THE EFFECT OF INQUIRY-BASED CHEMISTRY COURSE ON STUDENTS' UNDERSTADING OF ATOM CONCEPT, LEARNING APPROACHES, MOTIVATION, SELF-EFFICACY, AND EPISTEMOLOGICAL BELIEFS

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ABSTRACT

THE EFFECT OF INQUIRY-BASED CHEMISTRY COURSE ON STUDENTS' UNDERSTADING OF ATOM CONCEPT, LEARNING APPROACHES, MOTIVATION, SELF-EFFICACY, AND EPISTEMOLOGICAL BELIEFS

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The purpose of this study was to explore the effects of inquiry-based high school chemistry course and gender differences with respect to students' understanding of atom concept, learning approaches, motivational goals, self-efficacy, and epistemological beliefs.

In this study, 47 ninth grade students from classes of a chemistry course were taught by the same teacher in Private Yüce Science High School in the 2003-2004-spring semester were enrolled.

There were two groups in the study. Two instruction methods used in this study were randomly assigned to each group. The experimental group who received Inquiry-Oriented Instruction (IOI) consisted of 22 students while the control group who received Traditionally Designed Chemistry Instruction (TDCI) consisted of 25 students. To examine the effect of the treatment on dependent variables; students' understanding of atom concepts measured by Chemistry Achievement Test (CAT), meaningful learning and rote learning measured by Learning Approach Questionnaire (LAQ), learning-goal orientation, performance-goal orientation and self-efficacy measured by Achievement Motivation Questionnaire (AMQ), and epistemological beliefs measured by Science Knowledge Questionnaire (SKQ).

t-test and ANOVA were used to test hypotheses of the study. The results showed that the students who used the inquiry oriented instruction had significantly higher scores with respect to achievement related to atom concept than the students who taught with the traditionally designed chemistry instruction. On the other hand, inquiry oriented instruction did not effect students' learning approaches, motivational goals, self-efficacy, and epistemological beliefs. And also, the present study failed to find neither difference between boys and girls nor interaction between treatment (IOI vs. TDCI) and gender with respect to students' understanding of atom concept, learning approaches, motivational goals, self-efficacy, epistemological beliefs.

Keywords: Inquiry Oriented Instruction, Traditionally Designed Chemistry Instruction, Atom, Learning Approaches, Motivational Goals, Self-Efficacy, Epistemological Beliefs.

ÖZ

ARAŞTIRMAYA DAYALI KİMYA DERSİNİN ÖĞRENCİLERİN ATOM KONUSUNU ANLAMALARINA, ÖĞRENME YAKLAŞIMLARINA, MOTİVASYONLARINA, ÖZ-YETERLİKLERİNE, VE BİLİMSEL BİLGİ İNANÇLARINA OLAN ETKİSİ

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Bu çalışmanın başlıca amacı araştırmaya dayalı lise kimya dersisin ve cinsiyet farkının öğrencilerin atom konusunu anlamalarına, öğrenme yaklaşımlarına, motivasyonel amaçlarına, öz-yeterliklerine, ve bilimsel bilgi hakkındaki inançlarına olan etkisini araştırmak.

Bu çalışma, Özel Yüce Fen Lisesinden aynı öğretmenin 2 ayrı sınıfından 47 dokuzuncu sınıf öğrencisinin katılımıyla 2003-2004 öğretim yılı bahar döneminde gerçekleştirilmiştir.

Bu çalışmada iki grup vardır ve kullanılan iki öğretim metodu bu gruplara rastgele verilmiştir. Araştırmaya dayalı öğretim yöntemi uygulanan deney grubu 22 öğrenciden, geleneksel yöntem kullanılan kontrol grubu ise 25 öğrenciden luşmuştur. Araştırmada Atom Konu Testi, öğrencilerin atom kunusundaki başarılarının, Öğrenme Yaklaşımı Soru Formu, öğrenme yaklaşımlarını, Başarı Motivasyon Soru Formu, motivasyonel amaçlarını ve öz-yeterliklerini, ve Bilimsel Bilgi Soru Formu, bilimsel bilgi hakındaki inançlarının ölçülmesinde kullanılmıştır.

Bu çalışmanın hipotezlerini test etmek için t-testi ve varyasyon analizi kullanılmıştır. Analiz sonuçları, araştırmaya dayalı öğretim gören öğrencilerin atom konusu ile ilgili başarılarının, geleneksel kimya anlatımı öğrenimi gören öğrencilere göre daha yüksek olduğunu göstermiştir. Fakat araştırmaya dayalı öğretim yöntemi öğrencilerin öğrenme yaklaşımlarını, motivasyonel amaçlarını, öz-yeterliklerini, fen bilgisi hakkındaki inançlarını, ve akıl yürütme yeteneklerini etkilememiştir. Ayrıca bu çalışmada, ne kızlar ve erkekler arasında, nede cinsiyet ve uygulamanın etkileşiminde öğrencilerin atom konusunu anlamaları, öğrenme yaklaşımları, motivasyonel amaçları, öz-yeterlikleri, ve bilimsel bilgi hakkındaki inançları açısından bir fark bulunamamıştır.

Anahtar Sözcükler: Araştırmaya Dayalı Öğretim Yöntemi, Geleneksel Kimya Anlatım Yöntemi, Motivasyonel Amaçlar, Öz-Yeterlik, Bilimsel Bilgi Hakkında inançlar.

To My Family and Fiance

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TDCI: Traditionally Designed Chemistry Instruction

IOI: Inquiry Oriented Instruction

EG: Experimental Group

CG: Control Group

LGA: Learning Approach Questionnaire

AMG: Achievement Motivation Questionnaire

SKQ: Science Knowledge Questionnaire

RAT: Reasoning Ability Test

CAT: Chemistry Achievement Test

ML: Meaningful Learning

RL: Rote Learning

LG: Learning Goal Orientation

PG: Performance Goal Orientation

SE: Self-Efficacy

SB: Epistemological Beliefs about the nature of Science

RA: Reasoning Ability

X: Mean of Sample

df: Degrees of Freedom

SS: Sum of Squares

MS: Mean Squares

F: f statistic

P: Significance Level

t: T statistic

CHAPTER 1

INTRODUCTION

Science used to be defined as "knowledge gained through repeatable experimentation and observation", with no biases about where that study must lead. And also, "Systematized knowledge derived from observation, study, and experimentation carried on in order to determine the nature or principles of what is being studied." (Abd-El-Khalick, F., Bell, R.L., & Lederman, N.G.,1998). Science and technology are in a trend of development in today's world. A good education is more important than any time in order to adapt the developing science and technology, and this education should include a good science education. Sensing the power of science and sience based technology on economic change and development, educators in general science educators in particular attached ever increasing importance to the development of scientific thinking and understanding of the nature and processes of concerning the goals of education and science education. Here the problem: how students come to understand scientific knowledge. Meaningful learning of science involves coming to understand scientific ideas as they are used for their intended purposes including description, prediction and explanation of phenomena in their natural world. An important goal of science education is to help students develop an understanding of concepts and use them when solving a problem in new situation.

Sund and Trowbridge (1967) indicate that the schools have to produce an intelligent citizenry, and scientific literacy partly determines the citizens' understanding of national and international problems. And also they state that an individual have to have some understanding of science to do true judgment as a citizen. Renner and Stafford (1972) also indicate the goal of science education is to prepare students for effective citizenship, which can be achieved by scientific literacy and the ability to think and inquire.

Hurd (1970) states that the major goal of science education must be scientific enlighten. Hurd's major concern was that the characteristics of a scientifically literate person should be defined, and these definitions should serve as the goals for the general education in science. In order to achieve these goals it is necessary to include instructional materials a wide range of methodologies, logical process, and inquiry procedures selected from both the natural sciences and behavioral sciences. Rubba and Andersen (1978), Hurd (1970) and Klopfer (1971) indicate that the major goal of science education should be developing students "scientific literacy".

After indicating the major goal of the science education, which is developing students' "scientific literacy", how this goal can be achieved in the schools is the problem. Since the goal of science education is related to very important questions which are "why teach science to who teach science and at what level", there is a relationship between the method of instruction and the attainment of objectives (Baez, 1971). As indicated in the above statements, methodology is the dominant factor in science teaching to achieve the goals of science education. Among these different kinds of methodologies, inquiry method has an important place.

Science in general seems to be inductive in nature. When science utilizes inductive process for solving problems, it generally begins with observed events then reaches to construction of laws. This natural structure has been emphasized in science curriculum. For this reason the new science instruction has been inquiry oriented. An important charge for science education is that students are not only expected to learn science content but also acquire scientific attitudes and grasps the intricacies of scientific inquiry. In order to teach science perfectly, science teachers must be opposed to the rote memorization of the mere facts and minutiae of science. By contrast, they stand foursquare for the teaching of the scientific method, critical thinking, the scientific attitude, the problem-solving approach, the discovery method, and, of special interest here, the inquiry method. Rutherford (1964) states, “We need to teach science as a process or method rather than as content”. Like Rutherford (1964), Kyle (1980) defines scientific inquiry as “a systematic and investigative performance ability, which incorporates unrestrained inductive thinking capabilities after a person has acquired a broad and critical knowledge of particular subject matter through formal learning processes”.

Zachary (1985) and Suchman’s (1972) inquiry states that inquiry teaching is an alternative to lecturing and is designed to involve students more actively and deeply in course material. It aspires to create an attitude of open-minded curiosity while engaging the highest cognitive skills. Inquiry teaching is based on a five-step approximation of the traditional scientific, which includes forming hypotheses, collecting data, evaluating hypotheses, drawing conclusions, and testing conclusions against new data. Inquiry teaching is a method that aims to engage the student’s full range of cognitive abilities. A species of what is sometimes termed “discovery learning”, inquiry teaching requires the student to engage in hypothesis formation, collection and evaluation of evidence, and the drawing of logical conclusions. In addition to increasing the use of higher cognitive skills, inquiry teaching aims to create in the student attitudes of curiosity, open-mindedness, and tolerance for ambiguity.

Like Zachry, Bibens (2001) proposes that there are three basic phases in the inquiry learning process. These states are exploration, intervention and discovery. According to Bibens (2001) a greatly simplified interpretation of inquiry might suggest that it enquires direct involvement of student with subject content in the learning process, in the quest for meaning and understanding. This implies active student participation, and emphasizes understanding rather than merely knowing about a subject area.

They propose that, inquiry model cannot take place in any kind of classroom. An open climate of discussion is a requirement. Then the discussions are oriented around hypothetical solutions of problem situations. Knowledge is viewed as hypotheses, which are continually tested. Another condition for inquiry model is the reliability and validity of facts are considered as well as the testing of a hypothesis. And as a result the major purpose of the model is to teach students how to be reflective about significant social problems. A Massialos and Cox (1972) state that school has to be an active participant in what they call the “creative reconstruction of the culture”.

Finally, according to above studies considering the range of terms and phrases the contributors use to characterize the role of inquiry in science education. These include scientific processes; scientific method; experimental approach: problem solving; conceiving problems, formulating hypotheses, designing experiments, gathering and analyzing data, and drawing conclusions; deriving conceptual understandings; examining the limitations of scientific explanations; methodological strategies; knowledge as “temporary truths,” practical work; finding and exploring questions; independent thinking; creative inventing abilities; and hands-on activities.

Students’ understanding of nature and structure of matter is crucial to understand much of the physical, life and earth sciences as well as chemistry. Both reasoning ability and experiences with concepts account for the understanding of chemistry concepts hence a spital curricular model makes sense for the understanding of chemistry. Because of these, meaningful understanding of chemistry by the student becomes an important issue. Chemistry teachers and educators taught that chemistry as a difficult subject for young students. Most of studies in chemistry content area explore a problem that many students are unable to integrate their nature of matter knowledge in chemical or physical events. In particular, the ability to represent matter at the particulate level is important in explaining phenomena, chemical reactions, and changes in state, gas law, stoichiometric relationships, and solution chemistry. Therefore it is important to study the atom concept.

Records (1982) stated that, a constant problem for teachers of high school chemistry is to provide meaningful learning activities for the students, and this is especially difficult with the topic of atomic theory. In this study, the purpose is to describe several atomic theory activities, which are feasible for high school students to perform using resources easily obtainable by teachers. The following atomic models were used in this study; Dalton's Uniform Sphere Model, Thomson's "Raising Pudding" Model, Rutherford's Nuclear Model, Bohr's Energy Level Model and Orbital Model from Quantum Mechanics. Records (1982) found that students with experimental evidence gain more confidence in atomic theory. In addition to a higher level of confidence, the historical development progressing from Dalton to Bohr gives the student a more realistic view of science.

Keiffer (1995), who is a chemistry teacher, used Lite Brite, an illuminated pegboards, in her study. The Lite Brite allows students to replicate atomic structures using different colored pegs to represent the different parts of the atom. The tools also provide the opportunity for students to work in groups, with each group member responsible for part of the hands-on assignment. By this way it is found that, the students better understand the atom concept than the classical methods.

Niaz, Aguilera, Maza, and Liendo (2002) tried to facilitate freshman general chemistry students' understanding of atomic structure based on the work of Thomson, Rutherford, and Bohr. All three models were presented to the experimental and control group students in traditional manner. After this, experimental group participated in the discussion of six items with alternative responses. Results obtained showed that given the opportunity to argue and discuss, students' understanding could go beyond the simple regurgitation of experimental details. It is concluded that if we want our students to understand scientific progress and practice, then it is important that we include the experimental details not as" rhetoric of conclusions" but as "heuristic principles", which were based on arguments, controversies, and interpretations of the scientists.

As can be seen from the related literature, there were most of the studies, which were related to the atom concept. However, little work has been done at the high school level regarding the impact of inquiry-oriented curricula on constructs important to achieving in atom concept. In this respect, we aimed to improve ninth grade students understanding of atom concept with inquiry oriented instruction.

In recent years, many researchers have attempted to understand reasons why undergraduate girls typically have lower achievement in science. Shortages of girl science professionals remain profound. Improving girls' undergraduate achievement in science may be a key to increasing their graduate school enrollment. Thus it is relevant to examine variables of learning among girls and boys in high school chemistry course within the context of inquiry-oriented instruction to better understand these issues. Girls' science interest and achievement may be improved through inquiry-oriented instruction. On the other, previous studies of gender difference in motivation have shown either little difference in boy and girl scores on motivation surveys (BouJaoude& Giuliano, 1994). And, some of the students do not construct relationships between information, process of science and concepts, and then they learn science by rote (Cavallo & Schafer, 1994). Also, there were differences in students' epistemological beliefs. Because, some of the students viewed science as a fixed body of knowledge (Saunders, Cavallo, and Abraham, 1999), but some of the students had stronger beliefs of science as "fixed and already known" (Cavallo, Rozman, Blickenstaff, Walker, Turoczi and Watters, 2000). As a result this study aims to better understand the impact of a unique, inquiry-oriented instruction on girl and boy students' learning approaches, motivational goals, self-efficacy, epistemological beliefs, and the acquisition of sound scientific understanding of atom concept.

