# THE EFFECT OF EXPLICIT METHOD OF PROBLEM SOLVING ACCOMPANIED WITH ANALOGIES ON UNDERSTANDING OF MOLE CONCEPT

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# ABSTRACT

## THE EFFECT OF EXPLICIT METHOD OF PROBLEM SOLVING ACCOMPANIED WITH ANALOGIES ON UNDERSTANDING OF MOLE CONCEPT

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The aim of this thesis was to analyse the effectiveness of explicit method of problem solving accompanied with analogy instruction over traditionally designed chemistry introduction on understanding of mole concept and attitude toward chemistry as a school subject.

Participants for this research consisted of 53 students at ninth grade level from two classes taught by the same teacher in Atatürk Anadolu Lycee. The study was carried out during the second semester in the 2004-2005 school year.

During the treatment, students in the experimental group were instructed with explicit method of problem solving accompanied with analogies. Students in the control group studied only with traditionally designed chemistry instruction.

Both groups were administered Mole Concept Achievement Test and Attitude Scale toward Chemistry as a School Subject as pre-tests and post-tests.

To analyse the data, statistical techniques paired samples t-test and independent samples t-test were used in this study. Statistical analyses were carried out by using the SPSS 10.0.

Results of the study showed that explicit method of problem solving accompanied with analogy instruction caused a significantly better acquisition of scientific conception related to mole concept but produced no significant positive attitudes toward chemistry as a school subject than the traditionally designed chemistry instruction.

Keywords: Mole Concept, Analogy Instruction, Explicit Method of Problem Solving, Attitudes Toward Chemistry as a School Subject

# ÖZ

## BENZEŞTİRME YÖNTEMİ İLE DESTEKLİ KATEGORİZE EDEREK PROBLEM ÇÖZME YÖNTEMİ İLE ÖĞRETİMİN ÖĞRENCİLERİN MOL KAVRAMINI ANLAMALARINA ETKİSİ

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Bu çalışmanın amacı benzeştirme yöntemi ile birlikte verilen kategorize ederek problem çözme tekniği ile öğretimin öğrencilerin mol kavramını anlamadaki başarılarına ve kimya dersine karşı tutumlarına etkisini incelemek ve geleneksel yöntemle karşılaştırmaktır.

Bu çalışmaya Atatürk Anadolu Lisesinde aynı öğretmen tarafından eğitim verilen iki sınıftan toplam 53, 9. sınıf öğrencisi katılmıştır. Çalışma 2004-2005 öğretim yılının ikinci sömestrinde yürütülmüştür.

Çalışma süresince, deney grubundaki öğrencilere kategorize ederek problem çözme tekniğine eşlik eden benzeştirme yöntemi ile eğitim verilmiştir. Kontrol grubundaki öğrenciler ise yalnızca geleneksel öğretim yöntemi ile eğitilmiştir. Her iki gruba da ön test ve son test olarak Mol Kavramı Başarı Testi ve Kimya Dersi Tutum Ölçeği verilmiştir.

Verileri analiz etmek için, eşli örneklem t-testi ve bağımsız örneklem t-testi istatistiksel teknikleri kullanılmıştır. İstatistiksel analizler SPSS 10.0 kullanılarak gerçekleştirilmiştir.

Çalışmanın sonucu kategorize ederek problem çözme tekniğine eşlik eden benzeştirme yönteminin, geleneksel öğretim yöntemine göre bilimsel kavramların anlaşılmasında daha etkili olduğunu ancak Kimya dersine karşı daha olumlu bir tutum oluşturmadığını göstermiştir.

Anahtar Kelimeler: Mol Kavramı, Benzeştirme Yöntemi, Kategorize Ederek Problem Çözme Tekniği, Kimya Dersi Tutum Ölçeği

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EMPSA : Explicit Method of Problem Solving Accompanied with Analogies
TCIPPS : Traditionally Designed Chemistry Instruction Accompanied with Proportionality Method of Problem Solving
MCAT : Mole Concept Achievement Test
ASTCh : Attitude Scale Toward Chemistry as a School Subject
df : Degrees of Freedom
F : F Statistic
N : Population Size
p : Significance Level
s : Standart Deviation of the Sample
t : t Statistic
$\overline{X}$ : Mean of the sample

# CHAPTER 1

# INTRODUCTION

There are few topics which chemistry students find more difficult to understand than the concept of the mole, yet for its mastery it is absolutely essential to use chemical reasoning (Kolb, 1978). The importance of the topic is supported by the existence of abundant research into the problem of the teaching-learning of the mole concept in the last decades (Dierks, 1981; Cervellati *et al.*, 1982; Lazonby *et al.*, 1985; Nelson, 1991; Tüllberg *et al.*, 1994; Staver & Lumpe, 1995, Furió *et al*., 2002). Various causes have been identified for the difficulty that is presented by the mole concept. Staver and Lumpe (1995) point to the cognitive demand of this abstract theoretical concept. Students have also been shown to have difficulty in linking sequential operations, which is demanded by many mole calculations (Lazonby *et al.* 1982). Gabel and Sherwood (1984) suggest that it is the term `mole' itself that is confusing and not the underlying concepts. Novick and Menis (1976) point to the difficulty caused by the phonetic similarity with molecule, molecular, molar etc., all terms that are introduced to students within a relatively short space of time.

Numerous studies exist in the science education literature that deal with the main learning difficulties about the mole concept (Furió *et al*., 2000). García *et al.* (1990) carried out a survey using a large student sample from secondary education (16 years old) to first-year university course (19 years old). They reported an increased proportion of wrong answers concerning the mole concept, that is, answers that differ from the I.U.P.A.C. definition. They concluded that there is a superficial learning of the concept.

In another study carried out with a large sample of secondary school students, Cervellati *et al.* (1982) showed that students perceived the mole as a mass, and did not use it as a unit of the ”amount of substance‘. The authors connected these deficiencies to the students’ difficulties in the resolution of stoichiometric problems. According to these authors, the only possible causes of this situation must be attributed to aspects of instruction such as: the inadequate content of the curriculum, the methodology of instruction used the system of evaluation and the training of educators. With the purpose of overcoming these difficulties they pointed out the need to review the instructional methods.

In another study that involved a very large sample (more than 6000 secondary education students) Schmidt (1990) sought to find out the way students carry out stoichiometric calculations. He concluded that when they make these calculations they tend to think that the proportion of the number of molecules that are combined in a chemical reaction is identical to the proportion of masses of reacting substances. He also observed that the students equaled the proportion of molar masses of the reacting substances to the proportion of combination masses, without considering the stoichiometric coefficients. With regard to the calculation of masses in chemical formulas, he pointed out that students usually do not consider that the atoms of different elements have different atomic masses. In a study conducted later, Schmidt (1994), in order to get a sound understanding of the strategies used in the resolution of simple exercises on stoichiometric calculations, emphasized that students avoid the direct calculation of amounts expressed in moles. He deduced that this may be due to the difficulties arising from the mole concept. In addition, the students examined did not use the reasoning strategies for which they had been trained, but their personal methods.

One of the means teachers can use to help students to understand chemical topics and concepts is the explicit method of problem solving method.

Since problem solving is important in science education, the next issue then would be to look at the difficulties faced by students in this area and find ways to help them overcome these difficulties. One instructional method that has been used to address both problem-solving performance and conceptual understanding is explicit problem-solving instruction. Explicit problem solving is instruction that directly teaches students how to use more advanced techniques for solving problems. Therefore, to test the effect of explicit problem-solving instruction, this study was designed to determine if high school students who were taught how to use an explicit problem-solving strategy exhibited more improvement in problem-solving performance and more improvement in conceptual understanding of mole concept than students who were taught by traditionally designed chemistry instruction.

Analogies and models are frequently used in science and science teaching and much research is devoted to examining their effectiveness. Analogies can be more effective for lower cognitive development students. A positive affective effect to most students was also found. Analogical models enhance understanding because some part(s) of an everyday object or process resembles some part(s) of a scientific object or process. When such a model is used to transfer information and construct understanding, the *analog* refers to everyday objects, events or processes that credibly map onto objects, events or processes in the scientific *target* concept (Gentner, 1983). Analogical reasoning can be used to overcome learning difficulties and have a lot of advantages. Also the purpose of this study is to investigate the effects of analogy-enhanced instruction on understanding of mole concept.

