EFFECTS OF 7E LEARNING CYCLE MODEL ACCOMPANIED WITH COMPUTER ANIMATIONS ON UNDERSTANDING OF DIFFUSION AND OSMOSIS CONCEPTS

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THE EFFECT OF 7E LEARNING CYCLE MODEL ON THE NINTH GRADE STUDENTS' UNDERSTANDING OF THE CONCEPTS RELATED TO THE DIFFUSION AND OSMOSIS IN BIOLOGY

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ABSTRACT

EFFECTS OF 7E LEARNING CYCLE MODEL ACCOMPANIED WITH COMPUTER ANIMATIONS ON UNDERSTANDING OF DIFFUSION AND OSMOSIS CONCEPTS

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The main purpose of the study was to compare the effectiveness of the instruction based on 7E learning cycle model accompanied with computer animations and traditionally designed biology instruction on 9th grade students' understanding and achievement related to diffusion and osmosis concepts and their attitudes toward biology as a school subject.

Quasi experimental design was used in this study. A total number of 66 ninth grade students from four intact classes of a biology course taught by the same biology teacher in a private high school in Istanbul were enrolled. The study was conducted during spring semester of 2008-2009 academic year.

This study included two experimental and two control groups. Experimental and control groups were randomly assigned. The students in the control group were instructed with traditionally designed biology instruction, while the students in the experimental group were instructed with 7E learning cycle model based instruction accompanied with computer animations. In the experimental group, students were taught with respect to the sequence of 7E learning cycle model which are elicit, engage, explore, explain, elaborate, evaluate, and extend through the use of activities such as demonstration, computer animations, laboratory activities, and discussions. In the control group, traditionally designed biology instruction was implemented through the teacher explanation, demonstrations, and use of textbook.

Diffusion and Osmosis Diagnostic Test (DODT), Diffusion and Osmosis Achievement Test (DOACH), Attitude Scale Toward Biology (ASTB) were administered to both groups as a pre-test and post-test to assess students' understanding and achievement of diffusion and osmosis concepts, and students' attitudes toward biology respectively. Science Process Skill Test (SPST) was given at the beginning of the study to determine students' science process skills. Moreover classroom observations were conducted.

The hypotheses were tested by using analysis of covariance (ANCOVA) and two-way analysis of variance (ANOVA). The results indicated that instruction based on 7E learning cycle model accompanied with computer animations caused significantly better acquisition of the scientific conceptions related to diffusion and osmosis concepts than traditionally designed biology instruction. Science process skill was determined as a strong predictor in the concepts related to diffusion and osmosis. Moreover instruction based on 7E learning cycle model accompanied with computer animations was more effective for improvement of students' attitudes as a school subject. However no significant effect of gender difference on students' understanding, achievement, and attitudes toward biology as a school subject was found.

Keywords: Learning Cycle Model, 7E Learning Cycle Model, Computer Animations, Diffusion and Osmosis, Understanding, Achievement, Misconceptions, Attitude toward Biology, Science Process Skills

ÖZ

BİLGİSAYAR ANİMASYONLARI DESTEKLİ 7E ÖĞRENME DÖNGÜSÜ MODELİNİN DİFÜZYON VE OSMOZ KONUSUNU ANLAMAYA ETKİSİ

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Bu çalışmanın başlıca amacı, bilgisayar animasyonları desteki 7E öğrenme döngüsü modeline dayalı öğretim yönteminin 9. sınıf öğrencilerinin difusyon ve osmoz konuları ile ilgili kavramaları anlamalarına, başarılarına ve biyolojiye karşı tutumlarına etkisini geleneksel biyoloji öğretim yöntemi ile karşılaştırarak incelemektir.

Bu çalışma, İstanbul'da özel bir lisede, aynı öğretmenin biyoloji derslerinde bulunan toplam 66 dokuzuncu öğrencilerinin katılımı ile gerçekleşmiştir. Bu çalışma 2008-2009 eğitim-öğretim yılının bahar döneminde yapılmıştır.

Bu çalışmada, rasgele seçilen iki deney ve iki kontrol grubu olmak üzere 4 grup yer almaktadır. Kontrol grubundaki öğrencilere geleneksel biyoloji öğretim yöntemi uygulanırken, deney grubundaki öğrencilere bilgisayar destekli 7E öğrenme döngüsü modeline dayalı öğretim yöntemi uygulanmıştır. Deney grubunda dersler, 7E öğrenme döngüsü modelinin içerdiği sıralamaya uygun bir biçimde; gösteriler, bilgisayar animasyonları, laboratuvar aktiviteleri ve tartışma yöntemine dayalı olarak işlenirken kontrol grubunda, öğretmen açıklamalarına, biyoloji öğretim programında yer alan deneysel uygulamalara ve ders kitaplarına dayalı olarak işlenmiştir.

Difüzyon ve osmoz kavram yanılgıları testi, difüzyon ve osmoz başarı testi ve biyoloji tutum ölçeği; öğrencilere ön-test ve son-test olarak uygulanmış, öğrencilerin difüzyon ve osmoz konularını anlamaları, bu konularına yönelik başarıları ve biyolojiye karşı olan tutumları değerlendirilmiştir. Bilimsel işlem becerilerini belirlemek üzere, çalışmanın başında öğrencilere bilimsel işlem beceri testi uygulanmıştır. Ayrıca bu çalışmada sınıf gözlemleri yapılmıştır.

Araştırmanın hipotezleri, ortak değişkenli varyans analizi (ANCOVA) ve iki yönlü çok değişkenli varyans analizi (ANOVA) kullanılarak test edilmiştir. Analiz sonuçları, bilgisayar destekli 7E öğrenme döngüsü modelinin, öğrencilerin difüzyon ve osmoz konularına yönelik kavramları anlamalarında ve başarılarında geleneksel biyoloji öğretim yöntemine göre daha etkili olduğunu göstermiştir. Öğrencilerin bilimsel işlem becerilerinin, difüzyon ve osmoz konularına yönelik kavramları anlamalarında belirleyici bir unsur olduğu tespit edilmiştir. Ayrıca bilgisayar destekli 7E öğrenme döngüsü modeline dayalı öğretim yönteminin öğrencilerin biyoloji dersine karşı olan tutumlarının gelişimesinde daha etkili olduğu gözlenmiştir. Bununla birlikte, cinsiyet farkının, öğrencilerin difüzyon ve osmoz konularını anlamalarında, başarılarında ve biyoloji dersine karşı tutumlarında bir etkisinin olmadığı görülmüştür.

Anahtar Kelimeler: Öğrenme Döngüsü, 7E Öğrenme Döngüsü Modeli, Bilgisayar Animasyonları, Difüzyon ve Osmos, Anlama, Başarı, Kavram Yanılgıları, Biyoloji Dersine Karşı Tutum, Bilimsel İşlem Becerileri

To my son, Süleyman Utku….

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DODT	: Diffusion and Osmosis Diagnostic Test
DOACH	: Diffusion and Osmosis Achievement Test
ASTB	: Attitude Scale toward Biology
SPST	: Science Process Skill Test
7ELCM	: Instruction Based on 7E Learning Cycle Model
TM	: Instruction Based on Traditional Methods
ATB	: Attitude toward Biology
EG	: Experimental Group
CG	: Control Group
N	: Number of Students
f	: Effect Size
df	: Degrees of Freedom
SS	: Sum of Squares
MS	: Mean of Square
$\overline{X}$	: Mean of the Sample
p	: Significance Level
F	: F statistics
t	: t Statistics

CHAPTER 1

INTRODUCTION

The process of globalization is an important trend affecting the world deeply in the new millennium. It has started a new era during which nations have to face huge changes in their social, economic and cultural ways. Responding to these challenges, education systems have to change towards a new paradigm in order to create new generations of this globalized world. Unlike the traditional paradigm of education which equips students only with knowledge and skills to survive in a local community, this new paradigm of education creates students who will be engaged in life long learning and will creatively contribute a multiple intelligence society. According to this new paradigm of education, learning should be borderless and student-centered, should focus on how to learn rather than how to gain and should be based on individualized rather than standardized programs.

The main role of current science education is to help students to be the citizens of the world. It stimulates students' curiosity and inquiry in order to foster a spirit of discovery and enjoyment of learning; equips them with the skills to learn and to acquire knowledge, individually or collaboratively, and to apply these skills and knowledge accordingly across a broad range of areas.

One of the most important problems facing education and training today is that most instructive approaches do not corresponds to the needs of today's children and young people or the type of society in which they live. In the constructivist framework, the emphasis is not on teaching, but rather on contexts or learning environments, individuals create or construct their own new understandings or knowledge through the interaction of what they already know or believe and the ideas, events, and activities with which they come in contact (Richardson, 2003). In traditional approaches to teaching, it is the designer who takes the decisions regarding what students have to learn, in what context they should learn, what strategies they should use to attain this knowledge and how this acquisition should be evaluated (Gros, 2002). Therefore, exploring ways to improve students' ability to think critically is in main step with the current reform movement in education. Research studies showed that most of the students come to classroom environment with alternative views of science concepts (Postner et al., 1982, Resnik, 1983; Strike, 1983). The ideas which are different from the commonly accepted scientific conceptions were defined as misconceptions or preconceptions (Schmidt, 1997). “The resulting misunderstandings or alternative conceptions, if not challenged, become a part of students’ cognitive structures and interfere with subsequent learning and as a consequence of this, students will have difficulty in integrating any new information within their cognitive structures, resulting in an inappropriate understanding of the new concept” (Tregaust, 2006).

As Ausubel (1968) stated that the most important factor influencing learning is what the learner already knows. There are different instructional approaches based on constructivism developed to provide more meaningful learning by helping students overcome and improve their misconceptions. In most of these instructions, the main purpose is directing the attention of students to deliberate questioning activities so that forcing them to confront misconceptions to resolve their discrepancies and helping students see the relationship between sciences and their daily lives or potential careers (Yager & Lutz, 1994). Therefore, questioning the "fit" between the world outside and inside their own minds could also contribute to resolving this problem. In addition to individual processing, Driver, Asoko, Leach, Mortimer, and Scott (1994) stress the value of discourse in learning about science concepts. As a learner meets new experiences and tries to make them meaningful, construction or reconstruction of ideas becomes important.

A learning strategy having inquiry basic requires active participation of students in the learning process that emulates a real-world learning environment (National Research Council, 2000). The process works best when it is student-centered and the students choose the area of interest and the questions themselves. The role of the teacher alone is able to crush or nurture a student's participation in the learning process by acting as a facilitator, and providing guidance. Organizing his own repertoire of information allows the student to reflect on the ways the information has been created and organized (Vighnarajah, et al., 2008).

There are different forms of inquiry learning. In structured inquiry the teacher provides the input for the student with a problem to investigate along with the procedures and materials. This type of inquiry learning is used to teach a specific concept, fact or skill and leads the way to open inquiry where the student formulates his own problem to investigate. An example of a structured inquiry learning approach is the Learning Inquiry Cycle Model, based on Piaget's theory of cognitive learning (Bevevino, Dengel, & Adams, 1999). The learning cycle model is a teaching procedure consistent with the inquiry nature of science and with the way children naturally learn (Cavallo & Laubach, 2001). Many versions of the learning cycle appear in science curricula with phases ranging in number from 4E to 5E to 7E. Regardless of the quantity of phases, every learning cycle has at its core the same purpose (Settlage, 2000). The research studies about the instructions based on learning cycle model showed that learning cycle approaches help students make sense of scientific ideas, improve their scientific reasoning and their attitudes toward science, increase their engagement in science class, and overcome students' misconception (Cambell, 1977; Cumo, 1992; Davis, 1978; Klindienst, 1993; Shadburn, 1990; Davidson, 1989; Saunders & Shepardson, 1987; Renner et al., 1988; Purser & Renner, 1983; Lawson & Thompson, 1988; Marek et al., 1994; Scharmann, 1991, Gang, 1995; Garcia, 2005; Akar, 2005; Boddy et al., 2003; Balcı et al., 2006; Lord, 1997; Settlagh, 2000; Cavallo(1997; Lawson & Musheno, 1999; Odom & Kelly, 2001; Schlenker et al., 1997; Wilder & Shuttlewoth, 2005; Spencer & Guillaume, 2006, Brown & Sandra, 2007; Mecit, 2006, Ceylan & Geban, 2008, Kaynar et., al., 2009). For example, Balcı, Çakıroğlu, and Tekkaya (2006) investigated the effects of the Engagement, Exploration, Explanation, Extension, and Evaluation (5E) learning cycle, conceptual change texts, and traditional instructions on 8th grade students' understanding of photosynthesis and respiration in plants. Results of their study indicated a statistically significant difference between the experimental and control groups in the favor of experimental groups after treatment.

It was found that computer animations have two basic functions namely, enabling function and facilitating function (Mayer, 2001). Gobert (2000) stated that dynamic representations such as three dimensional animations provide visual explanations for scientific phenomenon that is impossible to observe directly. Also computer animations might lead to decrease in cognitive load and support active learning (Urhahne, et al., 2009). There are also research studies that showed that instructions based on learning cycle is more effective in the development of scientific reasoning, interest, and attitudes toward science (Perrier & Nsengiyunva, 2003; Bybee, et al., 2006; Sasmaz & Tezcan, 2009).

More specifically research studies about the students' understanding of biology concepts in the past few decades has revealed that students possess several ideas that are at variance with scientifically accepted knowledge. Most of these studies have focused on cell division (Lewis & Wood-Robinson, 2000, Krüger et al., 2006), cell concepts (Kaynar, et al., 2009); diffusion and osmosis (Marek et al., 1994; Odom, 1995; Lawson, 2000; Odom & Kelly, 2001), photosynthesis and respiration in plants, photosynthesis, and plant nutrition (Bell, 1985; Wandersee, 1985; Haslam & Treagust 1987; Stavy, et al., 1987, Barker, 1989;. Anderson et al., 1990; Griffard & Wandersee, 2001; Mikkila, 2001; Balcı et al., 2006), human circulatory system (Arnaudin & Mintzes, 1985), genetics (Cavallo, 1996; Banet & Ayuso, 2000; Lewis & Wood- Robinson, 2000; Tsui & Treagust, 2004; Doğru & Tekkaya, 2008), evolution (Passmore & Steward, 2001; Bishop & Anderson, 1990), ecology (Adeniyi, 1985; Munson, 1994; Sander et al, 2006); plant reproduction (Sharmann, 1991), protein synthesis (Fisher, 1985), cell metabolism (Mauricio & Pinto, 2008). There are also studies that have explored the difficulties students have with learning diffusion and osmosis (Marek et al., 1994; Odom, 1995; Lawson, 2000; Odom & Kelly, 2000).

In the light of evidence of above research studies, designing new instructions to improve biology achievement through the use of more effective instructional strategies by promoting the active role of the learner and promoting the facilitative role of the teacher become essential. These studies suggest that more effective methods are required to teach these concepts. Johnstone and Mahmoud (1980) surveyed high school biology students on their perceived difficulty of isolated biology topics and reported that osmosis and water potential were regarded as one of the most complex subject in biology.

Although the need to identify students’ misconceptions concerning diffusion and osmosis concepts has been widely expressed in science education literature, there are few studies on how these misconceptions can be treated (Marek et al., 1994; Christianson & Fisher, 1999; Odom & Kelly, 2001; Tekkaya, 2003). However, to promote meaningful learning, ways must be found to eliminate or prevent misconceptions. Various instructional methods can be used for this purpose. One such method involves the use of a learning cycle approach (Özkan, 2001; Johnstone & Mahmoud, 1980, Tekkaya, 2003).

Since concepts of diffusion and osmosis are keys to understanding many important life processes in biology, increasing students’ understanding and achievements by preventing the formation of any misconceptions and eliminate the pre-existing ones and also increasing their attitudes toward biology are important. For example diffusion is a simple way of short distance transport in a cell and cellular systems. Similarly, correct addressing of the osmosis concepts is required to understand the processes of the water uptake from soil into root cells, the mechanism that lies behind the movement of water through the xylem tissues of plants, water balance in land and aquatic creatures, turgor pressure in plants, transport in living organisms, gas exchange between respiratory surfaces and surrounding environment and between body fluid and tissues. In addition, diffusion and osmosis are closely related to concepts in physics and chemistry, such as permeability, solutions, and the particulate nature of matter (Friedler et al., 1987).

In this study, 7E learning cycle instruction model modified by Arthur Eisenkraft (2003) was used. It requires the instruction of seven discrete elements: *elicit, engage, explore, explain, elaborate, evaluate, and extend* (Eisenkraft, 2003). Odom and Kelly (2000) carried out a study to investigate the effectiveness of concept mapping (CM), learning cycle (LC), expository (EX), and concept mapping/learning cycle (CM-LC) on enhancing the conceptual understanding of diffusion and osmosis. The results of their studies showed that both the concept mapping/learning cycle and concept mapping strategies enhance learning of diffusion and osmosis concepts than expository teaching. However, the two treatments (CM and CM-LC) were not significantly different from the LC treatment. They stated that they have limited and conflicting data about the effectiveness of learning cycle at teaching diffusion and osmosis concepts and because of this, they suggested additional research to determine the role of the learning cycle at teaching diffusion and osmosis concepts (Odom & Kelly, 2000).

Therefore, the main purpose of the present study was to investigate the effectiveness of instructions, one based on traditional learning and the other based on 7E learning cycle model accompanied with computer animations, on ninth grade students' understanding of diffusion and osmosis concepts, on their achievements, and attitude toward biology as a school subject. In addition, science process skills determined as an important factor affecting students' understanding in science was examined to find its contribution to students' understanding of diffusion and osmosis concepts.

1.1 Purpose

The purposes of the study were to: (1) identify and examine students' misconceptions about diffusion and osmosis concepts; (2) compare the effectiveness of instruction based on 7E learning cycle model accompanied with computer animations and instruction based on traditional method on students' understanding of diffusion and osmosis concepts; (3) compare the effectiveness of instruction based on 7E learning cycle model accompanied with computer animations and instruction based on traditional method on students' achievement of diffusion and osmosis concepts; (4) compare the effectiveness of instruction based on 7E learning cycle model accompanied with computer animations and instruction based on traditional method on students' attitude towards biology as a school subject; (5) investigate the effect of gender on students' understanding and achievement of diffusion and osmosis concepts and their attitudes toward biology as a school subject.

1.2 Significance of the study

The central goal of science education is promoting meaningful understanding of scientific concepts. The achievement of this goal requires active engagement of students in the process of learning. In addition, students must be provided with opportunities seek to relate new concepts to prior knowledge, and use their new conceptual understanding to explain experiences they encounter (Ausubel, 1963; Novak, 2002). As Ausabel stated that if these misconceptions are not discovered and overcomed, they become a apart of students' cognitive structures and interfere with their subsequent learning process. In order to prevent occurrence of rote learning where students do not integrate new concepts to their prior knowledge to form a coherent framework, conscious linking of new knowledge to relevant concepts they already possess is required (Ausabel, 1968). As a result, they tend to rely on memorizing isolated facts; therefore, students who frequently use rote learning tend to generate misconceptions concerning scientific concepts (BouJaoude, 1992; Cavallo, 1996). Therefore, in science education, identification of pre-existing misconceptions and development of an effective instruction method for their elimination help curriculum developers, educators and teachers for designing activities and appropriate assessment techniques. One of the aims of this study is to identify and present students' misconceptions about diffusion and osmosis.

Research studies showed that by the use of traditional instruction approach most of the teachers have difficulty to diagnose their students' learning problems or misconception (Costa, et al., 2000; Taber, 2001). So, the type of instruction method for promoting meaningful learning and eliminating misconceptions is very important. As learning cycle is one of the instructional model based on the constructivist approach, which promotes conceptual change (Stepans, et al., 1988), in this study, an instruction based on 7E learning cycle model accompanied with computer animations, which facilitate students' learning by visualizing processes related to diffusion and osmosis, was designed and implemented. For this instruction method, different laboratory activities, demonstrations, computer animations, hand-on activities, assessment tests and discussion questions were developed. All these activities and materials can be used by teachers to remediate their students' misconceptions, promote students' conceptual change, and to assess their students' achievement. Moreover, the difference in terms of application ways and the effectiveness of all these materials and activities used within the 7E learning cycle approach and traditional instructional approaches were discussed.

The activities related to diffusion and osmosis concepts and their application sequence used during the implementation of instruction based on 7E learning cycle model in this study can clarify students' thought processes and correct their misconceptions about these diffusion and osmosis concepts. They stimulate students' curiosity and inquiry in order to foster a spirit of discovery and enjoyment of learning; equip them with the skills to learn and to acquire knowledge, individually or collaboratively, and to apply these skills and knowledge to new situations and new contexts. So that students have opportunities to explore their own conceptions, to construct new ones, to explain and discuss these new conceptions.

In literature, it was stated that students' attitudes toward science is also critical in developing meaningful understanding of science concepts (Perrier & Nsengiyumva, 2003). Glynn and Koballa (2007) stated that effective science instructions that include some elements as hand on science activities, laboratory works or field works to improve students' attitude towards science. Therefore, in this study, instruction based on 7E learning cycle model accompanied with computer animations fosters teachers to organize learning environment in a way that students improve their attitudes toward chemistry.

In Turkish high schools, the concepts covered in 9th grade biology curriculum are compulsory for all students. The instruction of biology curriculum is achieved by considering instruction methods as specified in the national curriculum and by the use of the textbooks approved by the Ministry of Education and therefore mostly traditional designed instruction methods are used to teach biology concepts from these textbooks. In addition, the biology curriculum and the number of teaching hours for biology per week are the same in all high schools in Turkey. Because of this, high school biology curriculum in Turkey needs some modifications and revisions with respect to contemporary approaches in science education. This study, therefore, has a potential to give some ideas to curriculum developers about how to design an effective instruction to increase students' achievement by eliminating their misconceptions in diffusion and osmosis concepts. Moreover, in Annual Autumn/ Spring Teachers' Conference and International Baccalaureate Day in Turkey, this study will be presented as an example of better instruction method than traditional one with respect to elimination of students' misconceptions about diffusion and osmosis concepts and so increasing their achievement and attitudes toward biology as a school subject. In other words, this study will be shared with teachers and educators attending either national or international seminars as an applied example of an instruction based on a learning cycle model and so that can be integrated into national and international IB curriculum programs by teachers and curriculum developers for promoting meaningful understanding science concepts.

1.3 Definitions of the Terms

The terms that needed to be defined are stated in the following part;

Accommodation: Reconstructing the existing structure when the new knowledge or inputs do not fit existing structure (Duit & Treagust, 1998).

Achievement: Something accomplished successfully, especially by means of exertion, skill, practice, or perseverance.

Assimilation: The adaptation of new knowledge when it fit the existing cognitive structure (Duit & Treagust, 1998).

Attitude: A general and enduring positive and negative feeling about some person, object, or issue (Petty & Cacioppo, 1981).

Constructivism: A theory rest on the assumption that knowledge is constructed by learners as they attempt to make sense of their experiences.

Conception: Particular interaction of a concept by a person (Kaplan, 1964).

Computer animation: Images in motion (Mayer, 2001).

Diffusion: The primary method of short-distance transport of small molecules in a cell and cellular systems from an area of high molecular concentration to an area of low molecular concentration (Odom & Barrow, 1995).

Equilibration: A balance between new information and the existing structure (Duit & Treagust, 1998; Yıldırım, Güneri, & Sümer, 2002).

Inquiry-based learning: The process of learning in which students directly involve in the learning process by searching, investigating, asking questions and in which they develop their thinking (Bevevino, Dengel, & Adams, 1999).

Inquiry process: The process in which the student, through active and self-directed learning, delves into an area of individual and personal or group cooperative learning topics of his interest (Kuhn et al., 2000).

Misconception: Students' conceptions or ideas that are different from the definitions accepted by experts or scientific community (Driver & Easley, 1978; Hewson & Hewson, 1984; Treagust, 1988; Lawson and Thompson, 1988; Schmidt, 1997).

Osmosis: The net movement of water molecules across a selectively permeable membrane from a hypotonic solution (solution having fewer dissolved particles) to a hypertonic solution (solution having more dissolved particles) (Odom & Barrow, 1995).

Preconception: Students' conceptual framework that already present from everyday experience and from previous formal and informal education (Teichert & Stacy, 2002).

Traditional instruction: Instruction method based on lecture and discussion, use of textbooks, strategies relayed on teacher explanation without considerations of students' alternative conceptions.

Understanding: Perceiving the meaning of or grasping the idea of something.

CHAPTER 2

REVIEW OF RELATED LITERATURE

This chapter presents the related literature review of the following eight topics: Process of Learning, Constructivism, Inquiry-based Learning, Learning Cycle Approach, 7E Learning Cycle Model, Misconceptions, Computer Animations, and Attitude toward Science. The main concepts and ideas reviewed and discussed under these topics can be summarized as below:

Under the topics of The Process of Learning, Constructivism and Inquiry-based Learning; characteristics and requirements of a meaningful learning process, the role of the teachers and students in such a process, fundamentals and assumptions of the constructivism, inquiry-based learning as a learning strategy for constructivism and how it supports the constructivist theory of learning were discussed to create a base for learning cycle and 7E learning cycle model.

Under the topics of Learning Cycle Approach and 7E Learning Cycle Model; learning cycle model as an instructional model based on the constructivist approach for promoting conceptual change, development and types of learning cycle models, the role of learning cycles in overcoming of students' misconceptions and implications of learning cycle models to educational settings were discussed.

Under the topics of Misconception; definition, sources, and characteristics of students' misconceptions in literature were discussed. Also studies about misconceptions in different biology topics were presented. Among these misconceptions in biology topics, misconceptions on diffusion and osmosis concepts were analyzed specifically as the topic of this study.

Under the topic of Computer Animations; functions and effectiveness of the computer animations on students' understanding were pointed out. Finally, under the topic of Attitude toward Science; definition of attitude that plays a significant role for learning, and related literature about attitude of students toward science were reviewed and discussed.

2.1 Process of Learning

The learning process as well as it product is more productive in an active learning environment when comparing in a traditional learning environment (Roblyer, et al., 1997). Roblyer et al. (1997) define traditional instruction method as an approach that enables students to submissively grasp and regurgitate information as and when conveyed by the teacher. The traditional approach can be considered as more teacher-centered as the teacher is viewed as the only source of information. In such a teaching and learning environment, only a little learning process can take place in the classroom eventhough there appears to be an active transfer of information (Vighnarajah, et al., 2008). However, the process of learning can be defined as a continuous developmental process in which one constructs an individual understanding of the environment through specific experiences and interactions with the surrounding (Ertmer & Newby, 1993). There are numerous studies that have revealed that students involves enthusiastically in a learning environment that replicates a real-world learning environment. In addition to this, in a traditional learning environment, students are placed in a passive role that only allows them to absorb and regurgitate information (Vighnarajah, et al., 2008).

The quality of an educational program and at the end the competence of graduates depends on a teacher's performance (Dolmans, Wolfhagen, Schmidt & Van der Vleuten, 1994). Similarly, Albanese (2004) points out the importance of the role of a techer on flourishing or crushing the outcome of students' participation in the teaching and learning process. In the traditional teaching and learning environment, teacher normally has a dominat role in the classroom instruction while students passively receive the information given by the teacher. Boud and Feletti (1991) stated that there is a less amount of students' participation in a traditional teaching and learning environment. Optimal students' participation in a traditional teaching and learning process was also argued by Ng (2005). In order to achieve required skills and qualities, it is necessary for students to have more time for reflection of what they have studied, for deliberate reflective reading, for assimilating the best of the original literature in each field. There is a shift in the teacher's role from a dominant information feeder to a facilitator offer (Normala, Othman, & Maimunah Abdul Kadir, 2004). According to this, it is expected from teachers to adapt their instruction by taking into account the developmental levels of their students. Considering these individual differences, teachers must engage them in active learning. As considering students as an integral dimension of the teaching and learning process, teachers must constantly assess their understanding. For example, teachers must analyze the students' perception of learning outcome and compare it to the learning objectives outlined in the course structure (Santrock, 2001).