CHAPTER 2

REVIEW OF LITERATURE

This chapter devoted to the presentation of the previous studies that have produced theoretical and empirical background for this study. These research papers are related with the different types of teaching methods, especially inquiry method, in science teaching on the achievement and attitude will be examined. And also there are papers, which are related to the students learning approaches, motivational goals, self-efficacy, and epistemological beliefs.

It seems logical to begin with the discussion with the aims of science education and then to consider the inquiry method. Baez (1971) states that the goals of science education are related to the important questions like " why teach science?" "...to whom?" and "...at what age?" He discusses the position taken by the curriculum developers for not considering the goals of science education as the determinants of what to teach and how to teach.

Gagne (1963) states that if the correct conditions for learning are established, we will be able to infer what the student is able to do, which he name as "terminal capability". To make inferences about the "terminal capability" of a learner, he indicates the importance of observing some kinds of behaviors, which may be referred as "terminal behaviors". He defines the set of conditions, which are used to bring about a "change" in the learner's capability as "instructional conditions". According to Gagne, these conditions include everything that is done to or by the student from some initial point in time to some other point in time.

Robinson (1965) states that many articles in literature indicate that the process of science is more important in science education than the products of science education. He further stress that many other studies suggest that process of inquiry and teaching of science concepts are also have the most importance. And according to the Robinson, a good science teaching includes properties, which are the separability, identifiably, and teachability of the process and products of science. And he also lists the following questions for science education:

- How do product and process relate to the structure of science, and what is meant by structure of science?
- Can process be separated from product in science?
- Does this structure become most significantly stated as an array of products, concepts, facts, theories, and laws of nature? (P.37)

In this study Robinson try to answer the above questions by replacing the dichotomy of products and process of scientific investigation by a unity.

Klopher (1971) indicates that the goals of science education in the fallowing categories:

- Knowledge and comprehension
- Process of scientific inquiry
    - Observing and measuring
    - Seeking a problem and seeking ways to solve it
    - Interpreting data and formulating generalizations
    - Building, testing, and revising a theorical model
- Application of scientific knowledge and methods.
- Manual skills
- Attitudes and interests
- Orientation
    - relationships among and distinctions between various types of statements in science
    - recognition of the limitations of scientific explanations and of the influence of scientific inquiry on general philosophy
    - recognition of the background of science

- realization of the relationships among scientific progress, technical achievment, and economic development
- awareness of the social and moral implications of scientific inquiry and its results for the individual, community nation and the world

As a result, in this study Klopher gives a brief discussion of the goals of science education. And he indicates that "realization", "awareness", and "recognition" are the key terms in the aims of science education.

There are many studies, which are related to the aims of science education. According to the above studies the major goals of science education is the "understanding the process and nature of science". As can be seen from these studies, in science education the teaching method has a very important place. After discussing the goals of science education it is better to examine the papers, which are related to the inquiry method. Because in this study, the affect of inquiry method on chemistry concepts and student's learning approaches, motivational goals, self-efficacy, and epistemological beliefs will be examined.

2.1 Inquiry Method

"Inquiry" has been a perennial and central term in the thetoric of past and present science education reforms in the United States. During the second half of the twentieth century, "good science teaching and learning" has come to be distinctly and increasingly associated with the term inquiry (Anderson 2002). An undercurrent theme in these conceptions is advancing and distinguishing between inquiry as means and ends. "Inquiry as means" (or inquiry in science) refers to inquiry as an instructional approach intended to help students develop understandings of science content. "Inquiry as ends" (or inquiry about science) refers to inquiry as an instructional outcome: Students learn to do inquiry in the context of science and develop epistemological understandings about nature of science and the development of scientific knowledge, as well as relevant inquiry skills (e.g., identifying problems, generating research questions, designing and conducting investigations, and formulating, communicating, and defending hypotheses, models, and explanations).

National Science Education Standard in the USA, present lively vignettes of how an inquiry approach to teaching and learning would be enacted in precollege science classrooms (Anderson, 2002). Such vignettes put aside, however, the only kind of (inquiry) teaching that happens in the kind that is enacted in actual classrooms. Irrespective of how inquiry has been conceptualized during the past 50 years or so, and conceptions of inquiry have changed during this period, research has consistently indicated that what is enacted in classrooms is mostly incommensurate with visions of inquiry put forth in form of documents, past and present (e.g., Anderson, 2002)

The history of science education reforms in the United States has taught us that when envisioned conceptions of inquiry meet the reality of schools and classrooms teaching, and the associated social, political, economic, and cultural spheres, these more philosophical conceptions are often transformed into practical curricula and then translated into incongruent enactments or classrooms practices. This incongruence has long been recognized and researched and was often explained in term of barriers that impeded the enactment of inquiry in classrooms and schools. These barriers ranged from the localized to those that cut across contexts, from the technical to the political, and from factors associated with science teachers to those related to the culture of school science (e.g., Anderson, 2002).

Before the inquiry method, science education is still traditional in nature: Instruction is largely limited to a didactic chalk-and-talk approach coupled with occasional verification-type laboratory experiences. Certainly doing inquiry provides students with an important experimental base, but we are educating the over helming majority of our students to become critical consumers of science and participants in a scientifically laden culture. Zachry (1985) compares the lecture method with the inquiry method. And he found the following contrasts:

- Active participation of student both during and outside class is required in inquiry method.
- The number of topics covered versus the depth of coverage is different between the methods.
- The inquiry method is flexible and may be adapted to a variety of class situations.

And also, Zachry (1985), states that inquiry approach increased classroom participation and deeper level of intellectual involvement with course material. The method demands more of students, gets more from them, and even gets them to like the inquiry attitude. And he describes inquiry method as a five-step process. The steps are as fallows:

- To define a problem
- To develop hypotheses
- To search for evidence by which hypotheses may be tested
- To draw conclusions by evaluating hypotheses in light collected evidence.
- To test the adequacy of the conclusion by applying it to new evidence.

Bibens (2001) studies to determine the classroom conditions for using inquiry method effectively. He states that, there are three basic phase of inquiry learning process, which are exploration, invention, and discovery. According to him, a teacher, who wishes to use inquiry method effectively in his class, should keep the following points in mind;

- Attempt to shift the focus of attention away from the teacher and toward the student and the content.
- Do not gear instruction to the idea of teaching *x* number of concepts in *y* minutes.
- Be prepared to accept any decision reached by a student, and through the use of the question, guide him back in the desired direction.

- Do not tell students they have made a mistake, or identify for them where the error might be.
- Accept what students tell you that they think is a correct answer, and counter with questioning designed to move the focus of their attention in another direction.
- Do not allow students to quit in the learning cycle when they have identified “an answer.”
- Look for ways of encouraging students to move beyond the search for “the” answer.
- An excellent response to the student who has identified what he believes is the solution to be a problem is: “why do you think that’s the answer?” At that point, the student has to review the steps through while he has progressed, and may well discover on his own where he stayed from his path to the objective.

As a result, Bibens states that, a teacher, who obeys these rules, uses inquiry method effectively in his classroom. And also, this teacher will be a good science teacher.

Student knowledge about inquiry and nature of science does not occur by accident. Students do not develop such understandings simply through experiencing inquiry any more so than we would expect them to develop understandings of photosynthesis simply by watching plants grow. Teachers need to explicitly address the reform-based goals related to knowledge about inquiry and nature of science within instruction about “traditional” science content and process skills. This end is best accomplished by having students’ perforö scientific investigations followed by reflection on these activities and the nature of the knowledge produced. “Explicit” in this context does not refer to direct instruction. Indeed, allowing students to come to the desired understanding on their own with the aid of carefully crafted experiences and reflective questions is a much more effective approach. For several years now, we have consistently provided empirical evidence (e.g., Abd-El-Khalick, Bell, & Lederman, 1998; Akerson, Abd-El-Khalick, & Lederman, 2000; Khishfe& Abd-El-

Khalick, 2002) for the succes of an explicit reflective approach in improving both students' and teachers' conceptions of scientific inquiry and nature of science.

The lack of a clear framework for inquiry in the science curriculum resulted in conveying contradictory messages to teachers in curricular materials. The topic of atomic structure is an illustrative case. Recent research in science education indicates that the historical study of atomic structure serves as a useful context for helping students investigate and internalize some consensus views about nature of science, such as tentative nature of scientific theories and develop fundamental understandings about nature of inquiry (Niaz, 1998,2000). According to Niaz, the potential of this unit to contribute to students' understandings about the scientific endeavor is thus minimized, probably because of the lack of a clearly articulated vision of the relationship between nature of science, inquiry, and constructing understandings of scientific concepts in the science education. In the absence of such an articulated and informed vision, it appears that the inclusion of some aspects of inquiry learning and nature of science in the Venezuelan secondary education curriculum will not ensure its implementation in the classroom.

Anderson (2002) indicates that the range of terms and phrases the contributors use to characterize the role of inquiry in science education. These includes, scientific processes; scientific method; experimental approach; problem solving; conceiving problems; formulating hypotheses; designing experiments; gathering and analyzing data, and drawing conclusions; deriving conceptual understandings; examining the limitations of scientific explanations; methodological strategies; knowledge as "temporary truths," practical work; finding and exploring questions; independent thinking; creative inventing abilities; and hands-on activities.

Peterson (1978) examined the nature of scientific inquiry instruction for high school students. And also, he aimed to develop a secondary level training program. The sample consisted of 67 subjects enrolled physics classes in a high school. Subjects were enrolled, in three class groups, which received different instructional treatments. Group one, completed Project Physics units V and VI. Instruction consisted of readings, lectures, guided laboratories and exams. Group two completed the same laboratory. In addition they received verbal learning units on scientific inquiry in which observational strategies, questioning, experimental design and reporting were emphasized. Group three, completed a program in scientific inquiry.

At the end of the study, the scientific inquiry assessment instrument used for each subject. According to the results, no gender differences were detected in the training programs. The training programs were effective in improving performance in a variety of inquiry skills. A model of scientific inquiry performance in which the various processes, such as observing, questioning and designing experiments were not equivalent processes, was used. They did not respond equivalently to the same training.

Widesook (1982) investigated the understanding of the knowledge of inquiry teaching among the science instructors in teachers' colleges. One-hundred fifty-eight science instructors participated in the study. The results of the study showed that educational background was the only factor that affected the knowledge of inquiry teaching of science instructors. And there was no relation among the knowledge of inquiry teaching and the use of inquiry behaviors of science instructors. Furthermore, science instructors who had a master's degree understand the knowledge of inquiry teaching better than science instructors who had a bachelor's degree. However, the educational background did not affect the science instructors' use of inquiry behaviors.

According to above studies, the classes, which are inquiry method is used, are better than the classes, which are the traditional method is used. However, in the following studies inquiry method has no priority to the traditional methods.

McMeen (1983) studied to determine the role of an inquiry oriented laboratory approach in facilitating cognitive growth and development. 122 college chemistry students participated the study. In this study pre-post logical thinking test were administered. Results showed that both students who had exposure to a traditional chemistry program and students who had inquiry oriented laboratory based chemistry program showed equivalent increases in intellectual development.

Carl (1980) studied to determine the use of inquiry science instruction could faster creavity in forth, fifth and sixth grade students. The treatment group received intensive training in the use of inquiry instructional techniques that provided them with a unique mastery of the necessary procedures. Verbal and the Figural Test of the Torrance Tests of Creativity Thinking were used to gather data and they used as pre and post-tests. To analyze the data, ANOVA method was used. No significant difference was found between the scores on the Verbal Test for the fourth grade treatment and control subjects and no significant differences were observed between the scores of the two groups on the figural test.

In most of the elementary and secondary school science assessments are of the paper-and-pencil type and gauge student linguistic and logical thinking abilities rather than performance skills. Even in laboratory situations, students are assessed using reports rather than performance activities. Few teachers actually assess student inquiry skills. Students' performance on inquiry related skills are sporadically assessed during science fairs and related extracurricular activities. Moreover, science teachers believe that it is their duty to cover all the science content outlined in textbooks to help students achieve high scores on exit examinations, and complain that this goal is not tenable given in the time available to them. They argue that, compared to lecturing, teaching science concepts through inquiry would take too much instructional time. The additional time needed to engage in inquiry is perceived as less efficient when compared with lecturing about science concepts. Thus, examination-related anxieties, accountability pressure, lack of instructional time, and efficiency beliefs directly influence the way teachers approach science teaching. By addressing these impediments, we hope that more inquiry teaching would occur and that students would come to develop the desired inquiry (Abd-El-Khalick, Boujaoude, Duschl, Lederman, Hofstein, Niaz, Treagust, & Tuan, 2003).

Existing studies on effectiveness of inquiry method showed inconsistent results. Some of the experimental studies indicated favor inquiry method,
(Peterson, 1978; Niaz, 1998,2000; Bibens, 2001; Zachry, 1985; Anderson, 2002) while others indicated no favorable results on inquiry method (Carl, 1980; McMeen, 1983). On the other hand, some of the studies criticize the importance of inquiry method (Abd-El-Khalick, Boujaoude, Duschl, Lederman, Hofstein, Niaz, Treagust, & Tuan, 2003).

As can be seen from the above literature review there are most of studies about inquiry method. However, there are little work examines the impact of inquiry-based curricula on constructs important to learning and achieving in science: students' learning approaches, motivational goals, self-efficacy, and epistemological beliefs. And these constructs are examined in this study, and they may be described as fallows.

2.2 Learning Approaches

In order to understand science concepts, students must formulate interrelationships among information, concepts and process of science. And also, students must construct knowledge and link new ideas to what is known. Ausubel (1963, 1968) described the relationships that students form between information, process of science and concepts, and this is known as "meaningful learning." However, most of the students do not construct relationships between information, process of science and concepts, and then they learn science by rote and they isolate to each other (Cavallo & Schafer, 1994; Cavallo, 1996; Novak, 1988). Rote learning is taught to impede the learning of new science ideas (Novak, 1988) and interfere with students' formulation of sound scientific understandings. According to Ausubel (1963) in order to obtain meaningful learning, three criteria must be met. These criteria's are as fallows:

- The learner must have relevant prior knowledge.
- The learner must be provided with meaningful learning tasks.

- The learner must initiate what is called the meaningful learning “set”

He stated that, if one more of these criteria are not met, learners might resort to using rote learning strategies.

Cavallo and Schafer (1994) explored the factors, which high school students acquired meaningful understanding of the biological topics. The finding indicated that meaningful learning orientation explained a unique portion of the variance from that explained by aptitude and achievement motivation in two of the five regression analyses. And also, meaningful learning orientation alone predicted students’ mental model scores of the procedural relationship and conceptual relationship between the topics.