# CHAPTER 2

# REVIEW OF LITERATURE

In this chapter of the study, previous work done relevant to the instruction techniques used in this research will be presented.

Traditionally, chemistry is a very difficult subject for students to master. Although the mole is a central topic of high school chemistry, it is consistently one of the more difficult topics for students to learn. Some of the major reasons for this lack of understanding are:

1. students are rote learning (memorizing definitions and statements) instead of learning meaningfully (relating new knowledge to knowledge previously learned);
2. students are unable to recognize the key concepts and concept relationships needed in order to understand the material; and
3. the key concepts or concept relationships may not be clearly presented by the instructor (Pendly et al., 1994).

The objective of this study was to trace the development of student understandings of the mole concept. This review looks at a variety of aspects such as analogy instruction and explicit method of problem solving that influence the learning of mole concept.

## 2.1 Explicit Method

One pedagogical approach has been to have the student "learn" to recognize problem types and to memorize the corresponding solution steps (constructing a solution). However, when the student faces problems that are new and novel there is no "construction" that exactly fits the problem under discussion. The explicit method of problem solving method attempts to overcome this shortcoming by providing students with a linear-thinking approach to problem solving. Using explicit problem-solving strategy in presentations and in student assignments promote learning because the strategy frees the student's short-term memory for analysis and for planning the solution to problems (Bunce, 1990).

Bunce and Heikkinen (1986) have proposed the explicit method of problem solving (EMPS) which aims to teach novice students the problem-solving analysis procedures used by experts. According to Reif (1981), this analysis helps students *encode* the pertinent information of the problem, which is a major difference in the problem-solving behaviour of experts and novices. Encoding is defined by Sternberg (1981) as the identification of each term in the problem, and retrieval from long-term memory of the attributes of these terms that are thought to be relevant to the solution of the problem.

Research on the differences between experts and novices has led in turn to the development of explicit problem-solving strategies designed to teach students how to use more advanced techniques. Numerous studies have reported that explicit problem-solving instruction can help improve students' problem-solving performance more than traditional or textbook problem-solving instruction (Mestre, et al., 1993; Heller, Keith, & Anderson, 1992; Van Heuvelen, 1990; Wright & Williams, 1986; Heller & Reif, 1984; Larkin & Reif, 1979, Reif, Larkin, & Brackett, 1976). Each of these studies measured slightly different aspects of problem-solving performance, but in general, students who learned the explicit problem-solving strategies exhibited more advanced problem-solving performance, including better qualitative descriptions of problems, more extensive planning, and more complete solutions.

In the EMPS method, students must write down what is Given and Asked for in the problem, after which they attempt Recall and develop an Overall Plan that will provide the logic for the mathematical solution. The Objective and Given provide a very concise summary of the problem. The advantage of doing these steps explicitly is that all relevant information is then isolated (Bunce and Heikkinen, 1986). Since most people can only keep a limited amount of information in their conscious memory at any given time, it makes sense to make use of this type of external memory (Newell and Simon, 1972). The visual aspect is very important: having a concise summary of all information facilitates the thinking process.

According to Bunce, Gabel, and Samuel (1991), an important part of the encoding process is problem categorisation. If students cannot correctly categorise a problem, they will not be able to retrieve the relevant information from long-term memory. A subsequent step in EMPS leads students to relate the encoded parts of the problem in a schematic diagram of the solution path. After such an analysis, students can use mathematics to reach an algebraic solution and eventually a numerical answer. The above authors Bunce et al. further examined the effectiveness of EMPS and reported that specific instruction in problem categorisation techniques improved achievement scores for combination problems, requiring more than one chemical concept in their solutions, but not for single-concept problems. On the other hand, such training alone was found insufficient to lead to conceptual understanding.

## 2.2 Analogy

There is a significant body of research into the use and usefulness of analogies in teaching. A dictionary definition of an analogy describes the concept as: a relationship of similarity or likeness between two or more entities. The importance of this definition lies in the fact that an analogy must compare two or more entities. This is the feature that distinguishes an analogy from a metaphor. An analogy compares structures explicitly whereas a metaphor compares implicitly and does not aim to compare features of two domains (Duit, 1991). In this sense analogies are more functional in the instructional process.

Whenever an analogy is spoken or written, reference is being made to pictures and ideas in long term memory. The generative learning model (Osborne and Wittrock, 1983; Wittrock, 1985) describes the development of understanding during learning as being a vigorous interplay between prior knowledge and current experience. Osborne and Wittrock (1983) state that the brain is not a passive consumer of information. Instead it actively constructs its own interpretation of information, and draws inferences from them. The stored memories and information processing strategies of the brain interact with the sensory information received from the environment to actively select and attend to the information and to actively construct meaning.

Studies suggest that, as science teachers, we spontaneously use analogies to help pupils understand. Similar observations were made by Treagust et al (1992). They showed that science teachers used analogies extensively but with little advance reparation or introducing after explaining the target idea. They recognised that opportunities for pupil understanding were limited as teachers often did not fully explain the analogy being used. A more systematic and planned use of models in teaching may provide significant help to pupils in grasping concepts

Chemistry and biochemistry classes are full of abstract concepts that are not easy to understand unless they are related to something from our everyday experiences. Effective analogies can clarify thinking, help students overcome misconceptions, and give students ways to visualize abstract concepts. Misleading or confusing analogies, on the other hand, can be more than just a waste of class time; they can interfere with students learning of class material (Orgill and Bodner, 2004).

According to Gentner (1989), an analogy is a mapping of knowledge between two domains such that the system of relationships that holds among the objects in the analog domain also holds among the objects in the target domain. Thus, the purpose of an analogy is to transfer a system of relationships from a familiar domain to one that is less familiar (Mason and Sorzio, 1996).

Some teachers often use analogies to describe and explain difficult science phenomena. Teachers' analogies exhibit a rich variety of form and content (Dagher, 1995) and teacher analogies can be planned or spontaneous (Thiele & Treagust, 1994). Successful analogies are systematic, include multiple mappings and utilise relational thinking (Gentner & Medina, 1998).

Amongst the appealing simple comparison type analogies (Curtis and Reigeluth, 1984) is Biermann's (1988) example in which a cell making a protein molecule is likened to tradesmen building a house. Also in this category is the analogy in which the activation energy of a chemical reaction is compared to a hill (Hunter, Simpson and Stranks, 1976; Licata, 1988) or a high jump (Parry et al., 1973). Other secondary science analogies are the disco-electron orbitals analogy (Battino, 1991); the polarised light-comb analogy (Murphy and Smoot, 1982); the supermarket-classification analogy (Australian Academy of Science, 1990) and the crowd-kinetic theory analogy (Coffman and Tanis, 1990).

Two detailed reviews of analogy use in school science (Dagher, 1995; Duit, 1991) concentrate on the conceptual growth potential of analogies and devote limited attention to their interest-generating power. In his review, Duit shows that analogies are effective conceptual change agents because they enhance understanding by making connections between scientific concepts and the students' life-world experiences, and by helping students visualise abstract ideas. He points out that analogies "provoke students' interest and may therefore motivate them" (1991) but interest is the last factor in his list of analogy's advantages. Duit explains in detail the constructivist benefits of analogy, but does not explore the motivational power of analogies and models. The absence of detail pertaining to interest and motivation is easily explained: few studies of analogy discuss this factor.

Stepich and Newby (1988) proposed a teaching sequence for the use of analogies. Their scheme which involved constructivist ideas was built on the following sequence:

1. What do the learners already know?
2. What is the nature of the specific learning task involved in the instruction?
3. Construction of the analogy.
4. Presentation of the analogy.

These authors believe that the placement of the analogy in the teaching sequence is a critical factor in its effectiveness. As analogies are designed to operate during the encoding of new information, they should be presented early in the instructional sequence. Once introduced, there should be time allowed for the students to compare the analog with its target. It is important that this time is factored into the instructional sequence and that it be adequate for the group involved.