2.2 Constructivism

Constructivism as an epistemology of a learning or meaning-making theory that offers an explanation of the nature of knowledge and how human beings learn has become the most powerful learning theory during the last two decades (Ernest, 1993; Tobin, 1993). According to the constructivist point of view, individuals create or construct their own new understandings or knowledge through the interaction of what they already know and believe and the ideas, events, and activities with which they come in contact (Richardson, 1997). Santrock (2001) stated that learning is best achieved when the individuals actively construct knowledge and understanding and therefore individuals must actively participate in the teaching and learning process in order to discover, to reflect and to think critically on the knowledge they acquire. So, rote memorization is not allowed by constructivist approach, rather than it encourages the construction of meaningful knowledge and understanding (Richardson, 1997).

As opposed to the theory of behaviorism, the pioneer learning theory in the first half of this century, the constructivist theory attempts to understand the response of the learner when the learner is subjected to a particular stimulus. It focuses on what drives the students to learn, achieve and to efficiently comprehend and utilize what they learn outside the four borders of the classroom (Roblyer et al., 1997). With the arising of Piaget ideas on intellectual development by the end of the 1960, science education were not influenced by behaviorists theories as it had occurred (Duit & Treagust, 1998). Science education community has been accepted and benefited his idea of equilibration of assimilation and accommodation (Lawson, 1993). Although there are many critiques of his approach, the impacts of Piaget thinking including his idea of stages of cognitive development on contemporary view of learning can't be ignored. In order to understand his ideas more effectively, it is necessary to consider his ideas not psychological aspects but epistemological aspects (Bliss, 1995). His views about epistemology are strongly influenced by Immanuel Kant who asserted that knowledge is necessarily determined by knower's ways of perceiving and conceiving (Lawson, 1994; Von Glasersfeld, 1992). Piaget believed that in thinking process there are two basic tendencies that all human beings naturally have two: organization and adaptations, which are gradually changed by biological maturation and environmental factors (Pulaski, 1980; Yıldırım et al., 2002). In order to gain new knowledge and use them effectively, human beings need organizing frameworks. This can be defined as organization. According to the Yıldırım, Güneri, and Sümer, the terms can be used more effectively by the ability of systematically organize knowledge such as combining and categorizing. Hendry, Frommer and Walker (1999) pointed out the fact that a person's sensation, perception, and knowledge cannot exist outside his mind, which is a fundamental assumption in the constructivist approach (Hendry et al., 1999).

According to Lawson, Abraham, and Renner (1989), there are basically two fundamental types of knowledge: declarative and procedural. Declarative knowledge is basically “know that,” and procedural knowledge is “to know how.” The acquisition of declarative knowledge is very much a constructive process that makes use of procedural knowledge. Students can learn by memorization, but such learning will not improve procedural knowledge. The reason we should improve procedural knowledge is that when students participate in the constructive process, the learning of declarative knowledge becomes more meaningful and retention more complete (Odom & Kelly, 2001). This, in turn, will give students the tools to better understanding and the ability to explain the world by being able to generate and test their own ideas. This process of constructing knowledge usually will begin with an observation and question. The ability to generate declarative knowledge depends on procedural knowledge, which is dependent on the ability to generate and test hypotheses.

There are two main principles of constructivism: Psychological and epistemological principles. In the case of psychological principle knowledge cannot be directly transferred from teachers to learners. Epistemological principle, on the other hand, is about reality. Von Glasersfeld (1992) indicates that constructivism is a way of knowing that recognizes the real world as a source of knowledge. According to Von Glasersfeld, there is an external world made up of objects and events, which students to learn about, however students as well as scientists can never fully know reality. They can form approximations of reality, but never a true picture of it. Viable knowledge can be applied to further our purposes and the quality of life. This notion implies that reality is dependent upon the mind for its existence, hence knowledge is constructed by the mind rather than being a facsimile of reality (von Glasersfeld, 1992).

As Jonassen (1991) argued that constructivist learning environment should include different elements. These elements can be summarized as below:

1. A real world environment, based on the learning context, should be created.
2. Realistic approaches should be provided to solve real-world problems.

3. The instructor should act as a guider, facilitator, and analyzer.
4. Multiple representations and perspectives on the content should be presented.
5. Instructional goals and objectives should be negotiated.
6. The learning environment and materials should be presented in a way that they facilitate learners to interpret the multiple perspective of the content.
7. Learning should be internally controlled and mediated by the learner.

As a summary, the constructivism theory of learning considers the many advantages of the learning theories in encouraging optimal students' participation in the teaching and learning process. Numerous review of related literature that points out the role of the student as an active participant and the teacher as a facilitatorin a teaching and learning process supported the constructivism theory of learning (Vighnarajah, et al., 2008).

In this study, 7E learning cycle model which is based on constructivist principle was used.

2.3 Inquiry-based Learning

In recent years the argument in favor of inquiry learning has gained significant support as it is an educational activity in which students are placed in the position of scientists gathering knowledge about the world. Students direct their own investigative activity, completing all the stages of scientific investigation such as formulating hypotheses, designing experiments to test them, collecting information, and drawing conclusions (Keselman, 2003). As described in a National Research Council report (Bransford, Brown, & Cocking, 1999), the method of inquiry learning ‘‘provides a richer, more scientifically grounded experience than the conventional focus on textbooks or laboratory demonstrations.’’ Students, typically at the middle school or high school level, construct their understanding of the world using methods similar to those of real world scientists. They study complex phenomena by identifying variables that are potentially instrumental to their mechanisms, changing the levels of those variables, observing the resulting changes in outcomes, and drawing conclusions. Such activities foster children's natural curiosity, promote scientific activity as an intellectual value, and reinforce the view of the world as being subject to investigation. Furthermore, advances in instructional technology and the spread of computers throughout schools expand the scope of subjects to which inquiry learning can be applied (Kuhn, et al., 2000).

Alla Keselman (2003), in his study with the participation of 74 students, forming three intact sixth-grade science classes at a New York City public middle school supported inquiry learning by fostering meta-level prerequisites of effective experimentation. His study showed that students often perceive a single causal variable as responsible for any outcome, and do not feel the need to control for the effects of other variables in their experimentation. In his study he described an intervention that supports children's inquiry learning by strengthening their models of multivariable causality and provided an overview of research on scientific thinking that links successful inquiry learning performance to meta-cognition and normative conception of complex causality.

In a inquiry based learning process, a learning activity takes place based on scientific method; the students can learn how to be a scientist that always perceives as well as analyzes any information. Specifically, it can be explained that inquiry strategy has potency to empower students thinking skill (Lawson, 1993). "This learning strategy is a paradigm of constructivism and supports the constructivist theory of learning. It develops questioning skills, critical thinking skills and problem solving skills. It allows students to create, organize and build new information from preexisting knowledge for better understanding" (Fitzpatrick, 2001).

“There are different forms of inquiry based learning approach. The learning can take the form of structured inquiry, guided inquiry or open inquiry. In structured inquiry the teacher provides the input for the student with a problem to investigate along with the procedures and materials. This type of inquiry learning is used to teach a specific concept, fact or skill and leads the way to open inquiry where the student formulates his own problem to investigate. Open inquiry is the ultimate goal for all students to develop an understanding of a concept by using reasoning skills. In guided inquiry the teacher provides the material and problems to investigate. The students come up with their own procedures for solving the problem while the teacher just facilitates the investigation” (Fitzpatrick, 2001). An example of a structured inquiry learning approach is the “Learning Inquiry Cycle Model”, based on Piaget’s theory of cognitive learning (Bevevino, Dengel, & Adams, 1999). There is a discussion of the exploration between the teacher and students. “The teacher introduces new concepts through a mini lecture. In the application and expansion phase of the model, the students use knowledge gained from exploration and discussion to address a new problem. An activity to use with this approach can be the students coming to a consensus about a mutual, beneficial, and workable alternative to armed conflict where they would use all components of the learning cycle model” (Fitzpatrick, 2001).

“Inquiry learning is considered as a useful teaching strategy. Since inquiry learning is a student-centered, self-directed, and active learning approach to the development of metacognitive skills, it falls into the scope of the instructional theories provided by the leading constructivist: Piaget, Bruner, and Vygotsky. It also shows relevance to Blooms taxonomy of educational objectives. The three theorists strongly believe that students should be actively involved in the construction of their own knowledge of the world, through engagement by using discovery. This can be attained by the use of technology of World Wide Web or through social interaction with meaningful adults. They feel also that inquiry learning contributes to students’ social development as well as their intellectual development” (Fitzpatrick, 2001).

The outcomes developed through inquiry learning are listed by Herman Fitzpatrick (2001) are as follows:

1. Information processing skills
2. Understanding content in a larger conceptual framework
3. Nurtured habits of mind
   - -keeping focused
   - -asking good questions
   - -being attentive
   - -finding solutions
   - -cooperative and collaborative skills
   - -competing
   - -self discipline
4. Critical and creative thinking skills
5. Effective oral and written communication
6. Gathering and organizing information
7. Turning information into useful knowledge
8. Generating future questions
9. Critical observation
10. The ability to value questions
11. The ability to make connections to preexisting knowledge
12. Plan learning activities
13. Engaging in authentic formative self-assessment

Drayton and Falk (2002) defined the inquiry-based classroom as where the student is the one who is doing the most important part of the intellectual work, rather than the teacher. Their study revealed that the effective inquiry based classrooms include more peer-work, problem solving, investigation, discussion and argumentation about science. They summarized inquiry-based learning as it places a high emphasis on conceptual learning; enable the learner to think critically, motives the learner to continue learning, to ask questions. They also mentioned the importance of examining the ways that hands-on activities serve student sense-making and learning in order to understand the state of inquiry in the classroom.

In summary, as Sunal and Sunal (2003) also pointed out the importance of the fact that the inquiry teaching strategy considers students' developmental levels and helps them use their prior knowledge as they learn new thought processes, develop higher levels of thinking, and became aware of their own reasoning. (Sunal & Sunal, 2003).

In this study, learning cycle model as a structured inquiry learning approach was used. Therefore in the following section the learning cycle approach was discussed.

2.4 Learning Cycle Approach

"Improving science achievement through the use of more effective instructional strategies, promoting the active role of the learner, and promoting the facilitative role of the teacher has long been an aspiration of science educators" (Odom & Kelly, 2001). Therefore, type of teaching approach in education is an important issue in science for promoting meaningful learning and eliminating misconceptions. One such approach is the use of a conceptual change approach, according to which as learner encounters a new knowledge which is not compatible with his previous knowledge he uses his conceptual ecology to decide whether the new knowledge he uses his conceptual ecology to decide whether the new knowledge is rational, believable, internally consistent and have explanatory predictive power (Hewson, 1992).

Another type of instructional model based on the constructivist approach, which promotes conceptual change and can be used to incorporate shared instructional principles is the learning cycle (Stepans, et al., 1988). Since its inception in the 1960s, the learning cycle has been the focus of hundreds of studies designed to assess its effectiveness (Lawson, 1995). It incorporates the

Piaget's Theory of Cognitive Development into a succinct methodology of learning: experiencing the phenomena or concept (Exploration Phase), applying terminology to the concept (Concept Introduction), and the application of the concepts into additional conceptual frameworks (Application) (Odom & Kelly, 2001).

"No doubt, the early influence of science explains the obvious connection between Dewey's conception of thinking and scientific inquiry. In *How We Think* (1910, 1933), Dewey outlines what he terms a complete act of thought and describes what he maintains are indispensable traits of reflective thinking which include (1) defining the problem, (2) noting conditions associated with the problem, (3) formulating a hypothesis for solving the problem, (4) elaborating the value of various solutions, and (5) testing the ideas to see which provide the best solution for the problem. By 1950, a variation of John Dewey's instructional model emerged in science methods textbooks (Dewey, 1971). The authors based their "learning cycle" on Dewey's complete act of thought. Table 2.1 presents that learning cycle" (Bybee et al., 2006).

Table 2.1 Heiss, Obourn, and Hoffman Learning Cycle Phase Summary

Phase	Summary
Exploring the Unit	Students observe demonstrations to raise questions, propose a hypothesis to answer questions, and plan for testing.
Experience Getting	Students test the hypothesis, collect and interpret data, and form a conclusion.
Organization of Learning	Students prepare outlines, results, and summaries; they take tests.
Application of Learning	Students apply information, concepts, and skills to new situations.

"In general, the symbols represent phases of an instructional model that includes unstructured exploration, multiple programmed experiences, and didactic instruction. The model described by Hawkins provides the basic strategies for the units developed by the Elementary Science Study (ESS). The systematic approach to instruction did not, however, gain the widespread acceptance of other curriculum development studies, in particular the Science Curriculum Improvement Study (SCIS)” (Bybee et al., 2006).

When the learning cycle model was first developed by Robert Karplus, professor of physics and accepted as the father of modern learning cycle, it involved three consecutive phases known as exploration, concept introduction, and concept application. Karplus (1977) declared that the learning cycle is an effective inquiry-based instructional strategy for helping students to learn concepts and conceptual systems while fostering cognitive development. Karplus and Atkin from the University of Illinois, in 1962, proposed two phases, for which they did not use the term “learning cycle”. In this model, first phase was the initial introduction of a concept, called as invention and the second phase was the subsequent verification, called as discovery (Hanley, 1997). In a learning environment, students could not invent scientific concepts themselves; therefore an introduction of concepts based on students’ initial observation by the teacher was required and in the second phase, the discovery stage, students would discover new patterns (Lawson, et al., 1989).

The three phase learning cycle approach that included exploration, invention, and discovery stages was developed by Karplus and Thier in 1967 (Lawson, Abraham, & Renner, 1989) (See Table 2.2).

Table 2.2 Atkin-Karplus Learning Cycle

Phase	Summary
Exploration	Students have an initial experience with phenomena.
Invention	Students are introduced to new terms associated with concepts that are the object of study.
Discovery	Students apply concepts and use terms in related but new situations

Because of the complexity of the meanings of phases, Karplus revised the name of the phases of learning cycle as exploration, concept introduction, and concept application (Hanley, 1977). This approach has proven effective at helping students construct concepts and conceptual systems as well as develop more effective reasoning pattern and was derived from Piaget's model of mental functioning (i.e., assimilation, disequilibration, accommodation, and organization) (Lawson 1995).

The first phase of the learning cycle, exploration, is designed to cause students to assimilate data and eventually reach a state of disequilibration. In other words, students gather data, look for trends or relationships in the data, and, from this, they become disequilibrated. The next phase, concept development, is structured to lead students through the interpretation of their data, construction of the concept, and accommodation to the concept, which results in reequilibration. The expansion (concept application) phase is designed to give students opportunities to organize their newly learned concept with other concepts they already know. Relationships between mental functioning and learning cycle phases can be seen in Table 2.3 (Marek & Cavallo, 1997).

Table 2.3 Mental Functioning and the Phases of the Learning Cycle

Mental Functioning	**Learning Cycle Phases**
Assimilation → Disequilibration	Exploration
Accommodation (Reequilibration)	Concept Development (Explanation)
Organization	Expansion (Extension)

As learning cycle model has been used, researched, and refined over the years, some practitioners have extended the three stages into five, known as the 5E learning cycle, which has been used by Biological Sciences Curriculum Study (BSCS) as one of the instructional model in the development of new curriculum materials since the late 1980s. This learning cycle model requires instruction to include the following discrete elements: *engage*, *explore*, *explain*, *elaborate*, and *evaluate* (Bybee et al., 2006). When formulating the BSCS 5E Instructional Model, the SCIS learning cycle was used. The middle three elements of the BSCS model are fundamentally equivalent to the three phases of the SCIS learning cycle as shown in Table 2.4.

Table 2.4 Comparison of the Phases of the SCIS and BSCS 5E Models

SCIS Model	**BSCS 5E Instructional Model**
	Engagement (New Phase)
Exploration	Exploration (Adapted from SCIS)
Invention (Term Introduction	Explanation (Adapted from SCIS)
Discovery (Concept Application)	Elaboration (Adapted from SCIS)
	Evaluation (New Phase)

In the Karplus and Atkin's learning cycle and BSCS 5E instructional model, students' initial concepts are redefined, reorganized, elaborated and changed through self-reflection and interaction with their peers and their environments which promotes conceptual change (Bybee, 1997).

"Each phase has a specific function and contributes to the teacher's coherent instruction and to the learners' formulation of a better understanding of scientific and technological knowledge, attitudes, and skills. By the 1980s, evidence for the effectiveness of the learning cycle was clear" (BSCS, 2006). The 5E learning cycle has been shown to be an extremely effective approach to learning (Lawson 1995; Guzzetti et al. 1993).

Engagement: The students are engaged in the learning task and mentally focus on an object, problem, situation, or event. Students can make connections to past experiences with the activities of this phase and exposed their prior knowledge. Students can be engaged and focused on a problematic situation by asking a question, defining a problem, showing a discrepant event, and acting out a problematic situation. The instructor only presents the situation and identifies the instructional task. The rules and procedures for establishing the task are set by the instructor as well. This phase brings about disequilibrium (Bybee, 1997).

Exploration: "The students have a psychological need for time to explore the scientific concepts and ideas. Exploration activities are designed so that the students in the class have common, concrete experiences upon which they continue formulating concepts, processes, and skills. Exploration initiates the process of equilibration. This phase should be concrete and hands on. Educational software can be used in the phase, but it should be carefully designed to assist the initial process of formulating adequate and scientifically accurate concepts" (Bybee, 1997).

"The goal of exploration activities is to establish experiences so that teachers and students can use later for the formal introduction and discussion of the concepts, processes, or skills. During these activities, the students have opportunities to explore objects, events, or situations. As a result of their mental and physical involvement in these activities, students establish relationships, observe patterns, identify variables, and question events. The role of the teacher in the exploration phase is a facilitator or a coach. He or she initiates the activity and let students investigate objects, materials, and situations by providing required materials and time. If called upon, the teacher may coach or guide students as they begin reconstructing their explanations" (Bybee, et al., 2006).

Explanation: "In the process of explanation the students and the teacher are provided with a common use of terms relative to the learning task. In this phase, teacher takes students' attention to specific aspects of the experiences gained during engagement and exploration phases. At first, the teacher provides necessary environment for students to explain their experiences and share their findings. Second, the teacher provides information about scientific or technological explanations in a direct, explicit, and formal manner. Explanations are ways of ordering the exploratory experiences. The teacher should base the initial part of this phase on the students' explanations and clearly connect the explanations to experiences in the engagement and exploration phases of the instructional model. Main characteristic of this phase is to provide information about concepts, processes, or skills briefly, simply, clearly, and directly and to move on to the next phase. Teachers may have a variety of techniques and strategies to elicit and develop student explanations" (Bybee et al., 2006).

"Eventhough commonly used strategy is verbal explanations; there are numerous other strategies, such as computer animations, videos, films, and educational courseware. This phase continues the process of mental ordering and provides terms for explanations. In the end, students should be able to explain exploratory experiences and experiences that have engaged them by using common terms" (Bybee et al., 2006).

Elaboration: "After receiving explanations about main ideas and terms for their learning tasks, it is important to involve the students in further experiences that extend, or elaborate, the concepts, processes, or skills. This elaboration phase facilitates the transfer of concepts to closely related but new situations. In some cases, students may still have misconceptions, or they may only understand a concept in terms of the exploratory experience. Elaboration activities, therefore, provide another chance for the students still having misconceptions and further time and experiences that contribute to learning process" (Bybee et al., 2006).

Evaluation: This is the important opportunity for students to use the skills they have acquired and evaluate their understanding. In addition, the students should receive feedback on the adequacy of their explanations. Informal evaluation can occur at the beginning and throughout the 5E sequence. The teacher can complete a formal evaluation after the elaboration phase. As a practical educational matter, teachers must assess educational outcomes. This is the phase in which teachers administer assessments to determine each student's level of understanding (Bybee et al., 2006).

Recent studies have shown that learning cycles have been found to be effective at helping students eliminate scientific misconceptions. For example Guzzetti et al., (1993) conducted a meta-analysis of 47 learning cycle base studies and found effect size in favor of the learning cycle students that varied from 1/4 to $1^{1/2}$ standard deviations. Benford (2001) found that the extent of college students' reasoning improvements was significantly related to the instructors' skill at engaging students in the learning cycle based inquiries. BSCS 5E Instructional Model can be summarized on Table 2.5.

Table 2.5 Summary of the BSCS 5E Instructional Model

Phase	**Summary**
Engagement	The teacher or a curriculum task accesses the learners' prior knowledge and helps them become engaged in a new concept through the use of short activities that promote curiosity and elicit prior knowledge. The activity should make connections between past and present learning experiences, expose prior conceptions, and organize students' thinking toward the learning outcomes of current activities.
Exploration	Exploration experiences provide students with a common base of activities within which current concepts (i.e., misconceptions), processes, and skills are identified and conceptual change is facilitated. Learners may complete lab activities that help them use prior knowledge to generate new ideas, explore questions and possibilities, and design and conduct a preliminary investigation.
Explanation	The explanation phase focuses students' attention on a particular aspect of their engagement and exploration experiences and provides opportunities to demonstrate their conceptual understanding, process skills, or behaviors. This phase also provides opportunities for teachers to directly introduce a concept, process, or skill. Learners explain their understanding of the concept. An explanation from the teacher or the curriculum may guide them toward a deeper understanding, which is a critical part of this phase.
Elaboration	Teachers challenge and extend students' conceptual understanding and skills. Through new experiences, the students develop deeper and broader understanding, more information, and adequate skills. Students apply their understanding of the concept by conducting additional activities.
Evaluation	The evaluation phase encourages students to assess their understanding and abilities and provides opportunities for teachers to evaluate student progress toward achieving the educational objectives.

Lawson (2001) stated that the approach has proven effective at helping students construct concepts and conceptual systems as well as develop more effective reasoning patterns, primarily because it allows students to use if/then/therefore reasoning to test their own ideas and to participate in the knowledge construction process. He stated that the learning cycle has proven very effective at teaching science concepts and improving generalizable reasoning skills in students from first grade to college. For example, three large scale studies conducted in 1980s with high school chemistry and physics students investigated the role of played by each phase of learning cycle by systematically eliminating a phase and by varying the phase sequence (Renner et al., 1988). Five key conclusions were drawn at the end of their studies:

1- All three phases are necessary for the optimum concept learning.
2- Students prefer learning cycles with all three phases.
3- Students dislike learning cycles with long or complex application phases.
4- The combination of exploration and term introduction phases is more effective than term introduction phase alone.
5- The application phase may substitute for term introduction if the application includes the use of term(s) used to refer to the concept(s).

Learning cycle approach used to teach photosynthesis by Lawson, Rissing and Faeth (1990) indicated that a substantial portion of students who enroll in a nonmajors, one semester introductory biology course taught at Arizona State University, have poorly developed scientific reasoning skills. They stated that students learn facts but do not experience science as a process of describing and attempting to explain nature. Considering the scientific reasoning as one of the fundamental abilities of inquiry, they renewed the course on the basis of learning cycle approach to help students acquire an explicit awareness of and an ability to use the reasoning patterns. In their study there was no evidence supporting the gain in deeper understanding of biological concepts and the development of scientific reasoning skills in students. This study offered the application of learning cycle approach on photosynthesis well, but the student outcomes were not measured either quantitatively or qualitatively. Also, the generalization on the effectiveness of the learning cycle in many biological concepts was unsupported in this study (Lawson et al., 1990).

In another investigation carried out by Balcı, Çakiroglu and Tekkaya (2006), the effect of 5E learning cycle instruction on 8th grade students' understanding of photosynthesis and respiration in plants was investigated. In their study, they also used conceptual change text based instruction as another learning tool. Their findings revealed that students in the 5E learning cycle treatment group demonstrated better performance on photosynthesis and respiration in plants concept test over the students in the traditional instruction control group.

In the light of above explanations, it can be stated that the learning cycle is a way of structure inquiry in school science and occurs in several sequential phases to help students eliminate scientific misconceptions. A learning cycle moves children through a scientific investigation by having them first explore materials, then construct a concept, and finally apply or extend the concept to other situations. Why the learning cycle? Because it is a theory which based on the instructional design for inquiry learning when implemented well (Marek, 2008).

In this study, 7E learning cycle instruction model was used. It requires the instruction of seven discrete elements: *elicit, engage, explore, explain, elaborate, evaluate, and extend* (Eisenkraft, 2003) that were discussed in the section below.

2.5 7E Learning Cycle Model

Sometimes a current model must be amended to maintain its value after new information, insights, and knowledge has been gathered. Such is now the case with the highly successful 5E learning cycle and instructional model (Bybee, 1997). Researches on how people learn and incorporation of these researches into lesson plans and curriculum development demands that 5E model be expanded to a 7E model, (Eisenkraft, 2003).

5E learning cycle model requires instruction to include the following discrete elements: *engage, explore, explain, elaborate,* and *evaluate.* The proposed 7E model expands the *engage* element into two components - *elicit* and *engage.* Similarly, 7E model expands the two stages of *elaborate* and *evaluate* into three components - *elaborate, evaluate,* and *extend.* The intention of these changes are not suggesting any complexity, but rather ensuring instructors do not omit crucial elements for learning from their lessons while under the incorrect assumption they are meeting the requirements of the learning cycle. The transition from the 5E model to the 7E model is illustrated in Figure 2.1 (Eisenkraft, 2003).

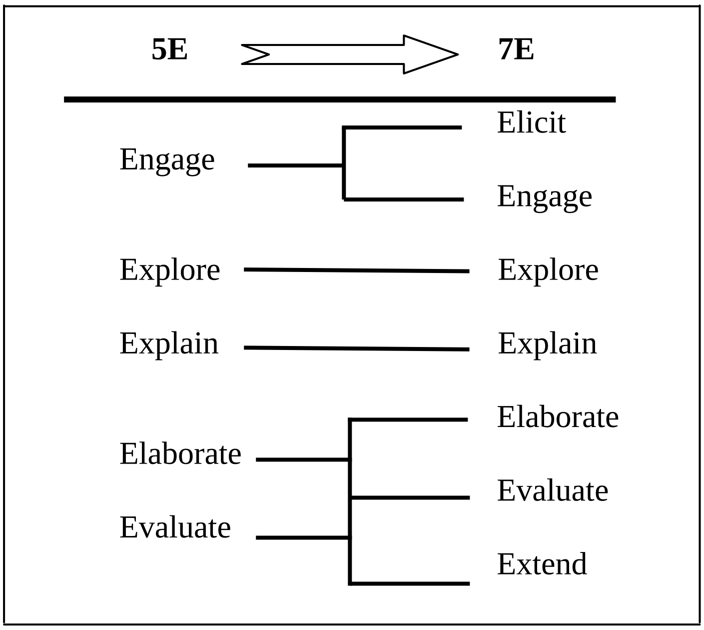

Figure 2.1 Proposed 7E learning cycle and instructional model.

"Current research in cognitive science has shown that eliciting prior understandings is a necessary component of the learning process. Research also has shown that expert learners are much more adept at the transfer of learning than novices and that practice in the transfer of learning is required in good instruction" (Bransford, Brown, and Cocking, 2000).

Elicit

When learning new things, the prior knowledge serves as background information and the learners usually use the original experience to recognize new information. If the new material fits their original knowledge structure, they are able to assimilate the information, otherwise they have to reorganize or change their schema. The e*licit* phase focuses on making learners retrieve existing experience that is associated with the new knowledge. Balci, Cakiroglu, and Tekkaya (2006) gave a good example for the elicit phase by asking critical thinking questions to students about photosynthesis and respiration. The students might know the concept about photosynthesis and respiration before, and by asking them questions the teacher want students to remember this prior knowledge (Huang, Liu, Graf, & Lin, 2008).

Engagement

"The *engage* component of the model is intended to capture students' attention, get students thinking about the subject matter, raise questions in students' minds, stimulate thinking, and access prior knowledge. It includes both accessing prior knowledge and generating enthusiasm for the subject matter. Teachers may excite students, get them interested in and ready to learn, and believe they are fulfilling the engage phase of the learning cycle, while ignoring the need to find out what prior knowledge students bring to the topic. The importance of *eliciting* prior understandings in ascertaining what students know prior to a lesson is imperative. Recognizing that students construct knowledge from existing knowledge, teachers need to find out what existing knowledge their students possess. Failure to do so may result in students developing concepts very different from the ones the teacher intends" (Bransford, Brown, & Cocking, 2000).

"The proposed expansion of the 5E model does not exchange the *engage* component for the *elicit* component; the *engage* component is still a necessary element in good instruction. The goal is to continue to excite and interest students in whatever ways possible and to identify prior conceptions. Therefore, the *elicit* component should stand alone as a reminder of its importance in learning and constructing meaning" (Eisenkraft, 2003).