In another study, Cavallo (1996) explored relations between school students’ meaningful learning orientation, reasoning ability and acquisition of meaningful understandings of genetics topics, and ability to solve problems. The results showed that, meaningful learning orientation best predicted students’ understanding of genetics interrelationships. And also, meaningful learning orientation best predicted students’ performance, expect open-ended test questions.

In Cavallo, Rozman, Blickenstaff and Walker, (2004)’ study, they aimed to explore students’ learning approaches, reasoning abilities, motivational goals and epistemological beliefs relative to science concept understanding and course achievement. The subjects of the study were, biology students, physics nonmajors and physics majors of a college. Results showed that biology students used the most rote learning strategies; by the way they earn high grades. Meaningful learning positively related to learning goals. Students who learn by rote also seek high grades, and not to seek to learn for the sake of learning. On the other hand, for the physics nonmajors’ rote learning negatively predicted course achievement, which means that rote learners could not achieve this inquiry course. And also, for physics nonmajors reasoning ability was negatively related to meaningful and rote learning.

In Saunders, Cavallo and Abraham's (2001) study they aimed to explore possible relationships among students' learning approaches, their epistemological beliefs about science, gender and the type of instruction experienced. Results showed that, type of instruction was not correlated with meaningful or rote learning orientation.

Some research has indicated that when students consistently learn science information and ideas by rote, they tend to formulate misconceptions or misunderstandings (BouJaoude, 1992). And another study (Williams, Cavallo; 1995) also showed that, more rote learning was related to more misconceptions. As a result, students tend to use either more meaningful learning, or more rote strategies in learning concepts. It is states that in inquiry-based classrooms, students may use more meaningful learning strategies in understanding the concepts. And also, in this study it is investigated that if there are gender differences in students' approaches to learning or if learning approaches may change in an inquiry-based chemistry course.

2.3 Motivational Goals

Achievement motivation is defined as students' motivation toward "performance goals," such as high grades, praise, or performing better than the others, or toward "learning goals," such as learning something new, learning for the sake of learning or improving oneself. Given the findings of motivational factors on students' learning as reported in the literature (Ames& Archer, 1988; Dweck, 1986; Maehr, Stallings, 1972), it is speculated that students in classrooms that focus on the process of learning versus the products may tend toward high learning goals, rather than performance goals. Previous studies of gender difference in achievement motivation have shown either little difference in male and female scores on achievment motivation surveys (BouJaoude& Giuliano, 1994) of slightly higher scores among males (Steinkamp and Maehr, 1984). BouJaoude and Giuliano (1994) studied freshman chemistry students.

Ames and Archer (1988) wanted to explore the relationship between motivational process and mastery and performance goals. They state that students who received an emphasis on mastery goals in the classroom using more effective strategies, preferred challenging tasks, had a more positive attitude toward the class, and had a stronger belief that success fallows one's effort. On the other hand, students who perceived performance goals as salient tended to focus on their ability, evaluating their ability negatively and attributing failure to lack of ability.

Dweck (1986) state that,

> "a performance goal focuses children on issues of ability. Within this goal, children' confidence in their ability must be high if they are to choose approximately challenging tasks and pursue them in effective ways. A strong orientation toward this goal can thus create a tendency to avoid challenge, or to show impaired performance in the face of challenge. In contrast, a learning goal focuses children on effort of surmounting obstacles, and of increasing their ability. Not only is effort perceived as the means to accomplishment, it is also the factor that endangers pride and satisfaction with performance. The adaptation of learning goals thus encourages children to explore, initiate, and pursue task that promote intellectual growth." (p. 1046)

In Cavallo, Rozman, Blickenstaff and Walker, (2004)' study, they aimed to explore students' learning approaches, reasoning abilities, motivational goals and epistemological beliefs relative to science concept understanding and course achievement. The subjects of the study were biology students, physics nonmajors and physics majors of a college. Results showed that, biology students who learn by rote also seek high grades, and also not to seek to learn for the sake of learning. And also, learning goals was not related to reasoning ability. The findings on learning goals in biology show students must have the desire to make sense of concepts to achieve in the course. It makes sense that a high learning goal would be important, given the amount of material students needed to learn in this biology course.

Leondari & Gialamas (2002) studied the relationships between motivational goals and different variables. They explored relations between implicit theories of intelligence, goal orientations, perceived competence, and school achievment. The results showed that implicit theories were not related to academic achievment. Goal orientations had an indiret effect on achievment that was mediated through perceived competence. In summary this study shows that implicit theories of intelligence are related to students' achievment goals and that students with different goal orientations differed in respect to achievement.

In a different study, Salili & Lai (2003) examined the effects of banding (grouping of the schools based on ability) and the medium of instruction on students' achievment orientation and performance. They hypothesized that both the mediun of instruction and banding of schools would have effects on students' motivational orientation. The results showed that learning strategies, motivational factors and performance were affected by the school bands and the medium of instruction. They also found gender differences. Students studying in lower bands (high-ability schools) used more strategies in learning than in the upper bands. They also had higher levels of self-efficacy. The results on motivational goals showed that all the students regardless of their band, rated higher on performance goal than learning goal orientation. This result shows the competitive and exam-oriented education context of Hong Kong. Female students in both types of bands had higher scores on performance goal orientations than male students. This difference showed the fact that; female students are more concerned with studying and getting good grades. The results for the learning goal showed that males in both bands had higher scores for learning goals. This gender differences are inconsistent with the above studies, which had no gender differences. As a result this study showed that the context of learning has an important effect on the learning and achievment orientations of students.

This present research needs to seek better understanding of boys and girls' motivational goals in learning chemistry concepts, how these goals may change in an inquiry-based course, and on how motivational goals may be related to concept understanding.

2.4 Self-Efficacy

Self-efficacy represents students’ belief in their own capability to be successful in a particular subject area or course (Bandura, 1995). He also stated that, self-efficacy theory concerns people’s judgements about their ability to perform actions that prospective situations demand. Self-efficacy asessments are judgements about how well one can perform in a specific situation, and have been demostreted to contribute to motivation across a wide variety of situations. Individuals who believe they possess the appropriate skillss are easily discouraged when performance does not meet expectations. In conrast, those who believe in their ability to attain their goals increase their efforts when performance fails to match goals, and persist until success is attained.

Students with high self-efficacy also tend to attain higher achievement in a subject, however those with lower self-efficacy tend to also be less successful. In inquiry-based courses, students can better assess their strengths and weaknesses in the subject, and assume control of their own learning (Shavelson & Bolus, 1982). It is posed that students in inquiry-based courses will gain greater self-efficacy of their ability toward succeeding in that subject.

In this study, it is stated that females tend to have lower self-efficacy in science than males. The gender differences tend to be small in elementary grades, but increase in higher grades.

Stevens, Tara, Olivarez, Arturo, Lan, William, Tallent-Runnels, Mary, (2004) aimed to evaluate self-efficacy and motivational orientation across Hispanic and Caucasian students to predict variables related to mathematics achievement, including mathematics performance and students' plans to take additional mathematics courses. Results showed that self-efficacy plays an important role in predicting mathematics performance and motivation for Hispanic and Caucasian students. They indicate that educators can focus on mathematics self-efficacy that will likely improve the mathematics performance of all students.

Self-efficacy not only affect achievment, it also affect choices. Whyte, Saks and Hook (1997) investigated self-efficacy judgements as potentially important individual differences in escalating commitment to alosing course of action. Subjects were told the study was about decision making under risk and that they would be asked to respond to e set of secision problems. The rsults showed that intentions to escalate commimment wre expressed more frequently and were more severe in the high perceived self-efficacy condition thatn in the control ondition. Intentions to escalate commiment were expressed less often, and were less severe, in the low self-efficacy condition as compared with the control condition. The present findings provide additional evidence that positive self-efficacy assessments alone lead people to expend greater effort and to persist longer to attain their goals. These findings further attests to the generality of the relationship between perceived self-efficacy and motivation.

In a different study, Yı and Hwang, (2002) states that self- efficacy and learning goal orientation have an important role in determining the actual use of computer systems.

On the other hand, Bra°ten, Samuelstuen, Strømsø (2004) aimed to examine whether perceived self-efficacy moderated the relationship between performance goals and self-regulatory strategy use in two different samples. They found that perceived self-efficacy moderated the relation between performance-avoidance goals. However, there seemed to be a negative effect of increased performance-avoidance goal orientation for students with high self-efficacy and a positive effect of increased performance-avoidance goal orientation for students with low self-efficacy.

Lack of school engagement among adolescents in America remains a problem that can have serious concequences. To identify psychological variables of individuals would contribute greatly to the understanding of how to increase adolescents' psychological well-being and their achievment motivation and associated school engagement. Reinke and Hall (2003) examined the degree of association of three specific self-variables (self-efficacy, goal orientation, and fear of failure) with school engagement for high school students recruited from a southeastern metropolitan high school. They hypothesed that self-efficacy and goal orientation will have significant positive associations with school engagement. this study also explored whether there were any age, gender, or ethnicity differences in self-efficacy,goal orientation, fear of failure, or school engagement. results showed that the more confident adolecnts are about general level of competence, the more likely are to get better grades in school and to be more engaged in various aspects of school. In addition to this, findings also suggest that goal orientation influences students' level of engagement in school. However, there are any gender differences in self-efficacy, goal orientation, fear of failure or school engagement in adolescents. This gender differences results are inconsistent with the study of Shavelson & Bolus, (1982).

In different countries, there were lost of studies about self-efficacy. However, there was limited works studied cross-cultural self-efficacy. Klassen (2004) examined much of the research investigating self-efficacy beliefs through cross-cultural comparisons. Two electronic databases were searched for the time period 1977-2002. Abstracts were scanned for the inclusion of a quantitative measure of self-efficacy, and for inclusion of cross-cultural comparison groupings. Two sets of cross-cultural comparison groups are examined: Asian versus Western, and Eastern versus Western European and American groups. Almost all of the 20 studies reviewed found efficacy beliefs to be lower for non-Western cultural groups. And realistic-as opposed to optimistic-efficacy beliefs do not necessarily predict poor performance for all cultural groups, as has been suggested by self-efficacy theory.

As can be seen from the related literature there are inconsistent results, so further studies must be done. And, in this present study, students' self-efficacy in chemistry course at the high school level is examined and also how self-efficacy may change after experiencing an inquiry-based chemistry course.

2.5 Epistemological Beliefs

Epistemologial beliefs may be defined as systems of personal and often implicit beliefs or assuptions that students hold about the nature of knowledge and learning (Schommer. 1990). Science education research has identified to opposing views, or epistemological beliefs of science among students. One view is that science is an authoritative, unchanging, fixed body of knowledge; the other view is that science is a tentative, dynamic process. A recent study on first and second year college chemistry students found that a large number of students viewed science as a fixed body of knowledge (Saunders, Cavallo, and Abraham, 1999). In another study, it is found that college physics students had stronger beliefs of science as "fixed and already known" compared to biology students (Cavallo, Rozman, Blickenstaff, Walker, Turoczi and Watters, 2000). The implication of such findings is that students who view science as "already known" may believe that the best way to learn science is to memorize the body of knowledge.

Saunders, Cavallo and Abraham, (2001) state that,

> "Beliefs about the origin of knowledge, the formation of knowledge and the characteristics of knowledge are called epistemological bliefs. It was hypothesized that the epistemological assumptions of the laboratory instruction and the students' personal epistemological belief about science are related to the student's meaningful or rote learning orientation." (p. 1)

In this study, they aimed to explore possible relationships among students' learning approaches, their epistemological beliefs about science, gender and the type of instruction experienced. The relationships that may exist among students' instructional experiences, students' beliefs and their approaches to learning were investigated by observing students' introductory chemistry laboratory experiences. Results showed that, there is significant difference between male and female students' epistemological beliefs. Male students were more likely to believe in the reasoned nature of knowledge in science; while female students were more likely believe in the received nature of knowledge in science. And also, the type of instruction was not correlated with epistemological beliefs. On the other hand, meaningful learning approach was not related to student' epistemological beliefs. Students reported using meaningful approaches to learning regardless of beliefs in knowledge as reasoned or received. However, rote learning approach and epistemological beliefs were correlated. Students believed in the reasoned nature of science knowledge use fewer rote approaches to learning than students who believe in the received nature of knowledge. As a result, if students believe that knowledge is certain, and the source of knowledge and justification for knowing is an authority, it fallows that learning requires only rote strategies such as memorization. If knowledge is simple, ther is no reasons to try to make connections between new information and prior knowledge.

In Cavallo, Rozman, Blickenstaff and Walker, (2004)' study, they also aimed to explore students' learning approaches, reasoning abilities, motivational goals and epistemological beliefs relative to science concept understanding and course achievement. The subjects of the study were biology students, physics nonmajors and physics majors of a college. Results showed that, for biology students' epistemological beliefs were positively related to learning goals, which means these support motivation to learn for the sake of learning. And also, students, held a tentative view of science were higher achievers in the course. However, because epistemological beliefs were associated with learning goals, it was not a significant predictor of course grade.

As can be seen from the above studies epistemological beliefs are positively related to learning approaches. The purpose of Tsaı (1998) study was also to acquire a better understanding of the interaction between scientific epistemological beliefs and learning orientations in a group of Taiwanese eight grade students. A qualitative analysis through interviewing of the subjects showed that students holding constructivist epistemological beliefs about science (knowledge constructivists) tended to learn through constructivist-oriented instructional activities, and employ a more active manner as well as more meaningful learning strategies whem learning sience, however students having epistemological beliefs, more aligned with empricism (knowledge empricists), tended to learn through rote-learning strategies to enhance their understanding. Knowledge consructivist subjects tended to have more pragmatic views about the sience and they were motivated by their interest about science, but knowlegde empricists were motivated by performance on exams.

Another study which examine the relationships between learning approaches and epistemological beliefs is Hogan (2000). Hogan's purpose was to explore how different kinds of knowledge about the natuer of science might affect students' learning of science in school. In order to do this, two categories are introduced that classify how students' understanding of the nature of science has been operationalized. Distal knowledge about the nature of science refers to knowlegde about the enterprise and epistemology of professional science. Proximal knowlegde comprises metacognitive and personal epistemological knowledge about one' own science knowledge and its acquisition. Whether distal and proximal knowledge of the nature of science differ in how they influence students' learning depend in part on what type of learning task we consider, as well as on the age or developmental level of the student. Perhaps proximal knowledge provides more direct injuctions for behaviors such as choosing for acquiring information and skills, whereas distal knowledge requires several layers of translation before influencing learning behaviors, yet can more readily affect a person's informed action and attitudes as citizens in a scientific society.