Analogies can play several roles in promoting meaningful learning. They can help learners organize information or view information from a new perspective. Thiele and Treagust (1991) argue that analogies help to arrange existing memory and prepare it for new information. Analogies can also give structure to information being learned by drawing attention to significant features of the target domain (Simons, 1984) or to particular differences between the analog and target domains (Gentner and Markman, 1997). Gick and Holyoak (1983) argue that analogies can make the novel seem familiar by relating it to prior knowledge and make the familiar seem strange by viewing it from a new perspective.

Analogies can also play a motivational role in meaningful learning (Bean, Searles and Cowen, 1990; Dagher, 1995; Glynn and Takahashi, 1998; Thiele and Treagust, 1994). The use of analogies can result in better student engagement and interaction with a topic. Lemke (1990) asserts that students are three to four times more likely to pay attention to the familiar language of an analogy than to unfamiliar scientific language. The familiar language of an analogy can also give students who are unfamiliar or uncomfortable with scientific terms a way to express their understanding of and interact with a target concept.

Analogies are one of the conceptual change activities to enhance and to facilitate students' understanding by challenging the students' pre-existing ideas (e.g., Iding, 1997; Stavy, 1991; Taylor & Coll, 1997; Tsai, 1999). Analogical reasoning can be thought of as a process of schema transfer from a familiar domain into an unfamiliar situation so that analogies can enable students to capture insight of the given events, especially at sub-microscopic level (Wong, 1993). In this process, the greater the match of knowledge between target and analog occurs, the better the analogy works. Therefore, the new knowledge domain becomes more meaningful because students can now visualize the given phenomena with their familiar one. But, while doing this, teachers should stress that this is only analogical reasoning. If not, the analogies may lead students to develop various alternative conceptions (i.e., Coll & Treagust, 2001; Calik & Ayas, 2005b; Newton, 2003; Yerrick, et al., 2003). It must be stated that in spite of the prevalent use of analogy in chemistry teaching, there have been few studies about the use of analogy during instruction because there has been a shortage of research as to how analogies can be exploited in the classroom (Duit, 1991; Ganguly, 1995).

Analogies can play a role in promoting conceptual change by helping students overcome existing misconceptions (Brown and Clement, 1989; Dupin and Johsua, 1989; Brown, 1992, 1993; Clement, 1993; Dagher, 1994; Mason, 1994; Venville and Treagust, 1996; Gentner et al., 1997). Ideally, analogies can help students recognize errors in conceptions they currently hold, reject those conceptions, and adopt new conceptions that are in line with those accepted by the scientific community. Analogies may make new ideas intelligible and initially plausible by relating them to already familiar information. If students can assimilate new information in terms of their existing knowledge, they are likely to be able to understand that information, relate it in their own words, and comprehend how that new information might be consistent with reality- all necessary conditions for conceptual change (Posner, Strike, Hewson and Gertzog, 1982).

Harrison and Treagust (1996) highlight what happens when models are not used carefully in explaining chemical phenomena. In studying pupils' mental models of atoms and molecules, they found such misconceptions as: atoms grow and reproduce and atomic nuclei divide; electron shells are visualised as shells that enclose and protect atoms, while electron clouds are structures in which electrons are embedded. They attribute some of these misconceptions to inadequate explanation and exploration of the models presented by the teacher. They argue that analogical models are an intrinsic part of chemical understanding and suggest that student understanding may break down when models are used 'because the students often do not recognise that the explanation or process they are using is a model and, consequently, they mistake the model for reality'. They make two recommendations from this detailed study: Students should be given time to develop modelling skills, including using models to explain ideas and recognising the strengths and limitations of particular models; Whenever an analogy or model is used, ‘teachers should consciously ensure that the analogy is familiar and that they make the effort to identify both the shared and unshared attributes with the students’.

Analogical reasoning can be used in two distinct cases (Vosniadou, 1989). In one case, the underlying structure shared between the analogue and the target domains is present in the subjects’ representation of both domains at the time when the analogy is used. In the other case, the underlying structure needs to be present only in the subjects’ representation of the analogue. This latter case is important for the acquisition of new knowledge. Thus, the instructional use of analogy where the analogue is given, and similarity in explanatory structure is discovered by the learner on the basis of similarity in the salient properties of two systems, is an instance where analogical reasoning can lead to the acquisition of new knowledge. This case is therefore of paramount importance to the chemistry teacher (Sarantopoulos and Tsaparlis, 2004).

Glynn, Duit and Thiele (1995) provided an overview of the teaching-with-analogies (TWA) model (Glynn, 1989), which shows how to use an analogy systematically to explain fundamental concepts in a meaningful way. In addition, Glynn, Duit and Britton (1995) have examined the use of analogies by students when solving problems to plan, monitor, evaluate, and improve their problem-solving efforts. Dagher (1994) has reviewed the contribution of analogies to conceptual change and noted a modest contribution of analogies to normal conceptual change. In another paper (Dagher, 1995), the analogies used by science teachers in naturalistic instructional settings were analysed, and some of their special characteristics highlighted. On a similar line, the use of analogies in science instruction by student teachers has been examined by Jarman (1996). The effectiveness of teaching science with pictorial analogies has been tested, through a conceptual problem-solving test, on the concepts of density, pressure, and atmospheric pressure in Year-8 classrooms (Lin, Shiau, & Lawrenz, 1996); it was found that students taught with pictorial analogies scored significantly higher than the control group, while low achievers benefited more from this teaching than high achievers. Learning from analogy-enhanced science text, where an elaborate analogy having both graphic and text components was used, has been found conducive to better biology learning by sixth and eighth graders (Glynn & Takahashi, 1998). Thile and Treagust (1994) reported the relevant practice by four teachers. The teachers used analogies spontaneously and on a planned basis, both for the whole classes and individually for students who had conceptual difficulties. The study described why the teachers chose to use analogies, the variation of the characteristics of the analogies from teacher to teacher, and the origin of the analogies. According to the authors, the analogies used had a motivational impact on the students.

To teach the concept ‘relative weight formula’ of a substance, Felty (1985) proposed as an analogical situation the preparation of a fruit salad with equal number of grapes and cherries. Furthermore, with the purpose of teaching the concept ‘average atomic mass’ of an element with two isotopes, Last & Webb (1993) used an analogy based on household economic calculations. Another more frequent analogical example consists in associating currencies to atoms to learn the concept ‘relative atomic mass’ (Henson & Stumbles, 1979). The selection of this type of analogy is based on the fact that students are familiar with the idea that it is easier for banks to weigh the coins than to count them, especially when they have to operate with great amounts. Myers (1989) proposed a similar situation using pence and cents, whereas De Berg (1986) proposed to use fine cardboard pieces of different masses. In relation to the same concept, ‘relative atomic mass’, other authors propose analogies with different types of animals: pigs, dogs and chickens (Chamberlain et al., 1991; Fortman, 1993).

There are also proposals to facilitate the understanding of certain aspects related to applications of the mole concept. For example, in order to overcome the students' difficulties when using the molar fraction of solute instead of the concentration in solutions, De Lorenzo (1980) proposed as a familiar analogy the previous calculation of the fraction of female students in a mixed class. With the purpose of drawing the students' attention to the importance of the number of moles or molecules of the substances that take part in a chemical reaction, Fortman (1994) proposed the use of analogies around the question 'which has more amount'. Students should establish comparisons between the number, the volume or the mass of diverse sets of daily objects (eggs, melons, bars of gold, etc).

There are plenty of analogies proposed to facilitate the learning of the mole and the number of Avogadro. Fulkrod (1981) proposed the calculation of the volume occupied by Avogadro's number of drops of water, for which he started by assuming that 20 drops of water occupy a volume of one $cm^3$. In order to show to what extent the molecules are small and the magnitude of Avogadro's number huge, Alexander et al*.* (1984) proposed several analogical situations. In one of them they compared the size (diameter) of an atom of carbon with the average growth in length of a beard in a second of time, taking as reference a centimeter per month (3.9 nm per second, that is, 10 times the diameter of the carbon atom). In order to estimate the size of the molecules they imagine the possibility that a person could reduce his size to such an extent that an ant standing on its legs would seem to have the height of one mile with respect to it; in that case a water molecule would seem to have the size of a salt grain. In order to illustrate the magnitude of Avogadro's number they compared it with the volume of the Pacific Ocean, which expressed in milliliters (it has $7.10^{23}$ milliliters) is a similar amount.