Explore

"The *explore* phase of the learning cycle provides an opportunity for students to observe, record data, isolate variables, design and plan experiments, create graphs, interpret results, develop hypotheses, and organize their findings. Teachers may frame questions, suggest approaches, provide feedback, and assess understandings. An excellent example of teaching a lesson on the metabolic rate of water fleas (Lawson, 2001) illustrates the effectiveness of the learning cycle with varying amounts of teacher and learner ownership and control" (Gil, 2002).

Explain

"Students are introduced to models, laws, and theories during the *explain* phase of the learning cycle. Students summarize results in terms of these new theories and models. The teacher guides students toward coherent and consistent generalizations, helps students with distinct scientific vocabulary, and provides questions that help students use this vocabulary to explain the results of their explorations. The distinction between the *explore* and *explain* components ensures that concepts precede terminology" (Eisenkraft, 2003).

Elaborate

The *elaborate* phase of the learning cycle provides an opportunity for students to apply their knowledge to new domains, which may include raising new questions and hypotheses to explore. The elaboration phase ties directly to the psychological construct called "transfer of learning" (Thorndike, 1923). Schools are related and supported with the expectation that more general uses of knowledge will be found outside of school and beyond the school years (Hilgard

& Bower, 1975). Transfer of learning can range from transfer of one concept to another (e.g., Newton's law of gravitation and Coulomb's law of electrostatics); one school subject to another (e.g., math skills applied in scientific investigations); one year to another (e.g., significant figures, graphing, chemistry concepts in physics); and school to nonschool activities (e.g., using a graph to calculate whether it is cost effective to join a video club or pay a higher rate on rentals) (Bransford, Brown, & Cocking, 2000).

Extend

"The addition of the *extend* phase to the *elaborate* phase is intended to explicitly remind teachers of the importance for students to practice the transfer of learning. Teachers need to make sure that knowledge is applied in a new context and is not limited to simple elaboration" (Eisenkraft, 2003).

Evaluate

This phase of the learning cycle includes strategies that help the continuity of both formative and summative evaluations of student learning. If teachers well design and implement learning cycle and experiments that students conduct in the classroom, then they should be able to include aspects of these investigations on assessment instruments. Theys should include questions from laboratory investigations that students carried out. For the purpose of assessment, students should be asked to interpret data from a lab similar to the one they completed. Students should also be asked to design experiments as part of their assessment (Colburn & Clough, 1997).

For the formative evaluation of students' success only a particular phase of the cycle should not be considered. Formative evaluation process must take place during all the activities which includes students' interactions. The *elicit* phase is a formative evaluation phase. The *explore* phase and *explain* phase must always be accompanied by techniques whereby the teacher checks for student understanding (Eisenkraft, 2003).

With the development of 7E learning cycle model eliciting prior understandings and opportunities for transfer of learning are not omitted. This extended model provides teachers with *engagemrnt* and *eliciting* and students with *elaboration* and *extention*. The 5E model is itself an enhancement of the three-phrase learning cycle that included exploration, invention, and discovery (Karplus & Their, 1967).

There are several studies that examined the effectiveness of learning cycle based instruction with respect to reaching important learning outcomes in science. Renner (1986) tested the effectiveness of the learning cycle (experimental group) versus traditional instruction (control group) in promoting gains in content achievement and intellectual development of 9th- and 10thgrade students. The results of his study showed that there is a significant difference between groups instructed with the learning cycle method and the groups instructed with traditional method in promoting gains in content achievement and intellectual development in the favor of experimental group students. Purser and Renner (1983) and Schneider and Renner (1986) have also reported similar findings that revealed the effectiveness of instruction based on learning cycle model over the traditionally designed instruction model on the achievement of learning outcomes. Working with 6th graders, Saunders and Shepardson (1987) investigated the effects of concrete (learning cycle) and formal (traditional) instruction on reasoning and science achievement.

A study conducted by Coulson (2002) to explore how varying levels of fidelity to the BSCS 5E learning cycle model affected student learning showed that students who were instructed BSCS learning cycle model with medium or higher levels of fidelity experienced learning gains that were nearly double than the students who were instructed different that BSCS learning cycle model. The results of the study of Akar (2005) indicated that instruction based on 5E learning cycle model caused a significantly better acquisition of scientific conceptions related to acid-base produced significantly higher positive attitudes toward chemistry as a school subject than the traditionally designed chemistry instruction.

Boddy, Watson, and Aubusson (2003) also stated that BSCS learning cycle model have positive impact on scientific reasoning (Boddy, et al., 2003).

Renner, Abraham, and Birnie (1988) found greater achievement and retention when concepts were introduced after experiences. Gerber, Cavallo, and Marek (2001) found that students taught via a learning cycle scored higher on a test of scientific reasoning. Beeth and Hewson (1999) studied one teacher's science instruction in grades 4–6. She alternated hands-on activities with goal-directed discussion; her students improved their science understanding as well as their engagement in scientific discourse (Patrick & Sandra, 2007).

In 2001, Odom and Kelly explored the effectiveness of concept mapping, the learning cycle, expository instruction, and a combination of concept mapping/learning cycle in promoting conceptual understanding of diffusion and osmosis. Four high school biology classes were taught diffusion and osmosis concepts with the aforementioned treatments. Conceptual understanding was assessed immediately and seven weeks after instruction with the Diffusion and Osmosis Diagnostic Test (DODT). The results indicated the concept mapping/learning cycle and concept mapping treatment groups significantly outperformed the expository treatment group in conceptual understanding of diffusion and osmosis (Odom & Kelly, 2001).

Balcı, Çakıroğlu, and Tekkaya (2006) investigated the effects of the (5E) learning cycle, conceptual change texts, and traditional instructions on 8th grade students' understanding of photosynthesis and respiration in plants. 101 8th-grade students in three intact classes of the same school located in an urban area were used. The classes were randomly assigned as control and experimental groups. Students in the first experimental group received 5E learning cycle instruction, students in the second experimental group received conceptual change text instruction, and students in the control group received traditional instruction. Statistical analysis of the results showed a statistically significant difference between the experimental and control groups in the favor of experimental groups after treatment. However, no statistically significant difference between two experimental groups (5E *versus* conceptual change text instruction) was found.

Mecit (2006) also investigated the effect of 7E learning cycle model on the improvement of fifth grade students' critical thinking skills. She found that 7E learning cycle model caused significantly better improvement on students' critical thinking skills than traditional method. A total of 46 fifth grade students from two different classes of the same science teacher were involved in the study. Two classes were randomly assigned as experimental group and control group. While students in the control group were instructed with traditional method, inquiry based learning was carried out in the experimental group. Her results indicated that inquiry-based learning improved students' critical thinking skills.

Doğru and Tekkaya (2008) investigated the effectiveness of the learning cycle and traditional instruction models on 8th-grade students' achievement in genetics. Analysis of the results indicated a statistically significant difference between the experimental and control groups in favor of the experimental group. Results also revealed that students' logical thinking ability and meaningful learning orientation were also important for a significant portion of variation in genetics achievement.

Similarly, Sasmaz and Tezcan (2009) investigate the effectiveness of the learning cycle approach on learners' attitude toward science in seventh grade science classes of elementary school. Their results indicated that the learning cycle instruction group produced significantly higher positive attitudes toward science as a school subject than the traditionally designed science instruction group. Kaynar, Tekkaya, and Cakıroğlu (2009) investigated the effectiveness of 5E learning cycle on 6th-grade students' achievement of cell concepts, and their scientific epistemological beliefs. They found that treatment had a significant effect on the collective dependent variables.

Since the 5E learning cycle has been shown to be an extremely effective approach to learning (Lawson, 1995; Guzzetti et al. 1993), the goal of the 7E learning model is to emphasize the increasing importance of eliciting prior understandings and the extending, or transfer, of concepts. With this new model, teachers should no longer overlook these essential requirements for student learning (Eisenkraft, 2003).

So the overall goal of the learning cycle is to help students make sense of scientific ideas, improve their scientific reasoning, and increase their engagement in science class as it provides students construct new knowledge by creating conceptual change through interaction with the social and natural world.

In summary, as it is argued that the most appropriate way to help students develop skills in using the reasoning patterns involved in generating and testing hypothesis and acquire a set of scientifically valid conceptions is to teach in a way that allows students to reveal their prior conceptions and test them in an atmosphere in which ideas are openly generated, debated, and tested with the means of testing becoming an explicit focus of classroom attention (Lawson, 1988). Since learning cycle based instruction can allow this to happen, in this study, 7E learning cycle based instruction method was used.

In the following section of this study students' misconception about different science concepts were reviewed.

2.6 Misconceptions

During past 2 decades studies in science education have demonstrated that students have alternative views of science concepts (Odom & Barrow, 1995). These alternative views have been described as mistakes, errors, misunderstandings, misleading ideas, and misinterpretation of facts (Barrass, 1984). Over the past years the research tradition that owes its existence in part to Ausubel's theory and in part to Piaget's has focused on students' alternative conceptions or "misconceptions". It provides an opportunity to synthesize the best of available theory into a view of the learning process that leads directly to a theory of instruction. For students to overcome prior misconceptions they must become aware of the scientific conceptions, as well as their own alternative conception(s) (Lawson, 1988).

Duit (2004) has categorized, synthesized and summarized the large body of research literature on students' understanding of science concepts and how researchers have attempted to provide interventions. This provides researchers a great help in order to gain a holistic understanding of the field. Other research studies showed that many of the teachers have difficulty to effectively diagnose their students' learning problems, especially at an early stage of the student learning process (Taber, 2001). Consequently, how teachers can address their students' learning needs by incorporating specially designed assessment procedures that are consistent with constructivist teaching approaches into their instructional repertoires became an integral part of their teaching (Treagust, et al., 2001).

For the achievement of meaningful learning students must consciously link new knowledge to relevant concepts they already possess. Otherwise, rote learning occurs, in which case students do not integrate new concepts to their prior knowledge to form a coherent framework (Ausubel, 1968). Related research studies indicated that generation of misconceptions concerning scientific concepts is greater for students who frequently use rote learning (BouJaoude, 1992; Cavallo, 1996).

Lawson and Thompson (1988) examined effectiveness of formal reasoning ability of 7th-grade students on successfull dealing with misconceptions and developing scientifically acceptable conceptions of genetics and natural selection following standard lecture-textbook-based instruction. The results of their study indicated that high-formal students requiring concrete objects to make rational judgments and are capable of hypothetical and deductive reasoning performed better than did low-formal students.students have also developed sound understanding of abstract concepts. It was found that they are capable of looking for relations, generating and testing alternative solutions to problems, and drawing conclusions by applying rules and principles. Low-formal students, on the other hand, are concrete reasoners who are unable to develop sound understanding of abstract concepts and are able to understand only concrete concepts. The researchers found that the number of misconceptions is consistently, statistically, and significantly related to reasoning ability (Lawson & Thompson, 1988).

As an earlier study in 1975, Lawson and Renner reported that for interpretation and solving of genetics problems formal-level operations such as probabilistic, combinational, and proportional reasoning that is in line with Piaget's developmental theory, are required. As defined by Cavallo and Schafer (1994), learning orientation is the extent to which learners use meaningful or rote approaches to learn new information. While students developing a meaningful learning orientation try to make connections among concepts, students developing rote learning orientation concentrate on memorizing ideas, concepts, and facts.

Besides reasoning ability and meaningful learning orientation, researchers have revealed another important issue, which is the relevant prior knowledge, for promoting meaningful understanding of a concept (Dogru & Tekkaya, 2008). For example, Haidar (1988) compared applied and theoretical knowledge of high school chemistry students about the concepts related to particulate theory. Results of his study pointed out the effect of students' formal reasoning ability and preexisting knowledge on their conceptions and use of the particulate theory. Likewise, BouJaoude and Giuliano (1994) demonstrated that prior knowledge, logical thinking ability, and meaningful learning orientation accounted for 32% of the variance in chemistry achievement (BouJaoude & Giuliano, 1994). Johnson and Lawson (1998) made contribuiton to the previous studies by studying the relative effects of reasoning ability and prior knowledge on biology achievement in relation to types of instruction. They found that reasoning ability -but not prior knowledge- explained a significant amount of variance in post exam scores in both traditionally designed and inquiry based instruction methods (Johnson & Lawson, 1998).

Hewson (1992) stated that when two individuals exposed to same events, these were may be perceived and interpreted in very different ways because of the fact that individuals may have different knowledge and believes that may influence or be influenced by social interaction in different ways (Hewson, 1992). In other words, knowledge which is constructed by learner is affected by the learner’s prior knowledge and experience and the social context in which learning takes place (Grayson et al., 2001; von Glasersfeld, 1992). Moreover, it was stated that learning new scientific knowledge is strongly influenced by students’ preexisting beliefs that have crucial role in subsequent learning (Arnaudin & Mintez, 1985; Boujaoude, 1992; Driver & Oldham, 1986; Shuell, 1987; Tsai, 1996). Similarly Hunt and Minstrel (1997) stated that since students’ preexisting concepts and believes is ignored before the instruction, students encounter with difficulties in science learning, and this cause loosing communication between teachers and learners (Hunt & Minstrell, 1997).

As one of the major source of students’ misconception, Haidar (1997) stated that instruction method is important. Students may fail to apply correct information and use the closest available information to solve given problem. It may also be because of the difficulty of the knowledge concepts (Haidar, 1997). Another source of misconceptions may be the instructor as Ginns and Watters (1995) stated that teachers may cause the students’ alternative conceptions. Taber (2001) stated that since teacher may misunderstand the concepts which they will teach may cause students to create misconceptions (Taber, 2001).

Sometimes if students have original concepts in their mind they may have difficulties in understanding new concepts. Therefore terminology which is used by teacher or textbooks may be another source of reason in causing misconceptions (Schmidt, et al., 2003). Since students may get lots of idea from their peers, families and media, interaction with friends, parents, media, newspapers, internet, etc. can be other sources of misconceptions (Ceylan & Geban, 2009).

2.6.1 Misconceptions in Biology

As it has been known that the nature and extent of students' understanding of scientific concepts and phenomena are the key components of any science curriculum (Bahar, Johnstone, & Hansell, 1999). Research studies on students' understanding of scientific concepts started after the end of nineteenth century have revealed that students possess several ideas that are at variance with scientifically accepted knowledge (Treagust et al., 1996).

The large body of research studies on students' understanding of science concepts and how researchers have attempted to provide interventions has been categorized, synthesized and summarized by Duit (2004) in a manner that enables researchers to gain a holistic understanding of the field. In the literature research studies to improve biology teaching during the past two decades has been originally dominated by two major theories: Ausubel's theory of verbal learning that focused attention on ways students acquire domain of specific biology concepts (Ausubel 1963; Ausubel, Novak & Hanesian 1978; Ausubel 1979; Novak 1977; Novak 1979; Novak 1980; Harty, Hamrick & Samuel 1985; Lehman, Carter & Kahle 1985) and Piaget's developmental theory that focused attention on ways students acquire and use general scientific reasoning patterns (Flavell 1963; Inhelder & Piaget 1958; Karplus 1977; Piaget 1964; Piaget 1972; Lawson & Renner 1975; Lawson 1988).

Many of these studies on students' understanding of science concepts in biology have focused students' misconceptions in biology. These studies can be summarized with respect to subject areas as: cell division (Lewis & Wood-Robinson, 2000, Krüger et al., 2006), cell concepts (Kaynar, et al., 2009); diffusion and osmosis (Marek et al., 1994; Odom, 1995; Lawson, 2000; Odom & Kelly, 2001), classification (Trowbridge & Mintzes, 1988), photosynthesis and respiration in plants, photosynthesis, and plant nutrition (Bell, 1985; Wandersee, 1985; Haslam & Treagust 1987; Stavy, et al., 1987, Barker, 1989;. Anderson et al., 1990; Griffard & Wandersee, 2001; Mikkila, 2001; Balcı et al., 2006), respiration (Sanders, 1993), circulatory system (Arnaudin & Mintzes, 1985; Sungur et al., 2001), the digestive system (Teixeira, 2000), genetics (Cavallo, 1996; Banet & Ayuso, 2000; Lewis & Wood- Robinson, 2000; Tsui & Treagust, 2004; Doğru & Tekkaya, 2008), evolution (Passmore & Steward, 2001; Bishop & Anderson, 1990), ecology (Adeniyi, 1985; Munson, 1994; Sander et al, 2006); plant reproduction (Sharmann, 1991), protein synthesis (Fisher, 1985), cell metabolism (Mauricio & Pinto, 2008) .

In the following part of the study research studies about students' misconceptions on diffusion and osmosis concepts in biology were summarized.

2.6.2 Misconceptions in Diffusion and Osmosis Concepts

High school biology curriculum is consisting of many topics composed of concepts that are basic to biology knowledge and interrelated with each other. Since concepts of diffusion and osmosis are keys for the understanding many plants and animal physiological processes, increasing students' understanding and achievements by preventing the formation of any misconceptions and eliminate the pre-existing ones are important. For example diffusion is a simple way of short distance transport in a cell and cellular systems. Similarly, correct addressing of the osmosis concepts is required to understand the processes of the water uptake from soil into root cells, the mechanism that lies behind the movement of water through the xylem tissues of plants, water balance in land and aquatic creatures, turgor pressure in plants, transport in living organisms, gas exchange between respiratory surfaces and surrounding environment and between body fluid and tissues. In addition, diffusion and osmosis are closely related to concepts in physics and chemistry, such as permeability, solutions, and the particulate nature of matter (Friedler et al., 1987).

Diffusion and osmosis are among such concepts that students may have misconceptions (Tekkaya, 2003). Studies focusing on students' understanding of diffusion and osmosis indicated that students had a considerable degree of misconceptions in various grade levels and these misconceptions are resistant to change by traditional teaching methods (Friedler et al., 1987; Simpson & Marek, 1988; Westbrook & Marek, 1991; Marek et al., 1994; Zukerman, 1994; Odom & Barrow, 1995; Odom & Kelly, 2001; Christianson & Fisher, 1999; Kelly & Odom, 1997). For example, a study conducted by Friedler et al. (1987) indicated that high school students had difficulties in understanding dynamic equilibrium, osmotic relations in plants, solute-solvent and concentration-quantity relations. In addition to this, Odom and Barrow (1995) stated 20 misconceptions about particulate and random nature of matter, concentration and tonicity, the influence of life forces on diffusion and osmosis, the process of diffusion and the process of osmosis among college biology students (Odom & Barrow, 1995).

Several research studies suggested that different instructional strategies leading to learning cycles and conceptual change could be implemented to eliminate students' misconceptions about diffusion and osmosis concepts.

Johnstone and Mahmoud (1980) surveyed high school biology students on their perceived difficulty of isolated biology topics and reported that osmosis and water potential were regarded by students and teachers as being among the most difficult biological concepts to understand.

Murray (1983) studied students' misconceptions related to osmosis. Those reported in his study related to the concepts of concentration, semi permeability, and pressure. He indicated that conceptions of concentration and diffusion may be acquired by children through direct experience and believes these existing conceptions can be used to provide a foundation for the scientific conceptions needed to understand the role of concentration in osmotic events. In terms of semi permeability of membranes most students in his study believed there was either no movement of materials or the solute moved across the membrane. Only a small percentage of had any understanding that pressure was related water movements and osmosis (Murray, 1983).

Friedler (1985) identified students' conceptual difficulties in understanding concepts and processes associated with cell water relationships (osmosis), determined possible reasons for these difficulties, and pilot-tested instruments and research strategies for a large scale comprehensive study. Research strategies used in the study included content analysis of commonly used textbooks, three paper-pencil questionnaires featuring 72 true/false items, and individual interviews based on two demonstration experiments. One hundred forty-two students in grades 9, 10, and 11 served as subjects. Among the findings are those indicating that: (1) serious misconceptions exist among high school students and student teachers with regard to basic concepts such as solutions, solubility, particulate nature of matter, and molecular movement, and these misconceptions may well be among the reasons for difficulties in understanding osmosis and osmotic relationships; (2) students use textbook definitions of osmosis and diffusion without fully understanding the concepts; (3) teleology and anthropomorphism are widely used among students, as they provide causal explanations; (4) certain textbooks (such as the Biological Sciences Curriculum Study textbooks) hardly mention osmosis; (5) the terms water potential, osmotic potential, osmotic pressure, and hemolysis are rarely dealt with in high schools; and (6) the research instruments and strategies appear to be adequate and effective (Friedler, 1985).

Odom and Barrow (1995) carried out a study with 117 biology majors enrolled in an introductory biology course. Diffusion and Osmosis Diagnostic Test was administered to the students. The result of their study showed that there was no significant difference between male and female students with respect to understanding of diffusion and osmosis concepts and major misconceptions were detected in three areas: the particulate and random motion of matter; the process of diffusion and the process of osmosis. They administered the Diffusion and Osmosis Diagnostic Test (DODT) to 116 secondary biology students, 123 college nonbiology majors, and 117 biology majors. Misconceptions were detected in five of the seven conceptual areas measured by the test: the particulate and random nature of matter, concentration and tonicity, the influences of life forces on diffusion and osmosis, the process of diffusion, and the process of osmosis. There was no significant difference found between secondary and nonbiology majors' understanding of diffusion and osmosis concepts. However, there was a significant difference between biology majors and secondary/ nonbiology majors.

In a cross age study of the understanding of the concept of diffusion, Westbrook and Marek (1991) reported that misconceptions are prevalent in students from 7^{th} grade through college. They found no obvious increase in level of understanding of diffusion as well. Results of an earlier similar study by Marek (1986) with tenth graders also identified a high number of specific misunderstanding related to diffusion.

McNight and Hackling (1994) found that students' misconceptions about diffusion and osmosis have their basis in misunderstanding of particle motion and kinetic theory. The possible origins of these fundamental misconceptions are many and varied. The unobservable nature of particles and their behavior is likely to be a significant barrier to meaningful learning.

Christianson and Fisher (1999), in their studies, described data which suggest that a 'deep understanding' of the topics being covered and the ability to reason effectively about those topics may be forfeited in large lecture biology courses, even with skilled and dedicated teachers. They compare student understanding of two concepts, diffusion and osmosis, in three non-major biology courses at three different universities. The first two courses follow a traditional pattern of instruction, with lectures given in large lecture halls to all of the students enrolled in the course and laboratory experiences occurring in multiple smaller sections (up to 24 students). The third is an integrated laboratory/discussion class that employs many facets of inquiry teaching and discovery-based, constructivist learning (Christianson & Fisher, 1999). Their results indicated that students learned about and understood diffusion and osmosis most deeply in the small laboratory/discussion course.

To explore the effectiveness of the learning cycle and concept mapping in promoting understanding of diffusion and osmosis in high school biology, Odom and Kelly (2001) conducted a study. They proposed that the learning cycle and the concept mapping provide a unique approach to learning that can help students construct knowledge. The topics they selected to study, diffusion and osmosis, involve many complex process that require multiple learning cycles. From this point of view, one of the negative viewpoints of the learning cycle approach was mentioned in this study: With the learning cycle there is no formal mechanism to make connections between numerous concepts and activities. Thus, Odom and Kelly (2001) studied with 108 secondary, in grades 10 and 11, students enrolled in four different sections of college preparatory biology course. They randomly assigned students into four different treatment groups: concept mapping (CM) (n=26); learning cycle (LC) (n=28); expository (EX) (n=27); and the concept mapping/learning cycle (CM/LC) (n=27). Each group took eight lessons on the defined instruction strategy. The conceptual understanding of students was measured with the Diffusion and Osmosis Diagnostic Test. This study was set out to investigate the effectiveness of concept mapping, the learning cycle, expository and the concept mapping/learning cycle instructional strategies on enhancing achievement in diffusion and osmosis content. The results indicated that both the CM/LC and CM strategies enhanced learning of diffusion and osmosis concepts more effectively than expository teaching. However, the two treatments (CM/LC and CM) were not significantly different from the LC treatment ($p>.05$). They stated that concept mapping and the learning cycle provide an exceptional combination of strategies, because each method brings a unique epistemology to learning, additional research is needed to determine the role of the learning cycle at teaching diffusion and osmosis concepts. They also stated that additional research is needed to determine the role of the learning cycle at teaching diffusion and osmosis concepts. Therefore the effect of the learning cycle at teaching diffusion and osmosis concepts was not clearly identified in their study.

Tekkaya (2003) carried out a study to investigate the effectiveness of combining conceptual change text and concept mapping strategy on students' understanding of diffusion and osmosis. She measured students' conceptual understanding of diffusion and osmosis by using the Diffusion and Osmosis Diagnostic Test developed by Odom and Barrow (1995). "The test was administered as pretest and post-test to a total of 44 ninth-grade students in two intact classes of the same high school located in an urban area. The experimental group was a class of 24 students who received concept mapping and conceptual change text instruction. A class of 20 students comprised the control group who received a traditional instruction. Group Assessment of Logical Thinking Test (GALT) and pretest scores were used as covariates in this study. A pretest–post-test control group design utilizing the analysis of covariance showed a statistically significant difference between the experimental and control groups in the favour of the experimental group after treatment. The results of the study indicated that while the average percentage of students in the experimental group holding a scientifically correct view had risen from 22.5% to 54.1%, a gain of 31.6%, the percentage of correct responses of the students in the control group had increased from 19.1% to 38.7%, a gain of 19.6% after treatment" (Tekkaya, 2003).

Meir, Perry, Stal, Maruca, and Klopfer (2005) stated that students have deep-rooted misconceptions about how diffusion and osmosis work, especially at the molecular level. They hypothesized that this might be in part due to the inability to see and explore these processes at the molecular level. In order to investigate this, they developed new software, OsmoBeaker, which allows students to perform inquiry-based experiments at the molecular level. They showed that these simulated laboratories do indeed teach diffusion and osmosis and help overcome some, but not all, student misconceptions.

Odom and Barrow (2007) investigated students' understanding about scientifically acceptable content knowledge by exploring the relationship between knowledge of diffusion and osmosis and the students' certainty in their content knowledge. Data were collected from a high school biology class with the

Diffusion and Osmosis Diagnostic Test (DODT) and Certainty of Response (CRI) scale. All data were collected after completion of a unit of study on diffusion and osmosis. The results of the DODT were dichotomized into correct and incorrect answers, and CRI values were dichotomized into certain and uncertain. Values were used to construct a series of 2 X 2 contingency tables for each item on the DODT and corresponding CRI. High certainty in incorrect answers on the DODT indicated tenacious misconceptions about diffusion and osmosis concepts. Low certainty in incorrect or correct answers on the DODT indicated possible guessing; and, therefore no understanding, or confusion about their understanding. Chi-square analyses revealed that significantly more students had misconceptions than desired knowledge on content covering the Influence of Life Forces on Diffusion and Osmosis, Membranes, the Particulate and Random Nature of Matter, and the Processes of Diffusion and Osmosis. Most students were either guessing or had misconceptions about every item related to the concepts osmosis and tonicity. Osmosis and diffusion are important to understanding fundamental biology concepts, but the concept of tonicity should not be introduced to high school biology students until effective instructional approaches can be identified by researchers (Odom & Barrow, 2007).

Cook, Carter and Wiebe (2008) examined how prior knowledge of cellular transport influenced how high school students in the USA viewed and interpreted graphic representations of this topic. The participants were Advanced Placement Biology students (*n* = 65); each participant had previously taken a biology course in high school. After assessing prior knowledge using the Diffusion and Osmosis Diagnostic Test, two graphical representations of cellular transport processes were selected for analysis. Three different methods of data collection -eye tracking, interviews, and questionnaires- were used to investigate differences in perceived salient features of the graphics, interpretations of the graphics, and processing difficulty experienced while attending to and interpreting the graphics. The results from the eye tracking data, interviews, and instructional representation questionnaires were triangulated and revealed differences in how high and low prior knowledge students attended to and interpreted particle differences, concentration gradient, and the role of adenosine triphosphate, endocytosis and exocytosis, and text labels and captions. Without adequate domain knowledge, low prior knowledge students focused on the surface features of the graphics (eg. differences in particle color) to build an understanding of the concepts represented. On the other hand, with more abundant and better-organized domain knowledge, high prior knowledge students were more likely to attend to the thematically relevant content in the graphics, which enhanced their understanding. The findings of this study offered a more complete understanding of how differentially prepared learners view and interpret graphics and have the potential to inform instructional design (Cook et al., 2008).