Research has consistently demostrated that the motivational beliefs of college students have direct effects on their academic performance. And the motivation of students to learn is also related to their epistemological beliefs. Paulsen & Feldman (1999) examined emprical relationships between motivational and epistemological beliefs. Moreover, they aimed to provide practical recommendations to help teachers promote their students' motivation to learn by designing learning activities that facilitate their students' development of more sophisticated and motivationally productive epistemological beliefs. Results clearly showed that there was a significant relationship between the epistemological beliefs of students and their motivation to learn in a particular course of study. They suggest that college teachers can enhance the motivation of their students to learn by promoting “motivationally productive” epistemological beliefs. This would mean helping students advance from the naïve beliefs which knowledge is simple, absolute, and certain, that learning takes place quickly, and that the ability to learn is fixed through more sophisticated beliefs which knowledge is complex, tentative, and evolving, that learning takes place gradually over time, and that one’s ability to learn can be improved.

In inquiry-based chemistry courses, students may tend to formulate a more realistic understanding of the nature of science. And in the present study, it will be investigated that if there are gender differences in epistemological beliefs about the nature of science.

In the light of the investigations and analysis taken from the present relevant literature inconsistent results were observed. The reasons of these inconsistencies may be coming from irrelevant research designs, use of insufficient analysis techniques or uncontrolled variables. And also, there is little work examines the impact of inquiry-based curricula on constructs important to learning and achieving in science: students’ learning approaches, motivational goals, self-efficacy, and epistemological beliefs. Furthermore, it is better to examine these variables between males and females in high school chemistry course within the context of inquiry-based instruction, in order to see the differences in gender. Thus, further research is needed to overcome the existing inconsistencies in inquiry-based instruction and to explore the extent to which students’ engagement in three week period, inquiry-based chemistry course may be related to differential shifts in learning approaches, motivational goals, self-efficacy, epistemological beliefs, and chemistry concept understanding.

CHAPTER 3

PROBLEMS AND HYPOTHESES

In this chapter, the main problem, related sub-problems and the hypotheses will be presented.

3.1 The Main Problem and The Sub-Problems

3.1.1 The Main Problem

The main purpose of this study is to explore the effects of inquiry-based high school chemistry course and gender differences on students' understanding of atom concepts, learning approaches, motivational goals, self-efficacy, and epistemological beliefs.

3.1.2 The Sub-Problems

1. Is there a significant difference between the groups receiving traditionally designed chemistry instruction (TDCI) and inquiry oriented instruction (IOI) on understanding of atom concepts?

2. Is there a significant difference between boys' and girls' understanding of atom concepts?

3. Is there a significant effect of interaction between gender and treatment with respect to understanding of atom concepts?

4. Is there a significant mean difference between the groups receiving traditionally designed chemistry instruction (TDCI) and inquiry oriented instruction (IOI) on their learning approaches?

5. Is there a significant difference between boys' and girls' learning approaches?

6. Is there a significant effect of interaction between gender and treatment with respect to learning approaches?

7. Is there a significant difference between the groups receiving traditionally designed chemistry instruction (TDCI) and inquiry oriented instruction (IOI) on their motivational goals?

8. Is there a significant difference between boys' and girls' motivational goals?

9. Is there a significant effect of interaction between gender and treatment with respect to motivational goals?

10. Is there a significant difference between the groups receiving traditionally designed chemistry instruction (TDCI) and inquiry oriented instruction (IOI) on their self-efficacy?

11. Is there a significant difference between boys' and girls' self-efficacy?

12. Is there a significant effect of interaction between gender and treatment with respect to self-efficacy?

13. Is there a significant difference between the groups receiving traditionally designed chemistry instruction (TDCI) and inquiry oriented instruction (IOI) on their epistemological beliefs?

14. Is there a significant difference between boys' and girls' epistemological beliefs?

15. Is there a significant effect of interaction between gender and treatment with respect to epistemological beliefs?

3.2 Hypotheses

$H_0$1. There is no statistically significant difference between the post-test mean scores of the students taught with traditionally designed chemistry instruction (TDCI) and those taught with inquiry oriented instruction (IOI) with respect to understanding of atom concepts.

$H_0$2. There is no statistically significant difference between the post-test mean scores of boys and girls with respect to understanding of atom concepts.

$H_0$3. There is no statistically significant effect of interaction between gender and treatment with respect to understanding of atom concepts.

$H_0$4. There is no statistically significant difference between the post-test mean scores of the students taught with traditionally designed chemistry instruction (TDCI) and those taught with inquiry oriented instruction (IOI) with respect to learning approaches.

$H_0$5. There is no statistically significant difference between the post-test mean scores of boys and girls with respect to learning approaches.

$H_0$6. There is no statistically significant effect of interaction between gender and treatment with respect to learning approaches.

$H_0$7. There is no statistically significant difference between the post-test mean scores of the students taught with traditionally designed chemistry instruction (TDCI) and those taught with inquiry oriented instruction (IOI) with respect to motivational goals.

$H_0$8. There is no statistically significant difference between the post-test mean scores of boys and girls with respect to motivational goals.

$H_0$9. There is no statistically significant effect of interaction between gender and treatment with respect to motivational goals.

$H_0$10. There is no statistically significant difference between the post-test mean scores of the students taught with traditionally designed chemistry instruction (TDCI) and those taught with inquiry oriented instruction (IOI) with respect to self-efficacy.

$H_0$11. There is no statistically significant difference between the post-test mean scores of boys and girls with respect to self-efficacy.

$H_0$12. There is no statistically significant effect of interaction between gender and treatment with respect to self-efficacy.

$H_0$13. There is no statistically significant difference between the post-test mean scores of the students taught with traditionally designed chemistry instruction (TDCI) and those taught with inquiry oriented instruction (IOI) with respect to epistemological beliefs.

$H_0$14. There is no statistically significant difference between the post-test mean scores of boys and girls with respect to epistemological beliefs.

$H_0$15. There is no statistically significant effect of interaction between gender and treatment with respect to epistemological beliefs.

CHAPTER 4

DESIGN OF THE STUDY

4.1 The Experimental Design

In this study the Non-Equivalent Control Group Design as a type of Quasi-Experimental Design was used. Because the random assignment of already formed classes to experimental and control groups was employed to examine the treatment effect due to exposure to the combined strategy. Intact classes were used because it would have been too disruptive to the curriculum and too time consuming to have students out of their classes for treatment.

Table 4.1 Research design of the Study

Groups	Pre-Test	Treatment	Post-test
EG	LGA, AMQ, SKQ, RAT	IOI	LGA, AMQ, SKQ, RAT, CAT
CG	LGA, AMQ, SKQ, RAT	TDCI	LGA, AMQ, SKQ, RAT, CAT

In this table, EG represents the Experimental Group instructed by inquiry oriented instruction (IOI). CG represents the Control Group instructed by traditionally designed chemistry instruction (TDCI). LGA is the Learning Approach Questionnaire. AMG is the Achievement Motivation Questionnaire. SKQ is the Science Knowledge Questionnaire. CAT is the Chemistry Achievement Test.

To determine the effect of the treatment on dependent variables and to control students' learning approaches, motivational goals, self-efficacy, epistemological beliefs, three tests (LGA, AMQ, and SKQ) were administered to the students in both groups as a pre-test. At the end of the treatment, five tests (LGA, AMQ, SKQ, RAT, ACT) were given to the students in both groups. The original languages of the tests (LGA, AMQ, SKQ) were English. Since, the language of the school, which the research was performed, is Turkish the tests were translated into Turkish. Translation was performed by an expert interpreter, and checked by an expert chemistry instructor. Therefore, a pilot study was done to examine the reliability of the test. The subjects of the pilot study were 41 ninth grade students from Private Yüce High School.

4.2 Subjects of the Study

47 ninth grade students from 2 classes of a chemistry course were taught by the same teacher in Private Yüce Science High School in the 2003-2004 spring semester were the subjects of the study.

Two teaching methods used in this study were randomly assigned to each group. The experimental group who received inquiry oriented instruction (IOI) consisted of 22 students while the control group who received traditionally designed chemistry instruction (TDCI) consisted of 25 students. Students' ages ranged from 15 to 16 years old. The socioeconomic background of students was similar, with the majority of coming from the high-class families. Students attended the chemistry course two times, each lasted about 90 minutes, in a week and the study took about three weeks. Two different teaching methods were applied to groups, and before and after the treatment same test was applied to the experimental and control group students.

4.3 Variables

Independent variables are the treatment or manipulated variables, which are the investigator, chose to study and often manipulate in order to assess their possible effects on one or more other variables. And the variable that the independent variable is presumed to affect is called the dependent variable.

4.3.1 Independent Variables

The independent variables in this study were the treatment; (Inquiry-Based Instruction vs. Traditionally Designed Chemistry Instruction) and the gender.

4.3.2 Dependent Variables

Dependent variables were the students' understanding of atom concepts measured by ACT, meaningful learning and rote learning measured by LAQ, learning-goal orientation, performance-goal orientation and self-efficacy measured by AMQ, and epistemological beliefs measured by SKQ. The variables used in this study are given in Table 4.2.

Table 4.2 Types of variables

Variables	Type
CAT Scores	Dependent
LAQ Scores	Dependent
AMQ Scores	Dependent
SKQ Scores	Dependent
Treatment	Independent
Gender	Independent

4.4 Instruments

4.4.1 Chemistry Achievement Test

The researcher developed the test. It consisted of 20 multiple-choice questions. Each question had one correct answer and four distracters. Content of the test was determined from the lecture materials and some chemistry books (Dinçer, A. 1995; Oylumlu, F. 2002). The items were related to atomic structure of matter and atomic models. During the developmental stage of the test the following procedure was followed; first the instructional objectives for the atom concepts were stated

(Appendix A). Second, the item books are carefully examined in order to find the items, which were suitable for the instructional objectives. After the developmental stage, the experts controlled the items. The test was written in Turkish, because the language of the school, which the research was performed, is Turkish.

The test consisted of nine conceptual, ten algorithmic and one visual question. The conceptual questions aimed to asses' students' qualitative understanding of the atomic models. The algorithmic questions measured the students' understanding of the atomic particles, which are neutron, proton and electron. The visual question was related to graphical representation of isotones, isobar, and isotope concepts.

The reliability of the test (Cronbach Alpha) was found to be 0.63. The test was applied as a post-test to both experimental and control groups. (See Appendix B)

4.4.2 Learning Approach Questionnaire

The Learning Approach Questionnaire (LAQ) used in this research was a 22-item Likert instrument used and developed in previous research (Bou Jaoude, 1992; Cavallo & Schafer, 1994). The instrument was designed to measure students' learning approach as ranging from rote to meaningful. The instrument asked students to respond to questions regarding how they learn. A high score on the RL indicates a higher degree of rote learning and a high score on the ML indicates a higher degree of meaningful learning. The rote learning skill (RL) consisted of 10 items, and meaningful learning (ML) skill consisted of 12 items. The rote scores from the LAQ were reverse-scored so that high score represents a more meaningful learning orientation and low scores represented a more rote learning orientation. Examples of the 10 items constituting the rote learning scale are as follows: "I tend to remember things best if I Concentrate on the order in which they were presented by the instructor."; "I have to concentrate on memorizing a good deal of what I have to learn." And examples of the 12 items from the meaningful learning scale are as fallows: "I generally put a lot of effort into trying to understand things that initially seem difficult."; "I try to relate new material, as I am reading it, to what I already know on the topic."

In the pilot study the Cronbach alpha internal consistency for this instrument was found as .86 for the meaningful scale, and .67 for the rote learning scale. (See Appendix C)

4.4.3 Achievement Motivation Questionnaire

The achievement motivation Questionnaire (AMQ) was a 14-item Likert scale instrument, ranging from strongly disagree to strongly agree, adapted from questionnaires of Dweck (1986) and Ames and Archer (1988) and used in a previous research Cavallo, Rozman, Blickenstaff, Walker, Turoczi and Waters (2000). The AMQ consists of three scales that measure students' learning-goal orientation (LG), performance-goal orientation (PG) and students' self-efficacy (SE) in the chemistry course. The learning-goal orientation (LG) consisted of 5 items, the performance-goal orientation (PG) consisted of 5 items and students' self-efficacy (SE) consisted of 4 items. The set of motivational goal items were designed to assess students' perceptions of the learning and performance dimensions of classroom goal structure, as outlined in Table 4.3 (Ames and Archer, 1988)

Table 4.3 Achievment Goal Analysis of Classroom Climate

Climate Dimensions	Learning Goal	Performance Goal
Success defined as…	Improvement, progress	High grades, high normative performance
Value placed on…	Effort/ learning	Normatively high ability
Reasons for satisfaction…	Working hard, challenge	Doing better than others
Teacher oriented toward…	How student are learning	How students are performing
View of errors/mistakes…	Part of learning	Anxiety eliciting
Focus of attention…	Process of learning	Own performanced relative to others
Reasons for effort…	Learning something new	High grades, performing better than others
Evaluation criteria…	Absolute, progress	Normative

A factor analysis on the total item sample yielded a three-factor solution that confirmed a priori classification of items into learning and performance-goal orientation and self-efficacy categories. Examples of the 5 item constituting the learning-goal orientation are as fallows: “One of my primary goals in the class is to understand the science activities that we do.” ; “One of my primary goals in this class is to under5stand the material that we study.” Examples of the 5 items from the performance-goal orientation are as fallows: “One of my primary goals in this class is to do better than other students.” ; “One of my primary goals is to not look foolish or stupid when doing science activities in this class.” And examples of the 4 items from the self-efficacy scale are as fallows: “I am confident I can do well on the science problems we are given in this class.” ; “I possess the skill needed to solve problems like the ones given in this class.”

The Cronbach alpha reliability of pilot test was .79 for the learning-goal scale, .70 for the performance-goal scale, and .60 for the self-efficacy scale. (See Appendix D)

4.4.4 Science Knowledge Questionnaire

The Science Knowledge Questionnaire (SKQ) used in this study was a 16-item Likert instrument measuring students’ epistemological beliefs about the nature of science. The items related to epistemology of science. The items on the questionnaire were complied from several instruments used in science education research that contain items related to epistemology of science. A high score represents a belief that science is dynamic, changing, and tentatively known. A low score represents a belief that science is fixed, unchanging and authoritatively known. The Science Knowledge Questionnaire was used in a previous research (Cavallo and Schafer, 1994) and developed by Saunders (1998). The Cronbach Alpha reliability, which is obtained from the pilot study, was .52. (See Appendix E)

4.5 Treatment (IOI vs. TDCI)

The study was conducted over 3 weeks during the 2003-2004-spring semester at Private Yüce Science High School. 47 ninth grade students in two chemistry classes of the same teacher were enrolled in the study.

In this study, there were two groups; experimental and control group. The experimental group was instructed by inquiry-based teaching method. On the other hand, the control group was instructed by traditionally designed chemistry education. Both experimental and control groups were given LGA, AMQ, and SKQ as a pre-test at the beginning of the treatment in order to determine whether there would be a significant difference between two groups. In addition to this, a regular exam was used instead of a pre-test of CAT. And this exam contained 10 multiple choice items related to Atom concept. These items were exactly consisted with the items of CAT.

During the treatment period, the atom topics were covered as apart of the regular classrom curriculum in the chemistry course. The classroom instruction was two 90-minute sessions per week.