Gabel (1998) contends that using analogies to solve problems in chemistry results in higher achievement on problems involving moles, sitoichiometry and molarity but she again cautions that students often have difficulty understanding the analogies used. Obviously a variety of teaching strategies are required to involve the largest number of students in the learning process but it would seem that, used appropriately, there is a place for analogies.

In order to promote understanding of concepts related to the mole and to find out if the size of the particle influences or not student achievement, Gabel & Sherwood (1984) proposed the use of household tasks with oranges and sugar grains. Thus, for example, from the information provided on the mass, the volume and the number of grains that a sugar bag contains, the authors asked the students to calculate the mass of a sugar grain, the volume of five sugar bags, the number of grains contained in a certain mass of sugar, etc.

Though analogical reasonings can be used to overcome misconceptions (Brown and Clement 1989, Stavy 1991), they can also suggest or reinforce false associations between domains and lead to development of misconceptions about target concepts (Zook and Di Vesta 1991). Analogies have their limitations (Webb 1985). Complete mapping between analogue and target may not be possible and they must not be stretched or bent too much. Unless analogies are used carefully, the following kinds of problem may arise in instructional situations (Thiele and Treagust 1995).

- Students may take the analogy too far and may not be able to separate it from the content being learnt.
- Students may only remember the analogy and not the content under study.
- Students may focus on extraneous aspects of the analogy to form spurious conclusions relating to the target content.

It thus stands to reason that analogies be made an essential part of the teaching-learning process where all dimensions of analogies are carefully incorporated.

# CHAPTER 3

# PROBLEMS AND HYPOTHESES

## 3.1 The Main Problem and Subproblems

### 3.1.1 The Main Problem

The aim of this study is to investigate the efficiency of explicit method of problem solving accompanied with analogy instruction compared to traditionally designed chemistry instruction accompanied with the proportionality method of problem solving on 9th grade students' understanding of mole concept topic of chemistry and their attitudes toward chemistry as a school subject.

### 3.1.2 The Subproblems

- Is there a considerable difference between the efficiency of explicit method of problem solving accompanied with analogy instruction (EMPSA), and traditionally designed chemistry instruction accompanied with proportionality method of problem solving (TCIPPS) on students' comprehension of mole concept?
- Is there a considerable difference among the influence of, EMPSA and TCIPPS on students' attitudes toward chemistry as a school subject?

- What is the effect of EMPSA on students' comprehension of mole concept?
- What is the effect of TCIPPS on students' comprehension of mole concept?

## 3.2 Hypotheses

In this research designated hypothesis connected to the stated problems were developed. They are stated in null form at a significant level of 0.05.

**Ho 1:** There is no significant difference between post-test mean scores of the students taught with EMPSA and those taught with TCIPPS respect to mole concept achievement.

**Ho 2:** There is no significant difference between the post-test mean scores of the students receiving EMPSA and those receiving TCIPPS with respect to attitudes towards chemistry as a school subject.

**Ho 3:** There is no significant difference between the pre- and post-test mean scores of the students taught with EMPSA respect to achievement in mole concept.

**Ho 4**: There is no significant difference between the pre- and post-test mean scores of the students who utilized TCIPPS with respect to mole concept achievement.

# CHAPTER 4

# DESIGN OF THE STUDY

## 4.1 The Experimental Design

In experimental group and control group the Mole Concept Achievement Test (MCAT) and Attitude Scale Toward Chemistry as a School Subject (ASTCh) were given as pre- and post-tests to measure students' learning and problem solving efficiency about their attitudes toward chemistry as a school subject and the mole concept .

Table 4.1. Research Design of the Study

| Groups | Pre-test | Treatment | Post-test |
|---|---|---|---|
| EG | T1,T2 | EMPSA | T1,T2 |
| CG | T1,T2 | TCIPPS | T1,T2 |

In the given table EG represents the Experimental Group using explicit method of problem solving and analog instruction. CG represents the Control Group using traditionally designed chemistry instruction accompanied with proportionality method of problem solving. T1 is the Concept Achievement Test

(MCAT), T2 is the Attitude Scale Toward Chemistry as a School Subject (ASTCh).

## 4.2. The Subjects of the Study

Participants for this research consisted of 53 students at ninth grade level from two classes taught by the same teacher in Atatürk Anadolu Lycee. The study was carried out during the second semester in the 2004-2005 school year.

Teaching approaches used in the present research were assigned randomly to one class. The experimental group was consisted of 26 students. The control group included 27 students.

## 4.3. Variables

### 4.3.1 Independent Variables

The independent variable of this research was the treatment. There were two different types of treatment; explicit method of problem solving accompanied with analogy instruction (EMPSA) and traditionally designed chemistry instruction accompanied with proportionality method of problem solving (TCIPPS).

### 4.3.2 Dependent Variables

The dependent variables of this study were students' comprehension of mole concept measured with MCAT and their attitudes toward chemistry as a school subject measured with ASTCh.

## 4.4 Instruments

### 4.4.1 Mole Concept Achievement Test (MCAT)

The test applied in the research was prepared by researcher and a chemistry teacher who has 28 years experience in teaching; she has worked at several private schools and has written test books. The test contained 43 multiple choice questions at the knowledge, comprehension and application levels of Bloom's taxonomy (1956). Questions given in the test have different levels of difficulty and were covered the mole concept. Questions had only one correct answer and four distracters.

Questions given in the test were prepared parallel to the curriculum. The applied test was prepared in Turkish (See Appendix A) because the instruction language of the chemistry lesson was Turkish.

The test was given as a pre-test and post-test to determine students' understanding level of the mole concept. The reliability coefficient of the test was found to be 0.74.

### 4.4.2 Attitude Scale Toward Chemistry as a School Subject (ASTCh)

The Attitude Scale toward Chemistry as a school subject was developed previously (Geban et al. 1992) was used to measure students' attitudes. This scale consisted of 15 item in 5 point likert type scale (fully agree, agree undecided, partially agree, fully disagree). The reliability was found to be 0.78. This test was given before and after treatment both groups (see Appendix B).

## 4.5. Treatment

This research was carried on over a 4-weeks period during the 2004-2005 spring semester. Participants for this study were ninth grade chemistry students in Atatürk Anadolu Lycee. There were 53 students in total; 26 in experimental group and 27 in control group. The same teacher taught both classes. The groups received chemistry instruction for the same amount of time but not at the same time, as they were taught by the same teacher. Course teacher was experienced in instruction with concept mapping, explicit method and analogy instruction.

The experimental group (EG) treated with explicit method of problem solving accompanied with analogyinstruction. Prior to each method application, an explanation covering the instruction method was given to participants. First applied method was the explicit method of problem solving (EMPS). A serious difficulty experienced by weaker students in high school is a lack of skills in solving word problems. The explicit method of problem solving method attempts to overcome this shortcoming by providing students with a linear-thinking approach to problem solving. The explicit method, a proven successful strategy in teaching students to solve chemistry problems, includes the following six steps:

1. Write what information is GIVEN, either symbolically or in narrative.

2. Write what is being ASKED.

3. RECALL any information from past learning that may prove useful and write it down.

4. Make a PLAN to solve the problem. Flow-chart symbolism is useful here.

5. SOLVE the problem using mathematics. This step also includes checking the accuracy of the mathematics.

In the application of this method, the teacher gave information about problem solving by using EMPS prior the lesson. Students were required to solve the given mole problem worksheet by using this method (See Appendix C1). Sample problems solved by EMPS in the classroom using overhead projector. Overhead projector attracts much more attention than solving problems on blackboard. After solving sample problems, students' responses to the given worksheet were discussed together.

Second applied method was the analogy instruction. The analog used in the instruction of mole concept was eggs. The calculation of analog sample problems resemble to the method used in calculation of mole concept problems. By combining daily life with mole concept, students' understanding the subject was enhanced. For example, mass of four package eggs was compared to mass of four mole Fe atoms. The teacher firstly solved analog problems in the classroom and afterwards solved the equivalent mole problems. A worksheet including both analog problems and mole problems were given to students (See appendix C2). At the top of the worksheet required information for understanding the analogy were given. In next lesson solution of the problems were discussed together.

