araştırma	Derste öğretmen ve öğrenciler birlikte araştırma etkinlikleri yaptı			
		Öğrenciler araştırma konusu ile ilgili hipotezler kurdu			
		Öğretmen irdeleyici sorularla araştırmayı derinleştirdi			
		Öğretmenin görevi öğrencilere rehber olmaktı			
		Öğretmen araştırma sorularının cevaplanmasına fırsat verdi			
		Öğretmen araştırma etkinliklerini bağlamla ilişkilendirdi			
	Açıklama	Araştırma sonuçlarının rapor edilmesi sağlandı			
		Öğrenciler açıklamaları gerekçeleriyle sundu			
		Öğretmen açılamalarını öğrencilerin açıklamaları üzeriden yaptı			
		Açıklamalar bağlamla ilişkilendirildi			
		Tüm öğrencileri açıklama yapmalarına fırsat verildi			
	Genişletme	Öğrencilerin öğrendiklerini başka bir bağlama genişletebildi			
		Bilimsel açıklamalar yeni durumlarda kullanıldı			
		Öğrencilerin yeni durumlarla ilgili bilgilerinin genişletilmesi sağlandı			
		Bağlam üzerinden kavramsal bilgi genişletildi			
	Değerlendirme	Öğrenciler öğrendikleri kavramları bağlam üzerinden ilişkilendirebilmeleri değerlendirildi			
		Öğretmen bağlama dayalı sorularla öğrencileri değerlendirdi			
		Öğrenciler bağlamı ve kavramları anladı			
		Öğrencilerin bilgi gereksinimlerinin karşılanıp karşılanmadığı sorgulandı			

H: Hayır, K: Kısmen, E: Evet

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EDUCATION

Degree	Institution	Year of Graduation
Ph.D.	METU, SSME	2012
MS with BS	METU, Chemistry Education	2005
High School	Anatolian Teacher High School, Muş	1999

WORK EXPERIENCE

Year	Place	Enrollment
2006 - Present	Atılım University, Chemistry Group, ANKARA	Research Assistant
2005-2006	Mobilsoft/ Meteksan, ANKARA	Content Development
2004-2005	Film Armoni Produksiyon, ÖSS-ÖYS Konu Anlatımı VCD, İSTANBUL	Chemistry Teacher

FOREIGN LANGUAGES

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PUBLICATIONS

Arslan, H. O., Çiğdemoğlu, C., & Moseley, C. (2012). A three-tier diagnostic test to assess pre-service teachers' misconceptions about global warming, greenhouse effect, ozone layer depletion, and acid rain. *International Journal of Science Education*, DOI:10.1080/09500693.2012.680618

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