As a result of the finding of studies in literature it can be seen that students at different grade levels have many misconceptions about diffusion and osmosis concepts. In this study, for designing the instruction, implementation of computer animations and developing the diffusion and osmosis achievement test the misconceptions determined in the literature were considered. In the section below development of diagnostic assessment tests used for the determination of misconceptions were discussed.

2.6.3 Diagnostic Assessment Tests

Over the past decade, there have been several science education reforms in different countries as in Australia (Curriculum Corporation, 1994), in United States of America (National Research Council, 1996), in England (Department of Education and Employment, 1995), and in Canada (Council of Ministers of Education, Canada 1997) as well as in many other countries. All of these reform studies have indicated an increasing awareness that the science curriculum offered in schools is not meeting the needs of society today and is likely to be inadequate for the future. Similarly, research studies on this issue have shown that the majority of teachers do not take in consderation with their students’ learning problems, especially at an early stage of the student learning process (Costa, Marques & Kempa 2000; Taber 2001).

One component of this reform studies pointed out the importance of making judgments about students' performance as they learn scientific concepts in the curriculum that are much more complex than initially might appear (Duit & Treagust, 2003). "In most of these reports about curriculum reform, the concerns about measuring students' performance by the use of different assessment techniques are usually presented as refinements of existing technical testing procedures. Nevertheless, there have been notable changes from the norm of testing procedures. For example, in several instances, items are being used that assess broad scientific understanding, referred to as scientific literacy, rather than essential scientific facts, however, the items in these latter tests are used in a summative manner, and are not designed to provide teachers and students with feedback about students' learning of the concepts being investigated" (Treagust, 2006).

The nature and extent of students' understanding of scientific concepts and phenomena are key components of any science curriculum. In order to gauge the effectiveness of classroom instruction to facilitate students' understanding of scientific concepts, appropriate assessment tools have to be readily available for use by classroom teachers (Duit & Treagust 2003). Consequently, how teachers can address their students' learning needs by incorporating specially designed assessment procedures into their instructional repertoires that are consistent with constructivist teaching approaches have become an integral part of their teaching process (Bell 2000; Black 1999; Treagust, Jacobwitz, Gallagher & Parker 2001). "Wiggins and McTigue (1998) suggest redesigning the curriculum in a way that includes informal and formal assessment procedures for understanding as part of the curriculum by the use of a wide range of both formative and summative assessment methods to gain feedback on student learning. However, the difficulty with most effective methods is that they are very time consuming and rarely practical for busy classroom teachers to create" (Treagust, 2006).

The supporters of alternative approaches to assessment did not specifically elaborate on the value of specially created diagnostic tests. However, they have recommended assessment items that "require an explanation or defense of the answer, given the methods used" (Wiggins & McTighe 1998, p.14) – precisely the outcome of two-tier test items.

With a two-tier item with two selections on the first tier and four selections on the second tier, there is a 12.5% chance of guessing the correct answer combination (Odom & Barrow, 1995)." In this type of diagnostic tests, the first tier of each item consists of a content question having usually two to four choices and the second tier contains a set of usually four possible alternative reasons for the answer give to the first part. The reasons consist of a desired answer together with identified alternatives of students' conceptions and/or misconceptions. There are a wide range of specially created two-tier multiple-choice instruments (Treagust 1988, 1995) which have been developed and used to determine students' understanding of the concepts in several science disciplines (Treagust, 2006).

The construction of two-tier multiple-choice items that test students' higher level abilities can be considered as long and difficult. "Table 2.6 illustrates certain examples of instruments used to investigate topics in biology, in chemistry and in physics (Treagust, 2006).

"As a sensitive and effective way of assessing meaningful learning among students, Tamir (1989) pointed out the use of justifications when answering multiple-choice test items aand he addresses, to some extent, the limitations of traditional multiple-choice test items. As a result, he proposed the use of multiple-choice test items that included a main content choice with alternative responses on student misconceptions, and a desired answer (Tamir, 1971)" (Treagust, 2006).

Table 2.6 Summary of the development of diagnostic instruments since the 1980s

Topic/concept	Authors
Photosynthesis and respiration	Haslam and Treagust (1987)
Photosynthesis	Griffard and Wandersee (2001)
Diffusion and osmosis	Odom and Barrow (1995)
Breathing and respiration	Mann and Treagust (1998)
Internal transport in plants and human circulatory system	Wang (2004)
Flowering plant growth and development	Lin (2004)
Covalent bonding	Birk and Kurtz (1999)
Covalent bonding and structure	Peterson, Treagust and Garnett (1989)
Chemical bonding	Tan and Treagust (1999)
Qualitative analysis	Tan, Treagust, Goh and Chia (2002)
Chemical equilibrium	Tyson, Treagust and Bucat (1999)
Multiple representation in chemical reactions	Chandrasegaran, Treagust &. Mocerino (2005)
Ionization energies of elements	Tan, Taber, Goh and Chia (2005)
Acids and bases	Chiu (2001, 2002)
States of matter	Chiu, Chiu and Ho (2002)
Light and its properties	Fetherstonhaugh and Treagust (1992)
Formation of images by a plane mirror	Chen, Lin and Lin (2002)
Forces	Halloun and Hestenes (1985) Hestenes, Wells and Schwackhamer (1992)
Electromagnetism	Paulus and Treagust (1991)
Electrical circuits	Millar and Hames (2001)
Force, heat , light and electricity	Franklin (1992)

“It was stated that two-tier test items has been used by the National Science Council in Taiwan as the central part of their national assessment project and the American Chemical Society as recommended examples for conceptual questions. Because these two-tiered multiple-choice tests has been considered as more readily administered and scored than the other methods of ascertaining students’ understanding, and thus are particularly useful for classroom teachers enabling them to use the findings of research to inform their teaching” (Treagust, 2006).

The use of these diagnostic instruments at the beginning or on completion of a specified topic help science instructors achieve better understanding about the nature of students’ understanding and the existence of any alternative conceptions or misconceptions in a particular topic being studied (Treagust, 2006). After the identification of students’ alternative conceptions, they can be modified to remedy the problem by developing and/or utilizing alternative teaching approaches that specifically address students’ non-scientifically acceptable conceptions. In the diagnostic instrument on qualitative analysis, for example, it was found that students had difficulty grappling with the concepts of oxidation and reduction; at least three models of redox reactions are commonly encountered in a chemistry course (Treagust, 1988).

As an example taken from biology, a 13-item two-tier multiple-choice instrument, the “Flowering Plant Growth and Development Diagnostic Test” was designed by Lin (2004). 156 students from Year 10 and 321 students from Year 11 took the test (161 science majors and 160 non-science majors). As a result of this study, it was found that there were 14 alternative conceptions held by at least 10% of the 161 science majors in Year 11. Table 2.7 illustrates several of these alternative conceptions (Treagust, 2006).

Table 2.7 Several alternative conceptions determined from administration of the Flowering Plant Growth and Development Diagnostic Test to Year 11 students (N=161)

Alternative conceptions	% of students with alternative conceptions
Seed germination	
-Seeds need water during photosynthesis to produce nutrients for germination.	23
-Seeds do not need oxygen for germination because seeds themselves provide energy for germination.	13
-The organic matters in soil are used as nutrition for seed germination.	27
Plant nutrition	
-Plants transfer solar energy directly into energy for cellular activity.	16
Mechanism of growth and development	
-Roots turn and grow into the ground for getting more food.	16
-Temperature control will make plants change the time to produce florigen and adjust flowering.	18

It was recommended that the use of these diagnostic instruments in classroom instruction as a means of planned formative assessment will enable teachers to diagnose students' conceptions in particular areas as well as serve as a means of remediation prior to any summative assessment. In addition to this, through designing a cooperative group work as well as a variety of individual learning opportunities, teachers can provide opportunities for students examine their own understanding. When used effectively, these tests can contribute to students' deeper understanding of the science concepts in the curriculum (Treagust, 2006).

Odom and Barrow (1995) developed and applied a two-tier diagnostic test measuring students' understanding of diffusion and osmosis after a course of instruction. The conceptual knowledge examined by the test was particulate and random nature of matter, concentration and tonicity, the influence of life forces on diffusion and osmosis, membrane, kinetic energy of matter, the process of diffusion, and the process of osmosis. In this study, this Diffusion and Osmosis Diagnostic Test (DODT) was used. But before administration of the test, it was modified by considering the recommendations of the authors for the future study and results of semi structured interviews with teachers about the misconceptions examined by the test.

2.7 Computer Animations

In the constructivist framework, the emphasis is not on teaching, but rather on context or learning environment so the importance of the technology integrated science teaching is highly recognized by many researchers (Linn & Hiss, 2000). Recent studies have reported the influences of technologies in the classroom and more specifically in inquiry or laboratory based science (Land & Hannafin 1997, Tomei 1997, Zimmerman 1997). Similarly, using computer simulations, students can access the abstract domains of economics (e.g., discovering features optimizing the smooth running of a city) (Shute & Glaser, 1990), biology (Tabak, et al., 1996), and social science (Kuhn, et al., 2000).

Hakkarainen and Sintonen (2002) argued that in an appropriate environment, it is entirely possible with computer-support for collaborative learning for young students to engage in a sophisticated interrogative process of inquiry analogous to scientific inquiry. Participation in progressive inquiry can be facilitated through computer-supported collaborative learning environments that provide sophisticated tools for supporting inquiry process as well as sharing of knowledge and expertise (Hintikka, 1999).

Mayer (2001) considered multimedia as the presentation of learning materials by using both pictorial and verbal elements. Animations as one of the important combination of multimedia can be defined as an images in motion (Dwyer & Dwyer, 2003).

From the constructivist point of view, Marbach-Ad, Rotbain and Stavy (2008) argued that students' misconceptions and difficulties in science can be overcomed by using animations and models. The Urhanhe et al. (2009) investigated the success of three dimensional simulations in students' understanding of chemical structures and their properties. But for the effective use of computer animations the attention of the students should be drawn to the relevant motion taking place in the animation (Raiber, 1990).

Meir, Perry, Stal, Maruca, and Kopfer (2005) stated that diffusion and osmosis are central concepts in biology, both at the cellular and organ levels, they are presented several times throughout most introductory biology textbooks, yet both processes are often difficult for students to understand (Odom, 1995; Zuckerman, 1994).

There are some studies that support computer-based education in biology. For example Meir et al. (2005) hypothesized that students have deep-rooted misconceptions about how diffusion and osmosis work, especially at the molecular level and this might be in part due to the inability to see and explore these processes at the molecular level. In order to investigate this, they developed new software, OsmoBeaker, which allows students to perform inquiry-based experiments at the molecular level. Here we show that these simulated laboratories do indeed teach diffusion and osmosis and help overcome some, but not all, student misconceptions (Meir et al., 2005). OsmoBeaker is a CD-ROM designed to enhance the learning of diffusion *and* osmosis by presenting interactive experimentation to the student. The software provides several computer simulations that take the student through different scenarios with cells, having different concentration of solutes in them (Sack, 2005).

As it was proved that effective use of technology integrated instruction in the classroom environments helps students overcome difficulties arising from visualization and therefore improve their misconceptions (Ferk et al., 2003), in this study the effectiveness of 7E learning based instruction accompanied with computer animations on students' understanding and achievement of diffusion and osmosis concepts was investigated.

2.8 Attitude toward Science

Besides research studies that support the effectiveness of the learning cycle in promoting meaningful learning of scientific concepts, there are several other studies that have focused on identifying the variables which affect students' achievement. In some of these studies, researchers have investigated the role of cognitive variables such as reasoning ability and learning approach, and while some others investigated the role of affective domains such as attitude and motivation on science achievement (BouJaoude, 1992; BouJaoude, Salloum, & Khalick, 2004; Cavallo, 1996; Johnson & Lawson, 1998; Lawson & Thompson, 1988; She, 2005, Cavallo, Rozman, Blickenstaff, & Walker, 2003; Cavallo, Rozman, & Potter, 2004; Balcı et al., 2005; Kang, Scharmann, Noh, & Koh, 2005, Doğru & Tekkaya, 2008, Ceylan & Geban, 2009, Saşmaz & Tezcan, 2009)

Therefore, the results of the review of related literature in science education revealed that better understanding of scientific concepts for promoting meaningful learning can not be only explained by the examination of cognitive factors as reasoning ability, learning approach, and prior knowledge as there are other factors as that may affect students' attitude and motivation. For example, Glynn and Koballa (2007) stated that meaningful relationships among affective construct and cognition are become more explicit than ever in the research on science learning.

With the recognition of the impact of those affective domains on science learning, a series of investigations were carried out to examine the effect of instructional strategies (Freedman, 2002), age (George, 2000), gender (Barmby, Kind, & Jones, 2008) and grade level (Pell & Jarvis, 2001) on students' attitude toward students' understanding and achievement.

In literature, attitude can be defined as a general and enduring positive and negative feeling about some person, object, or issue (Petty & Cacioppo, 1981). Simpson, et al. (1994) defined attitude as the predisposition to respond positively and negatively to things, places, people or ideas. There are other definition of attitude in the literature but in all of them attitude is considered as the tendency to think, fell, or act positively or negatively toward any object (Eagly & Chaiken, 1993; Petty, 1995).

Cavallo and Laubach (2001) found that attitude toward science may be related to the students' science course enrolment. Similarly, Webster and Fisher (2000) carried out a study by the use of data collect as a part of the Third International Mathematics and Science Study (TIMSS). Their results revealed that attitudes toward science have strong effect on science achievement.

Except from only a few studies (Neiswandt, 2006; Hobbs & Ericson, 1980), the impact of attitude in science learning is quite obvious in most of the science education researches.

On the other hand, there are research studies that have supported the effectiveness of the learning cycle in encouraging students to think creatively and critically, facilitating a better understanding of scientific concepts, developing positive attitudes toward science, improving science process skills, and cultivating advanced reasoning skills (Lawson et al., 1988; Lawson, 1995; Balcı at al., 2005). Similarly, Campbell (1977) found that students in learning cycle group had more positive attitudes towards laboratory works, scored higher in laboratory exam, and were not likely to withdrawn from the course.

The summary of the related literature showed that the inquiry teaching strategy takes into account students' developmental levels and helps them use their prior knowledge as they learn new thought processes, develop higher levels of thinking, and became aware of their own reasoning. (Sunal & Sunal, 2003). As research studies indicated that students come to school with varying experience with, ideas about, and explanations of the natural world and these ideas and explanations. These ideas and explanations that students generate are often different from those of scientists and defined as misconceptions (Fisher, 1985). In order to promote meaningful learning in science education it is required that students need to consciously link new knowledge to relevant concepts they already possess. Otherwise, rote learning occurs (Ausubel, 1968). As it was stated in the above related literature it is quite difficult to overcome these students' misconceptions as they are persuasive, stable, and resistant to change by the use of traditional instruction methods in which most of the students' misconceptions are not taken into consideration. It is argued that the most appropriate way to help students develop skills in using the reasoning patterns for generating and testing hypothesis and acquire a set of scientifically valid conceptions is to teach in a way that allows students to reveal their prior conceptions and test them in an atmosphere in which ideas are openly generated, debated, and tested with the means of testing becoming an explicit focus of classroom attention (Lawson, 1986). Learning cycle based instruction, as a constructivist learning strategy, can allow this to happen. Learning cycle based instructions promote conceptual change by encouraging students to think creatively and critically, facilitating a better understanding of scientific concepts, developing positive attitudes toward science, improving science process skills, and cultivating advanced reasoning skills (Lawson, 1995). Moreover, computer animations integrated instruction in the classroom environments were shown to help students overcome difficulties arising from visualization and therefore improve their misconceptions (Ferk et al., 2003).

In the related literature, studies focusing on students' understanding of diffusion and osmosis, as one of the basic topic of the biology curriculum, indicated that students had a considerable degree of misconceptions in various grade levels and these misconceptions are resistant to change by traditional teaching methods (Friedler et al., 1987). Therefore, in this study, the instruction based on 7E learning cycle model accompanied with computer animations was developed to promote meaningful learning in diffusion and osmosis concepts. In addition, as it was seen from the related literature that attitude of students toward science also plays a significant role for learning to occur. Because of this developing an instruction model that helps students overcome their misconceptions about diffusion and osmosis concepts by taking into consideration of their attitudes is necessary.

CHAPTER 3

PROBLEMS AND HYPOTHESES

This chapter presents the one main problem, nine sub-problems and nine hypotheses of the study.

3.1 The Main Problem and Sub-problems

3.1.1 The Main Problem

What are the effects of the instruction based on 7E learning cycle model accompanied with computer animations and gender differences on 9th grade students' understanding and achievement related to diffusion and osmosis concepts and their attitudes toward biology as a school subject?

3.1.2 The Sub-Problems

1. Is there a significant mean difference between the groups exposed to instruction based on 7E learning cycle model accompanied with computer animations and traditionally designed biology instruction with respect to students' understanding of diffusion and osmosis concepts when science process skill is controlled as a covariate?

2. Is there a significant mean difference between the groups exposed to instruction based on 7E learning cycle model accompanied with

computer animations and traditionally designed biology instruction with respect to students' achievement in diffusion and osmosis concepts when science process skill is controlled as a covariate?

3. Is there a significant mean difference between males and females with respect to students' understanding of diffusion and osmosis concepts when science process skill is controlled as a covariate?

4. Is there a significant mean difference between males and females with respect to students' achievement in diffusion and osmosis concepts when science process skill is controlled as a covariate?

5. Is there a significant effect of interaction between gender differences and treatment with respect to students' understanding of diffusion and osmosis concepts when science process skill is controlled as a covariate?

6. Is there a significant effect of interaction between gender differences and treatment with respect to students' achievement in diffusion and osmosis concepts when science process skill is controlled as a covariate?

7. Is there a significant difference between the effects of instruction based on 7E learning cycle model and traditionally designed biology instruction on students' attitudes toward biology as a school subject?

8. Is there a significant mean difference between males and females with respect students' attitudes toward biology as a school subject?

9. Is there a significant effect of interaction between gender differences and treatment with respect students' attitudes toward biology as a school subject?

3.2 Hypotheses

$H_0$1: There is no significant mean difference between post-test mean scores of students taught with the instruction based on 7E learning cycle model accompanied with computer animations and students taught with traditionally designed biology instruction in students' understanding of diffusion and osmosis concepts when science process skill is controlled as a covariate.

$H_0$2: There is no significant mean difference between post-test mean scores of students taught with the instruction based on 7E learning cycle model accompanied with computer animations and students taught with traditionally designed biology instruction in students' achievement in diffusion and osmosis concepts when science process skill is controlled as a covariate.

$H_0$3: There is no significant mean difference between post-test mean scores of males and females on their understanding of diffusion and osmosis concepts when science process skill is controlled as a covariate?

$H_0$4: There is no significant mean difference between post-test mean scores of males and females on their achievement in diffusion and osmosis concepts when science process skill is controlled as a covariate?

$H_0$5: There is no significant effect of interaction between gender difference and treatment on students' understanding of diffusion and osmosis concepts when science process skill is controlled as a covariate?

$H_0$6: There is no significant effect of interaction between gender differences and treatment on students' achievement in diffusion and osmosis concepts when science process skill is controlled as a covariate?

$H_0$7: There is no significant mean difference between the students taught with instruction based on 7E learning cycle model accompanied with computer animations and students taught with traditionally designed biology instruction with respect to their attitudes toward biology as a school subject?

$H_0$8: There is no significant mean difference between males and females with respect to students' attitudes toward biology as a school subject?

$H_0$9: There is no significant effect of interaction between gender difference and treatment on students' attitudes toward biology as a school subject?

CHAPTER 4

DESIGN OF THE STUDY

This chapter is devoted to detailed description of research design, population and sample, instruments used to collect data, methods and activities used, treatment, data analyses method, treatment fidelity and treatment verification, internal validity threats and assumption and limitation of the study.

4.1 The Experimental Design of the Study

Non-equivalent control group design as a part of quasi experimental design was used in this study (Gay & Airasion, 2000). Since the school administration had already formed the groups at the beginning of the semester, the students were not randomly assigned to experimental and control groups. However, two of the classes from same school were randomly assigned as control groups (CG) and two of the classes in the same school were randomly assigned as experimental groups (EG).

In the experimental group, instruction based on 7E learning cycle model accompanied with computer animations was implemented; while in the control group instruction based on traditional method was implemented. Both groups were instructed by the same biology teacher. Before the implementation of treatment the teacher was informed about the purpose of the study, 7E learning cycle based instruction, and computer animations. The study was conducted over 4 weeks. There were three 40-minute teaching sessions per week for each group.

Before treatment process, in order to test whether the groups were equal in understanding and achievement in diffusion and osmosis concepts and in attitudes toward biology as a school subject, Diffusion and Osmosis Diagnostic Test (DODT), Diffusion and Osmosis Achievement Test (DOACH) and Attitude Scale toward Biology (ASTB) were administered to students in both groups. In addition to this, Science Process Skill Test was applied to the students in both treatment groups to check students' intellectual abilities. Table 4.1 below presents the design of the study.

Table 4.1 Research Design of the Study

Groups	Pre-tests	Treatment	Post-test
Experimental Groups (EG)	DODT	7ELCBI	DODT
	DOACH		DOACH
	ASTB		ASTB
	SPST		
Control Groups (EG)	DODT	TDBI	DODT
	DOACH		DOACH
	ASTB		ASTB
	SPST		

The meanings of the abbreviations used in the table are listed below:

DODT : Diffusion and Osmosis Diagnostic Test
DOACH : Diffusion and Osmosis Achievement Test
ASTB : Attitude Scale toward Biology
SPST : Science Process Skill Test
7ELCBI : 7E Learning Cycle Based Instruction
TDBI : Traditional Designed Biology Instruction
EG : Experimental Group
CG : Control Group

4.2 Population and Subjects

All ninth grade students in Istanbul were identified as the target population of the study. Nevertheless, it is not easy to contact with this target population, it is coherent to define an accessible population for the study. Therefore, all ninth grade students in Sarıyer districts in Istanbul were defined as accessible population and the results of this study will be generalized to this accessible population.

Four classes of grade nine biology courses from a private high school in Sarıyer districts in Istanbul were selected randomly. Since the classes were formed at the beginning of the semester by school administration, it was not possible to assign students randomly to both experimental and control groups. But the classes were randomly assigned as control and experimental group. 66 ninth grade students (28 female and 38 male) participated this study. In the experimental groups to which instruction based on 7E learning cycle model was implemented there were 34 students while in the control group to which instruction based on traditional method was implemented there were 32 students.

4.3 Variables

There were six variables in this study; three of them were determined as independent variables and three of them were determined as dependent variables.

4.3.1 Independent Variables

The independent variables of this study were types of instruction methods which were instruction based on 7E learning cycle model and instruction based on traditional method, gender, and science process skill test scores. The types of instruction and gender were taken as categorical variables which differ qualitatively not in degree, amount, or quantity (Fraenkel & Wallen, 2006).

4.3.2 Dependent Variables

The dependent variables of this study were identified as; students' conceptual understanding of diffusion and osmosis concepts measured by Diffusion and Osmosis Diagnostic Test (DODT), students' achievement in diffusion and osmosis concepts measured by Diffusion and Osmosis Achievement Test (DOACH), students' attitudes toward biology as a school subject measured by Attitude Scale toward Biology (ASTB). All of these dependent variables were considered as quantitative variable.

4. 4 Instruments

The instruments used in this study were Diffusion and Osmosis Diagnostic Test (DODT), Diffusion and Osmosis Achievement Test (DOACH), Attitude Scale toward Biology (ASTB), and Science Process Skill Test (SPST). In addition non-systematic classroom observations were carried out in the experimental and control groups by the researcher.

Since classes in the school were already formed by school administration at the beginning of the semester and therefore the random assignment of the individuals to the experimental and control group was not possible, SPST was administered to students in both control and experimental groups in order to check the pre-existing difference in groups. Since preventing the possibility of any differences that can result from the nature of the groups was impossible, science process skills of the students in both groups was defined as covariate. DODT, DOACH, and ASTB were administered as pre-test and post test to both groups to assess the differences on students' understanding, achievement and attitude.

4.4.1 Diffusion and Osmosis Diagnostic Test (DODT)

Conceptual understanding of students about diffusion and osmosis concepts was measured by the use of Diffusion and Osmosis Diagnostic Test

(DODT). The test has previously been determined to be a good indicator of student understanding of diffusion and osmosis (Odom & Barrow, 1995; Christianson & Fisher, 1999; Odom & Kelly, 2001; Tekkaya, 2003). But semi structured interviews were conducted with five different biology teachers in order to check whether these misconception were also valid for their students.

Items for diagnostic instrument were based on the two-tier multiple choice format described by Treagust (1985). The test is composed of 12, two-tiered, multiple-choice designed items. The first tier consisted of a content question about diffusion and osmosis with two, three, or four choices. The second tier consisted of four possible reasons for the first part: three alternative reasons and one desired reason. For the formation of alternative reasons misconceptions detected during the multiple-choice test with free response reason and the interview sessions were considered (Odom & Barrow, 1995). The 12 pair questions cover enough topics so that one can be assure that a high score on the test indicates that student has a good understanding of diffusion and osmosis (Christianson & Fisher, 1999; Odom & Kelly, 2001).

Before the use of the test for this study some modifications were made on this diagnostic test in the light of recommendations made by the researchers applied the test in their studies before. Two modifications were made on the wordings of some items and in the format of the test.

Modifications about the wordings were done for items 1, 5, 11, and 12 in the DODT. In the alternative response (a) of the fist tier of the item 1 instead of using only “osmosis”, “diffusion of water by osmosis” was used and similarly in the alternative response (b) instead of using only “diffusion”, “simple diffusion” was used. So that a possible confusion in the mind of students about the process of diffusion and osmosis was prevented because it may cause that osmosis is something different than the process of diffusion, which is actually the diffusion of water. For question 5 and 11, the same modifications made by Christianson and Fisher (1999) were done in order to remove perceived ambiguities in the time frames. In question 5a “a very long period of time” was changed into “several days”. In question 11a, the word “immediately” was added [… with poison and *immediately* placed the dead cell…..]. For alternative “a” of the question 12, term “selective permeable” was used instead of “semi permeable”, so that confusion about the permeability of the cell membrane was prevented. Because students may think that cell membrane allow any half of the molecules to pass through the membrane without any selection over them.

Second modification was about the format of the test. Odom and Barrow grouped each question pair under a single question number (1a/b – 12a/b). The two-tiered format tests are randomly used in schools in Turkey and therefore students are not familiar with this format. The question pairs were separated by assigning odd numbers for main question and assigning even numbers for the corresponding reason questions. So that there were 24 multiple choice questions in the test rather than 12 two-tiered questions.

All 22 propositional knowledge statements required for understanding of diffusion and osmosis at a level of sophistication appropriate for biology students listed in Figure 4.1 were matched to the Diffusion and Osmosis Diagnostic Test (DODT). All the items (questions in the new version), except one, incorporated more than one of the propositional knowledge statements (Figure 4.2). Item number 4 matched only propositional knowledge statement number 5, which was concerned with concentration as measured by the number of particles per unit volume (Odom & Barrow, 1995).

The DODT was initially constructed to assess freshman college biology students’ understanding of diffusion and osmosis. Subsequent studies have indicated that DODT was appropriate for secondary biology students (Odom and Barrow, 1995; Christianson & Fisher, 1999; Odom & Kelly, 2001; Tekkaya, 2003).

1. All particles are in constant motion.
2. Diffusion involves the movement of particles.
3. Diffusion results from the random motion and/or collisions of particles (ions or molecules).
4. Diffusion is the net movement of particles as a result of a concentration gradient.
5. Concentration is the number of particles per unit volume.
6. Concentration gradient is a difference in concentration of a substance across a space.
7. Diffusion is the net movement of particles from an area of high concentration to an area of low concentration.
8. Diffusion continues until the particles become uniformly distributed in the medium in which they are dissolved.
9. Diffusion rate increases as temperature increases.
10. Temperature increases motion and/or particle collisions.
11. Diffusion rate increases as the concentration gradient increases.
12. Increased concentration increases particle collisions.
13. Diffusion occurs in living and nonliving systems.
14. Osmosis is the diffusion of water across a selectively permeable membrane.
15. Tonicity refers to the relative concentration of particles on either side of a selectively permeable membrane.
16. A hypotonic solution has fewer dissolved particles/per unit volume relative to the other side of the membrane.
17. A hypertonic solution has more dissolved particles/per unit volume relative to the other side of the membrane.
18. An isotonic solution has an equal number of dissolved particles/per unit volume on both sides of the membrane.
19. Osmosis is the net movement of water (solvent) across a selectively permeable membrane from a hypotonic solution to a hypertonic solution.
20. Osmosis occurs in living and nonliving systems.
21. A selectively permeable membrane is a membrane that selectively allows the movement of some substances across the membrane while blocking the movement of others.
22. Cell membranes are selectively permeable.