In the control group, students were instructed by traditional lecture and discussion methods. Because of the time spent with explanations of the methods and solution of the sample problems in the experimental group, to equalize the duration of the lessons, additional problems were given to the control group. Given problems were chosen by teacher, to be related with the subject being taught in the class. When teaching the mole concept, teacher only used the presentation style and proportionality method of problem solving.

Mole Concept Achievement Test and Attitude Toward Chemistry as a School Subject were applied to both groups as a pre-test and post-test because the study was carried out using a pre-test and post-test control group design (Campbell and Stanley, 1966).

## 4.6 Analysis of Data

In this study, statistical techniques paired samples t-test, independent samples t-test were used to analyse the data. Statistical analyses were carried out by using the SPSS 10.0.

## 4.7 Assumptions and Limitations

### 4.7.1 Assumptions

1. The teacher equally treated both groups during the mole concept education.

2. Participants of both groups had the equal prior knowledge base before the treatment.

3. All students participated to the research gave voluntary responses to applied tests and students in the experimental group willingly joined to practiced activities.

4. There was no interaction between the participants of experimental and control group during the treatment which can affect the achievement levels.

### 4.7.2 Limitations

1. The research was covered only the mole concept topic.
2. Students participated to the research constituted only from ninth grade high school students.
3. Treatment time did not expend more than four weeks.
4. The subject of this research was limited to 53 students in two groups.

# CHAPTER 5

# RESULTS AND CONCLUSIONS

In this chapter results obtained from testing each of the hypothesis stated earlier are presented. The hypotheses are tested at a significant level of 0.005. Paired samples t-test and independent samples t-test was used to test hypotheses. In this study, statistical analyses were carried out by using the SPSS 10.0

## 5.1 Results

In order to identify the relative performances of the students' previous learning in the mole concept, prior attitude toward science as a school subjects were administered two pre-tests that were MCAT and ASTCh.

The results showed that there was no significant difference between groups in terms of mole concept achievement (EMPSA Group: $\overline{X}$ = 23.84, sd= 8.73; TCIPPS Group: $\overline{X}$ = 22.92, sd= 6.45, t= 0.437, p= 0.269); attitudes towards chemistry as a school subject (EMPSA Group: $\overline{X}$ = 3.21, sd=0.35; TCIPPS Group: $\overline{X}$ = 3.24, sd= 0.26, t= -0.361, p=0.219).

**Hypothesis 1:**

To answer the question posed by hypothesis 1 stating that there is no significant difference between the post test mean scores of the students taught by EMPSA and taught by TCIPPS with respect to achievement related to mole concept analysis of independent samples t-test was used. The measures obtained are present in Table 5.1.

Table 5.1 Measures Obtained from the Testing of Significance of the Difference between Post Means of Mole Concept Achivement Test of EMPSA Group and TCIPPS Group

| Groups | N | $\overline{X}$ | S | Levene's Test for Equality of Variances | | df | t-value | p |
|---|---|---|---|---|---|---|---|---|
| | | | | F | Sig. | | | |
| EMPSA Group | 26 | 38.42 | 4.24 | 1.09 | 0.301 | 25 | 2.34 | 0.028 |
| TCIPPS Group | 27 | 35.3 | 5.60 | | | | | |

The result showed that there was a significant difference between the post-test mean scores of the students taught by EMPSA and taught by TCIPPS with respect to the achievement related to mole concept. EMPSA group scored significantly higher than TCIPPS group.

As a result, the students in the experimental group instructed by EMPSA understood mole concept better than the students in the control group instructed by TCIPPS.

**Hypothesis 2:**

To answer the question posed by hypothesis 1 stating that there is no significant difference between the post test mean scores of the students taught by EMPSA and taught by TCIPPS with respect to attitudes towards chemistry as a school subject analysis of independent samples t-test was used. The measures obtained are given in Table 5.2.

Table 5.2 The Analysis of Data for Group Comparison with Respect to Post Attitude Scale toward Chemistry as a School Subject (ASTCh) Results.

| Groups | N | $\overline{X}$ | S | Levene's Test for Equality of Variances | | df | t-value | p |
|---|---|---|---|---|---|---|---|---|
| | | | | F | Sig. | | | |
| EMPSA Group | 26 | 3.22 | 0.297 | 0.008 | 0.928 | 51 | -0.98 | 0.327 |
| TCIPPS Group | 27 | 3.31 | 0.298 | | | | | |

The results showed that there was no significance difference between the mean scores of the students taught by EMPSA and those taught by TCIPPS with respect to the ASTCh. The EMPSA group and TCIPPS group showed the same attitude.

**Hypothesis 3:**

To answer the question posed by hypothesis 3 stating that there is no significant difference between pre and post-test mean scores of the students who received EMPSA with respect to mole concept achievement, paired samples t-test was used. Table 5.3. represent the analysis of data for comparison of the pre and post MCAT scores.

Table 5.3 Measures Obtained from the Testing of Significance of the Difference between Pre and Post Means of Mole Concept Achievement Test of EMPSA Group

| Tests | N | $\overline{X}$ | S | df | t-value | p |
|---|---|---|---|---|---|---|
| Pre-MCAT | 26 | 18.66 | 5.71 | 26 | -17.85 | 0.000 |
| Post-MCAT |  | 36.40 | 5.07 |  |  |  |

The result showed that there was a significant difference between the pre and post-test mean scores of the students taught by EMPSA with respect to the achievement related to mole concept. It can be said that there was a significant increase in MCAT scores of EMPSA group.

**Hypothesis 4:**

To answer the question posed by hypothesis 3 stating that there is no significant difference between pre and post-test mean scores of the students who utilized TCIPPS with respect to mole concept achievement, paired samples t-test was used. The analysis of data for comparison of the pre and post MCAT scores is shown in Table 5.4.

Table 5.4 Measures Obtained from the Testing of Significance of the Difference between Pre and Post Means of Mole Concept Achievement Test of TCIPPS Group

| Tests | N | $\overline{X}$ | S | df | t-value | p |
|---|---|---|---|---|---|---|
| Pre-MCAT | 27 | 18.66 | 5.71 | 26 | -12.41 | 0.000 |
| Post-MCAT |  | 35.33 | 5.60 |  |  |  |

The result revealed that there was a significant difference between the pre and post-test mean scores of the students who used TCIPPS with respect to mole concept achievement. It can be said that there was a significant increase in MCAT scores of TCIPPS group.

## 5.2. Conclusions

The following conclusions can be deduced from the results:

1. The EMPSA caused a significantly better acquisition of scientific conceptions related to mole concept than the TCIPPS.
2. The EMPSA and TCIPPS produced the same attitudes toward chemistry as a school subject.
3. When the pre and post means of MCAT scores of EMPSA group were compared, a significant increase in scores was observed. It can be said that the growth in understanding of mole concept of the subjects utilizing EMPSA was significant.
4. When the pre and post means of MCAT scores of TCIPPS group were compared, a significant increase in scores was observed. It can be said that the growth in understanding of mole concept of the subjects utilizing TCIPPS was significant.

# CHAPTER 6

# DISCUSSION, IMPLICATIONS AND RECOMMENDATIONS

## 6.1 Discussion

The main purpose of this study was to investigate the effectiveness of explicit method of problem solving accompanied with analogy instruction over traditionally designed chemistry instruction on 9th grade students' understanding of mole concept topic of chemistry and attitudes toward chemistry as a school subject.

At the beginning of the study Mole Concept Achievement Test was applied to all subjects as a pretest in order to determine the equality of groups included in the study. Results of the test showed that there was no significant difference between two groups in terms of mole concept achievement. This was an important requirement for validation of the effectiveness of educational techniques used in this research. Same test was applied as post test to compare the effect of given educational techniques on mole concept understanding.

Based on the analysis of results from this study, it may be concluded that the explicit method of problem solving accompanied with analogy instruction caused a significantly better acquisition of mole concept than the traditionally designed instruction.