Students in experimental group were enrolled in a highly inquiry-based, student-centered instruction. The course was designed to improve student's understanding of atom concept as compared what may be done in traditionally designed chemistry courses. The inquiry-oriented instruction focused on students' attainment of meaningful conceptual understandings of chemistry concepts. Teaching procedure developed from simple to complex. The students, who received inquiry-oriented intsruction emphasized the teaching of scientific methodology rather than rote memorization, the inquiry-oriented intsruction used to introduce, explore, and suggest problems rather than to confirm the already taught instruction on a particular unit.

According to Rachelson (1977), an inquriy teaching method should involved the following steps:

- To bring the students to an awareness of the problem to be investigated.
- To construct hypotheses as tentative solutions of the problem.
- To collect evidence on hypotheses.
- To organize the data in order to test their own hypotheses.
- To make conclusions, verifications, generalizations, and implications.

According to these steps, it is possible to say that inquriy process has two components. One of them was hypothesis construction, the other was hypothesis testing. Students did not create facts but they developed to order known facts on the problem situation. During the treatment procedure, students did hypothesis construction and hypothesis testing. In order to bring the students to an awareness of the problem to be investigated, the teacher asked the main problem of the lesson to the students. Then, to construct hypotheses as tentative solutions of the problem, the teacher asked to the students their ideas about the solutions of the problem. For collecting evidence on hypotheses, the students discuss each other. Students organized the obtained data by writing their discussed ideas to teir notebooks. Finally, to make conclusions, the students discussed their ideas with the teacher, and obtained the solution of the problem.

Students' homework and quizzes were based on real-life situations. Students were encouraged to link these situations to atomic models and atomic particles studied through the course. In order to see the students' conceptual understandings, they responded the chemistry problems with written explanations in addition to calculations.

As a result, the inquiry-based teaching approach uses the "inductive" teaching-learning methodology. And the role of the teacher was, to provide guidance to the students.

On the other hand, in the control group the students were instructed only with traditionally designed chemistry course. During the traditionally designed instruction, the teacher used lecture and discussion methods. And also the teacher solved algorithmic problems and make suggestions when needed. The teacher acted as a facilitator. In summary, traditionally designed teaching method used “deductive” teaching-learning methodology.

4.6 Analysis of Data

Analysis of Variance (ANOVA) was used in order to identify the effects of treatment, gender differences and interaction between treatment and gender on students’ understanding of atom concept, learning approaches, motivational goals, self-efficacy, and epistemological beliefs. And also, independent t-test statistics was used to determine the difference between the per-test mean scores of the students who used IOI and those using TDCI with respect to understanding of atom concept, learning approaches, motivational goals, self-efficacy, and epistemological beliefs.

4.7 Assumptions and Limitations

4.7.1 Assumptions

1. The teacher was not biased during the treatment.
2. Students in both groups answered the questions of instruments seriously.
3. The tests were administered under the standard conditions.
4. Students in both groups did not interact with each other.
5. There is no other factor than the use of inquiry-based instruction that changes the post-test results of students in the experimental group.

4.7.2 Limitations

1. The subjects of this study were limited to 47 ninth grade students from Private Yüce Science High School.
2. The study was limited to the unit of “Atomic Particles”.
3. The study was limited to three weeks period.

CHAPTER 5

RESULTS AND CONCLUSIONS

Results obtained through testing each of the hypotheses, which were stated in Chapter 3 are presented in this chapter. The hypotheses are tested at a significant level of 0.05. Independent t-test and Analysis of Variance (ANOVA) models were used in order to test the hypotheses. Statistical analyses were carried out by using Statistical Package for social Sciences for Personal Computers, (SPSS).

5.1 Results

LAQ, AMQ, SKQ were given to the students before the treatment in order to find out students' prior learning approaches, motivational goals, self-efficacy, and epistemological beliefs, respectively. And a regular school exam was used as a pre-test of CAT in order to determine whether there would be a significant difference between two groups.

The analyses showed that there was no significant difference between IOI group and TDCI group in terms of scores on LAQ, AMQ, SKQ, and CAT before the treatment. The statistical scores are summarized in the table 5.1 as follows:

Table 5.1 Independent t-Test Summary

	LAQ		AMQ			SKQ	CAT
	ML	RL	LG	PG	SE	SB	UAC
T	0.040	0.488	0.800	0.403	0.480	0.067	0.467
P	0.968	0.628	0.428	0.689	0.633	0.947	0.652

In this table, ML represents Meaningful Learning and RL represent Rote Learning. LG is the Learning Goal orientation. PG is the Performance Goal orientation. SE is the Self-Efficacy. SB is the epistemological beliefs. UAC is the understanding of atom concept.

5.1.1 Chemistry Achievment Results

To answer the questions posed by hypotheses 1 stating that there is no statistically significant difference between the post-test mean scores of the student taught with traditionally designed chemistry instruction (TDCI) and those taught with inquiry oriented instruction (IOI) with respect to understanding of atom concept, hypotheses 2 stating that there is no statistically significant difference between the post-test mean scores of boys and girls with respect to understanding of atom concept, and hypotheses 3 stating that there is no statistically significant effect of interaction between gender and treatment with respect to understanding of atom concept, analysis of variance was used. The analysis of data is summarized in Table 5.2.

Table 5.2 ANOVA Summary (Achievement)

Source	df	A)	MS	F	p
Gender	1	68.172	68.172	0.257	0.654
Treatment	1	1795.784	1795.784	6.781	0.013
Interaction	1	46.717	46.717	0.176	0.677
Error	43	11387.340	264.822		

The analysis results showed that there was statistically significant difference between the post-test mean scores of IOI group and TDCI group with respect to understanding of atom concept. IOI group scored significantly higher than the TDCI group ($\overline{X}$ (IOI)=77,73; $\overline{X}$ (TDCI)=65,20). However, there was not statistically significant difference between the post-test mean scores of boys and girls with respect to understanding of atom concept, and also there was not statistically significant interaction between gender and treatment with respect to understanding of atom concept.

5.1.2 Learning Approach Results

To answer the questions posed by hypotheses 4 stating that there is no statistically significant difference between the post-test mean scores of the student taught with traditionally designed chemistry instruction (TDCI) and those taught with inquiry oriented instruction (IOI) with respect to learning approaches, hypotheses 5 stating that there is no statistically significant difference between the post-test mean scores of boys and girls with respect to learning approaches, and hypotheses 6 stating that there is no statistically significant effect of interaction between gender and treatment with respect to learning approaches, analysis of variance was used. The analysis of data is summarized in Table 5.3 and Table 5.4.

Table 5.3 ANOVA Summary (ML)

Source	Df	SS	MS	F	P
Gender	1	50.902	50.902	2.021	0.162
Treatment	1	0.593	0.593	0.024	0.879
Interaction	1	43.861	43.861	1.741	0.194
Error	43	1083.144	25.189		

Table 5.4 ANOVA Summary (RL)

Source	df	SS	MS	F	P
Gender	1	7.125	7.125	0.482	0.491
Treatment	1	5.607	5.607	0.380	0.541
Interaction	1	1.668E-02	1.668E-02	0.001	0.973
Error	42	620.256	17.768		

The analysis results showed that there was not statistically significant difference between the post-test mean scores of IOI group and TDCI group with respect to meaningful learning orientation. Also there was not statistically significant difference between the post-test mean scores of boys and girls with respect to meaningful learning orientation, and there was not statistically significant interaction between gender and treatment with respect to meaningful learning orientation.

And the same results obtained for rote learning orientation. According to table 5.4 it can be said that, there was not statistically significant difference between the post-test mean scores of IOI group and TDCI group with respect to rote learning orientation. Also there was not statistically significant difference between the post-test mean scores of boys and girls with respect to rote learning orientation, and there was not statistically significant interaction between gender and treatment with respect to rote learning orientation.

5.1.3 Motivational Goals Results

To answer the questions posed by hypotheses 7 stating that there is no statistically significant difference between the post-test mean scores of the student taught with traditionally designed chemistry instruction (TDCI) and those taught with inquiry oriented instruction (IOI) with respect to motivational goals, hypotheses 8 stating that there is no statistically significant difference between the post-test mean scores of boys and girls with respect to motivational goals, and hypotheses 9 stating that there is no statistically significant effect of interaction between gender and treatment with respect to motivational goals, analysis of variance was used. The analysis of data is summarized in Table 5.5 and Table 5.6.

Table 5.5 ANOVA Summary (LG)

Source	Df	SS	MS	F	P
Gender	1	16.917	16.917	3.677	0.062
Treatment	1	8.917	8.917	1.938	0.171
Interaction	1	16.457	16.457	3.577	0.065
Error	42	193.233	4.601		

Table 5.6 ANOVA Summary (PG)

Source	df	SS	MS	F	P
Gender	1	0.249	0.249	0.021	0.884
Treatment	1	1.681	1.681	0.145	0.705
Interaction	1	15.561	15.561	1.342	0.253
Error	42	486.939	11.594		

The analysis results showed that there was not statistically significant difference between the post-test mean scores of IOI group and TDCI group with respect to performance goal orientation, there was not statistically significant difference between the post-test mean scores of boys and girls with respect to performance goal orientation, and also there was not statistically significant interaction between gender and treatment with respect to performance goal orientation.

And the same results obtained for rote learning orientation. The analysis results showed that there was not statistically significant difference between the post-test mean scores of IOI group and TDCI group with respect to learning goal orientation, there was not statistically significant difference between the post-test mean scores of boys and girls with respect to learning goal orientation, and also there was not statistically significant interaction between gender and treatment with respect to learning goal orientation.

5.1.4 Self-Efficacy Results

To answer the questions posed by hypotheses 10 stating that there is no statistically significant difference between the post-test mean scores of the student taught with traditionally designed chemistry instruction (TDCI) and those taught with inquiry oriented instruction (IOI) with respect to self-efficacy, hypotheses 11 stating that there is no statistically significant difference between the post-test mean scores of boys and girls with respect to self-efficacy, and hypotheses 12 stating that there is no statistically significant effect of interaction between gender and treatment with respect to self-efficacy, analysis of variance was used. The analysis of data is summarized in Table 5.7.

Table 5.7 ANOVA Summary (SE)

Source	Df	SS	MS	F	P
Gender	1	1.966	1.966	0.869	0.356
Treatment	1	1.780E-02	1.780E-02	0.008	0.930
Interaction	1	8.966	8.966	3.964	0.053
Error	43	97.247	2.262		

The analysis results showed that there was not statistically significant difference between the post-test mean scores of IOI group and TDCI group with respect to self-efficacy, there was not statistically significant difference between the post-test mean scores of boys and girls with respect to self-efficacy, and also there was not statistically significant interaction between gender and treatment with respect to self-efficacy.

5.1.5 Epistemological Beliefs Results

To answer the questions posed by hypotheses 13 stating that there is no statistically significant difference between the post-test mean scores of the student taught with traditionally designed chemistry instruction (TDCI) and those taught with inquiry oriented instruction (IOI) with respect to epistemological beliefs, hypotheses 14 stating that there is no statistically significant difference between the post-test mean scores of boys and girls with respect to epistemological beliefs, and hypotheses 15 stating that there is no statistically significant effect of interaction between gender and treatment with respect to epistemological beliefs, analysis of variance was used. The analysis of data is summarized in Table 5.8.

Table 5.8 ANOVA Summary (SB)

Source	Df	SS	MS	F	P
Gender	1	2.452	2.452	0.113	0.739
Treatment	1	9.592	9.592	0.441	0.510
Interaction	1	1.935	1.935	0.089	0.767
Error	43	935.510	21.756		

The analysis results showed that there was not statistically significant difference between the post-test mean scores of IOI group and TDCI group with respect to epistemological beliefs. There was not statistically significant difference between the post-test mean scores of boys and girls with respect to epistemological beliefs, and also there was not statistically significant interaction between gender and treatment with respect to epistemological beliefs.

5.2 Conclusions

The following conclusions can be deducted from the results:

1. The IOI caused a significantly better acquisition of scientific conceptions related to atom concept than the TDCI.
2. There is no statistically significant difference between the post-test mean scores of boys and girls with respect to students' understanding of atom concept, learning approaches, motivational goals, self-efficacy, and epistemological beliefs.
3. There is no statistically significant effect of interaction between gender and treatment with respect to students' understanding of atom concept, learning approaches, motivational goals, self-efficacy, and epistemological beliefs.

CHAPTER 6

DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

This chapter involves discussion of results and implications and recommendations for further research.

6.1 Discussion

The main purpose of this study is to explore the effects of inquiry-based high school chemistry course and gender differences on students' understanding of atom concept, learning approaches, motivational goals, self-efficacy, and epistemological beliefs.

In this study, before the treatment the experimental and control group students were examined in order to their school success. It was found that there is no statistical difference between experimental group and control group students ($\overline{X}$(IOI)=63.10; $\overline{X}$(TDCI)=64.30). Then the Atom Concept Test was administered to all subjects after the treatment to compare the effects of two different instructions (IOI vs. TDCI) on students' understanding of atom concept. Inquiry oriented instruction had a significantly higher post-test mean scores on the Atom Concept Test than the traditionally designed chemistry instruction group after the treatment ($\overline{X}$(IOI)=77.73; $\overline{X}$(TDCI)=65.20).The difference between learning activities provided in inquiry oriented instruction and traditionally designed chemistry instruction may cause to difference in achievement of students in both groups. The inquiry-oriented instruction was designed to lead students from their prior knowledge to the scientific knowledge. On the other hand, the traditionally designed chemistry instruction followed the logical presentation of atom concept generally seen in textbooks on chemistry.

The findings of this study indicated that inquiry oriented instruction was effective at students' understandings of scientific knowledge. The results of this study are consisted with the results of the studies conducted by Peterson (1978), Niaz (1998; 2000), Bibens (2001), Zachry (1985), Anderson (2002). On the other hand, this study is not consistent with the studies conducted by Carl (1980), McMeen (1983).

The inquiry-based instruction was a student-centered instruction. Therefore, the course was designed to improve student's understanding of atom concept and reduce misconceptions as compared what may be done in traditionally designed chemistry courses. The teacher gives fewer formulas and calculations, and conceptual understanding was emphasized as compared to traditionally designed chemistry course. The instruction focused on students' attainment of meaningful conceptual understandings of chemistry concepts. In order to see the students' conceptual understandings, they responded the chemistry problems with written explanations in addition to calculations. As a result, the "inductive" teaching-learning methodology was used. And the role of the teacher was, provide guidance to the students. By this way students became more effective. However in traditionally designed chemistry course students were passive listeners. An example of the inquiry-oriented instruction can be seen in Appendix F.

On the other hand, in this study, the difference between boys and girls and the interaction between treatment (inquiry oriented instruction vs. traditionally designed instruction) and gender with respect to understanding of atom concept was examined. The present study failed to find neither difference nor interaction. Levels of students in Private Yüce Science High School are similar because they were administered entrance examination for attending these schools.