Figure 4.1 Propositional knowledge statements required for understanding of diffusion and osmosis.

To establish face and content validity of the modified version of DODT, the test was examined by a biology expert from TUBITAK, a biology professor from science education, three experienced biology teachers, and the course teacher for the appropriateness of the modifications and necessary corrections were made by considering their feedbacks and recommendations. The split-half reliability of the original Diffusion and Osmosis Diagnostic Test was 0.74 (Odom & Barrow, 1993). In this study, the reliability coefficient was found to be 0.78.

Item no	Question no	Topic area	Propositional statements
1	1, 2	The process of diffusion	2, 4
2	3, 4	The particulate and random nature of matter	2, 4, 5, 6, 7, 12
3	5, 6	The particulate and random nature of matter	2, 3, 4, 11, 12
4	7, 8	Concentration and tonicity	5
5	9, 10	The process of diffusion	4, 5, 6, 8
6	11, 12	The particulate and random nature of matter	1, 2, 3, 8
7	13, 14	Kinetic energy of matter	9, 10
8	15, 16	The process of osmosis	14, 19, 22
9	17, 18	Concentration and tonicity	15, 16, 17, 18
10	19, 20	The process of osmosis	14, 19, 22
11	21, 22	The influence of life forces on diffusion and osmosis	13, 20
12	23, 24	Membranes	21, 22

Figure 4.2 Item number, propositional knowledge statements, and topic areas tested by the Diffusion and Osmosis Diagnostic Test

This test was administered to control and experimental groups as pre-test and post test. Pre-test scores were used to examine students' misconceptions before the treatment and post test scores were used to assess the effect of treatments on students' understanding of diffusion and osmosis concepts. An item in the test was scored as correct on Diffusion and Osmosis Diagnostic Test (DODT) when both the desired content and reason were selected correctly (See Appendix B).

4.4.2 Diffusion and Osmosis Achievement Test (DOACH)

Diffusion and Osmosis Achievement Test (DOACH) was developed by researcher. The purpose of the test was to assess students achievement in concepts related to diffusion and osmosis. The content of the test was determined by the use of instructional objectives (see Appendix A) prepared by considering the objectives of national biology curriculum and concepts covered in the diffusion and osmosis diagnostic test.

Diffusion and Osmosis Achievement Test included 20 multiple-choice items with four choices: three distracters and one desired answer. Each correct answer was credit with 1 point. Therefore the overall grading of the test was over 20 (see Appendix C). Most of the propositional knowledge statements used to define DODT was also used to define DOACH test (Figure 4.3).

Item Number	Topic area	Propositional statements
1.	Membranes	21, 22
2.	The process of diffusion	2, 4
3.	The process of diffusion and osmosis	2, 14
4.	The particulate and random nature of matter	4, 6
5.	The particulate and random nature of matter	2, 3
6.	The process of osmosis	14, 19
7.	The process of osmosis	14, 20
8.	The influence of life forces on diffusion and osmosis	13, 16, 20
9.	The particulate and random nature of matter	1, 4, 21, 22
10.	The particulate and random nature of matter and process of diffusion	4, 7
11.	Kinetic energy of matter	4, 9, 10, 12
12.	The influence of life forces on diffusion and osmosis	14, 16, 19,
13.	The influence of life forces on diffusion and osmosis	13, 16, 20
14.	Concentration and tonicity	15, 16, 17, 18
15.	The process of diffusion and membranes	21, 22
16.	The process of diffusion and osmosis	4, 8, 14, 19, 20, 22
17.	Kinetic energy of matter and diffusion	9, 10, 11
18.	Concentration and tonicity	15, 16, 17, 18
19.	Concentration and tonicity	15, 16, 17, 18, 20
20.	The process of osmosis and membranes	14, 19, 21, 22

Figure 4.3 Item number, propositional knowledge statements, and topic areas tested by the Diffusion and Osmosis Achievement Test

The content and face validity of the test was provided by three experienced biology teachers, a biology professor from science education, and a biology expert from TUBITAK who examined appropriateness of the questions in test to the instructional objectives. By taking their recommendation into account, necessary modifications were made with respect to feedbacks provided. As it can be seen from Figure 4.2, all 21 instructional objectives were matched to the items on Diffusion and Osmosis Achievement Test (DOAT). In addition, the test was controlled with respect to its grammatical and understandable aspects for students and this was used as evidence for face validity in validity issue. Before the use of this test for its actual aim, a pilot test was conducted by administering the test to 155 ninth grade students in a private high school. Results of this pilot study were used to evaluate reliability and validity aspects. Cronbach-alpha reliability of the pilot test scores was calculated as 0.81.

The test was administered to both control and experiment groups. Pre-test scores were used to assess students' achievement on diffusion and osmosis concepts, while the post test scores were used to determine the effect of treatment on students' achievement in diffusion and osmosis concepts.

4.4.3 Science Process Skill Test (SPST)

The test was developed by Okey, Wise and Burns (1982). There are 36 items in the test. It includes five subsets designed to measure the different aspects of science process skills. These are intellectual abilities of students related to identifying variables, identifying and stating the hypotheses, operationally defining, designing investigations and graphing and interpreting data. It was translated and adapted into Turkish by Geban, Aşkar and Özkan (1992). The reliability coefficient of the test was found to be 0.85. This test was given students in both control and experimental groups before the treatment. Students' answers in the test were assessed over 36 points as each correct answer was given 1 point (see Appendix D).

4.4.4 Attitude Scale toward Biology Test (ASTB)

This scale was originally developed by Geban, Ertepinar, Yilmaz, Altın, and Şahbaz (1994) to measure students' attitudes toward chemistry as a school subject and than adapted to biology by the researcher. The content and face validity of the adapted test was checked by three experienced biology teachers and a biology professor from science education. By taking their recommendation into account, necessary modifications were made with respect to feedbacks provided. This instrument consisted of 15 items in 5-point likert type scale: fully agree, agree undecided, disagree, and fully disagree. Total possible score from the test range from 15 to 75. Lower scores show negative attitude while higher scores show positive attitude towards biology. The reliability was found to be 0.83. This test was given students in both control and experimental groups as a pre-test and post-test (see Appendix E).

4.4.5 The Classroom Observations

In order to check the implementation of both treatments in control and experimental groups classroom observations were carried out. In the control group, implementation of instruction based on traditional method, in the experimental group implementation of instruction based on 7E learning cycle model accompanied with computer animations were analyzed carefully. During the process of observation, the interaction between teacher-students and students-students; participation and contribution of students into learning environment; behaviour and attitude of students and teacher as well as the physical conditions and material availability of the classroom were observed. Before observation of the real implementation process, researcher visited the classrooms 2 times, sat silently at the back and observed classroom. So that students become familiar with this process before observation of real implementation process. By doing this, naturalistic observation approach was intended. An observation checklist consisting of 20 items with 3-point likert type scale (Yes/No/Partially) was prepared by the researcher to be used during observation (see Appendix F).

4.5 Procedures

During this study, ERIC, Social Science Citation Index, and Dissertation Abstracts International databases (Frankel & Wallen, 2006) and national databases in YOK were searched by the researcher by using the keywords that researcher indentified. In addition, several national journals as Hacettepe Eğitim Fakültesi Dergisi, Eğitim ve Bilim Dergisi, and Milli Eğitim dergisi were searched. Moreover, search engines as Yahoo, Google, and Altavista were used periodically for the search of the same key words.

The key words that were identified by the researcher to search are; Learning theories, Constructivism, Conceptual understanding approach, Conceptual change models, Inquiry-based learning, Inquiry teaching and learning, Inquiry learning and science education, Traditional teaching and learning, Learning cycle, Learning cycle models, 3E and 5E learning cycle models, 7E learning cycle model, Learning cycle and diffusion and osmosis, Learning cycle and biology education, Misconceptions, Misconceptions, Misconceptions in biology, Misconceptions in diffusion and osmosis, Alternative conceptions, Conceptions, Biology attitude and achievement, Computer-based instructions, Animations, Animations on diffusion and osmosis, Diffusion, Osmosis, Simple diffusion, Facilitated diffusion, Concentration gradient, The particulate nature of matter, The random nature of matter, Kinetic energy of matter, Concentration and tonicity, Hypertonic solution, Hypotonic solution, Isotonic solution, Demonstrations and diffusion osmosis, Laboratory activities and diffusion osmosis, Discussions, attitude, science process skills.

4.6 Methods and Activities

Diffusion and osmosis concepts, in the experimental group, were thought by the use of instruction based on 7E learning cycle method; in the control group, by the use of instruction based on traditional method. In the study, there were two control and two experimental groups, which were instructed by the same teacher.

Diffusion and osmosis concepts were taught to both groups in parallel with national curriculum with the use of same textbook.

In the traditional instruction method, teaching and learning activities were based on an organized lecture supplemented by hand-outs, textbooks, overheads, power point illustrations, blackboard, and charts to illustrate concepts and ideas. Main teaching and learning strategies were based on teacher explanation, students' observations of the figures, charts or demos showed by the teacher, and textbooks. Students were acting as passive listeners and their alternative conceptions were not taken in consideration by the teacher.

In the instruction based on 7E learning cycle method, teaching and learning activities were designed to maximize students' active involvement in the learning process. These activities mainly based on laboratory investigations. In addition demonstrations, computer animations, power point illustrations, hand-outs, and text-book (Campbell et al., 2007) were used. Both traditional and inquiry classes used the same textbook and handouts. Activities were implemented by considering stages of 7E learning cycle model. Main purpose of these activities was to promote students' conceptual understanding of diffusion and osmosis concepts. Together with these activities, 5 computer animations related to diffusion and osmosis concepts were integrated into different stages of 7E learning cycle based instruction.

The activities used in the elicit phase focuses on making learners retrieve existing experience that is associated with the new knowledge. The students might know the concept about diffusion and osmosis before, and by asking them questions the teacher wanted students to remember this prior knowledge. With the activities used in the engagement phase, teacher tried to increase students' attention, get them interested and ready to learn. So that students had opportunities to make some connections between prior knowledge and present learning experiences. So that their thinking was organized toward learning out comes. In the exploration phase, intention was to create learning environments for students so that they could observe scientific processes, record data, isolate variables, design and plan experiments, create graphs, interpret results, develop hypotheses, and organize their findings. Teachers only provided questions, suggested approaches, gave feedbacks, and assessed understandings. Activities used in the explanation phase helped students demonstrate their understanding of related concepts. Teacher guided students toward coherent and consistent generalizations, helps students with distinct scientific vocabulary, and provided questions that help students use this vocabulary to explain the results of their explorations. Activities used in elaboration phase, provided an opportunity for students to apply their knowledge to new domains, which may include raising new questions and hypotheses to explore. The elaboration phase ties directly to the psychological construct called “transfer of learning” (Thorndike, 1923). The activities used in extend phase intended to help students practice the transfer of learning. With the activities used in the evaluation phase students had opportunity to assess their understanding and abilities. The activities in evaluation phases were also used by teacher for both formative and summative evaluations of student learning (Eisenkraft, 2003).

During the development of all these activities, students’ grade and therefore ability levels, their prior knowledge, and instructional objectives based on national biology curriculum and concepts covered in the diffusion and osmosis diagnostic test were considered. A biology professor from science education, three experienced biology teachers, and a biology expert from TUBITAK examined appropriateness of these activities with respect to students’ grade levels and the diffusion and osmosis content. In addition, the activities developed for the study were field examined by three biology teachers. By considering their feedbacks activities were revised before their application for this study.

4.7 Treatment (Research Methodology)

This study was conducted over 4 weeks during spring semester of 2008-2009 academic year. There were three 40-minute teaching sessions per week for both control and experimental groups (12 consecutive biology lessons). Total number of students from four classes participated for this study was 66. Non-equivalent control group design as a type of quasi experimental design was used (Gay & Airasion, 2000). Since the school administration had already formed classes at the beginning of the semester, students were not randomly assigned to experimental and control groups. However, two of the classes from same school were randomly assigned as control groups (CG) and two of the classes in the same school were randomly assigned as experimental groups (EG). Experimental group students were instructed with 7E learning cycle based instruction accompanied with computer animations whereas control group students were instructed with traditionally designed biology instruction. Both groups were instructed by the same biology teacher throughout the investigation and they covered the same subject matters and were used the same textbook.

Before the instruction the teacher was trained about the purpose and details of the instructions. It was not difficult for the researcher to explain details of the methods as she had enough educational background and experience about the related concepts as constructivism, misconceptions, and conceptual understanding. During the process of training, she was given with the list of students' possible misconceptions about diffusion of osmosis (the process of diffusion, the particulate and random nature of matter, concentration and tonicity, kinetic energy of matter, the process of osmosis, the influence of life forces on diffusion and osmosis, and membranes). Then she was informed about 7E learning cycle based instruction as an example for a constructivist learning strategy, and how to implement it. The details of the implementation process including application of the activities at each stages of the learning cycle were discussed and clarified. The implementation of traditional instruction in control groups was also discussed. For each lesson, detailed lesson plans for 7E learning cycle model instruction together with appropriate activities (see Appendix G) and computer animations were prepared by the researcher according to 7E Learning Cycle model proposed by Eisenkraft (2003) and before each lesson, they were shared with and explained to classroom teacher.

Approximately two weeks before the treatment started, Diffusion and Osmosis Diagnostic Test (DODT), Diffusion and Osmosis Achievement Test (DOACH), Attitude Scale toward Biology (ASTB), and Science Process Skill Test (SPST) were administered to students in both groups as pre-tests. Students were informed about the purpose of the tests and then asked to complete the questions on their own. Diffusion and Osmosis Diagnostic Test (DODT), Diffusion and Osmosis Achievement Test (DOACH) were applied in order to determine students' level of understanding and achievement in diffusion and osmosis concepts. The purpose of using Attitude Scale toward Biology (ASTB) as a pre-test was to measure students' attitude toward biology as a school subject. Science Process Skill Test (SPST), on the other hand, was applied to test students' science process skill levels. After the treatment, Diffusion and Osmosis Diagnostic Test (DODT), Diffusion and Osmosis Achievement Test (DOACH), and Attitude Scale toward Biology (ASTB) were administered as post-test in order to examine the effect of treatment.

In the traditional designed biology instruction implemented in control groups, teacher mainly used lecturing method to teach diffusion and osmosis concepts. She instructed the entire class as a unit, wrote notes on the blackboard about the definition of concepts, or used notes on the power-point slides, or over-head transparencies, and distributed lists of questions to students in order to answer without considerations of their alternative conceptions. The teacher explained, defined, and described each concept in the order of textbook. Students listened to the teacher, took notes, or followed the teacher from the textbook throughout the lessons. After finishing her explanation she directed questions to whole class to lead class discussions on the key concepts. Majority of the class time was used for explanation and discussion of the questions directed by the teacher. The remaining time were used for worksheet practices that required written responses or reading assignments from textbook. The lessons generally ended with discussing the answers of worksheet questions with a teacher directed strategy. Teacher gave homework assignments from the textbook, which were reviewed in the coming classroom session. She also applied quizzes from time to time to assess students' learning process. Providing clear and detailed information to students was the main idea behind this teacher-centered traditional instruction. The laboratory investigations carried out in experimental groups were demonstrated by the teacher. Therefore, students did not have enough opportunity to discover information themselves, be involved in group activities, manipulate laboratory equipments, or discuss their ideas and findings with their friends. Similarly, animations used in the experimental groups were also used in the control group but rather than in an integrated format they were used by the teacher for the summary of key concepts at the end of the unit.

For the experimental groups, teacher used 7E learning cycle based instruction, which had a student-centered rather than teacher-centred strategy. The role of the teacher was acting as a facilitator and as a consultant rather than the traditional model of teacher as the knower who dispenses knowledge. So teacher, as a facilitator, provided appropriate environment for the students learn rather than the teacher telling them what to learn and how. Therefore the main idea behind this student-centered instruction was active involvement of students by completing a laboratory investigation, manipulating objects, sharing and discussing ideas and findings with classmates. 7E learning cycle model implemented in experimental groups was composed of seven phases: Eliciting, Engagement, Exploration, Explanation, Elaboration, Extension, and Evaluation (see Appendix G).

In the first phase of the learning cycle, e*licit* (1), teacher tried to identify students' prior knowledge and misconceptions about diffusion and osmosis. For this purpose students were asked with a series of inquiry questions with respect to the list of students' alternative conceptions bout diffusion of osmosis. During the discussion of each question she showed a related picture on the screen from projector machine or a short animation process about the question being asked. So that she help students to visualize and recall the process in the question. For the question "How do plants can take water and minerals from soil?" she showed a picture of a plant root cell taking water and minerals from the soil; for the question “How does the gas exchange occur at respiratory surfaces of different animals as mammals, fish, insects, or earthworms?” she showed a simple animation about the exchange of oxygen and carbon dioxide taking place at mammalian lungs. Through this animation she wanted students think about the name of the mechanism by which this gas exchange process takes place and how these molecules moved from one area to another one. After the animation she used the pictures of other respiratory surfaces as a fish’s gills and an earthworm’s skin. Then she called one student to go one of the corners of the class and spray a perfume and waited for other student to smell the odour. Then she asked the question “What makes these perfume molecules reach you and so that you fee the odour?” Then she took a beaker of water prepared before the lesson and asked students that “What will happens when I dropped this crystal of a dye into this beaker full of water? At the end she asked students to give similar other examples about diffusion and osmosis concepts from daily life. Some students can give example as “a lump of sugar dropped into a glass of tea”. After each question she attempted to create a discussion environment, gave opportunities for students to share their ideas. By this way she tried to explore students’ prior knowledge about the concepts and revealed their misconceptions about diffusion and osmosis.

During *engagement* phase (2), teacher tried to get attention of students into the subject matter. For this purpose groups of students were given two beakers of water having two dialysis bags with different chemicals in each. The first tube was filled with 10 mL of water and 3 drops of phenolphthalein and second tube is filled with 10 mL of starch. Before starting activity she made a demonstration to show how the color of starch containing suspensions changes from original color of iodine (red) into blue-black and how the color of basic suspensions changes from original color of phenolphthalein (colorless) into pink. Then she asked students to think about the question: “What do you think that what will happen to the molecules inside or outside of the dialysis tube? In what direction they will move? Can they go out of the bags? If so, which ones? And Why?” and wanted them to discuss the answers of these questions together. At the end of the demonstration students realized some colour changes inside and outside of the bags. Teacher asked to discuss the below questions: How can you describe the colour changes in the two bags and their surrounding solutions? For which molecules and ions will this demonstration provide evidence for passage through the selectively permeable membrane? What characteristic distinguishes those molecules and ions passing through the membrane from those that do not pass through the membrane? She also used an animation about the movement of particles through the pores of a membrane by the process of diffusion (see Appendix I). Teacher acted as a facilitator in this discussion stage and supported students to realize that their present conceptions were not enough to explain some of these phenomena. In other words, a kind of disequilibrium was created in the students.

During the *exploration* phase (3), teacher provided some guidance for students and let them explore the new knowledge and solve related problems by themselves. For this purpose, teacher organized a laboratory investigation by dividing class into 4 study groups. Each group was informed about what materials they were going to use and what procedure they were going to apply. They were supposed to record their observations on a "Data Collection Tables" given with their lab sheets. Each group discussed the questions given by the teacher of their own groups considering their observations. At the end they were expected to share their data with other members of the class. With this activity teacher let the student manipulate materials to actively explore concepts, processes or skills and by this way a kind of equilibration was initiated by the teacher. The teacher was the facilitator. She observed and listened to students and suggested approaches, provided feedback, and assessed their understandings.

At the *explanation* phase (4), students discussed their observations and findings with peers and the teacher. First, teacher allowed students to share and explain their findings and ideas that they gained in the previous stages. So she tried to guide students to modify and enhance their concepts. Teacher clarified the answer of the questions asked in the previous phases and clearly connected these explanations with students' gained experiences. In addition, she used three types of animations in order to explain related concepts in an interactive, visual, and clear way. In the first animation, the process of osmosis and concepts related to concentration and tonicity were explained. In the second animation the structure of the cell membrane was shown and briefly explained at first, then passive transport mechanism as simple diffusion, facilitated diffusion and diffusion of water (osmosis) were animated with an explanation of each. The third animation was about the mechanism for the uptake of water and minerals from soil into plant root cells.

During the *elaboration* phase (5), teacher provided students with further investigations to extend or elaborate the concepts, processes, or skills gained during the previous stages. For this purpose she let students explore how osmosis and the rate of diffusion were affected by free-energy gradient. She aimed at finding out where students had difficulties and provided help to overcome them. Students in groups of 4 carried out an investigation in order to observe how the speed at which a substance diffuses from one area to another depends on the free-energy gradient between those areas. For example, if concentration of a diffusing substance at the two areas differs greatly, the free-energy gradient was steep and diffusion was rapid. By this way they could also observe what happens to a cell is a hypertonic, hypotonic and isotonic solution. During this phase, teacher used formal assessment methods to evaluate instructional objectives and misconceptions.

At the *extension* phase (6), the goal of the teacher was to transfer of students' learning to new concepts. So students were expected to remember knowledge and then use it to solve problems in a new situation. For this purpose, teacher asked students to discuss the forces that act on water within a plant in terms of the water's potential energy. Teacher provided information about water potential and states that water in a plant possesses potential energy for two reasons and sum of these potentials was known as water potential:

1) Pressure exerted by the atmosphere (pressure potential),
2) Pressure exerted by diffusion forces (solute potential).

Then students were asked to discuss water potential in different locations of a plant such as water potential in leaves and roots. They needed to relate direction of diffusion in accordance with a gradient in water potential. They were also expected to relate that water flows through a plant from the higher water potential of the root tissues toward the lower water potentials of leaves. For this purpose teacher organized an investigation in order to discover the effects of different solute concentration on potato cells and relate this concentration to water potential. The purpose of this experiment was to transfer of students' knowledge about diffusion and osmosis to the new concept of as the effect of different solute concentrations on living plant cells, which is related to plant transport unit of eleventh grade biology curriculum.

In the *evaluation* phase (7) of the 7E learning cycle, teacher encouraged students to assess their understanding and abilities; and evaluate their understanding and skills acquired during previous phases. For doing this, students were given a list of questions and shown with the figures of animal and plant cells and then teacher asked students to discuss what is happening to these cells placed in different solutions for each figure. Students were expected to compare plant and animals in each of these solutions by using the concepts of osmosis, hypertonic, isotonic, hypotonic solutions, or other related concepts they had learnt. Teacher collected students answer and then gave feedback about their understanding and skills.

4.8 Computer Animations

There were five computer animations related to diffusion and osmosis concepts. The content of the animation were decided by the researcher with respect to instructional objectives. These animations were taken from Media Manager CD resource set of textbook "Biology Concepts and Connection" (Campbell, Reece, & Taylor, 2007). Appropriateness of all these animations was examined by a biology professor from science education, three experienced biology teachers, a biology expert from TUBITAK, and classroom teacher.

First animation was about daily life examples of diffusion process. It was related with the process of diffusion and used during elicit phase of the learning cycle. In the animation, exchange of respiratory gases at mammalian lungs was shown. Students watched and listened to the details of animation about diffusion of the oxygen from alveolar air space into the blood and diffusion of carbon dioxide from blood into alveolar air space. During the use of animation the teacher took students' attention to the direction of the movement of gases molecules while showing the diffusion of gases from alveolar space of the lungs into blood stream of the mammal (see Appendix H).

Second animation was about movement of particles through a selectively permeable membrane by the process of diffusion and used during engagement phase of the learning cycle. It was related to the particulate and random nature of matter. The animation was composed of two parts: the first part was about diffusion of dye molecules from high to low concentration, the second part was about diffusion of two different substances having two different colours through a selectively permeable membrane (see Appendix I).

The third animation was related to the concepts about concentration and tonicity. It was used during the explanation phase of the learning cycle. The process of osmosis and concepts related to concentration and tonicity were explained on this animation (see Appendix J).

The fourth animation was about selective permeability of cell membrane and was used during explanation phase of the learning cycle. In the animation the structure of the cell membrane was shown and briefly explained at first. Then passive transport mechanism as simple diffusion, facilitated diffusion and diffusion of water (osmosis) were animated with a brief explanation of each (see Appendix K).

The fifth animation was related to influence of life forces on diffusion and osmosis and was used during explanation phase of the learning cycle. Through the mechanism about the uptake of water and minerals from soil into plant root cells were illustrated (see Appendix L).

4.9 Treatment Fidelity and Treatment Verification

Treatment fidelity provides researcher to ensure that another factor except treatment is not responsible for the difference in the dependent variable before study is conducted (Borelli et al., 2005; Detrich, 1999; Hennessey & Rumrill, 2003). A criterion list that explains the method for both EGs and CGs was formed. This criterion list involves not only what should be required but also involved what should not be required in the methods implemented in both EGs and CGs. In the next step to ensure treatment fidelity, a lesson plan that integrated with the criterion list and objectives of the lesson was prepared. One biology professor, one biology education expert, and three experienced biology teachers reviewed the activities (see Appendix G) and instruments whether they were appropriate for the purpose of the study. Their feedbacks were taken into consideration. The last step to ensure fidelity was to train the teacher with respect to lesson plan and activities that implemented in both EGs and CGs.

Treatment verification provides researcher to ensure that treatment was implemented as defined in the study (Shaver, 1983). An observation check list that consisted of 20 items with 3 point likert type scale (Yes/No/Partially) was formed. Researcher and a biology education professor rated this check list (see Appendix F). The minimum criterion was determined as at least 75% of the items were expected to be marked as average or above to say that the treatment was implemented as intended. Moreover, teacher and some students were interviewed to evaluate whether the treatment was implemented as expected. The interviews confirmed the checklist results which indicated that treatment was done as it was expected.

4.10 Internal Validity Threats

Internal validity means independent variables, not some other unintended variables, directly explain the observed differences on the dependent variable (Frankel & Wallen, 2006). Because of this, internal validity treats in a study must be controlled crucially. Frankel and Wallen (2006) identified internal validity threats as subject characteristics, mortality, location, instrumentation, testing, history, maturation, attitude of subjects, regression, and implementation.

Subject characteristics threat can be defined as the possibility of difference between individuals in the sample with respect to their characteristics such as age, intelligence, previous knowledge about the specific subject matter, science process skills, etc. (Frankel & Wallen, 2006). In this study, students' previous achievement, understanding, attitudes, and science process skills were analyzed at the beginning of the study. The analysis of results the showed that there were not any significant difference between subjects in terms of their achievement and understanding of diffusion and osmosis concepts, and attitude toward biology as a school subject. Since analysis results indicated that students' were different in their science process skills this variable was used as a covariate to minimize the prior differences that might effect observed differences on post test end of the study. In addition, all students participated in the study were the same grade level and almost at the same age (15-16 years old). However, since random sampling of students to both EGs and CGs was not possible because of the administration procedures other subject characteristics may correlate with dependent variables.

Mortality means lose of some subjects during the treatment (Frankel & Wallen, 2006). In this study, there was not any missing subject in both pre-test and post test and all students answered all of the items in the tests. Therefore mortality threat was controlled during the study.

Location threat means that students' responses may be affected from the location where data are collected or treatment is carried out (Frankel & Wallen, 2006). Since students participated to this study received both tests and instruction in their regular classes at school effect of location on students' responds were also controlled.

Instrument threat that occurs if unreliable or inconsistent measurements were used which may cause invalid assessment of performance (Gay & Airasian, 2000). The instruments that were used in this study were in multiple choice format (DODT, DOACH, SPST) and likert scale (ASTB), instrumentation decay threat was not a problem for this study. Moreover, data collection characteristics threat, which can be defined as the nature of data may be affected by data gatherers characteristics such as their gender, age, ethnicity, etc (Frankel & Wallen, 2006), was also controlled by the use of same person (teacher) as the data collector.