In this study, the explicit method of problem solving was used in order to help students to improve problem solving skills related to mole concept. Previous research indicates that explicit problem-solving instruction can help improve students' problem-solving performance more than traditional instruction (Mestre, Dufresne, Gerace, Hardiman, & Touger, 1993; Heller, Keith, & Anderson, 1992; Van Heuvelen, 1990; Wright & Williams, 1986; Heller & Reif, 1984; Larkin & Reif, 1979, Reif, Larkin, & Brackett, 1976). Solving problems in chemistry at the high school and college levels may seem like a mysterious process, often taught in textbooks and classrooms as if one must already know how to solve the problem before beginning. Some students develop an intuitive approach to problem solving, while others cope by memorizing the solutions to different types of problems. Both strategies, however, quickly lead to failure when completely new problems are presented (McCalla, 2003). As explicit problem solving is instruction that directly teaches students how to use more advanced techniques for solving problems, students taught with this method exhibited more improvement in problem-solving performance and more improvement in conceptual understanding of mole concept. According to the results of this study there is no doubt that explicit method of problem solving can contribute to the enhancement of learning.

Problem solving is considered an integral component in students' education in science. In school science, problems usually involve for their answer the use of mathematical relationships and the calculation of a numerical result. Such problems contain numerical data, and also the values of physical and chemical quantities and/or constants. In any case, to become good problem solvers, students must be given ample opportunity to do it. This will not give them just practice; it will develop confidence (Zikovelis & Tsaparlis, 2006).

The other technique used in this study was analogy instruction. Analogy-enhanced instruction was more effective when compared to traditionally designed teaching method. This result supports the findings of previous studies (Dagher, 1995; Duit, 1991, Glynn, Duit & Thiele; 1995, Lin, Shiau, & Lawrenz, 1996). For learning to be meaningful, new knowledge must be integrated with existing knowledge. Problem solving with analogy provides a rich opportunity to carefully match ideas and relationships. An analogy aids the visualisation process in learning (Wu and Shah, 2004). Construction of analogies encourages the teacher to consider the students' prior knowledge. Students' prior knowledge influences the way they perceive new concepts and it can be advantageous to consider what the student knows and how this knowledge can be utilised before teaching any concept. Analogies may also motivate students to learn by provoking their interest. Finally, having students create their own analogies also appears to be an effective instructional strategy. Analogies provide an interesting, visual and stimulating way of understanding chemical ideas. Models can really help and motivate low achieving pupils. In this study, these various advantages of analogies were used to solve problems more effectively in mole concept while compared to traditional instruction method.

The attitude scale towards chemistry as a school subject was administered to all subjects of the study before and after treatment. There was no significant difference between the pre- and post-test results of two groups in terms of attitude towards chemistry as a school subject. They all showed statistically the same attitude.  This can be explained by the limitations of the application time. If the duration of application could be a longer period of time, students may show more positive attitude.

Even the results showed a significant improvement in the mole concept achievement between the groups taught by EMPSA and TCIPPS, the results of ASTCh should be seriously considered. Despite the experimental group instructed by EMPSA understood mole concept better than the students in the control group instructed by TCIPPS, there was no improvement in the attitude towards chemistry as a school subject. Therefore the implication is that instruction needs to focus on the attitude towards chemistry to improve their understanding of the mole.

## 6.2. Implications

The results of this study have some important implications for teachers and researchers. The findings of the present study have the following implications:

1. The problem of lack of understanding of the concept ‘mole’ manifested by students is strongly connected to teachers’ ideas and to the methodologies used in the teaching of chemistry.

2. The analogies themselves proved a limiting factor for some individuals in the group. Linking the analogy to the target proved to be quite difficult for some students and the way that they attacked the practice problems did not guarantee success. It is probable that some students were confused and/or distracted by the analogies, which impeded their learning. If they did not actively participate in the discussion phase then they would not benefit fully and their depth of understanding would be affected.

3. Some care should be exercised to equate the time that learners in different conditions spend on learning. Clearly, if one group spends longer studying than another, this can cloud any effects of the particular learning treatment

4. In educational systems such as in our country, where the study of scientific disciplines within separate subjects starts early, there is a problem of providing correlation of contents, and positive transfer of knowledge from one field to another. This is a necessary precondition for a solid knowledge, as is to train students to perceive and explain a phenomenon or a change from different angles, to be able to use their knowledge with other examples both in school or everyday life. If this is not done, the same concept taught within different subjects will have separate meanings (atom in physics versus atom in chemistry).

Furthermore, we cannot expect success in studying a subject if we do not supply a student with a necessary basis provided for in another subject.

## 6.3 Recommendations

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

1. Similar research studies can be conducted with different chemistry subjects. The nature of the methods used for instruction and the way that students interact with them is a fruitful area for development.

2. Further research could involve further refinement of the current analogies and the production of further analogies for different topic areas or different subjects.

3. A similar research can be designed with different age, grade and gender groups.

4. The sample size can be increased for further studies to obtain more accurate results.

5. The time of instruction using the analogy and explicit method of problem solving can be increased.

6. Future research is strongly recommended to further validate the findings of this study.

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# APPENDIX A

## MOL KAVRAMI BAŞARI TESTİ

**1.**

**Aşağıdakilerden hangisi 160 gram**

**$NH_4NO_3$ için <u>doğru değildir</u>?**
(N:14 H:1 O:16)

A) 2 mol $NH_4NO_3$ tür.
B) 2 mol N atomu içerir.
C) 3 mol $O_2$ molekülü içerir.
D) Toplam 18 mol atom içerir.
E) $8.6{,}02.10^{23}$ tane H atomu içerir.

**2.**
**Aşağıdakilerden hangisi en az sayıda atom içerir?**

A) 2 mol $NO_2$
B) 1 mol $C_2H_4$
C) 2 mol O atomu içeren $CaSO_4$
D) 0,5 mol $Ca(NO_3)_2$
E) 8 mol O atomu içeren $SO_2$

**3.**
**0,2 mol $NH_4NO_3$ molekülünde kaç gram N vardır?** (N:14)

A) 1,4
B) 2,8
C) 5,6
D) 8,4
E) 11,2

**4.**
**Aşağıdakilerden hangisi 0,2 mol $N_2O_3$ için <u>doğru değildir?</u>**(N:14 O:16)

A) Kütlesi 15,2 gramdır.
B) 5,6 gram N atomu içerir.
C) 0,6 mol O atomu içerir.
D) Toplam $6{,}02.10^{22}$ tane atom içerir.
E) $1{,}204.10^{23}$ tane $N_2O_3$ molekülü içerir.

**5.**
**Hangi bileşiğin 1 gramı en az sayıda molekül içerir?** (N:14 H:1 O:16 C:12 S:32)

A) $CH_4$ B) $C_2H_6$ C) $NO_2$
D) $CH_3$ OH E) $SO_3$

**6.**

**Aşağıdakilerden hangi bileşiğin 0,1 molü**

**4,8 gram O atomu içerir?** (O:16)

A) $N_2O$ B) $C_2H_5OH$ C) $N_2O_5$

D) $H_2SO_4$ E) $Al_2O_3$

**7.**

**Aşağıdakilerden hangisi en az sayıda mo-**

**lekül içerir?** (C:12 O:16 N:14)

A) 1,6 gram $O_2$
B) 0,5 mol $N_2$
C) 3,2 gram $CH_4$
D) 1,2 gram C atomu içeren $CO_2$
E) 0,5 mol N atomu içeren $N_2O_5$

**8.**
**3,2 mol H atomu içeren $(NH_4)_2SO_4$ molekülünde toplam kaç tane atom vardır?**

A) $3.6{,}02.10^{23}$ B) $4.6{,}02.10^{23}$
C) $6.6{,}02.10^{23}$ D) $6{,}02.10^{23}/4$
E) $6{,}02.10^{23}/6$

**9.**

**Aşağıdakilerden hangisi toplam 6,02.$10^{23}$ tane atom içerir?**

( C:12 O:16 Cl:35,5 Fe:56 N:14)

A) 1 mol $O_2$ B) 14 gr. $N_2$ C) 22 gr. $CO_2$

D) 28 gr. Fe E) 71 gr. $Cl_2$

**10.**
I.N.K' da 5,6 lt $N_2$ gazı
II.3,01.$10^{22}$ tane $CO_2$ molekülü
III.9 gram NO gazı

**Verilen maddelerin mol sayılarının küçükten büyüğe doğru sıralanışı nedir?**
(N:14, O:16)

A) II,I,III B) III,I,II C) III,II,I

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

**11.**
I.1mol $H_2$ molekülü
II.1 tane $H_2$ molekülü
III.1 tane O atomu
IV.1 tane $CH_4$ molekülü

**Verilen maddelerin kütlelerinin sıralanışı hangisinde doğru verilmiştir?**
(C:12, H:1, O:16)

A)I=II<III<IV B)II<III=IV<I C)II<III<IV<I

D) I = II < IV < III E) II < IV < III < I

**12.**
**3,6 gram $H_2O$ için verilen bilgilerden hangisi yanlıştır?** (H:1, O:16)

A) 0,2 moldür.
B) 1,204.$10^{23}$ tane $H_2O$ molekülü içerir.
C) Toplam 0,6 mol atom içerir.
D) 0,2 gr. Hidrojen içerir.
E) 2,408.$10^{23}$ tane H atomu içerir.