Moreover, the main purpose of this study is to explore the effects of inquiry-based high school chemistry course and gender differences with respect to students' learning approaches, motivational goals, self-efficacy, and epistemological beliefs.

It is found that, there was not statistically significant difference between the post-test mean scores of the student taught with traditionally designed chemistry instruction (TDCI) and those taught with inquiry oriented instruction (IOI) with respect to learning approaches. The findings of this study are consisted with the study conducted by Saunders, Cavallo and Abraham (2001). They indicated that, type of instruction was not correlated with meaningful or rote learning orientation. Furthermore, the present study failed to find neither difference between boys and girls nor interaction between treatment (IOI vs. TDCI) and gender. These results consistent with the study conducted by Cavallo and Schafer (1994). They found no apparent difference between boys and girls' tendencies toward either rote or meaningful learning of genetic topics.

Results showed that there was not statistically significant difference between the post-test mean scores of the student taught with traditionally designed chemistry instruction (TDCI) and those taught with inquiry oriented instruction (IOI) with respect to motivational goals. Furthermore, the present study also failed to find neither difference between boys and girls nor interaction between treatment (IOI vs. TDCI) and gender. These results consistent with the previous studies of gender difference in achievement motivation have shown either little difference in male and female scores on achievement motivation surveys (BouJaoude& Giuliano, 1994) of slightly higher scores among males (Steinkamp& Maehr, 1984).

Similar results obtained for self-efficacy. Since, there was not statistically significant difference between the post-test mean scores of the student taught with traditionally designed chemistry instruction (TDCI) and those taught with inquiry oriented instruction (IOI) with respect to self-efficacy. This result is inconsistent with the study conducted by Shavelson and Bolus (1982). Because they posed that students in inquiry-based courses will gain greater self-efficacy of their ability toward succeeding in that subject. And also the present study failed to find neither difference between boys and girls nor interaction between treatment (IOI vs. TDCI) and gender. This result also is inconsistent with Shavelson and Bolus (1982)' study. Since they stated that females tend to have lower self-efficacy in science than males.

Findings showed that, there is no statistically significant difference between the post-test mean scores of the student taught with traditionally designed chemistry instruction (TDCI) and those taught with inquiry oriented instruction (IOI) with respect to epistemological beliefs. This result is consistent with the Saunders, Cavallo and Abraham (2001)' study. They indicated that, the type of instruction was not correlated with epistemological beliefs. And the present study failed to find neither difference between boys and girls nor interaction between treatment (IOI vs. TDCI) and gender. However this result is inconsistent with the study conducted by Saunders, Cavallo and Abraham (2001). Results of that study showed that, there is significant difference between male and female students' epistemological beliefs. Male students were more likely to believe in the reasoned nature of knowledge in science, while female students were more likely believe in the received nature of knowledge in science.

In summary, this study has shown that, inquiry oriented instruction did lead to better understanding of atom concept. However, inquiry oriented instruction did not affect the students' learning approaches, motivational goals, self-efficacy, and epistemological beliefs. And also the present study failed to find neither difference between boys and girls nor interaction between treatment (IOI vs. TDCI) and gender with respect to students' understanding of atom concept, learning approaches, motivational goals, self-efficacy, and epistemological beliefs.

6.2 Implications

This study has the following implications regarding students' understanding of atom concept and other chemical concepts in general:

1. Inquiry oriented instruction has been shown to be an effective teaching approach. And this approach suggests that science teachers should give the students an opportunity to develop the steps of scientific inquiry and to arrive at

generalizations, formulations of hypotheses and to test their own hypotheses. Traditionally designed chemistry instruction is teacher centered and it provides little opportunity for the students to develop their self-directed study habits.

2. Teachers must be informed about the usage and importance of inquiry oriented instruction.

3. Well-designed inquiry oriented instruction can cause a significantly better acquisition of scientific conceptions.

4. Teachers should be introduced to various instructional methods and instruments for better acquisition of scientific concepts.

5. The chemistry course content should be changed in order to provide teachers more time for developing instructional methods to obtain better understanding of scientific concepts.

6.3 Recommendations

On the basis of the findings from this study, the researcher recommends that:

A study can be conducted with different grade levels and different science courses.

This present study can be conducted with a larger sample size from different schools in order to get more accurate results and to make a generalization for Turkish student population.

Other instructional methods, which are problem solving, demonstration, concept map, etc., can be used.

REFERENCES

Abd-El-Khalick, F., Bell, R.L., & Lederman, N.G. (1998). The nature of science and instructional practice: Making the unnatural natural. Science Education, 82(4), 417-436.

Abd-El-Khalick, F., BouJaoude, S., Duschl, R., Lederman, N.G., Niaz, M., Treagust, D., Tuan, H. (2003). Inquiry in science education: International perspectives. Paper presented at an international symposium, USA

Akerson, V.L., Abd-El-Khalick, & Lederman, N.G. (2000). Influence of reflective explicit activity-based approach on elementary teachers' conceptions of nature of science. Journal of Research in Science Teaching, 37(4), 295-317.

Ames, C. & Archer, J. (1988). Achievement goals in the classroom: Students' learning strategies and motivation processes. Journal of Educational Psychology, 80, 260-267.

Anderson, R.D. (2002). Reforming science teaching: What research says about inquiry. Journal of Science Teacher Education, 13(1), 1-12.

Arık, A. & Polat, R. (2000). Oran chemistry 1 1st Ed., Oran Yayıncılık, İzmir.

Ausubel, D.P. (1963). The psychology of meaningful verbal learning. New York: Grune & Stratton.

Ausubel, D.P. (1968). A subsumption theory of meaningful verbal learning and retention. In R.G. Kuhlen (Ed.), Studies in educational psychology, (pp.167-174). Boston: Blaisdell Publishing.

Baez, A. (1971). “Aims, Contents and Methodology of Science Teaching”, in Science and Education in Developing States, edited by Gillon, H., Draeger Publishers, New York.

Bandura, A. (1995). Exercise of personal and collective efficacy in changing societies. In A.Bandura (ed.), Self-Efficacy in Changing Societies, (pp.1-45), New York: Cambidge University Press.

Bibens, R.F. (2001). Using Inquiry Effectively. Theory Into Practice, 19, 87-92.

BouJaoude, S. (1992). The relationship between high school students’ learning strategies and the change in their misunderstandings during a high school chemistry course. Journal of Research in Science Teaching, 29, 687-699.

BouJaoude, S. & Giuliano, F.J. (1994). Relationships between achievement and selective variables in a chemistry course for non-majors. School Science and Mathematics, 94, 296-302.

Braten, I., Samuelstuen, M. S., and Strømsø, H. I. (2004). Do students' self-efficacy beliefs moderate the effects of performance goals on self-regulatory strategy use? Educational Psychology, 24 (2), 231-247.

Carl, M. (1980). An evaluation of the effectiveness of the use of inquiry instruction to foster creativity in intermediate grade students. International Abstracts, 42, 642-A.

Cavallo, A.M.L., Rozman, M., Blickenstaff, J., Walker, N. (2004). Learning, reasoning, motivation, and epistemological beliefs. Journal of College Science Teaching, 33(3), 18-23.

Cavallo, A.M.L., Rozman, M., Blickenstaff, J., Walker, N., Turoczi, H., & Waters, J. (2000). Students’ learning aproaches, reasoning abilities, motivational goals, and epistemological beliefs in differing college science courses. Paper presented at the annual conference of the National Association for Research in Science Teaching, New Orelans, LA.

Cavallo, A.M.L. (1996). Meaningful learning, reasoning ability and students' understanding and problem solving of genetics topics. Journal of Research in Science Teaching, 33, 625-656.

Cavallo, A.M.L., and Schafer, L.E. (1994). Relationships between students' meaningful learning orientation and their understanding of genetics topics. Journal of Research in Science Teaching, 31, 393-418.

Cohen, H.D., Hillman, D.F. & Agne, R.M. (1978). Cognitive level and college physics achievement. American Journal of Physics, 46, 1026-1029.

Dinçer, A. (1995). Liseler için kimya 1 ders kitabı. 1st Ed., ABC Matbaacılık Yayıncılık, Ankara.

Diweck, C.S. (1986). Motivational processes affecting learning. American Psychologist, 41, 1040-1048.

Gagne, R.M. (1963) The Learning requirements for inquiry. Journal of Research in Science Teaching, 1, 144-153.

Hogan, K. (2000). Exploring a process view of students' knowledge about the nature of science. Science Education, 84, 51-70.

Hurd, P.D.H. (1970). Scientific enlightement for an age of science. The Science Teacher, January, 13-15,

Keiffer, B. (1995). Atom illumination. The Science Teacher, 62, 1, 29-31

Khishfe, R., & Abd-El-Khalick, F. (2002). The influence of explicit reflective versus implicit inquiry-oriented instruction on sixth graders' views of nature of science. Journal of Research in Science Teaching, 39(7), 551-578.

Klassen, R.M. (2004). Optimism and realisim: a review of self-efficacy from a cross-cultural perspective. Journal of Psychology, 39(3), 205-230.

Klopfer, L.E. (1971). Evaluation of learnings in science, In B.S. Bloom, J.T. Hastings, and G.F.Madaus. (Eds.), Handbook on Formative Summative Evaluation of Student Learning. New York, McGraw-Hill, 559-642.

Kyle, W. (1980). The distinction between inquiry and scientific inquiry and why high school students should be cognizant of the distinction. Journal of Research in Science Teaching, 17, 123-130.

Johnson, M.A., & Lawson, A.E. (1998). What are the relative effects of reasoning ability and prior knowledge on biology achievement in expository and inquiry classes. Journal of Research in Science Teaching, 35, 89-103.

Leondari, Am, Gialamas, V. (2002). Implicit theories, goal orientations, and perceived competence: Impact on students' achievment behavior. Psychology In The School, 39(3), 279-297.

Liben, L.S. & Golbeck, S.L. (1980). Sex differences in performance on Piagetian spatial tasks: Differences in competence or performance? Child Development, 51, 594-597.

Lynn, R., Irwing, P. (2002). Sex differences in general knowledge, semantic memory and reasoning ability. British Journal of Psychology, 93 (4)

Maehr, M.L. & Stallings, W.M. (1972). Freedom from external evaluation. Child Development, 43, 177-185.

Marek, E.A. & Cavallo, A.M.L. (1995). Passkeys to learning science in the elemantary schools: The data and language of science. Journal of Elementary Science Education, 7, 1-15.

Massialos, B. & Cox, M. (1972). Models of teaching. Prentice Hall Inc., Englewood Cliffs.

McMeen, J. (1983). The role of chemistry inquiry oriented laboratory approach in facilitating cognitive growth and development. Dissertation Abstracts, 44(01), 130-A.

Niaz, M., (1998). From cathode rays to alpha particles to quantum of action: A rational reconstruction of structure of the atom and its implications for chemistry textbooks. Science Education, 82, 527-552.

Niaz, M., (2000). The oil drop experiment: A rational reconstruction of the Millikan-Ehrenhaft controversy and its implication for chemistry textbooks. Journal of Research in Science Teaching, 37, 480-508.

Niaz, M., Aguilera, D., Maza, A., Liendo, G. (2002). Arguments, contradictions, resistances, and conceptual change in students' understanding of atomic structure. Science Education, 86, 204, 505-525.

Novak, J.D. (1988). Learning science and the science of learning. Studies in Science Education, 15, 77-101.

Oylumlu, F. (2002). ÖSS konu anlatımlı kimya. 1st Ed. Birey Eğitim Yayınları. 69-128.

Paulsen, M. B. & Feldman, K. A. (1999). Student motivation and epistemological beliefs. New Directions for Teaching And Learning, 78, 17-25.

Peterson, K. (1978). Scientific inquiry training for high school studies. experimental evaluation of a model program. Journal of Research in Science Teaching, 15, 153-159.

Piaget, J. (1964). Cognitive development in children: Piaget, development and learning. Journal of Research in Science Teaching, 2, 176-180.

Records, R.M., (1982). Developing models: What is the atom really like? Journal of Chemical Education, 59,4, 307-309.

Reinke, W.M. & Hall, C. (2003). Self-efficacy, goal orientation, and fear of failure as predictors of school engagement in high school students. Psychology in The Schools 40(4),417-427.

Renner, J.W. & Marek, E.A. (1990). An educational theory base for science teaching. Journal of Research in Science Teaching, 27, 241-246.

Renner J.W., & Stafford, D.G. (1972). Teaching science in the secondary school, New York, Harper and Row.

Robinson, J.T. (1965). Science Teaching and the nature of science. Journal of Research in Science Teaching, 3, 37-50.

Rubba, P.A. and Andersen, H.O., Development of an instrument to assess secondary school students' understanding of the nature of scientific knowledge. Science Education, 62(4): 449-458, 1978.

Rutherford, J. (1964). The role of inquiry, in science teaching. Journal of Research in Science Teaching, 2, 80-84.

Salili, F. & Lai, M.K. (2003). Learning and motivation of chinese student in Hong Kong : A longitudinal study of contextual influences on students' achievment orientations and performance. Psychology In The Schools, 40(1), 51-70.

Saunders, G.L., Cavallo, A.L., Abraham, M.R. (2001). Relationships among epistemological beliefs, gender, approaches to learning, and implementation of instruction in chemistry laboratory. Paper presented at the annual meeting of the National Association for Research in Science, Boston, MA.

Saunders, G.L., Cavallo, A.M.L., & Abraham, M.R. (1999, March). Relationships among epistemological beliefs, gender, approaches to learning, and implementation of instruction in chemistry laboratory. Paper presented at the annual conference of the National Association for Research in Science Teaching, Boston, MA.

Schommer, M. (1990). Effects of beliefs about the nature of knowledge on comprehension. Journal of Educational Psychology, 82(3), 498-504.

Shavelson, R.J. & Bolus, R. (1982). Self-concept: The interplay of theory and methods. Psychology, 74, 3-17.

Sprigler, Denelle M., Alsup, John K. (2003).An Analysis of gender and the mathematical reasoning ability sub-skill of analysis-synthesis. Education, 123 (4)

Steinkamp, M.W. & Maehr, M.L. (1984). Gender differences in motivational orientations toward achievement in school science: A quantitative synthesis. American Education Research Journal, 21, 39-59.

Stevens, Tara, Olivarez Jr., Arturo, Lan, William Y., Tallent-Runnels, Mary K. (2004). Role of mathematics self-efficacy and motivation in mathematics performance across ethnicity. Journal of Educational Research, 97 (4)

Suchman, R. queted in Joyce, B., Well, M. (1972). Models of teaching, prentice hall Inc., Englewood Cliffs.

Sund, R.B., Trowbridge, L.W. (1967). Teaching science by inquiry in the secondary school, Columbus, Ohio, Charles E. Merril Books, Inc.

Tsaı, C. C. (1998). An anlysis of scientific epistemological beliefs and learning orientations of Taiwanese eight graders. Science Education, 82, 473-489.