Testing means the improvement in students' post test scores because of having taken a pre-test (Frankel & Wallen, 2006). In this study, the time between pre- and post-tests was seven weeks, which was sufficient for desensitization.

History means any unplanned events occurred during treatment and can affect responses of students (Gay & Airasian, 2000). Even though probability of the occurrence of such an event increases as the time interval between pre- and pots-test measurements of the dependent variables increase, during the implementation of treatments there was not any occurrence of such an unexpected event. Therefore this threat was controlled.

Maturation can be defined as the possible changes in students due to passing of time rather than intervention (Frankel & Wallen, 2006). The treatments lasted seven weeks which was not long enough to anticipate any physiological or psychological changes in students. In addition instruments were administered to both groups in the regular classrooms in the same week. Therefore maturation threat was controlled.

Attitude of students toward the study can also create a possible treat for the study (Frankel & Wallen, 2006). In order to reduce the risk of this threat, students were convinced that none of the treatment was novel or superior to another. But students in EGs might tought that they had received special treatment, which may cause an increase their post-tests scores.

There were not any selections of students with respect to their low or high scores. Therefore there was no regression threat in the study.

In the study, the same teacher implemented the instructions in both EGs and CGs. Therefore the teacher quality was the same for both groups. In addition both CGs and EGs were observed to check whether the interventions in these groups were done as intended. As a result, implementation threat was assumed to be controlled.

4.11 Analysis of Data

SPSS was used to analyze the raw data obtained from this study both for descriptive and inferential purposes.

4.11.1 Descriptive Statistics

Mean, range, maximum and minimum values, standard deviation, skewness, kurtosis, frequency tables and bar graphs were used for the data obtained from students in experimental and control groups.

4.11.2 Inferential Statistics

Independent sample t-tests were used to check the equality of groups in the scores of diffusion and osmosis diagnostic test, diffusion and osmosis achievement test, attitude scale toward biology, and science process skill test before the treatment. According to the results of the t-test, students' science process skills were determined as covariate.

Analysis of Covariance (ANCOVA) and Analysis of Variance (ANOVA) were used for inferential statistics. ANCOVA was used to determine effectiveness of two different instructional methods and gender difference on students' understanding and achievement related to diffusion and osmosis concepts by controlling the effect of students' science process skills as a covariate. Two-way ANOVA was used to test the effect of treatment on students' attitudes toward biology as a school subject. In addition, two-way ANOVA was used to examine the gender effect on students' attitudes toward biology as a school subject.

4.12 Assumptions and Limitations

4.12.1 Assumptions of the Study

1. The teacher was not biased during the treatments
2. There was no interaction between groups
3. Standardized conditions were provided during the administrations of the test
4. The instruments were answered seriously and honestly
5. The classroom observations were performed under standardized conditions

4.12.2 Limitations of the Study

1. This study only covers the "Diffusion and Osmosis" concepts in biology
2. Random sampling was not used because of the administration procedures
3. The number of subjects of the study were limited to 66 ninth grade students
4. Students in the experimental groups worked in groups, which might affect the independency of observations assumptions of ANCOVA

CHAPTER 5

RESULTS AND CONCLUSION

In this chapter, descriptive analysis of treatment scores, inferential statistics about hypothesis given in Chapter III, results of Diffusion and Osmosis Diagnostic Test (DODT), and classroom observations were stated. For this purpose, descriptive analysis of pre-test and post-test scores, inferential statistics about hypothesis, analysis of Diffusion and Osmosis Diagnostic Test (DODT) scores, and analysis of classroom observations were presented.

5.1 Descriptive Statistical Analysis of Pre- and Post- test Scores of DODT, DOACH, ASTB, and SPST Scores

Table 5.1 presents the descriptive statistics results of students in experimental and control groups related to their DODT pre- and post- test scores, DOACH pre- and post- test scores, ASTB pre- and post- test scores, and science process skill test scores for the experimental and control groups.

Table 5.1 Descriptive Statistics Related to the Diffusion and Osmosis Diagnostic Test (DODT), Diffusion and Osmosis Achievement Test (DODT), Attitude Scale Toward Biology (ASTB), and Science Process Skill Test (SPST) scores in Control Group (CG) and in Experimental Group (EG)

Group	Test	N	Min	Max	Mean	SD	Skewness	Kurtosis
CG	PreDOACH	32	5	16	10.18	2.70	.445	-.296
	PostDOACH	32	6	18	12.40	2.93	-.037	.443
	PreDODT	32	1	5	2.62	1.10	.359	-.249
	PostDODT	32	2	8	5.12	1.49	.327	-.046
	PreASTB	32	36	65	48.44	6.35	.386	.989
	PostASTB	32	42	68	54.34	5.73	.927	1.691
	SPST	32	10	29	19.15	5.32	.021	-.715
EG	PreDOACH	34	4	17	11.55	3.28	.490	.190
	PostDOACH	34	11	20	18.56	2.33	-.829	.277
	PreDODT	34	1	5	3.08	1.02	.172	-.690
	PostDODT	34	4	12	8.88	1.71	.193	.137
	PreASTB	34	37	62	51.76	7.15	-.565	-.868
	PostASTB	34	49	70	62.94	5.25	-.696	-.031
	SPST	34	19	35	28.85	3.65	-.501	.081

When pre-diffusion and osmosis achievement test (PreDOACH) scores of students in the control and experimental group are examined; in the control group, students' pre-diffusion and osmosis achievement test scores range from 5 to 16 with a mean of 10.18, in the experimental group students' pre-diffusion and osmosis achievement test scores range from 4 to 17 with a mean of 11.55. The difference between the mean pre-diffusion and osmosis achievement test scores of students in the control and experimental group is 1.37. When the students' post-diffusion and osmosis achievement test (PostDOACH) scores in the control and experimental group are examined, in the control group, students' post-diffusion and osmosis achievement test scores range from 6 to 18 with a mean of 12.40 and in the experimental group students' post-diffusion and osmosis achievement test scores range from 11 to 20 with a mean of 18.56. There is a 7.01 increase in the mean scores of students in experimental group however there is a 2.22 increase in the mean scores of students in the control group. This means that mean score increase of students' diffusion and osmosis achievement test in experimental group is higher than in control group.

Students' pre-diffusion and osmosis diagnostic test (PreDODT) scores range from 1 to 5 in control group with a mean score of 2.62 and range from 1 to 5 in experimental group with a higher mean score of 3.08. The mean post-diffusion and osmosis diagnostic test (PostDODT) score of students in the control group is 5.12 while it is 8.88 for students in the experimental group. This means that there is a 5.8 increase in the mean scores of students in experimental group and a 2.5 increase in the mean scores of students in the control group.

Students' pre-attitude scales toward biology (PreASTB) scores range from 36 to 65 in control group with a mean score of 48.44 and range from 37 to 62 in experimental group with a higher mean score of 51.76. The mean post-attitude scale toward biology (PostASTB) scores of students in the control group is 54.34 while it is 62.94 for students in the experimental group. This means that there is a 5.9 increase in the mean scores of students in control group and a 11.18 increase in the mean scores of students in the experimental group.

Students' science process skills test scores range from 10 to 29 for control group and from 19 to 35 for experimental group. This greater range score for experimental group indicates these students in experimental group have higher abilities in solving science problems.

When examining the skewness and kurtosis values of all test scores, it can be seen that all of the scores are present in the range from -2 to +2 as an indication of normal distribution.

5.2 Inferential Statistics

This section presents the analysis of nine null hypothesis stated in Chapter III. For this statistical analysis process SPSS/PC (Statistical Package for Social Sciences for Personal Computers) was used. In order to test null hypothesis analysis of variance (ANOVA) and analysis of covariance (ANCOVA) were used at a significance level of .05.

Before performing the ANOVA and ANCOVA, independent sample t-test analyses were carried out to test whether there was a significant mean differences between experimental and control groups with respect to students' understanding of diffusion and osmosis concepts measured by diffusion and osmosis diagnostic test (DODT), students' achievement in diffusion and osmosis concepts measured by diffusion and osmosis achievement test (DOACH), students' attitude toward biology as a school subject measured by attitude scale toward biology (ASTB), and students' science process skills measured by science process skill test (SPST) before the treatment.

The results of this independent sample t-test analyses can be summarized as there was no significant mean difference between the 7ELCBI (7E Learning Cycle Based Instruction) group and TDBI (Traditional Designed Biology Instruction) with respect to students' understanding on diffusion and osmosis concepts ($t\ (64) = 1.770$, $p = .081$), students' achievement in diffusion and osmosis concepts ($t\ (64) = .974$, $p = .334$), and students' attitudes toward biology ($t\ (64) = 1.992$, $p = .055$) before the treatment. However, it was found that there was a significant difference between EG and CG with respect to students' science process skills ($t\ (64) = 8.675$, $p = .000$). Therefore, it was decided to use students' science process skill scores as a covariate in the statistical analysis of the post test scores in order to control pre-existing differences.

5.2.1 Null Hypothesis 1

First null hypothesis stated that there is no significant mean difference between post-test mean scores of students taught with the instruction based on 7E learning cycle model accompanied with computer animations and students taught with traditionally designed biology instruction in students' understanding of diffusion and osmosis concepts when science process skill is controlled as a covariate. Analysis of Covariate (ANCOVA) was conducted in order to test this hypothesis. Before the process of analysis, assumptions of ANCOVA were checked.

First assumption of ANCOVA is the univariate normality. When skewness and kurtosis values from Table 5.1 are controlled we can say that students' understanding of diffusion and osmosis diagnostic test (DODT) scores are normally distributed.

Second assumption is the independent observation. For this assumption, it is assumed that during the administration of the test standardized conditions were provided. In addition, during the test administration processes both classroom teacher and the observer made observations. Therefore it is possible to say that students during test administration process did not affect each other.

As a third assumption, equality of the variances must be checked. For this purpose Levene's Test of Equality was used. The results showed that the assumption of equality of the variances is provided ($F(1, 64) = .275$, $p>.05$).

Forth assumption of ANCOVA says that there should not be any interaction between independent variables and covariate (Group and SPST). As Table 5.2 below shows that there is no custom interaction between group and students' science process skill scores ($F(1,1) = 2.693$, $p> .05$).

Table 5.2 Tests of Between-Subjects Effects

Source	df	SS	MS	F	p
Group	1	2.534	2.534	2.306	.134
SPST	1	2.141	2.141	1.948	.168
Group*SPST	1	2.960	2.960	2.693	.106
Error	62	68.145	1.099		

The last assumption requires a significant correlation between dependent variable and covariate. In order to check this assumption correlation between students' diffusion and osmosis diagnostic test (DODT) scores and science process skill test (SPST) scores were correlated as shown in Table 5.3. As it can be seen from the table correlation is significant.

Table 5.3 Correlation between post-diffusion and osmosis diagnostic test (PostDODT) scores and SPST scores

		(PostDODT)	SPST
	Pearson Correlation	1	.648**
(PostDODT)	Sig.	.	.000
	N	66	66
	Pearson Correlation	.648	1
SPST	Sig.	.000	.
	N	66	66

The results of ANCOVA can be summarized in Table 5.4 since all assumptions of the ANCOVA were met.

Table 5.4 Summary of the ANCOVA

Source	df	SS	MS	F	p
SPST	1	9.918	9.918	3.974	.051
Group	1	65.105	65.105	26.087	.000
Gender	1	4.198	4.198	1.682	.200
Group*Gender	1	1.027	1.027	.411	.524
Error	61	152.236	2.496		

The results indicated that there was a significant mean difference between post mean scores of students instructed with 7E Learning Cycle Based Instruction (7ELCBI) accompanied with computer animations and students instructed with Traditional Designed Biology Instruction (TDBI) in students' understanding of diffusion and osmosis concepts when science process skill is controlled as a covariate (F (1, 61) = 26.086, p< .05). The 7ELCBI group scored significantly higher than TDBI group ($\overline{X}$ (7ELCBI) = 8.88, $\overline{X}$ (TDBI) = 5.12).

Table 5.5 presents concepts assessed by the Diffusion and Osmosis Diagnostic Test (DODT) and percentage of students' responses for TDBI (control) and 7ELCBI (experimental) groups in the test. Figure 5.1 presents the proportions of the students' correct responses to the questions (combination of desired choice and reason) in the DODT post-test for both TDBI (control) and 7ELCBI (experimental) groups. In addition Figure 5.2 shows percentage of post test performance of students in selecting desire choice and reason in DODT for 7ELCBI (control) group and TDBI (experimental) group.

Table 5.5 Concepts assessed by the Diffusion and Osmosis Diagnostic Test (DODT) and percentage of students' Responses for TDBI (control) and 7ELCBI (experimental) groups in the test

Concept Assessed	**Item no**	**Question pairs**	**TDBI group (control)**	**7ELCBI group (experimental)**
The process of diffusion	1	1,2	63	94
The particulate nature and random motion of matter	2	3,4	45	59
The particulate nature and random motion of matter	3	5,6	55	67
Concentration and tonicity	4	7,8	73	92
The process of diffusion	5	9,10	48	67
The particulate nature and random motion of matter	6	11,12	39	77
Kinetic energy of matter	7	13, 14	85	94
The process of osmosis	8	15, 16	25	53
Concentration and tonicity	9	17, 18	13	45
The process of osmosis	10	19, 20	47	55
The influence of life forces on diffusion and osmosis	11	21, 22	13	35
Membranes	12	23, 24	84	94

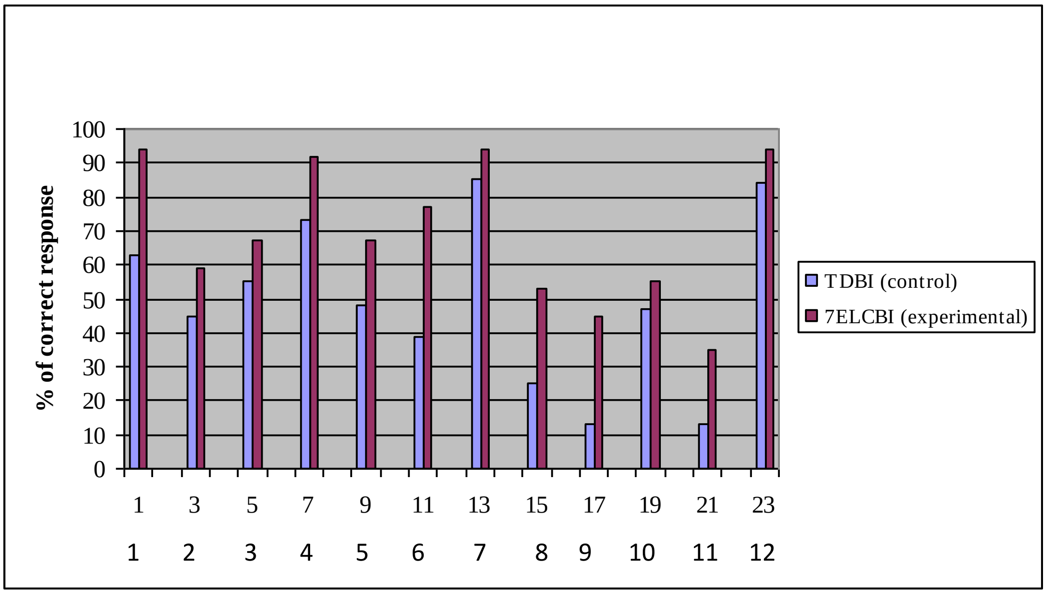

Figure 5.1 Percent comparison of DODT post-test performance of students in correctly selecting both desired choice and reason for 7ELCBI group and TDBI group

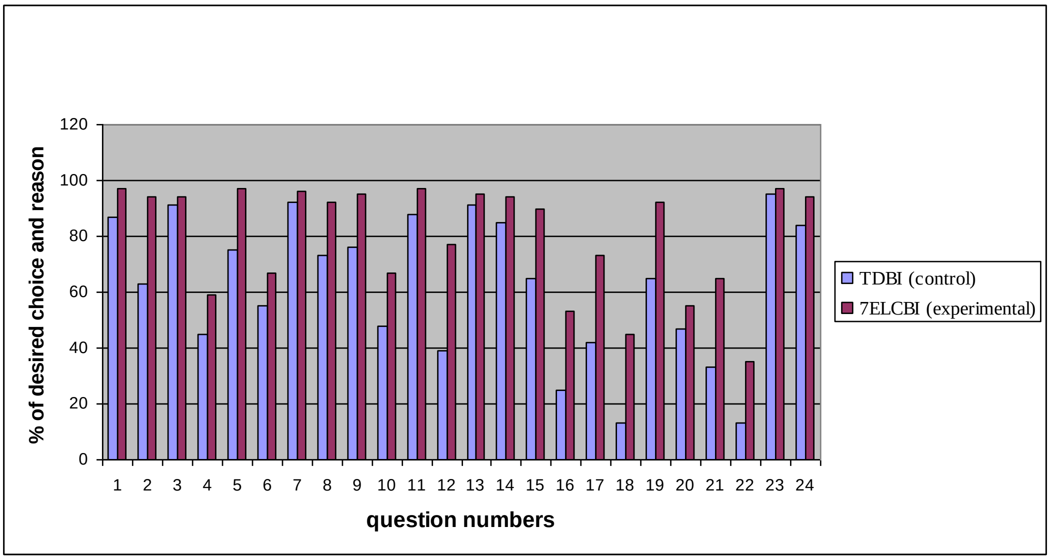

Figure 5.2 Percentage of post test performance of students in selecting desired choice (odd numbers) and reason (even numbers) in DODT for 7ELCBI (control) group and TDBI (experimental) group

It is clearly seen from the Figure 5.1 that the overall DODT post-test performance of students in correct selecting both desire content choice and reason was higher for 7ELCBI group than for TDBI group.

There were dramatic differences in the proportions of students in correct selecting of both desire choice and reason between two groups for the item number 6 (question 11 and 12), 8 (question 15 and 16), 9 (question 17 and 18) and 11 (question 21 and 22) in the DODT. These are mainly the items having complex reasoning (see Appendix B). These reasoning questions primarily assess students' understanding of the underlying mechanisms. That is because of this the content and reason items were graded together, so that insights into students' conceptual understanding of the process are obtained (Odom & Barrow, 1995).

Item 6 was about the particulate nature of random motion of matter. The content part (question 11) and its reasoning part (question 12) with their correct alternatives (∗) are stated below:

11. Suppose you add a drop of blue dye to a container of clear water and after several hours the entire turns light blue. At this time, the molecules of dye:
    a. Have stopped moving
    ∗b. Continue to move around randomly

12. The reason for my answer in question 11 is because:
    a. The entire container is the same color; if they were still moving, the container would be different shades of blue.
    b. If the dye molecules stopped, they would settle to the bottom of the container.
    ∗c. Molecules are always moving.
    d. This is a liquid: if it were solid the molecules would stop moving.

Before the treatment, a reasonable percentage of students in both groups selected desired content choice (68% in control group, 59% in experimental group) and its desired reason (25% in control group, 31% in experimental group). After treatment, while 88% of the students in the control and 97% of the students in the experimental group selected the desired content choice, 39% of the students in the control group and 77% of the students in the experimental group gave the correct reasoning (see Table 5.12). So it was found that 39% of the students in the control group and 77% of the students in the experimental group selected both desired content and its desired reasoning. This indicated that misconceptions on this question content were more improved for the students in the experimental group than for the students in the control group.

Item 8 was about the process of osmosis. The content part (question 15) and its reasoning part (question 16) part with their correct alternatives (∗) is stated below:

15. In *Figure 2*, two columns of water are separated by a membrane through which only water can pass. Side 1 contains dye and water; side two contains pure water. After 2 hours, the water level in side 1 will be;

∗a. higher
b. lower
c. the same height

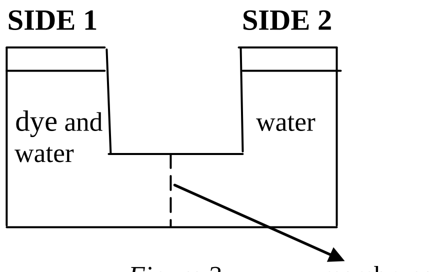

Figure 2

16. The reason for my answer in question 15 is because:
a. Water will move from the hypertonic to hypotonic solution.
∗b. The concentration of water molecules is less on side 1.
c. Water will become isotonic.
d. Water moves from low to high concentration.

For this question, 15% of the students in the control group, 17% of the students in the experimental group selected desired content choice before the treatment. For its reasoning, 11% of the students in control group and 9% of the students in experimental group selected correct choice. After treatment, 65% of the students in the control and 90% of the students in the experimental group selected the desired content choice while 25% of the students in the control group and 53% of the students in the experimental group selected its reasoning correctly (see Table 5.12). So it was found that 25% of the students in the control group and 53% of the students in the experimental group selected both content and its reasoning correctly. This result also indicated that after treatment process students misconceptions were more improved for the students in the experimental group than for the students in the control group.

Item 9 was about concentration and tonicity. The content part (question 17) and its reasoning part (question 18) with their correct alternatives (∗) is stated below:

17. In *Figure 3*, side 1 is [......] to side 2.
a. hypotonic
∗b. hypertonic
c. isotonic,

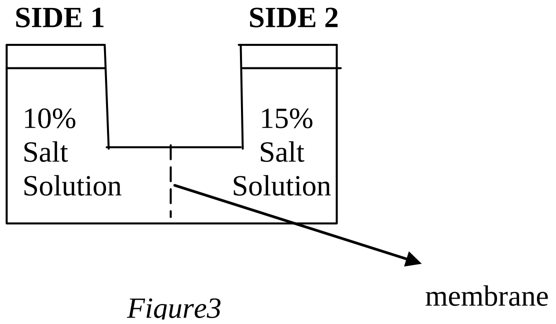

Figure3

18. The reason for my answer in question 17 is because:
a. Water is hypertonic to most things.
b. Isotonic means “the same”.
c. Water moves from a high to a low concentration.
∗d. There are fewer dissolved particles on side 1.

Before the treatment, 9% of the students in the control group, 9% of the students in the experimental group selected desired content choice before the treatment. For its reasoning, 4% of the students in control group and 3% of the students in experimental group selected correct choice. After treatment 42% of the students in the control and 73% of the students in the experimental group selected the desired content choice while 13% of the students in the control group and 45% of the students in the experimental group selected its reasoning correctly (see Table 5.12). So it was found that 13% of the students in the control group and

45% of the students in the experimental group selected both content and its reasoning correctly. It showed that after treatment process students misconceptions were more improved for the students in the experimental group than for the students in the control group.

Item 11 was about the influence of life forces on diffusion and osmosis. The content part (question 21) and its reasoning part (question 22) part with their correct alternatives (∗) is stated below:

21. Suppose you killed the plant cell in Figure 4 with poison and immediately placed the dead cell in a 25% saltwater solution.
    a. Osmosis and diffusion would not occur.
    ∗b. Osmosis and diffusion would continue.
    c. Only diffusion would continue.
    d. Only osmosis would continue.

22. The reason for my answer in question 21 is because:
    a. The cell would stop functioning.
    ∗b. The cell does not have to be alive.
    b. Osmosis is not random, whereas diffusion is a random process.
    c. Osmosis and diffusion require cell energy.

For this question, 5% of the students in the control group, 7% of the students in the experimental group selected desired content choice before the treatment. For its reasoning, 3% of the students in control group and 4% of the students in experimental group selected correct choice. After treatment, 33% of the students in the control and 65% of the students in the experimental group selected the desired content choice while 13% of the students in the control group and 35% of the students in the experimental group selected its reasoning correctly (see Table 5.12). So it was found that 13% of the students in the control group and 35% of the students in the experimental group selected both content and its reasoning correctly. This result also indicated that after treatment process students misconceptions were more improved for the students in the experimental group than for the students in the control group.

In summary, the results showed that the students instructed with 7ELCBI in experimental group had better understanding in diffusion and osmosis concepts than students in the control group instructed with TDBI model.

5.2.2 Null Hypothesis 2

The second null hypothesis stated that there is no significant mean difference between post-test mean scores of students taught with the instruction based on 7E learning cycle model accompanied with computer animations and students taught with traditionally designed biology instruction in students' achievement in diffusion and osmosis concepts when science process skill is controlled as a covariate. The testing of this hypothesis was controlled by the use of analysis of covariance (ANCOVA). Before the process of analysis, assumptions of ANCOVA were checked.

As the first assumption of ANCOVA, the univariate normality was checked. When skewness and kurtosis values from Table 5.1 are controlled we can say that students' achievement in diffusion and osmosis diagnostic test (DODT) scores are normally distributed.

As the second assumption of ANCOVA, the independent observation was met. For this assumption, it is assumed that during the administration of the test standardized conditions were provided. In addition, during the test administration processes both classroom teacher and the observer made observations. Therefore it is possible to say that students during test administration process did not affect each other.

As a third assumption, equality of the variances must be checked. For this purpose Levene's Test of Equality was used. The results showed that the assumption of equality of the variances is provided ($F(1, 64) = .931$, $p>.05$).

Forth assumption of ANCOVA says that there should not be any interaction between independent variables and covariate (Group and SPST). As table 5.6 below shows that there is no custom interaction between group and students' science process skill scores ($F (1,1) = .001$, $p > .05$).

Table 5.6 Tests of Between-Subjects Effects

Source	df	SS	MS	F	p
Group	1	4.581	4.581	.336	.434
SPST	1	.047	.047	.005	.868
Group*SPST	1	.005	.005	.001	.896
Error	62	451.550	7.099		

The last assumption requires a significant correlation between dependent variable and covariate. In order to check this assumption correlation between students' diffusion and osmosis achievement test (DOACH) scores and science process skill test (SPST) scores were correlated as shown in Table 5.7. As it can be seen from the table correlation is significant.

Table 5.7 Correlation between post-diffusion and osmosis diagnostic test (PostDOACH) scores and SPST scores

		(PostDOACH)	SPST
	Pearson Correlation	1	.688**
(PostDOACH)	Sig.	.	.000
	N	66	66
	Pearson Correlation	.688	1
SPST	Sig.	.000	.
	N	66	66

After checking all assumptions, ANCOVA was run and the results can be summarized in Table 5.8

Table 5.8 Summary of the ANCOVA

Source	df	SS	MS	F	p
SPST	1	70.563	70.563	11.482	.001
Group	1	61.719	61.719	10.043	.002
Gender	1	1.446	1.446	.235	.629
Group*Gender	1	.660	.660	.107	.744
Error	61	374.863	6.145		

The results showed that there was a significant mean difference between post mean scores of students instructed with 7E Learning Cycle Based Instruction (7ELCBI) accompanied with computer animations and students instructed with Traditional Designed Biology Instruction (TDBI) in students' achievement of diffusion and osmosis concepts when science process skill is controlled as a covariate ($F (1, 61) = 10.043$, $p< .05$). The 7ELCBI group scored significantly higher than TDBI group ($\overline{X}$ (7ELCBI) = 18.56, $\overline{X}$ (TDBI) = 12.40).

5.2.3 Null Hypothesis 3

The third hypothesis stated that there is no significant mean difference between post-test mean scores of males and females on their understanding of diffusion and osmosis concepts when science process skill is controlled as a covariate. In order to test this hypothesis analysis of covariance (ANCOVA) was used but before the process of analysis, assumptions of ANCOVA were checked.

The first assumption of ANCOVA is the univariate normality. Skewness and kurtosis values from Table 5.1 indicated that students' understanding of diffusion and osmosis diagnostic test (DODT) scores are normally distributed. For the independent observation assumption of the ANCOVA, it is assumed that standardized conditions were provided during test administration. For third assumption of the ANCOVA, which is the equality of the variances, Levene's Test of Equality was used. The results showed that the assumption of equality of the variances is provided (F (1, 64) = .535, p>.05).

Forth assumption of ANCOVA says that there should not be any interaction between independent variables and covariate (Gender and SPST). As Table 5.9 below shows that there is no custom interaction between gender and students' science process skill scores (F (1,1) = .615, p> .05).

Table 5.9 Tests of Between-Subjects Effects

Source	df	SS	MS	F	p
Gender	1	.574	.574	.504	.480
SPST	1	3.375	3.375	2.963	.090
Gender*SPST	1	.700	.700	.615	.436
Error	62	70.631	1.139		

The last assumption requires a significant correlation between dependent variable and covariate. In order to check this assumption correlation between students' diffusion and osmosis diagnostic test (DODT) scores and science process skill test (SPST) scores were correlated as shown in Table 5.3. As it can be seen from the table correlation is significant.