**13.**
**N.K' da 1,806.$10^{23}$ tane $CH_4$ molekülü için hangi bilgi yanlıştır?** (C:12, H:1)

A) 4,8 gramdır.
B) 1,2 gram H içerir.
C) Hacmi 6,72 litredir.
D) 1,2 mol $H_2$ içerir.
E) Toplam 1,5 mol atom içerir.

**15.**
**0,25 mol $CaSO_4$ bileşiği kaç gramdır?**
(Ca:40, S:32, O:16)

A) 27.2
B) 34
C) 38
D) 78
E) 136

**16.**
I.1 mol Azot molekülü
II.1 mol Azot atomu
III.10 tane Azot molekülü
IV.10 tane Azot atomu

**Yukarıda verilen Azot (N) miktarlarının kütle bakımından küçükten büyüğe doğru sıralanışı nasıldır ?** (N:14)

A) III,IV,I,II
B) III = IV, I = II
C) IV,III,II,I
D) IV,III,I,II
E) III,IV,I = II

**17.**
**N.K' da 1,12 litre $SO_3$ gazı ile aynı kütlede olan gaz aşağıdakilerden hangisidir?**
(S:32 O:16 C:12 H:1)

A) 0,1 mol $C_3H_4$
B) 0,5 mol $O_2$
C) 0,02 mol $SO_3$
D) 0,2 mol $CH_4$
E) 0,05 mol $SO_2$

**18.**

**Oda koşullarında,1 mol He atomu ile 1 mol Fe atomu için aşağıda verilenlerden hangisi aynıdır?**(He:4 Fe:56)

A) Kütleleri
B) Özkütleleri
C) Hacimleri
D) İçerdikleri atom sayısı
E) Elektrik iletkenlikleri

**19.**

**NK' da 8 gram $O_2$ gazının hacmi kadar hacimde bulunan hangisidir?**

(O:16 He:4 S:32)

A) 0,4 mol $SO_2$
B) 8 gr. He gazı
C) 0,5 mol $H_2$
D) 20 gr. $SO_3$
E) 11,2 lt. $CH_4$

**20.**

**1 mol $Fe_4$ [Fe $(CN)_6$ $]_3$ toplam kaç mol Fe atomu içerir?**

A) 3
B) 4
C) 7
D) 10
E) 22

**21.**

**2 mol $O_2$ molekülü içeren $Na_2O$ da kaç tane Na atomu vardır?**

A) 8.6,02.$10^{23}$ B) 4.6,02.$10^{23}$ C) 2.6,02.$10^{23}$

D) 6,02.$10^{23}$/4 E) 6,02.$10^{23}$/8

**22.**

**6,4 gram S atomu içeren $H_2SO_4$ molekülü kaç moldür?** (H:1, S:32, O:16)

A) 1 B) 0,5 C) 0,4

D) 0,2 E) 0,1

**23.**

**13,2 gram $CO_2$ molekülünde toplam kaç tane atom vardır?** (C:12, O:16)

A) 0,9 $N_A$ B) 0,3 $N_A$ C) 0,2 $N_A$

D) 0,9 E) 0,15

**24.**

**9,2 gram $NO_2$ bileşiğinde kaç tane O atomu vardır?** (N:14, O:16)

A) 0,2 $N_A$ B) 0,4 $N_A$ C) 9,2 $N_A$

D) 4 $N_A$ E) 0,3 $N_A$

**25.**

N.K' da 8 gram O atomu içeren $CO_2$ bileşiği için;

I.Hacmi 11,2 lt dir.
II.11 gr. dır.
III.Toplam 0,75 $N_A$ tane atom içerir.
**değerlerinden hangileri doğrudur?**
(C:12, O:16)

A) Yalnız I B) Yalnız II C) Yalnız III

D) II ve III E) I ve III

**26.**

**60 gram Ca atomu ile eşit sayıda atom içeren $CH_4$ kaç gramdır?**(Ca:40, C:12, H:1)

A) 1,5 B) 2,4 C) 4,8

D) 6,4 E) 7,2

**27.**

**Eşit molekül sayısında $H_2$ ve $O_2$ içeren karışım elde etmek için,8 gram $H_2$' ye kaç gram $O_2$ eklenmelidir?** (H:1, O:16)

A) 4 B) 8 C) 32

D) 64 E) 128

**28.**

**0,4 mol $C_2H_6$ bileşiğinde toplam kaç mol atom vardır?**

A) 0,32$N_A$ B) 0,4$N_A$ C) 0,4

D) 0,32 E) 3,2

**29.**

Avogadro sayısı kadar toplam atom bulunduran $NH_3$ bileşiği, (N:14, H:1)

I.0,25 moldür.

II.N.K.' da 22,4 lt hacim kaplar.

III.6,8 gr. dır.

**İfadelerinden hangileri doğrudur?**

A) Yalnız I B) Yalnız II C) Yalnız III

D) I ve II E) II ve III

**30.**

**7 gram N atomu bulunduran $N_2O_3$ bileşiği kaç moldür?**(N:14)

A) 0,1 B) 0,2 C) 0,25

D) 0,4 E) 0,5

**31.**

**N.K.' da 11,2 litre hacim kaplayan $C_3H_4$ bileşiğinde kaç gram C vardır?**
(C:12, H:1)

A) 6 B) 7,2 C) 8 D) 18 E) 20

**32.**

**13,8 gram $NO_2$ bileşiğinde kaç tane O atomu vardır?**(N:14, O:16)

A) $0{,}3N_A$
B) $0{,}5N_A$
C) $0{,}6N_A$
D) $0{,}7N_A$
E) $0{,}9N_A$

**33.**

**10,8 gram $N_2O_5$ bileşiğinde kaç tane $O_2$ molekülü vardır?**(N:14, O:16)

A) $3{,}01.10^{23}$ B) $6{,}02.10^{23}$
C) $3{,}01.10^{22}$ D) $6{,}02.10^{22}$
E) $1{,}505.10^{23}$

**34.**

**N.K.' da 5,6 litre hacim kaplayan $C_2H_2$ gazında kaç tane H atomu vardır?**

A) $0{,}25N_A$ B) $0{,}4N_A$ C) $0{,}5N_A$
D) $0{,}8N_A$ E) $0{,}2N_A$

**35.**

**0,1 mol $Fe_2O_3$ bileşiği ile 0.2 mol $C_3H_4$ bileşiği toplam kaç gramdır?**
(Fe:56, O:16, C:12, H:1)

A) 0,3
B) 12
C) 16
D) 24
E) 32

**36.**

**0,4 mol $N_2O_3$ ve 9 gram NO bileşiklerinde toplam kaç mol N atomu vardır?**
(N:14, O:16)

A) 0,7 B) 1,1 C) 1,5
D) 1,7 E) 9,4

**37.**

**$3{,}01.10^{23}$ tane H atomu bulunduran $CH_4$ bileşiği kaç gramdır?**(C:12, H:1)

A) 2 B) 4 C) 8 D) 12 E) 16

38.