Whyte, G., Saks, A.M. & Hook, S. (1997). When success breeds failure: The role of self-efficacy in escalating commitment to a losing course of action. Journal of Organizational Behavior, 18, 145-432.

Williams, K.A., & Cavallo, A.M.L. (1995). Reasoning ability, meaningful learning, and students' understanding of physics concepts. Journal of College Science Teaching, 24(5), 311-314

Wisedsock, S., (1982). Knowledge of inquiry and behaviors of science instructors in teachers' collage in Thailand. Dissertation Abstracts, 43(03), 749-A.

Yi, Y., Hwang, Y. (2002). Predicting the use of web-based information systems: self-efficacy, enjoyment, learning goal orientation, and technology acceptance model. International Journal of Human-Computer Studies, 59 (4), 431-449.

Zachry, W.H. (1985). How I kicked the lecture habit: Inquiry teaching in psychology. Teaching of Psychology, 12 (3), 129-131.

APPENDIX A

INSTRUCTIONAL OBJECTIVES

- To define atom.
- To define isotopes.
- To define isotones.
- To define isobars.
- To define atomic number.
- To define mass number.
- To define anions.
- To define cations.
- To give examples for isotopes.
- To explain the basic principles of Dalton Atomic Model.
- To explain the basic principles of Thomson Atomic Model.
- To explain the basic principles of Rutherford Atomic Model.
- To explain the basic principles of Bohr Atomic Model.
- To explain the basic principles of Modern Atomic Model.
- To identify how a proton number is calculating from a given mass and neutron number.
- To identify how an average atomic weight is calculating.
- To predict ionic charge of the given ion.
- To predict electron number of the given cations.
- To predict proton number of an ion from the given charge and electron number.
- To explain the differences between Dalton Atomic Model and Thomson Atomic Model.
- To predict the differences between Rutherford Atomic Model and Bohr Atomic Model.
- To calculate the mass number using proton and neutron numbers.

- To calculate the atomic number using mass number and neutron numbers.
- To compare the differences between Bohr Atomic Model and Modern Atomic Model.
- To draw an atom figure according to Modern Atomic Model principles.
- To discuss the differences between Rutherford Atomic Model and Bohr Atomic Model
- To differentiate isotones and isobars.
- To differentiate isotones and isotopes.
- To differentiate anions and cations.
- To differentiate atoms and ions.

APPENDIX B

KİMYA BAŞARI TESTİ

1. Dalton'un önerdiği atom modelinde aşağıdakilerden hangileri yer almaz?

I. Atomlar bölünemez ve yeniden yapılanamaz.
II: Bir elementin bütün atomları birbirinin aynıdır.
III. Protonlar + yüklü taneciklerdir.

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

2. Modern atom modeline göre aşağıdakilerden hangisi yanlıştır?

A) 3. enerji düzeyindeki (n=3) toplam orbital sayısı 9 dur.
B) 2. enerji düzeyindeki orbital türleri s ve p dir.
C) 3. enerji düzeyindeki d orbitalleri sayısı 5 tir.
D) 4. enerji düzeyinde maksimum 16 elektron vardır.
E) 2. enerji düzeyindeki p orbitallerinin enerji değeri aynıdır.

3. Aşağıda isimleri yazılı bilim adamlarından hangisi atomda (+) ve (-) yükler bulunduğunu ve yüklerin rastgele hareket ettiğini söylemiştir?

A) J.Dalton B)L.Rutherford C)J.Thomson
D) N.Bohr E) M.Planck

4. İzotop, izoton ve izobar atomlarla ilişkin aşağıdaki yorumlardan hangisi yanlıştır?

A) Proton sayısı aynı nötron sayısı faklı atomlar birbirinin izotopudur.
B) Nötron sayısı aynı proton sayısı farklı atomlar birbirinin izotonudur.
C) Nükleon sayısı (proton ve nötron sayısı toplamı) aynı, proton sayısı faklı atomlar birbirinin izobarıdır.
D) İzotop atomların kimyasal özellikleri aynı, fiziksel özellikleri farklıdır.
E) İzobar atomların fiziksel özellikleri aynı, kimyasal özellikleri farklıdır.

5. $^{16}_{8}O$ atomu için aşağıda verilen bilgilerden hangisi yanlıştır?

A) Çekirdek yükü 16'dır.
B) Proton sayısı 8'dir.
C) Nötron sayısı 8'dir.
D) Elektron sayısı 8'dir.
E) Kütle numarası 16'dır.

6. $^{32}_{16}S^{-2}$ iyonunda kaç tane elektron bulunur?

A) 16 B) 18 C) 14 D) 25 E) 29

7. I. Kimyasal özellikler
II. Fiziksel özellikler
III. Proton sayısı
IV. Nötron sayısı
V. Çekirdek yükü
Bir atomun izotop atomları için yukarıdakilerden hangisi farklıdır?

A) Yalnız IV B) Yalnız V C) I ve II
D) II ve IV E) I,II ve IV

8. I. Proton sayısı

II. Nötron sayısı

III. Elektron sayısı

Nötr atomlar için yukarıdakilerden hangileri her zaman aynıdır?

A) Yalnız I B) Yalnız II C) I ve III

D) I ve II E) II ve III

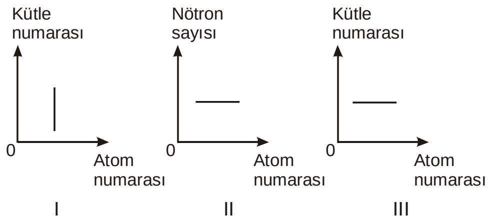
9.

Tanecik	**Proton sayısı**	**Nötron sayısı**	**Elektron sayısı**
X^m	11	12	10
Y^n	17	18	18
Z^k	12	12	12

X^m, Y^n ve Z^k taneciklerinin proton, elektron ve nötron sayıları yukarıdaki gibidir. Buna göre m, n ve k değerleri aşağıdakilerin hangisinde doğru olarak verilmiştir?

	M	**n**	**k**
A)	+1	-1	0
B)	-1	+1	0
C)	+1	-1	+2
D)	+2	-1	-2
E)	+1	-1	-1

10.



Yukarıda çizilen grafiklerin sınıflandırılması hangisinde doğru olarak verilmiştir?

	I	II	III
A)	İzotop	İzoton	İzobar
B)	İzotop	İzotop	İzoton
C)	İzoton	İzobar	İzoton
D)	İzobar	İzoton	İzotop
E)	İzotop	İzotop	İzobar

11. I. X^{+2} iyonu X atomuna

II. Y^{-2} iyonu Y atomuna

III. Z atomu Z^{+2} iyonuna

Dönüştüğünde elektron sayılarındaki değişimler aşağıdakilerden hangisinde doğru olarak verilmiştir?

	I	II	III
A)	Azalır	Artar	Azalır
B)	Artar	Azalır	Azalır
C)	Artar	Azalır	Artar
D)	Azalır	Azalır	Azalır
E)	Artar	Artar	Artar

12. X atomu X^{+1} iyonu haline dönüştüğünde;

I. Kimyasal özelliği
II. Yörünge sayısı
III. Çekirdek yükü

Hangileri kesinlikle değişmez?

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

13. Al^{+3} ile B^{-3} iyonlarının elektron sayıları eşit olduğuna göre atom numaraları arasındaki fark kaçtır?

A) 1 B) 2 C) 3 D) 4 E) 6

14. $^{23}_{11}Na$ atomu ile $^{35}_{17}Cl$ – $^{37}_{17}Cl$ izotop atomlarının oluşturduğu NaCl bileşikleri için;

I. Kimyasal özelliği
II. Fiziksel özelliği
III. Aynı şartlardaki yoğunlukları

niceliklerinden hangileri aynıdır?

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

15. Bir tane $C_2O_4^{-2}$ taneciğinde kaç tane elektron bulunur? ($^{12}_{6}C$, $^{16}_{8}O$)

A) 44 B) 46 C) 48

D) 50 E) 52

16. X^{-2} iyonunun elektron sayısı 8, nötron sayısı ile proton sayısı eşittir.

X in izotopu olan atom aşağıdakilerden hangisidir?

A) $^{16}_{8}X$ B) $^{13}_{7}X$ C) $^{20}_{10}X$

D) $^{17}_{8}X$ E) $^{13}_{6}X$

17. Proton (p), nötron (n), elektron (e) ile ifade edildiğine göre;

I. Nötr atomlarda, p=e dir.

II. Katyonlarda, p>e dir.

III. Anyonlarda, n>p dir.

İfadelerinden hangileri kesinlikle doğrudur?

A) Yalnız I B) Yalnız II C) I ve II

D) II ve III E) I, II ve III

18. Kütle numarası 40 olan X^{n} iyonunun proton sayısı nötron sayısına eşittir. Elektron sayısı 18 olduğuna göre n in değeri kaçtır?

A) -4 B) -2 C) -1

D) 0 E) +2

19.

Element	**Atom no**	**Kütle no**	**Nötron sayısı**
X	17		18
Y	17		20
Z		38	20

Tabloda verilen X, Y, Z elementleriyle ilgili aşağıdaki yargılardan hangisi yanlıştır?

A) X elementlerinin proton sayısı 17 dir.
B) Y elementlerinin kütle numarası 37 dir.
C) Y ve Z birbirinin izotonudur.
D) Y ve Z birbirinin izobarıdır.
E) X ve Y birbirinin izotopodur.

20. Galyum'un doğada kararlı iki izotopu vardır. Ga-69 %60 çoklukta ve Ga-71 %40 çoklukta bulunduğuna göre, Galyum'un ortalama atom kütlesi nedir?

A) 69,8 B) 70 C) 70,8
D) 71 E) 71,6

APPENDIX C

ÖĞRENME YAKLAŞIMI SORU FORMU

Açıklamalar

Lütfen cevap kâğıdına isminizi ve kimlik numaranızı yazınız.

Her bir soru için cevap kağıdında cevap şıkkınıza karşılık gelen kutucuğu doldurunuz. Tüm sorular, **FEN BİLGİSİ SINIFINDAKİ** öğrenme süreciniz ve çalışma alışkanlıklarınız ile ilgilidir. Her soru için “Her zaman” dan “Asla” ya da “Kesinlikle Katılıyorum” ile “Kesinlikle Katılmıyorum” arasında değişen dört basamaklı bir derecelendirme vardır. Sorulara cevap verirken uzun uzun düşünmeyin, genellikle vereceğiniz ilk tepkiniz doğrudur. Gerçek duygularınızı yazın. Cevaplarınız gizli tutulacaktır.

- Cümleyi dikkatlice okuyun.
- Her sorunun yanındaki harflerden **İLK** tepkinize en uygun olanı seçin.
- Lütfen soru kağıdı üzerine herhangi bir işaretleme yapmayın.
- Cevabınızı cevap kağıdına dikkatlice işaretleyin.

Lütfen tüm soruları yanıtlayın. Boş bırakmayın.

Öğrenme Yaklaşımı Soru Formu

Asla	Bazen	Genellikle	Her Zaman
A	B	C	D

1. Genellikle başlangıçta zor görünen şeyleri anlayabilmek için çok çaba sarf ederim.
2. Yeni bir konuyu okurken, o konu ile ilgili daha önce bildiğim şeylerle ilişkilendirmeye çalışırım.
3. Çalışırken genellikle çalıştığım konunun uygulanabileceği gerçek durumları düşünürüm.
4. Konuyu en iyi öğretmenin verdiği sırayla hatırlarım.
5. Öğrenmek zorunda olduğum çoğu şeyi ezberlemeye çalışırım.
6. Önemli konuları iyice anlayıncaya kadar tekrar ederim.
7. Öğretmenler, sınavda çıkmayacağı bilinen konular üzerinde öğrencilerin çok fazla vakit harcamasını beklememelidir.
8. Bir kez içine girdikten sonra hemen hemen her konu ilgimi çekebilir.
9. Sıklıkla derste öğrendiğimiz konuları ya da kitaplarda okuduklarımı sorgularım.
10. Benim için yeni olan bir konu hakkında, fikirlerin nasıl birbiriyle uyuştuğunu görerek genel bir bakış açısı edinmenin faydalı olduğunu düşünüyorum.
11. Bir dersten ya da laboratuvar dersinden sonra anladığımdan emin olmak için notlarımı tekrar okurum.
12. Bence bir konu hakkında çok fazla araştırma yapmak vakit kaybı, bu yüzden sadece sınıfta ya da ders notlarında anlatılanları ciddi bir şekilde çalışırım.
13. Okumam için verilen materyali, anlamını tam olarak kavramak amacıyla okurum.
14. Teorik konulardan çok pratiğe dayalı uygulamalı içeriği olan konuları severim.
15. Bir konuda öğrendiğim bir şeyi başka bir konuda öğrendiğimle ilişkilendirmeye çalışırım.

Asla	**Bazen**	**Genellikle**	**Her Zaman**
A	**B**	**C**	**D**

16. Benim için teknik terimlerin ne anlama geldiğini öğrenmenin en iyi yolu bu terimlerin kitaptaki tanımlarını hatırlamaktır.
17. Bulmacalar ve problemler, özellikle elinizdeki materyali mantıklı bir sonuca varmak için kullandığınız durumlar bana çekici gelir.
18. Okumam için verilen materyalin gerçekte ne gibi anlamları içerdiği konusunda pek fazla düşünmem.
19. Konuları genellikle ezberleyerek öğrenirim, hepsi aklımda kalana kadar tekrar ederim.
20. Genellikle, okuduğum şeyleri gerçekten anlamadan okurum.
21. Bir konu hakkında gereğinden fazla okumak kafa karıştıracağı için yalnızca derste öğrendiklerimiz ya da laboratuvarda yaptıklarımıza paralel olarak tavsiye edilen birkaç kitaba bakarım.
22. Ders çalışırken genellikle spesifik olarak verilen bilgiye odaklanırım, fazlasını yapmak bence gereksizdir.

APPENDIX D

MOTİVASYONEL AMAÇ SORU FORMU

Açıklamalar

Lütfen cevap kâğıdına isminizi ve kimlik numaranızı yazınız.

Her bir soru için cevap kağıdında cevap şıkkınıza karşılık gelen kutucuğu doldurunuz. Tüm sorular, **FEN BİLGİSİ SINIFINDAKİ** öğrenme süreciniz ve çalışma alışkanlıklarınız ile ilgilidir. Her soru için "Her zaman" dan "Asla" ya da "Kesinlikle Katılıyorum" ile "Kesinlikle Katılmıyorum" arasında değişen dört basamaklı bir derecelendirme vardır. Sorulara cevap verirken uzun uzun düşünmeyin, genellikle vereceğiniz ilk tepkiniz doğrudur. Gerçek duygularınızı yazın. Cevaplarınız gizli tutulacaktır.