After checking all assumptions, ANCOVA was run and the results can be summarized in Table 5.4. The results on the table showed that there was no significant mean difference between female and male students with respect to students understanding of diffusion and osmosis concepts when science process skill is controlled as a covariate (F (1, 61) = 1.682, p> .05). The mean post-test DODT scores for females and males were 5.37 and 6.53 respectively.

5.2.4 Null Hypothesis 4

The fourth hypothesis stated that there no significant mean difference between post-test mean scores males and females on their achievement in diffusion and osmosis concepts when science process skill is controlled as a covariate. In order to test this hypothesis analysis of covariance (ANCOVA) was used but before the process of analysis, assumptions of ANCOVA were checked.

The first assumption of ANCOVA is the univariate normality. Skewness and kurtosis values from Table 5.1 indicated that students' achievement in diffusion and osmosis achievement test (DOACH) scores are normally distributed. For the independent observation assumption of the ANCOVA, it is assumed that standardized conditions were provided during test administration. For third assumption of the ANCOVA, which is the equality of the variances, Levene's Test of Equality was used. The results showed that the assumption of equality of the variances is provided ($F\ (1, 64) = .649, p>.05$).

Forth assumption of ANCOVA says that there should not be any interaction between independent variables and covariate (Gender and SPST). As table 5.10 below shows that there is no custom interaction between gender and students' science process skill scores ($F\ (1,1) = 2.260, p> .05$).

Table 5.10 Tests of Between-Subjects Effects

Source	df	SS	MS	F	p
Gender	1	12.002	12.002	1.669	.201
SPST	1	70.489	70.489	9.802	.003
Gender*SPST	1	16.251	16.251	2.260	.138
Error	62	445.868	7.191		

The last assumption requires a significant correlation between dependent variable and covariate. In order to check this assumption correlation between students' diffusion and osmosis achievement test (DOACH) scores and science process skill test (SPST) scores were correlated as shown in Table 5.7. As it can be seen from the table correlation is significant.

After checking all assumptions, ANCOVA was run and the results can be summarized in Table 5.8. The results on the table showed that there was no significant mean difference between female and male students with respect to students' achievement in diffusion and osmosis concepts when science process skill is controlled as a covariate ($F(1, 61) = .235$, $p > .05$). The mean post-test DODT scores for females and males were 14.30 and 15.41 respectively.

5.2.5 Null Hypothesis 5

The fifth hypothesis stated that there is no significant effect of interaction between gender difference and treatment on students' understanding of diffusion and osmosis concepts when science process skill is controlled as a covariate. In order to test this hypothesis analysis of covariance (ANCOVA) was used. Table 5.4 shows the effect of interaction between gender difference and treatment on students' understanding of diffusion and osmosis concepts. The results showed that there was no significant interaction effect between gender and treatment on students' understanding of diffusion and osmosis concepts ($F(1, 61) = .411$, $p > .05$).

5.2.6 Null Hypothesis 6

The sixth hypothesis stated that there is no significant effect of interaction between gender differences and treatment on students' achievement in diffusion and osmosis concepts when science process skill is controlled as a covariate. In order to test this hypothesis analysis of covariance (ANCOVA) was used. Table 5.8 shows the effect of interaction between gender difference and treatment on students' achievement in diffusion and osmosis concepts. The results showed that there was no significant interaction effect between gender and treatment on students' achievement in diffusion and osmosis concepts ($F(1, 61) = .107$, $p > .05$).

5.2.7 Null Hypothesis 7

The seventh hypothesis stated that there is no significant mean difference between the students taught with instruction based on 7E learning cycle model accompanied with computer animations and students taught with traditionally designed biology instruction with respect to their attitudes toward biology as a school subject. In order to test this hypothesis two-way analysis of variance (ANOVA) was used but before the process of analysis, assumptions of ANOVA were checked at first.

As the first assumption of ANOVA univariate normality was tested. For this purpose, skewness and kurtosis values from Table 5.1 were examined. The results indicated that students' attitudes scales toward biology scores (ASTB) scores are normally distributed. For the second assumption of ANOVA, that is the independent observation, it is assumed that standardized conditions were provided during test administration. For the equality of the variances assumption of ANOVA, Levene's Test of Equality was used. The results showed that the assumption of equality of the variances is provided ($F(1, 64) = 2.829$, $p > .05$).

After checking all assumptions, ANOVA was run and the results can be summarized in Table 5.11.

Table 5.11 Summary of the ANOVA

Source	df	SS	MS	F	p
Group	1	1800.848	1800.848	62.829	.000
Gender	1	59.232	59.232	2.067	.156
Group*Gender	1	98.112	98.112	3.423	.069
Error	62	1777.075	28.662		

The results revealed that there was a significant mean difference between students taught with instruction based on 7E learning cycle model accompanied with computer animations and students taught with traditionally designed biology instruction with respect to their attitudes toward biology as a school subject ($F(1, 62) = 62.829$, $p < .05$). The 7ELCBI group scored significantly higher than TDBI group ($\overline{X}$ (7ELCBI) = 62.94, $\overline{X}$ (TDBI) = 51.34).

5.2.8 Null Hypothesis 8

The eighth null hypothesis stated that there is no significant mean difference between males and females with respect to students' attitudes toward biology as a school subject. In order to test this hypothesis two-way analysis of variance (ANOVA) was used. Table 5.11 shows the effect of gender difference on students' attitudes toward biology. The results showed that there was no significance difference between female and male students with respect to students' attitudes toward biology as a school subject ($F(1, 62) = 2.067$, $p > .05$).

5.2.9 Null Hypothesis 9

The ninth null hypothesis stated that there is no significant effect of interaction between gender difference and treatment on students' attitudes toward biology as a school subject. In order to test this hypothesis two-way analysis of variance (ANOVA) was used. Table 5.11 shows the interaction effect between gender difference and treatment on students' attitudes toward biology as a school subject. The results showed that there was no significance interaction effect between gender difference and treatment on students' attitudes toward biology as a school subject ($F(1, 62) = 3.423$, $p > .05$).

5.3 Analysis of Diffusion and Osmosis Diagnostic Test (DODT) Results

This section focuses on possible reasons for the difficulties related to diffusion and osmosis concepts; therefore each item on Diffusion and Osmosis Diagnostic Test (DODT) was examined. According to Gilbert (1997), if a multiple choice item has four to five distracters, understanding is considered satisfactory if 75% of the students answer the item correctly. With a multiple choice test with four possible selections, there is a 25% chance of guessing the correct answer. Gilbert' this criterion is used to discuss treatment groups and items on the DODT. For this study, for the first tier of the test, the range of the correct answers was 33% to 95% for control group and 65% to 97% for experimental group. It can be seen from Table 5.12 below. When the combination of both tiers considered, the range of correct response decreased to 13% to 85% for control group and 35% to 94% for experimental group.

Results of Diffusion and Osmosis Diagnostic Test suggest that students in the experimental group acquired a satisfactory understanding of diffusion and osmosis concepts. Because students in control group scored above 75% only on 2 of 12 items, students in experimental group scored above 75% on 5 of 12 items.

Conceptual areas covered by Diffusion and Osmosis Diagnostic Test were grouped under seven different headings: (1) particulate and random nature of matter, (2) concentration and tonicity, (3) the influence of life forces on diffusion and osmosis, (4) the process of diffusion, (5) the process of osmosis, (6) kinetic energy of matter, and (7) membranes.

Table 5.12 Concepts Assessed by the Diffusion and Osmosis Diagnostic Test and Percentage of post test performance of students in selecting desire choice and combination (both content choice and reason) for control and experimental group

			Control group		Experimental group	
Concept Assessed	**Item no**	**Question pairs**	**Content Choice**	**Combination**	**Content Choice**	**Combination**
The process of diffusion	1	1,2	87	63	97	94
The particulate nature and random motion of matter	2	3,4	91	45	94	59
The particulate nature and random motion of matter	3	5,6	75	55	97	67
Concentration and tonicity	4	7,8	92	73	96	92
The process of diffusion	5	9,10	76	48	95	67
The particulate nature and random motion of matter	6	11,12	88	39	97	77
Kinetic energy of matter	7	13, 14	91	85	95	94
The process of osmosis	8	15, 16	65	25	90	53
Concentration and tonicity	9	17, 18	42	13	73	45
The process of osmosis	10	19, 20	65	47	92	55
The influence of life forces on diffusion and osmosis	11	21, 22	33	13	65	35
Membranes	12	23, 24	95	84	97	94

Kinetic Energy of Matter

This concept was tested by item 7 in the test (question 13 and 14 in this study). When results were analyzed over 85% of the students in each treatment group selected correct combination of content and reason. In the question, students were asked to determine the effect of temperature on the rate of diffusion of green dye particles. In both group this concept was covered under the heading of “factors affecting the rate of diffusion”. The effect of temperature was discussed by the use of pictures on power-point slides in both groups, and it was related with the effect of other factors as solubility of the molecules in lipids, size or charge of the molecules, or concentration gradient. The reason why each treatment group scored high may be because the concept is related with chemistry and most of the students had already idea about the relation between temperature and kinetic energy of the molecules.

The Particulate Nature and Random Motion of Matter

This concept was tested by items 2 (question 3 and 4), 3 (questions 5 and 6), and 6 (questions 11 and 12) in the DODT. They measured students’ understandings of the movement of molecules from an area of high concentration to an area of low concentration at the molecular level. Students in the experimental group learnt this concept through the use of experimentation, integrated animations and demonstration methods however students in the control group only observed the demonstrations of diffusion process and saw the same animation at the end of the unit, not integrated into experiment. For example, teacher made a demonstration to show the movement of molecules across a differentially permeable membrane by using phenolphthalein, NaOH, starch, and iodine solutions. Molecular movement was observed as color changes after a period of time.

For item 2, students in the experimental group had an average score of 59%; which was 14% above the students in the control group with an average score of 45% for this item. Since both of the treatment group scores were below 75% on this item, an unsatisfactory understanding of the concept can be suggested. Desired response for this item was;

> "During the process of diffusion, particles will generally move from high to low concentrations because particles in areas of greater concentration are more likely to bounce towards other areas"

A common alternative response to item was "there are too many particles crowded into one area: therefore, they move an area with more room". It was probably due to a misunderstanding of tendency of molecules to move an area with more room. Students may think that molecules when crowded into an area always tend to move an area with more room. They may ignore tendency of molecules to move due to their kinetic energies. This result indicated that these students had partial understanding of diffusion process.

Item 3 was asked to assess students' understanding about the affect of concentration gradient on the rate of diffusion. The desired response for this item was;

> "As the difference in concentration between two areas increases, the rate of diffusion increases because there is a greater likelihood of random motion into other regions.

The average score of students for this question was 67% in experimental group and 55% in control group. Since both of the treatment group scores were below 75% on this item, an unsatisfactory understanding of the concept can be suggested. The most common alternative response to this item was "As the difference in concentration between two areas increases, the rate of diffusion increases because molecules want to spread out". Most probably students may think an area where molecules have difficulty to stay.

Item 6 was asked students to determine their understanding about what would happen to blue dye molecules after they had been evenly distributed throughout a large container of clear water. The desired response for this item was;

> "The molecules of dye continue to move around randomly because molecules are always moving".

The average score of students with 77% in experimental group was suggesting a satisfactory understanding but with 39% in control group was suggesting an unsatisfactory understanding. This difference can be explained by the use of observation, experimentation and integrated animations in the experiment group. The control group students observed the demonstration made by the teacher, so they were not given the opportunity for active construction of knowledge that was provided for experimental group students. They were also watched the animations but not as integrated into teaching instruction rather than as a summary at the end of the unit. One of the most common alternative responses to this item was "This is a liquid: if it were solid the molecules would stop moving". This was most probably because students may relate the alternative response of content part that was "the molecules of dye have stopped moving" with this alternative response of reason part.

Concentration and Tonicity

These concepts were tested by items 4 (question 7 and 8) and 9 (questions 17 and 18) in the DODT. They measured students' understandings of the movement of molecules from an area of high concentration to an area of low concentration at the molecular level. In control group students observed and in experimental group students participated in related activities. For example students in the experimental group investigated the effect of different solutions to a placed decalcified egg as a representative of a cell. Students in the control group, on the other hand, were given an explanation and discussion of this experiment with the use of power point slides. They were also given with the questions that students in the experimental group were investigated.

Item 4 was asked to assess students' understanding about the concept of concentration. The desired response for this item was;

> "A glucose solution can be made more concentrated by adding more glucose because it increases the number of dissolved particles".

The average score of students with 92% in experimental group was suggesting a satisfactory understanding but with 73% in control group was suggesting an unsatisfactory understanding as it was below 75%. This difference can also be explained by the use of observation, experimentation and integrated animations in the experiment group. The experimental group students investigated the effect of different sucrose solutions having different concentrations with the addition different amount of sucrose on the size of dialysis bags and watched an animation about the process of osmosis. Students in the control group were not given the opportunity for active construction of knowledge that was provided for experimental group students. One of the most common alternative responses to this item was "Concentration means the dissolving of something." This was possible that students were confused by the definition of concentration and becoming more concentrated.

Item 9 was asked to assess students' understanding about concepts of tonicity. The desired response for this item was;

> "In Figure 3, side 1 is hypotonic to side 2 because there are fewer dissolved particles on side 1".

Students in the experimental group had an average score of 45%; which was 32% above the students in the control group with an average score of 13% for this item. Since both of the treatment group scores were below 75% on this item, an unsatisfactory understanding of the concept can be suggested. This questions involved specific terminologies as hypotonic, hypertonic, or isotonic. The most common alternative responses to this item was “In Figure 3, side 1 is hypotonic to side 2 because water moves from a high to a low concentration”. This was possible that students had confusion about the content part and its reasoning part. Because content part asked about “hypotonic” solution but students thought about direction of the water flow. The reason for higher percentage of experimental group can be explained by the participation of them into an experiment directly related about concepts of concentration and tonicity, and the use of integrated animations related to these concepts.

The Influence of Life Forces on Diffusion and Osmosis

These concepts were tested by item 11 (question 21 and 22) in the DODT. These questions measured students’ understandings of the diffusion and osmosis concepts in both living and nonliving systems. For nonliving system activities osmosis observed with the use of dialysis tubes, while for living system activities osmosis observed with the use of potato slides. The desired response for this item was;

> “In a death plant cell immediately in a 25% salt water solution osmosis and diffusion would continue because the cell does not have to be alive”.

Students in the experimental group had an average score of 35%; which was 22% above the students in the control group with an average score of 13 for this item. Since both of the treatment group scores were below 75% on this item, an unsatisfactory understanding of the concept can be suggested. A common alternative response to this item was “cell would stop functioning”. Students may probably think that diffusion and osmosis stop in a death cell since it was not functional any more.

Membranes

Item 12 was used to assess students' understanding of membrane concept related to diffusion and osmosis. Activities used in the study included osmosis with dialysis tubes. Students in the experimental group had an average score of 84% and students in the control group with an average score of 94% for this item. Since both of the treatment group scores were above 75% on this item, a satisfactory understanding of the concept can be suggested. The desired response for this item was;

> "All cell membranes are selectively permeable because they allow some substances to pass".

The students in the experimental group participated in two different experiments with dialysis tubes. In both of the investigation they had observed the selective permeability of the dialysis tube as a model of cell membrane. This could explain the high scores in experimental group.

The Process of Diffusion

Item 1 (questions 1 and 2) and item 5 (questions 9 and 10) were used to assess students' understanding of concepts related to diffusion process. For item 1, spraying of perfume as a demo of diffusion of gases was used so that students could smell the odour without going to the corner of the class where perfume was sprayed. As a second activity students observed the movement of crystal of a dye into a beaker of water. The desired response for this item was;

> "The process responsible for blue dye becoming evenly distributed throughout the water is there is movement of particles between regions of different concentrations".

The average score of students with 94% in experimental group was suggesting a satisfactory understanding but with 63% in control group was suggesting an unsatisfactory understanding as it was below 75%. The common alternative response to this item was “the dye separates into small particles and mixes with water”. Students may probably consider dye as a unit of particles so when it was dropped into water its particles separated into small particles and mixed with water.

Item 5 was asked to assess students’ understanding about diffusion of solid particles. The desired response for this item was;

> “The sugar molecules will be evenly distributed throughout the container because there is movement of particles from a high to low concentration”.

The average score of students for this question was 67% in experimental group and 48% in control group. Since both of the treatment group scores were below 75% on this item, an unsatisfactory understanding of the concept can be suggested. The most common alternative response to this item was “The sugar molecules will be evenly distributed throughout the container because the sugar is heavier than water and will sink”. Most probably students may think solid particles can not dissolve and therefore can not diffuse into water

The Process of Diffusion

Item 8 (questions 15 and 16) and item 10 (questions 19 and 20) were used to assess students’ understanding of concepts related to diffusion process. They measured students’ understandings of the concepts related to osmosis process. Students in the experimental group learnt these concepts through the use of experimentation, integrated animations and demonstration methods however students in the control group only observed the demonstrations of osmosis process and saw the same animation at the end of the unit, not integrated into experiment.

Item 8 was asked to assess students' understanding about the process of the osmosis through a selectively permeable membrane. The desired response for this item was;

> "After 2 hours, the water level in side 1 will be higher because the concentration of water molecules is less on side 1".

Students in the experimental group had an average score of 53%; which was 28% above the students in the control group with an average score of 25% for this item. Similar to item 9, this questions involved specific terminologies as hypotonic, hypertonic, or isotonic, which were difficult for most of the students to memorize. The most common alternative responses to this item was "After 2 hours, the water level in side 1 will be higher because water will move from the hypertonic to hypotonic solution". This was possible that students had confusion about the meaning of hypotonic, hypertonic, or isotonic concepts.

Item 10 was asked to assess students' understanding of the process of osmosis in a plant cell. The desired response for this item was;

> "If the plant cell was placed in a beaker of 25% saltwater solution, the central vacuole would decrease in size because water will move from the vacuole to the saltwater solution".

The average score of students for this question was 55% in experimental group and 47% in control group. Since both of the treatment group scores were below 75% on this item, an unsatisfactory understanding of the concept can be suggested. The most common alternative response to this item was "……central vacuole would decrease in size because the salt will enter the vacuole". Most probably students may think that concentration of salt molecules were higher outside than inside of the cell. So they tended to enter into cell.

5.4 Classroom Observations

Treatment process of this study was conducted over 4 weeks in a private high school in Istanbul. There were three 40-minute teaching sessions per week for experimental and control groups. Same biology teacher attended all 40-minute sessions over this time period. She followed same biology curriculum and text book for both groups.

The process of simple diffusion, the process of osmosis, the concepts of concentration and tonicity, selective permeability of the cell membrane, and factors affecting the rate of diffusion concepts were covered over four weeks period in both groups.

Visiting classroom environments two times by researcher before observation of real implementation process, making students become familiar with the process and so, a naturalistic observation approach was intended. During observations, researcher sat silently at one of the back corner of the observed classroom and took notes in accordance with the aims of observation. She never involved the teaching or learning process in any way. Since the main purpose classroom observations was to check treatment verification, treatment implementation process, any kind of reactions of students to the process, their participations and contributions to learning environment, and interactions between teacher-students, and students-students, teacher and the students' behaviour and attitudes as well as the physical conditions and material availability of the classroom were all observed.

In the experimental group, students were instructed with 7E learning cycle based instruction accompanied with computer animations. Five animations organized by the researcher were integrated into phases of the learning cycle by the teacher. Stages of the learning cycle were implemented with the use of appropriate teaching techniques as discussion, demonstration, animation, laboratory activities, and reading. For example for the first phase of the learning cycle, e*licit*, she tried to identify students' prior knowledge and misconceptions about diffusion and osmosis by asking a series of inquiry questions with respect to the list of students' alternative conceptions about diffusion of osmosis. During the discussion of each question she showed a related picture on screen on the board from the projector, carried out a simple demonstration, and used a short animation process about the question being asked. So that she helped students to visualize and recall the process in the question. One of the animations was used in phase to take students' attention to the concepts of diffusion and osmosis and initiate their thinking about these concepts. At the beginning stage of the implementation, it was observed that only certain students participated discussions while the others waiting for teacher explanation or for direct questions from the teacher. By the end of the second week, it was observed that most of the students were participating learning activities except three or four students. During the whole implementation process, teacher tried to support students to participate in class discussions, or activities, especially during elicit phase and engagement phase to identify students' prior knowledge and misconceptions about diffusion and osmosis. Also during exploration and elaboration phases of the cycle she acted as a facilitator for encouraging students to carry out lab activities and think about the answer of critical thinking questions. It was observed that teacher was very efficient in her time and classroom management however she had some difficulties to use computer or overhead projector. It was observed that there two students who were good at using computers and so helped their teacher. There were also some students having some behaviour problems as being late or causing noise during the early stages of the learning cycle. In the following stages of the cycle, as students become more involved in the learning activities, their motivation and participation increased. They were actively engaged in constructing knowledge by manipulating materials, recording or presenting data, or analyzing results. In addition it was observed that the integration of animations into phases of learning cycle increased students' motivation as they were observed that they gave up making noise during watching or discussing the questions related to animations.

The students in the control group were instructed with traditionally designed biology instruction. Teacher used lecturing method. She explained the concepts by writing notes on the blackboard about the definition of concepts, or used notes transferred on the power-point slides, or over-head transparencies, and distributed worksheets to students in order to answer written questions without considering their alternative conceptions. The teacher explained, defined, and described each concept in the order of textbook. Students listened to the teacher, took notes, or followed the teacher from the textbook throughout the lesson. After finishing her explanation she directed questions to whole class to lead class discussions on the key concepts. Majority of the class time was used for explanation and discussion of the questions directed by the teacher. The remaining time were used for worksheet practices that required written responses or reading assignments from textbook. The lessons generally ended with discussing the answers of worksheet questions with a teacher directed strategy. Teacher gave homework assignments from the textbook, which were reviewed in the coming classroom. The laboratory investigations carried out in experimental groups were demonstrated by the teacher. Therefore students did not have enough opportunity to discover information themselves, be involved in group activities, manipulate laboratory equipments, or discuss their ideas and findings with their friends. Similarly animations used in the experimental groups were also used in the control group but rather than in a planned format teacher used these animations in order to summarize key concepts at the end of the unit. It was observed that there were only a few students willing to participate in learning environment themselves. Other students were waiting for teacher instructions. It was observed that tendency of students to create noise during classroom sessions was greater than that of students in the experimental group.

In summary, results of classroom observations supported that 7E learning cycle based instruction accompanied with computer animations was more effective than traditionally designed biology instruction in increasing students' active involvement in learning process and therefore affecting their attitudes toward biology as a school subject.

CHAPTER 6

DISCUSSION AND RECOMMENDATOINS

This chapter presents the summary of the study, discussion of the results obtained in Chapter 5, implications of the study, and some recommendations for further studies.

6.1 Summary of the Study

At the beginning stage of this study, first of all, related literature about students' misconceptions in diffusion and osmosis concepts were reviewed and then semi structured interviews about these misconceptions were conducted with different biology teachers in order to check validity of these misconceptions for their students. Two different instruction methods were designed for the study. An instruction based on 7E learning cycle model was designed for experimental group while a traditionally designed biology instruction was designed for control group. The main purposes of the study were to investigate the effectiveness of 7E learning cycle based instruction accompanied with computer animations on ninth grade students' understanding and achievement of diffusion and osmosis concepts and attitudes towards biology as a school subject. In the light of the related literature on students' misconceptions in diffusion and osmosis and semi structured interviews about these misconceptions, a plan for the study was organized and for this purpose tests that were going to be applied, activities that were going to be used, and lesson plans of the instructions that were going to be implemented were prepared. Four biology classes of grade nine biology courses consisted of 66 ninth grade students (28 female and 38 male) participated this study. In the experimental group instructed with 7E learning cycle model based instruction accompanied with computer animations there were 34 students, in the control group instructed with traditionally designed biology instruction there were 32 students. The study was conducted over 4 weeks. There were three 40-minute teaching sessions per week for each group. At the beginning of the study DODT, DOACHT, ASTB, and SPST were administered to both groups as pre-tests. Independent sample t-test analyses were used to analyze the results of these pre-tests in order to examine the differences between groups. In addition, DODT, DOACHT, and ASTB were administered as post-tests in order to examine the effectiveness of instructions. In order to analyze these test scores ANCOVA and two-way ANOVA were used.

The results of independent sample t-test revealed that there was no significant mean difference between 7ELCBI and TDBI groups in terms of students' understanding on diffusion and osmosis concepts, achievement in diffusion and osmosis concepts, and their attitude toward biology as a school subject before the treatment. However a significant difference was found between two groups with respect to their science process skills. Therefore SPST scores of students were used as covariate.

Both treatment groups were instructed by the same biology teacher throughout the investigation. The teacher had already information about constructivism and conceptual changes. Before starting the implementation, teacher was trained about the details of the implementation of both 7ELCBI and TDBI.

6.2 Discussion of the Results

It is generally accepted that learning process as well as its product is more productive in an active learning environment rather than in a traditional learning environment (Roblyer, et al., 1997). Learning is best achieved when individuals actively construct knowledge and understanding, that is, individuals must actively participate in the teaching and learning process to discover, to reflect and to think critically on the knowledge they acquire (Santrock, 2001). Inquiry teaching strategies take into account students' developmental levels and help them use their prior knowledge as they learn new thought processes, develop higher levels of thinking, and became aware of their own reasoning. (Sunal & Sunal, 2003). As research studies on students' understanding of scientific concepts have revealed that students possess several ideas that are at variance with scientifically accepted knowledge (Treagust et al., 1996). Meaningful learning occurs when students consciously link new knowledge to relevant concepts they already possess, otherwise, rote learning occurs (Ausubel, 1968). Therefore, learning new scientific knowledge is strongly influenced by students' preexisting beliefs that have crucial role in subsequent learning (Arnaudin & Mintez, 1985; Boujaoude, 1992; Driver & Oldham, 1986; Shuell, 1987; Tsai, 1996).

Giving the importance of students' misconceptions in science education, this study investigated students' misconceptions in diffusion and osmosis concepts. For this purpose, before conducting the main study, researcher reviewed related literature about students' misconceptions in diffusion and osmosis concepts and conducted semi structured interviews about these misconceptions with different biology teachers in order to check validity of these misconceptions for their students.

Studies focusing on students' understanding of diffusion and osmosis indicated that students had a considerable degree of misconceptions in various grade levels and these misconceptions are resistant to change by traditional teaching methods (Friedler et al., 1987; Simpson & Marek, 1988; Westbrook & Marek, 1991; Marek et al., 1994; Zukerman, 1994; Odom & Barrow, 1995; Odom & Kelly, 2001; Christianson & Fisher, 1999; Kelly & Odom, 1997). For example, a study conducted by Friedler et al. (1987) indicated that students had difficulties in understanding dynamic equilibrium, osmotic relations in plants, solute-solvent and concentration-quantity relations. Furthermore, Odom and Barrow (1995) identified 20 misconceptions related to the particulate and random nature of matter, concentration and tonicity, the influence of life forces on diffusion and osmosis, the process of diffusion and the process of osmosis among college biology students. Johnstone and Mahmoud (1980) reported that osmosis and water potential were regarded by students and teachers as being among the most difficult biological concepts to understand. Similarly, Murray (1983) and Friedler (1985) identified students' conceptual difficulties in understanding concepts and processes associated with cell water relationships (osmosis), semi permeability, and pressure.

Odom and Barrow (1995) administered the Diffusion and Osmosis Diagnostic Test (DODT) to 116 secondary biology students, 123 college non-biology majors, and 117 biology majors. Misconceptions were detected in five of the seven conceptual areas measured by the test: the particulate and random nature of matter, concentration and tonicity, the influences of life forces on diffusion and osmosis, the process of diffusion, and the process of osmosis.

The results of related literature review of students' misconceptions in diffusion and osmosis concepts revealed similar misconceptions. Therefore in this study, in order to measure students' misconceptions about diffusion and osmosis concepts, Diffusion and Osmosis Diagnostic developed by Odom and Barrow (1995) was modified by considering the recommendations of the authors for the future study and results of semi structured interviews with teachers about the misconceptions examined by the test, and used.