**2,7 gram Al bulunduran $Al_2S_3$ bileşiği kaç moldür?** (Al:27)

A) 0,02
B) 0,05
C) 0,1
D) 0,2
E) 0,5

**39.**

**33 gram Mn bulunduran $Mn_3O_4$ bileşiği toplam kaç mol atom bulundurur?**
(Mn:55)

A) 0,6 B) 0,7 C) 1,4
D) 4,2 E) 4

**40.**

**5,6 gram N bulunduran $Ca(NO_3)_2$ bileşiği kaç gramdır?**(Ca:40, N:14, O:16)

A) 11,6 B) 16,4 C) 23,2
D) 32,8 E) 65,6

**41.**

**Aşağıdakilerden hangisinin 0,25 molü 16 gramdır?(**C:12,H:1, S:32, O:16, N:14, He:4)

A) $SO_2$ B) $CH_4$ C) He
D) $CO_2$ E) $NO_2$

**42.**

**0,125 mol XS molekülü 10,5 gramdır.**

**$3{,}01.10^{23}$ tane $XS_2$ molekülü kaç gramdır?**

**(**S:32)

A) 5,8
B) 11,6
C) 58
D) 84
**E)** 116

**43.**

**X ve Y elementlerinin oluşturdukları $XY_2$ ve $X_2Y_5$ bileşiklerinin birer molleri sırasıyla 46 ve 108 gram olduğuna göre X ve Y atomlarının <u>atom ağırlıkları</u> nedir?**

| | X | Y |
|---|---|---|
| A) | 16 | 14 |
| B) | 8 | 16 |
| C) | 14 | 18 |
| D) | 28 | 32 |
| E) | 14 | 16 |

# APPENDIX B

## KİMYA DERSİ TUTUM ÖLÇEĞİ

Açıklama: Bu ölçek, Fen Bilgisi dersine ilişkin tutum cümleleri ile her cümlenin karşısında; TAMAMEN KATILIYORUM, KATILIYORUM, KARARSIZIM, KATILMIYORUM, ve HİÇ KATILMIYORUM olmak üzere beş seçenek verilmiştir. Her cümleyi dikkatle okuduktan sonra kendinize uygun seçeneği işaretleyiniz.

| | | Tamamen katılıyorum | Katılıyorum | Karasızım | Katılmıyorum | Hiç Katılmıyorum |
|---|---|---|---|---|---|---|
| 1 | Kimya çok sevdiğim bir alandır. | | | | | |
| 2 | Kimya ile ilgili kitapları okumaktan hoşlanırım. | | | | | |
| 3 | Kimyanın günlük yaşantıda çok önemli yeri yoktur. | | | | | |
| 4 | Kimya ile ilgili ders problemlerini çözmekten hoşlanırım | | | | | |
| 5 | Kimya konularıyla ilgili daha çok şey öğrenmek isterim. | | | | | |
| 6 | Kimya dersine girerken büyük sıkıntı duyarım. | | | | | |
| 7 | Kimya derslerine zevkle girerim | | | | | |
| 8 | Kimya derslerine ayrılan ders saatinin daha fazla olmasını isterim. | | | | | |
| 9 | Kimya dersine çalışırken canım sıkılır. | | | | | |
| 10 | Kimya konularını ilgilendiren günlük olaylar hakkında daha fazla bilgi edinmek isterim. | | | | | |
| 11 | Düşünce sistemimizi geliştimede kimya öğrenimi önemlidir. | | | | | |
| 12 | Kimya çevremizdeki doğal olayların daha iyi anlaşılmasında yardımcı olur. | | | | | |
| 13 | Dersler içinde Kimya dersi bana sevimsiz gelir. | | | | | |
| 14 | Kimya konuları ile ilgili tartışmaya katılmak bana cazip gelmez. | | | | | |
| 15 | Çalışma zamanımın önemli bir kısmını kimya dersine ayırmak isterim | | | | | |

# APPENDIX C

# Worksheet Samples

## C.1 EXPLICIT METHOD OF PROBLEM SOLVING SAMPLE

Aşağıda verilen problemleri kategorize yöntemi ile çözünüz.

1-) 5mol $CO_2$'de kaç tane oksijen atomu vardır?
Verilen:
Sorulan:
Hatırlatma:
Plan:
Çözüm:

2-) Yapısında $6,02.10^{23}$ tane hidrojen atomu bulunan $C_4H_{10}$ kaç moldür?
Verilen:
Sorulan:
Hatırlatma:
Plan:
Çözüm:

3-) $2,408.10^{23}$ tane Fe atomu kaç gramdır? (Fe=56)
Verilen:
Sorulan:
Hatırlatma:
Plan:
Çözüm:

4-) 1 tane $CO_2$ kaç gramdır? (C=12, O=16)
Verilen:
Sorulan:
Hatırlatma:
Plan:

Çözüm:

5-) 20 gram $SO_3$ kaç moldür? (S=32, O=16)
Verilen:
Sorulan:
Hatırlatma:
Plan:
Çözüm:

6-) $X_2O_3$ bileşiğinin 32 gramında 0,6 mol O atomu vardır. 1 mol X atomu kaç gramdır?(O:16)
Verilen:
Sorulan:
Hatırlatma:
Plan:
Çözüm:

7-) Bir X atomunun ağırlığı $3.10^{-23}$ gramdır. $AlX_3$ bileşiğinin molekül ağırlığı nedir? (Al:27, $N_A$:$6.10^{23}$)
Verilen:
Sorulan:
Hatırlatma:
Plan:
Çözüm:

8-) $3,01.10^{22}$ tane $N_2O_5$ molekülü kaç gramdır? (C:12, H:1, O:16, N:14)
Verilen:
Sorulan:
Hatırlatma:
Plan:
Çözüm:

9-) 2,46 gram $XCl_2$ bileşiği 1,04 gram X atomu içeriyor. X' in atom ağırlığı nedir? (Cl:35,5)
Verilen:
Sorulan:
Hatırlatma:
Plan:
Çözüm:

10-) 30,4 gram $X_2O_3$ bileşiğinde 0,3 mol $O_2$ vardır. 1 mol X atomu kaç gramdır? (O:16)
Verilen:
Sorulan:
Hatırlatma:
Plan:
Çözüm:

# C.2 ANALOGY SAMPLE

## BENZEŞME ÖRNEKLEMİ

1 koli yumurta 30 tane yumurta içerir ve 1,5 kg ağırlındadır.

Aşağıdaki soruları yukarıda verilen bilgilere dayanarak yanıtlayınız. Kolinin ağırlığı göz ardı edilmelidir.

1) 4 koli yumurtanın ağırlığı ne kadardır?

a. 0,75 b. 1,5 c.3
d.6 e. Hiçbiri

2) 45 tane yumurta kaç koli eder?

a. 3 b. 2,5 c. 2
d. 1,5 e. Hiçbiri

3) 8 koli yumurta kaç tane yumurta içerir?

a. 30 b. 60 c.120
d. 240 e.Hiçbiri

4) 105 tane yumurtanın ağırlığı ne kadardır?

a. 6 b. 5,25 c.4
d. 2,25 e. Hiçbiri

5) 6 kg yumurta kaç tane yumurta içerir?

a. 120 b. 100 c. 80
d. 60 e. Hiçbiri

1 mol Fe $6,02x10^{23}$ tane Fe atomu içerir ve 56 gramdır.

Aşağıdaki soruları yukarıda verilen bilgilere dayanarak yanıtlayınız.

1) 4 mol Fe'in ağırlığı ne kadardır?

a. 56 b. 112 c.186
d. 224 e. Hiçbiri

2) $3,01x10^{23}$ tane Fe kaç mol Fe eder?

a. 0,25 b. 0,5 c. 0,75
d. 1 e. Hiçbiri

3) 8 mol Fe kaç tane Fe atomu içerir?

a. $6,02x10^{23}$ b. $12,0810^{23}$
c. $48,16x10^{23}$ d. $52,03x10^{23}$
e. Hiçbiri

4) $12,0810^{23}$ tane Fe atomunun ağırlığı nedir?

a. 224gr b. 168 c.11
d. 56 e. Hiçbiri

5) 280 gr Fe kaç tane Fe atomu içerir?

a. 5 $0,3 x10^{23}$ b. $40,2 x10^{23}$
c. $30,1 x10^{23}$ d. $20,05 x10^{23}$
e. Hiçbiri