- Cümleyi dikkatlice okuyun.
- Her sorunun yanındaki harflerden **İLK** tepkinize en uygun olanı seçin.
- Lütfen soru kağıdı üzerine herhangi bir işaretleme yapmayın.
- Cevabınızı cevap kağıdına dikkatlice işaretleyin.

Lütfen tüm soruları yanıtlayın. Boş bırakmayın.

Başarı Motivasyonu Soru Formu

Kesinlikle Katılmıyorum	Genel olarak Katılmıyorum	Genel olarak Katılıyorum	Kesinlikle Katılıyorum
A	B	C	D

1. Bu dersteki ana hedeflerimden birisi yaptığımız bilimsel etkinlikleri anlamaktır.
2. Bu derste öğrendiğimiz konularla ilgili fen bilgisi problemlerini çözeceğim konusunda kendime güveniyorum.
3. Bu dersteki ana hedeflerimden birisi diğer öğrencilerden daha başarılı olmaktır.
4. Derste gördüğümüz problemlere benzer problemleri çözmek için gerekli beceriye sahibim.
5. Ana hedeflerimden birisi sınıfta ki fen bilgisi etkinliklerinde aptal ya da beceriksiz görünmemektir.
6. Bu dersteki ana hedeflerimden birisi diğerlerinden daha zeki görünmektir.
7. Bu dersteki ana hedeflerimden birisi çalıştığımız konuları anlamaktır.
8. Bu derste tek başıma bir deney yapacak olsam, eminim sorun yaşarım.
9. Bu dersteki ana hedeflerimden birisi bilgimi arttırmaya çalışmaktır.
10. Bu dersteki ana hedeflerimden birisi bu işi beceremeyen tek kişi olmamaktır.
11. Bu dersteki ana hedeflerimden birisi yaptığımız fen etkinlikleri sırasında gerçekte neler olduğunu anlamaktır.
12. Diğer öğrencilere kıyasla, sınıfta yaptığımız fen etkinliklerinde diğerleri kadar iyi değilim.
13. Bu dersteki ana hedeflerimden birisi, yeni bir şeyler öğrenmesem bile, iyi bir not almaktır.
14. Bu dersteki ana hedeflerimden birisi aldığım not her ne olursa olsun, yeni bir şeyler öğrenmektir.

APPENDIX E

BİLİMSEL BİLGİ SORU FORMU

Açıklamalar

Lütfen cevap kâğıdına isminizi ve kimlik numaranızı yazınız.

Her bir soru için cevap kağıdında cevap şıkkınıza karşılık gelen kutucuğu doldurunuz. Tüm sorular, **FEN BİLGİSİ SINIFINDAKİ** öğrenme süreciniz ve çalışma alışkanlıklarınız ile ilgilidir. Her soru için “Her zaman” dan “Asla” ya da “Kesinlikle Katılıyorum” ile “Kesinlikle Katılmıyorum” arasında değişen dört basamaklı bir derecelendirme vardır. Sorulara cevap verirken uzun uzun düşünmeyin, genellikle vereceğiniz ilk tepkiniz doğrudur. Gerçek duygularınızı yazın. Cevaplarınız gizli tutulacaktır.

- Cümleyi dikkatlice okuyun.
- Her sorunun yanındaki harflerden **İLK** tepkinize en uygun olanı seçin.
- Lütfen soru kağıdı üzerine herhangi bir işaretleme yapmayın.
- Cevabınızı cevap kağıdına dikkatlice işaretleyin.

Lütfen tüm soruları yanıtlayın. Boş bırakmayın.

Bilimsel Bilgi Soru Formu

Kesinlikle Katılmıyorum	Genel olarak Katılmıyorum	Genel olarak Katılıyorum	Kesinlikle Katılıyorum
A	B	C	D

1. Bilimsel bilgi değişmez.
2. Bilimsel teoriler keşfedilir, insanlar tarafından yaratılmaz.
3. Bugünün bilimsel kanunları, teorileri ve kavramları gelecekteki yeni deliller karşısında değiştirilmek durumunda kalabilir.
4. Belli bir bilimsel bilgi hakkındaki delil, aynı şartlarda diğer araştırmacılar tarafından da elde edilebiliyorsa, o bilgi doğru olarak kabul edilir.
5. Bilim adamlarının gözlemleri, o konu hakkındaki kendi fikirlerinden etkilenir.
6. Bilim daima somut ve yeni gözlemler ışığında değişimlere maruzdur.
7. Bilimsel bilgi bilim adamlarının yaratıcılığını yansıtır.
8. Bilimsel bilginin doğruluğu şüphe götürmez.
9. Bilimsel yöntem her zaman geçerli olduğu için bu yöntemin uygulanmasıyla elde edilen bilgi, bilim adamlarının seçimlerinden çok doğa tarafından belirlenir.
10. Bilimsel bilgi yeniden değerlendirilmeye ve değişime açıktır.
11. Bilimsel sorular, yöntemler ve sonuçlar tarihi, kültürel ve sosyal durumlara göre değişir.
12. Bilimsel gerçekler birkaç uzman tarafından keşfedilir.
13. Bilimsel bir kanun, evren hakkındaki gerçeğin tam bir raporudur.
14. Bilimsel bilgi keşfedilen gerçeklerle oluşturulur.
15. Bilim adamları arasındaki anlaşmazlıklar, gerçekleri (ya da gerçeklerin önem derecelerini) farklı şekilde yorumlamalarından kaynaklanır. Bu görüş ayrılıklarının sebebi ise farklı bilimsel teorilerdir.

Kesinlikle Katılmıyorum	**Genel olarak Katılmıyorum**	**Genel olarak Katılıyorum**	**Kesinlikle Katılıyorum**
A	**B**	**C**	**D**

16. Bilim adamlarının belli bir konu üzerinde (örneğin, düşük düzeydeki radyasyonun zararlı olup olmadığı konusunda) farklı görüşlere sahip olmalarının nedeni genellikle tüm gerçeklere sahip olmamalarıdır.

APPENDIX F

A SAMPLE RELATED TO INQUIRY-ORIENTED INSTRUCTION

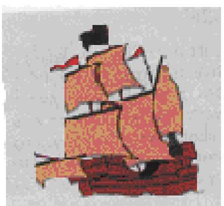
Developing a Model Using a Black Box

The teacher taught atom concepts in an inquiry-oriented instruction. The main aid of this lecture was to show that atom is the smallest particle of matter and all matters are composed of atoms. During this period, students were asked the following questions;

Why does a balloon expand when you blow air into it?

Why does a curtain in front of an open window move?

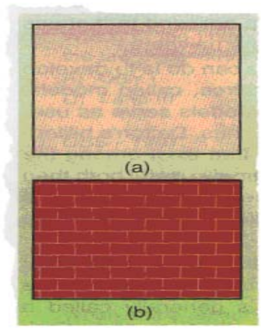
Why are the sails of a sailboat filled with air during excursion?



Expected answers were as fallows:

Maybe the gas that is blown into the balloon that moves the curtain and fills the sails is a combination of small particles resembling billiard balls. They might strike the surface of the sails, as the balls bounce the boundaries of the billiard table. As the particles hit the inner surface of the ballon, they inflate the balloon, fill the sail and move the curtain.

Then students were asked to give another examples and explain them according to particle model. The expected answers were as fallows;



The water, which fills the jug on our table and the walls surrounding our room, make us feel as if there was continuity in the substance. Likely, when we look around we cannot notice that the air in our room is a combination of little particles. It does not look or act as a though it is made of individual particles. But as seen, we've been able to express the behavior of the air with the particle model we chose. It is possible to apply the same model for the other substances? If we move the plaster on the wall we will see the bricks one on top of the other. That means the wall is not continuous. If we go to learn how a brick is made we can see it is made up with soil and water. If we can examine the soil particles by magnifying them we notice that they also include smaller particles. Again a waterfall with its spreading drops around shows us also the water is not a whole and but a combination of particles.

After identifying the atom concept, the students were asked to design an atomic model. In order to this, firstly they were asked to make a simple model by shaking a tin can. The teacher wanted students to find what is found in a tin can by shaking and to write their answers on their notebooks.

Expected answer was as fallows;

When we shake it, we hear and feel something slosh around inside. From this experiment of shaking the can, we form a mental model of what is inside. We conclude that the can contains a liquid. We have no idea what colour the liquid is or what it tastes or smells like, but we feel sure that it has a property of distinctive of liquids. From this model we can make a prediction: If you punch a small hole in the bottom of the can, liquid will drip out.

After these, students were asked to do an experiment with a "Black Box" which is more complicated than is the tin can. The purpose of the experiment was to expain how to grow a scientific model. The teacher used black boxes as materials for the experiment. And students were asked to do experiment according to the following procedure;

- Look at one box, shake it lightly, and tilt it back and forth in various directions. And listen carefully to the sounds.
- Write down your observations and compare with your classmates so that you can arrive at a model, make predictions, and test them.
- Try to imagine in a general way what is inside the box that could acoount for your observations. This will be your model for the box.
- Do not be distracted by details. Do not, for example, try to name the objects inside the box; only describe them by the properties. If you hear something sliding on one of the rods, you could equally well describe it as "a washer" or "a ring"; but the important point is something with a hole in it through which the rod passess.

- After you and your classmates have made models that account for your observations, predict what will happen as you pull out a particular rod.
- Then you or one of your classmates can remove this rod from only one of the boxes. Pulling out one of the rods may change things enough to prevent your checking your prediction of what would happened had you puuled out another rod first.
- If what happens confirms your prediction, you can use one of the other boxes to test your predictions.
- If, however, your first prediction was not confirmed, modify your model accordingly before futher experimentation.
- Continue this process until you have arrived at a model in which you have confidence.

After performing the experiment, students were asked the following questions;

- How many objects are there in one of the boxes? Are they on the same rod?
- Can you predict the shapes of the objects?
- Can you say anything about sizes, masses and colours of the objects?

Then students were asked to discuss their answers. And students reached the following conclusions;

In the experiment we have tried to predict indirectly what objects were in the black box. When we open the box the objects we see may or may not be the object we have predicted. Because our prediction ir reliable wtihin the boubdaries of our observing skill. Since many of the scientist have failed to make good predicitions, if we were able to predict the objects in the black box correctly, we could consider ourselves lucky.

After all, the students were asked to make relation between black box experiment and designing atomic models. And the expected anwer was as fallows;

The experiment we have done have many similarities with the experiments performed by scientist to elucidate the structure of matter. As we do not know what exists in the black box, they did not know internal structure of matter. They have learned much about the structure of matter by trial and error method. However many scientist agree on the fact that many mysterious properties of matter have not been discovered yet. It is better to study the development in the atomic models in order to understand how science proceeds and how scientists work.

Let's talk about best-known atomic models of scientists.

APPENDIX G

ARAŞTIRMAYA DAYALI KİMYA DERSİNE ÖRNEK

SİZCE ATOM NASIL KEŞFEDİLDİ ?

MADDELERİN EN KÜÇÜK YAPI TAŞI NASIL BULUNDU?

MADDELER SÜREKLİ BÖLÜNEREK SONSUZA KADAR GİDEBİLİR Mİ ? YOKSA BELLİ BİR YERDE DURUR MU?

Bilim adamları maddelerin sonsuza kadar bölünemeyeceğini elbet bir yerde sona ereceğine karar verdiler ve sonunda o en küçük parçaya Yunanca bölünemez anlamına gelen **Atom** dediler.

Daha sonra bilim adamları atomların hangi şekilde olduğunu araştırmaya başladılar. Çeşitli düşünceler ortaya atıldı ve atomların çeşitli şekil ve büyüklükte olacağına karar verildi.

Newton bir makalesinde "Atomlar Allah tarafından yapılmış, bölünemez, çeşitli büyüklük ve şekilde olan parçacıklardır" demiştir.

PEKİ SİZCE ATOM MODELLERİ NASIL ORTAYA ÇIKMIŞTIR?

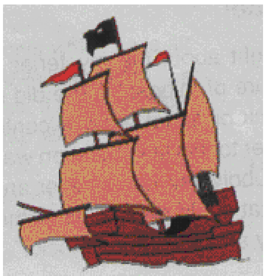
Atomlar direk gözlenemeyecek kadar küçük parçacıklar olduğu için bilim adamaları atom modellerini geliştirilmeye başlamışlardır.

İlk olarak Dalton bilardo topu modelini oluşturdu ve daha sonra çeşitli sorular ortaya atıldı:

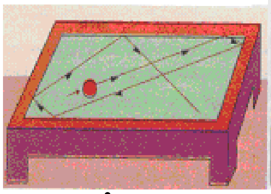
NEDEN İÇİNE HAVA ÜFLENİNCE BALON ŞİŞER

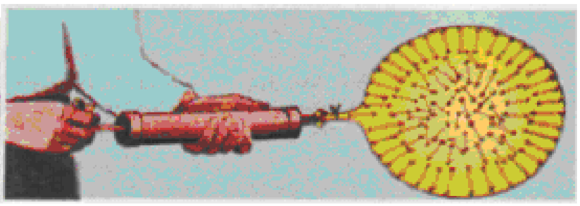
NEDEN PENCERE AÇIKKEN PERDELER HAREKET EDER?

NEDEN YELKENLİ TEKNENİN YELKENİ ŞİŞER?



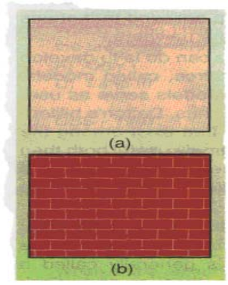
Bütün bu soruların cevabı hava bilardo topuna benzeyen parçalardan oluşmuştur ve bu parçacıklar balonu ve yelkeni şişirir, perdeleri hareket ettirir.





PEKİ SADECE HAVA MI PARÇACIKLARDAN OLUŞUR?

ÇEVREMİZE BAKTIĞIMIZDA BUNUN GİBİ ÖRNEKLER BULABİLİRMİYİZ?



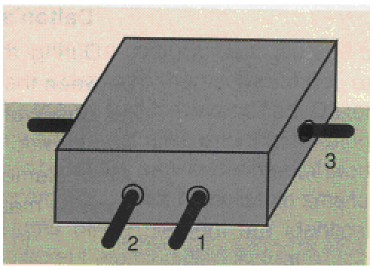
Mesela sınıfı çevreleyen duvar tuğlalardan, tuğlalar da su ve topraktan yapılmıştır. Eğer toprağı incelersek oda daha küçük parçacıklar içerir. Ya da su etrafa damlalar haline yayılır. Yani onunda küçük parçaları vardır.

İşte bu parçacık modeli havanın davranışını açıklıyor.

Örnek: Size bir konserve kutusu verilse onu sallayarak içinde ne olduğunu anlayabilir misiniz?

Cevap: Sallayarak içinde su ve bazı tanecikler olduğuna karar verebiliriz.

Deney: Kara Kutu kullanarak Model Geliştirme



İşte atom modelleri de bilim adamlar tarafından böyle keşfedildi.