For promoting a meaningful learning and eliminating students' misconceptions in science education type of teaching approach is an important issue. One such instructional model based on the constructivist approach by promoting conceptual change is the learning cycle. Therefore the main purpose of this study was to investigate the effectiveness of 7E learning cycle based instruction accompanied with computer animations on 9^{th} grade students' understanding of diffusion and osmosis concepts.

The early model of the learning cycle involved three consecutive phases known as exploration, concept introduction, and concept application (Karplus, 1977). Exploration phase was designed to cause students to assimilate data and eventually reach a state of disequilibration. In other words, students gather data, look for trends or relationships in the data, and, from this, they become disequilibrated. The next phase, concept development, is structured to lead students through the interpretation of their data, construction of the concept, and accommodation to the concept, which results in reequilibration. The concept application is designed to give students opportunities to organize their newly learned concept with other concepts they already know. Relationships between mental functioning and learning cycle phases can be seen in Table 2.3 (Marek & Cavallo, 1997). As one of the latest version of learning cycle, 5E learning cycle model requires instruction to include the following discrete elements: *engage, explore, explain, elaborate,* and *evaluate.* Researches on how people learn and incorporation of these researches into lesson plans and curriculum development demands that the 5E model be expanded to a 7E model. The proposed 7E model expands the *engage* element into two components -*elicit* and *engage*, and expands the two stages of *elaborate* and *evaluate* into three components - *elaborate, evaluate,* and *extend* (Eisenkraft, 2003). The common thing for all of them is that they have been found to be effective at helping students eliminate scientific misconceptions.

In the experimental group of this study, 7E learning cycle based instruction was implemented. The main idea behind this student-centered instruction was active involvement of students by completing laboratory investigations, manipulating objects, sharing and discussing ideas and findings with classmates. 7E learning cycle model implemented in experimental groups was composed of seven phases: *Eliciting, Engagement, Exploration, Explanation, Elaboration, Extension, and Evaluation.*

In the first phase of the learning cycle, e*licit,* when learning new things, the prior knowledge serves as background information and the learners usually use the original experience to recognize new information. If the new material fits their original knowledge structure, they are able to assimilate the information, otherwise they have to reorganize or change their schema. The e*licit* phase focuses on making learners retrieve existing experience that is associated with the new knowledge (Eisenkraft, 2003). In this phase students were asked with a series of inquiry questions with respect to the list of students' alternative conceptions about diffusion of osmosis. During the discussion of each question they were shown a related picture on the screen or a short animation process about the question being asked. So they visualized and recalled the process in the question. For the question "How does the gas exchange occur at respiratory surfaces of different animals as mammals, fish, insects, or earthworms?" she showed a simple animation about the exchange of oxygen and carbon dioxide taking place at mammalian lungs. Through this animation she wanted students think about the name of the mechanism by which this gas exchange process takes place and how these molecules moved from one area to another one. Teacher also made demonstration about the diffusion of gases and liquids. After each question she attempted to create a discussion environment, gave opportunities for students to share their ideas. By this way she tried to explore students' prior knowledge about the concepts and revealed their misconceptions about diffusion and osmosis.

In the *engagement* phase of the model, the intention was to capture students' attention, get students thinking about the subject matter, raise questions in students' minds, stimulate thinking, and access prior knowledge. It included both accessing prior knowledge and generating enthusiasm for the subject matter. For this purpose teacher tried to get attention of students into the subject matter. Students were given a simple experimentation about diffusion and osmosis. During the activity students were asked to think about the answers of some inquiry questions such as "What do you think that what will happen to the molecules inside or outside of the dialysis tube? In what direction they will move? Can they go out of the bags? If so, which ones? And Why?" Similarly at the end of the activity students were asked to discuss their observations and the reasons of their findings. Teacher acted as a facilitator in this discussion stage and supported students to realize that their present conceptions were not enough to explain some of these phenomena. The nature of the activities used in this phase was the key element of this stage. The main purpose of these activities was to create cognitive conflict and motivate students by increasing their interest and curiosity. This property of learning cycle served to achievement of conceptual change and meaningful learning. They resulted into the creation of a disequilibrium which occurred when there was not any consistency between existing cognitive structure and learnt information in this phase so that students recognized that there was something missing or wrong with their existing cognitive structure, which lead students to motivate learning activity. This phase also corresponds the dissatisfaction phase of conceptual change approach proposed by Postner et al. (1982).

The process of equilibrium which occurs when there is a balance between new information and the existing structure was initiated by the activities presented in *exploration* phase (Bybee et al., 2006). Activities used in this phase provide an opportunity for students to observe, record data, isolate variables, design and plan experiments, create graphs, interpret results, develop hypotheses, and organize their findings. They tried to find out the rationale behind their pre-existing ideas to overcome and remedy their misconceptions. For this purpose, teacher provided some guidance to students besides let them explore the new knowledge and solve problems by themselves. Students were involved in a laboratory activity. They were supposed to complete this laboratory investigation and record their observations. They were also given a set of inquiry questions to discuss. At the end they were expected to share their data with other members of the class by making a presentation. With this activity teacher let the student manipulate materials to actively explore concepts, processes or skills and by this way a kind of equilibration was initiated by the teacher. The teacher was the facilitator. She observed and listened to students. She suggested approaches, provided feedback, and assessed their understandings.

In the *explanation* phase, students were introduced to models, laws, and theories. Firstly, students were given opportunity to summarize their results in terms of new theories and models and give their own explanations and then teacher guided students toward coherent and consistent generalizations, helped students with distinct scientific vocabulary, and provided questions that help students use this vocabulary to explain the results of their explorations. Students were allowed to share and explain their findings and ideas that they gained in the previous stages. So that she tried to guide students to modify and enhance their concepts. Teacher clarified the answer of the questions asked in the previous phases and clearly connected these explanations with students' gained experiences. In addition, she used animations in order to explain related concepts in an interactive, visual, and clear way. The process of equilibration continued with this phase as the reasons of students' misconceptions and their correct scientific explanations were explained by the teacher (Eisenkraft 2003).

The *elaborate* phase of the learning cycle provided an opportunity for students to apply their knowledge to new domains, which may include raising new questions and hypotheses to explore. This phase tied directly to the psychological construct called "transfer of learning" (Thorndike, 1923). Students were provided with further hands-on activities and laboratory investigations to extend or elaborate the concepts, processes, or skills gained during the previous stages. This phase can be another chance for students who still had misconceptions to eliminate them and to comprehend their understanding. For this purpose teacher let students explore main concepts of the study by providing additional laboratory investigation. She aimed at finding out where students had difficulties and provided help to overcome them. Group activities were also used to help students to express their understanding so that they could also get feedbacks from their friends. During this phase, teacher used formal assessment methods to evaluate instructional objectives and misconceptions.

In the *extension* phase, students were involved in the activities in order to practice the transfer of their learning. So students were expected to remember knowledge and then use it to solve problems in a new situation. For this purpose, they were involved in a laboratory investigation. Teacher tired to observe that students can apply their knowledge in a new context. In the last phase, *evaluate*, students' learning and misconceptions were evaluated in both formative and summative ways. For this purpose students were given opportunities to monitor their level of understanding and misconception they still had.

In the control group of this study traditionally designed biology instruction was used. It was mainly based on lecturing method. Teacher instructed the entire class as a unit, wrote notes on the blackboard about the definition of concepts, or used notes on the power-point slides, or over-head transparencies, and distributed to students in order to answer written questions without considerations of their alternative conceptions. She explained, defined, and described each concept in the order of textbook. Students listened to the teacher, took notes, or followed the teacher from the textbook throughout the lessons. After finishing her explanation she directed questions to whole class to lead class discussions on the key concepts. Majority of the class time was used for explanation and discussion of the questions directed by the teacher.

In summary, the overall goal of learning cycle was to help students construct new knowledge by creating conceptual change through interaction with the social and natural world, therefore, it took into account students' developmental levels and helps them use their prior knowledge as they learn new thought processes, develop higher levels of thinking, and became aware of their own reasoning (Sunal & Sunal, 2003). There were many research studies that pointed out the effectiveness of learning cycle based instructions at helping students eliminate scientific misconceptions (Bevenino, et al., 1998; Bransford, et al., 2000; Huang, et al., 2008; Gil, 2002; Patrick & Sandra, 2007; Odom & Kelly, 2001; Balcı, et al., 200; Mecit, 2006; Doğru & Tekkaya, 2008; Lawson, 1995; Guzzetti et al. 1993; Akar, 2005). Moreover, when considering biology curriculum development studies in Turkey instructions based on 7E learning cycle model seem to be one of the appropriate model for the development of new curriculum.

Considering the statistical analyses results given in Chapter 5, it can be concluded that 7E learning cycle based instruction accompanied with computer animations caused significantly better acquisition of diffusion and osmosis concepts and elimination of misconceptions than traditionally designed biology instruction ($\overline{X}$ (7ELCBI) = 8.88, $\overline{X}$ (TDBI) = 5.12). Analysis of DODT results also supports this.

At the elicit stage of 7E learning cycle model, students' misconceptions about diffusion and osmosis were identified and in the engagement stage activities were used to capture students' attention, get students thinking about the subject matter, raise questions in students' minds, stimulate thinking, and access prior knowledge. However, students' misconceptions about diffusion and osmosis were ignored in instruction based on traditional method. Therefore, students who were instructed by traditional method could not construct knowledge and understanding for the meaningful learning of diffusion and osmosis. Because meaningful learning can only be achieved when students have appropriate mental structures and can relate it with new knowledge.

High school biology curriculum is consisting of many topics composed of concepts that are basic to biology knowledge and interrelated with each other. Since concepts of diffusion and osmosis are keys for the understanding many plants and animal physiological processes, increasing students' understanding and achievements by preventing the formation of any misconceptions and eliminate the pre-existing ones are important. For example diffusion is a simple way of short distance transport in a cell and cellular systems. Similarly, correct addressing of the osmosis concepts is required to understand the processes of the water uptake from soil into root cells, the mechanism that lies behind the movement of water through the xylem tissues of plants, water balance in land and aquatic creatures, turgor pressure in plants, transport in living organisms, gas exchange between respiratory surfaces and surrounding environment and between body fluid and tissues (Friedler et al., 1987). So the other purpose of this study was to investigate the effectiveness of 7E learning cycle based instruction accompanied with computer animations on students' achievement in diffusion and osmosis concepts. The results showed that students in experimental group got significantly higher scores on DOACH test than students in control group ($\overline{X}$ (7ELCBI) = 18.56, $\overline{X}$ (TDBI) = 12.40). This study indicated that students in the experimental group got significantly higher scores in both diffusion and osmosis diagnostic test (DODT) and diffusion and osmosis achievement test (DOACH).

The analysis of students' post-test scores of DODT and DOACH showed that students instructed with 7E learning cycle model accompanied with computer animations did well on each item compare to students instructed with traditionally designed biology instruction. For example, item 6 (question 11 and 12) was asked students to determine their understanding about what would happen to blue dye molecules after they had been evenly distributed throughout a large container of clear water. The desired response for this item was "The molecules of dye continue to move around randomly because molecules are always moving". The average score of students with 77% in experimental group was suggesting a satisfactory understanding but with 39% in control group was suggesting an unsatisfactory understanding. This difference can be explained by the use of observation, experimentation and integrated animations in the experiment group. The control group students observed the demonstration made by the teacher, so they were not given the opportunity for active construction of knowledge that was provided for experimental group students. They were also watched the animations but not as integrated into teaching instruction rather than as a summary at the end of the unit. One of the most common alternative responses to this item was "This is a liquid: if it were solid the molecules would stop moving". This was most probably because students may relate the alternative response of content part that was "the molecules of dye have stopped moving" with this alternative response of reason part. Similarly, item 8 (questions 15 and 16) was asked to assess students' understanding about the process of the osmosis through a selectively permeable membrane. The desired response for this item was “After 2 hours, the water level in side 1 will be higher because the concentration of water molecules is less on side 1”. Students in the experimental group had an average score of 53%; which was 28% above the students in the control group with an average score of 25% for this item. This questions involved specific terminologies as hypotonic, hypertonic, or isotonic, which were difficult for most of the students to memorize. The most common alternative responses to this item was “After 2 hours, the water level in side 1 will be higher because water will move from the hypertonic to hypotonic solution”. This was possible that students had confusion about the meaning of hypotonic, hypertonic, or isotonic concepts.

Therefore, the percentages of correct responses to each item in both groups indicated as evidence to say that instruction based on 7E learning cycle model accompanied with computer animations help students eliminate their misconceptions related to diffusion and osmosis concepts.

Another purpose of the study was to investigate whether there was a significant difference between male and female students with respect to their understanding and achievement of diffusion and osmosis concepts. There were different research studies that had showed that science was one of the areas in which gender difference was most strongly pronounced, however, in those studies researchers indicated no significant difference between males and females with respect to science achievement (Dimitrov, 1999; Hupper et al., 2002; Ugwu & Soyibo, 2004; Greenfiled, 1996; Azizoğlu, 2004, Doğru & Tekkaya, 2008; Shepardson & Pizzini, 1994; Thompson & Soyibo, 2002), other researches have reported significant gender differences (Alparslan at al., 2003; Cavallo et al., 2004; Soyibo, 1999; Young & Fraser, 1994). For example, Doğru and Tekkaya (2008) found no significant difference between girls’ and boys’ performance with respect to genetics achievement. Similarly, Ugwu and Soyibo (2004) reported no significant gender difference in Jamaican 8th grade students’ performance on nutrition and plant reproduction concepts. Young and Fraser (1994), however, reported significant gender differences in biology achievement in favour of boys.

Soyibo (1999) revealed that girls performed significantly better on a test of errors in biological labelling. In another experimental study, Alparslan et al., found out gender differences in the relative effectiveness of two modes of treatment (conceptual change instruction and traditional instruction) on 11th grade students' understanding of respiration. Their study indicated that a significant difference between girls' and boys' performance in favour of the girls, but they found the interaction of the treatment with gender difference to be nonsignificant for learning the concepts (Alparslan at al., 2003). The results of this study revealed that there was no significant mean difference girl and boy students. The mean post-DODT scores were 5.37 for girls and 6.53 for boys. Moreover the interaction between gender and treatment had no significant effect on students' understanding and achievement in diffusion and osmosis concepts.

Another aim of this study was to investigate the effectiveness of 7E learning cycle model instruction accompanied with computer animations on students' attitude toward biology as a school subject. At the beginning this study, students' attitude toward biology was investigated by the use of pre-ASTB to understand whether there was a significant difference between experimental and control group students with respect to students' attitude toward biology as a school subject. The analysis of pre-ASTB scores indicated that there was no significant difference between students who were instructed with 7E learning cycle model instruction accompanied with computer animations and students who were instructed with traditionally designed biology instruction with respect to their attitudes toward biology before the study. Cavallo & Laubach (2001) found that attitude toward science may be related to the students' science course enrolment. Except from only a few studies (Neiswandt, 2006; Hobbs & Ericson, 1980), the impact of attitude in science learning is quite obvious in most of the science education researches. For this study, the analysis post-ASTB scores showed that 7E learning cycle model instruction accompanied with computer animations was more effective than traditionally designed biology instruction on students' attitude toward biology as a school subject (X (7ELCBI) = 62.94, X (TDBI) = 51.34). Analysis of classroom observations of the study also supported this result. It was observed that students in experimental group students seemed very eager to attend activities, discuss questions, manipulate lab materials, and share their findings. In the related literature there are studies which have supported the effectiveness of the learning cycle in encouraging students to think creatively and critically, facilitating a better understanding of scientific concepts, developing positive attitudes toward science, improving science process skills, and cultivating advanced reasoning skills (Lawson et al., 1988; Lawson, 1995, Balcı at al., 2005). Similarly, Campbell (1977) found that students in learning cycle group had more positive attitudes towards laboratory works, scored higher in laboratory exam, and were not likely to withdrawn from the course. For example, the results of Lawson's study (1995) revealed that college students enrolled in learning cycle sections enjoyed their instructions more than those enrolled in traditionally designed sections.

The effect of gender on students' attitude toward biology as a school subject was also investigated in this study. The results showed that there was no significant mean difference between female and male students with respect to their attitudes toward biology as a school subject. In addition, there was not any significant interaction effect between gender and treatment on students' attitudes biology as a school subject in the study. There are contradictory findings about the relationship between gender difference and attitudes. For example, Dahindsa and Chung (2003) found no significant gender difference in attitudes toward science and achievement in science in coeducational schools. On the other hand, Barmby et al. (2008) revealed that attitude toward science decreases as students progressed through secondary school and this decrease was more for female students.

6.3 Implications

Based on the findings of this study, following implications can be offered;

1. One of the main purposes of today's science education is promoting meaningful learning. It can be achieved when learners can relate new

concepts to their prior knowledge, and use their new conceptual understanding to explain experiences they encounter. Therefore teachers should consider students prior knowledge for promoting meaningful learning process.

2. Students may have misconceptions which are different from scientific conceptions. These misconceptions may be pervasive, stable, and often resistant to be changed by traditional teaching methods. So teachers must consider their students' misconceptions and therefore should design their instruction strategies in such a way that they could determine these students' misconceptions, learn the sources of them, and remediate these misconceptions.

3. One of the ways to promote meaningful learning is the type of instructional method used by the teacher. Learning cycle as an inquiry teaching strategy takes into account students' developmental levels and helps them use their prior knowledge as they learn new thought processes, develop higher levels of thinking, and became aware of their own reasoning. Therefore science curriculum developers, textbook writers and teachers should be aware of the role of learning cycle based instruction in science education. So that teachers can design their instructions in such a way that it does not create new misconceptions. In addition, school administrations or ministry of national education should organize teacher training workshops where teacher can get opportunities to improve their personal skills. For this purpose, school administrations should force their teachers to attend these workshops.

4. Another source of misconceptions may be the instructor. Teachers may misunderstand the concepts which they will teach may cause students to create misconceptions. In order to prevent this they should continuously follow the changes in science education and should check their preexisting knowledge themselves.

5. Textbooks should be considered as another source of misconceptions. Even if students may have original concepts in their mind they may have difficulties in understanding new concepts. Therefore terminology and knowledge used in the textbook must be considered as causing any misconceptions in students' mind.

6. Students may have difficulties in understanding of science concepts in biology. One of the main reason of these difficulties bases on the fact that high school biology curriculum is consisting of many topics composed of concepts that are basic to biology knowledge and interrelated with each other. Instructions which help students to connect and transfer information and visualize events and prevent formation of misconceptions may help students overcome these difficulties.

7. Integration of technology into science education can be effective in visualization of life processes or demonstration of 3-D shapes and related biochemical reactions. Therefore, teachers must be aware of effectiveness of the use of technology in science education in terms of both quality of instruction and saving time. In addition, instruction designers should prepare teaching supporting materials for different topics in science.

8. Science process skills of students are highly effective in students' understanding in science education. Therefore, teachers and families should provide opportunities for students to improve their science process skills.

9. In addition to the role of cognitive variables, there are also some affective variables as self-efficacy, motivation, and attitude which may be effective on students' science achievement. Therefore, teachers

should consider development of these affective domains as well as cognitive ones in designing their instructional strategies. For this purpose, teacher education programs should include topics for the importance of affective domains in students' science achievement.

6.4 Recommendations

Based on the findings of this study, researcher recommends the following implications;

1. Similar studies can be conducted in different types of high schools or grade levels with a larger sample size to increase generalization of results.

2. Similar studies can be conducted to investigate the effect of instruction based on 7E learning cycle model accompanied with computer animations on students' understanding and achievement of concepts, and attitudes toward biology as a school subject other than diffusion and osmosis concepts.

3. Similar studies can be conducted to investigate the effect of instruction based on 7E learning cycle model accompanied with computer animations on students' understanding and achievement of concepts, and attitudes in other subject areas such as chemistry and physics.

4. Studies can be conducted to investigate effectiveness of instruction based on 7E learning cycle model accompanied with computer animations on retention of concepts.

5. Studies can be conducted to investigate the long term effects of instruction based on 7E learning cycle model accompanied with

computer animations on retention of concepts for a longer period of time.

6. Studies can be conducted to investigate effect of instruction based on 7E learning cycle model accompanied with computer animations on motivation and self-efficacy other than attitude.

7. Studies can be conducted to investigate the effects of computer animations with other constructivist method on students' understanding and achievement of scientific concepts.

8. Studies can be conducted to investigate the effectiveness of instruction based on 7E learning cycle model with different teaching strategies such as cooperative learning or problem based learning in remediation of students' misconceptions, their understanding and achievement in diffusion and osmosis concepts and attitudes toward biology as a school subject.

9. Similar studies with alternative assessment strategies can be conducted.

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APPENDIX A

INSRTUCTIONAL OBJECTIVES

1. To state that all particles are in constant motion
2. To state that diffusion involves the movement of particles
3. To define that concentration gradient is a difference in concentration of a substance across a space
4. To clarify that diffusion is the net movement of particles as a result of a concentration gradient
5. To explain that diffusion is the net movement particles from an area of high concentration to one of low concentration
6. To state that diffusion continues until the particles become uniformly distributed in the medium in which they are dissolved
7. To explain that diffusion rate increases as temperature or concentration gradient increases
8. To state that diffusion occurs in living and nonliving systems
9. To describe that a selectively permeable membrane is a membrane that allows the movement of some substances across the membrane while blocking the movement of others
10. To explain the difference between simple diffusion and osmosis
11. To define that osmosis is the diffusion of water across a semipermeable membrane
12. To describe that a hypotonic solution has fewer dissolved particles and hypertonic solution has more dissolved particles relative to the other side of the membrane while an isotonic solution has an equal number of dissolved particles on both sides of the membrane

13. To explain the effects of hypotonic, isotonic and hypertonic solutions on plant and animal cells
14. To clarify that osmosis is the net movement of water across a semipermeable membrane from a hypotonic solution to a hypertonic solution
15. To state that osmosis occurs in living and nonliving systems
16. Describe the effects of plasmolysis, deplasmolysis and turgor pressure on cells
17. To solve the problems related to osmosis
18. To state that cell membranes are selectively permeable
19. To describe the fluid mosaic of cell membrane
20. To explain the functions of the cell membrane
21. To distinguish between active and passive transport.

APPENDIX B

DIFFUSION AND OSMOSIS DIAGNOSTIC TEST

Directions: This assessment test consists of 24 questions that examine your knowledge of diffusion and osmosis. Each question is composed of two, three, or four alternative answers: one desired answer and distracter(s).

On the answer sheet provided, please circle one answer for the each question.

1. Suppose there is a large beaker full of clear water and a drop of blue dye is added to the beaker of water. Eventually the water will turn a light blue color. The process responsible for blue dye becoming evenly distributed throughout the water is:
    a. diffusion of water by osmosis
    b. simple diffusion
    c. a reaction between water and dye

2 . The reason for my answer in question 1 is because:
    a. The lack of membrane means that osmosis and diffusion cannot occur.
    b.There is movement of particles between regions of different concentrations.
    c. The dye separates into small particles and mixes with water.
    d. The water moves from one region to another.

3. During the process of diffusion, particles will generally move from:

   a. an area of greater number of particles per unit volume to an area of less number of particles per unit volume
   b. an area of less number of particles per unit volume to an area of greater number of particles per unit volume

4. The reason for my answer in question 3 is because:

   a. There are too many particles crowded into one area: therefore, they move an area with more room.
   b. Particles in areas of greater concentration are more likely to bounce towards other areas.
   c. The particles tend to move until the two areas are isotonic, and then the particles stop moving.
   d. There is a greater chance of the particles replling each other.

5. As the difference in concentration between two areas increases, the rate of diffusion:

   a. Decreases
   b. Increases

6. The reason for my answer in question 5 is because:

   a. There is less room for the particles to move.
   b. If the concentration is high enough, the particles will spread less and the rate will be slowed.
   c. The molecules want to spread out.
   d. There is a greater likelyhood of random motion into other regions.

7. A glucose solution can be made more concentrated by:

   a. adding more water
   b. adding more glucose

8. The reason for my answer in question 7 is because:

a. The more water there is the more glucose it will take to saturate the solution.
b. Concentration means the dissolving opf something.
c. It increases the number of dissolved particles.
d. For a solution to be more concentrated one must add more liquid.

9. If a small amount of sugar is added to a container of water and allowed to set for several days time without stirring, the sugar molecules will:

a. be more concentrated on the bottom and will sink.
b. be evenly distributed throughout the container

10. The reason for my answer in question 9 is because:

a. There is movement of particles from a high to low concentration.
b. The sugar is heavier than water and will sink.
c. Sugar dissolves poorly or not at all in water.
d. There will be more time for settling.

11. Suppose you add a drop of blue dye to a container of clear water and after several hours the entire turns light blue. At this time, the molecules of dye:

a. Have stopped moving
b. Continue to move around randomly

12. The reason for my answer in question 11 is because:

a. The entire container is the same color; if they were still moving, the container would be different shades of blue.
b. If the dye molecules stopped, they would settle to the bottom of the container.
c. Molecules are always moving.
d. This is a liquid: if it were solid the molecules would stop moving.

13. Suppose there are two large beakers with equal amounts of clear water at two different temperatures. Next, a drop of green dye is added to each beaker of water. Eventually the water turns light green (see Figure 1). Which beaker became light green first?

    a. Beaker 1

    b. Beaker 2

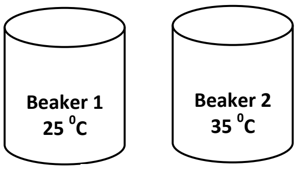


Figure 1

14. The reason for my answer in question 13 is because:

    a. The lower temperature breaks down the dye.

    b. The dye molecules move faster at higher temperatures.

    c. The cold temperature speeds up the molecules.

    d. It helps molecules to expand.

15. In *Figure 2*, two columns of water are separated by a membrane through which only water can pass. Side 1 contains dye and water; side two contains pure water. After 2 hours, the water level in side 1 will be;

    a. higher

    b. lower

    c. the same height

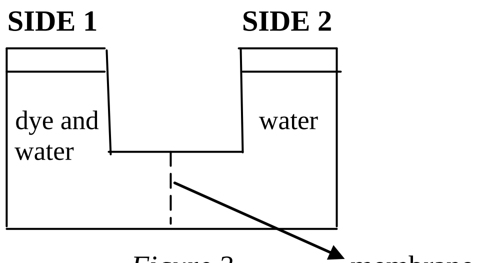


Figure 2

16. The reason for my answer in question 15 is because:

    a. Water will move from the hypertonic to hypotonic solution.

    b. The concentration of water molecules is less on side 1.

    c. Water will become isotonic.

    d. Water moves from low to high concentration.

17. In *Figure 3*, side 1 is [......] to side 2.

a. Hypotonic

b. Hypertonic

c. Isotonic

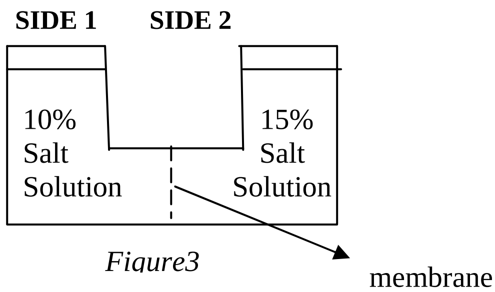


Figure3

18. The reason for my answer in question 17 is because:

a. Water is hypertonic to most things.

b. Isotonic means “the same”.

c. Water moves from a high to a low concentration.

d. There are fewer dissolved particles on side 1.

19. *Figure 4* is a picture of a plant cell that lives in freshwater. If this cell were placed in a beaker of 25% saltwater solution, the central vacuole would:

a. increase in size

b. decrease in size

c. remain the same size

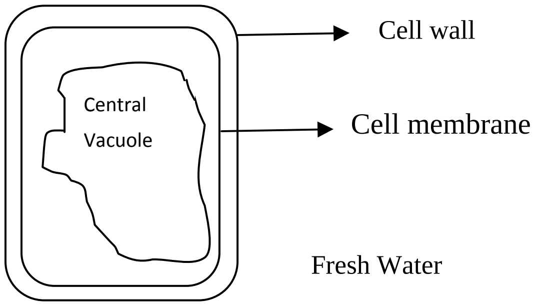


Figure 4

20. The reason for my answer in question 19 is because:

a. Salt absorbs the water from the central vacuole.

b. Water will move from the vacuole to the saltwater solution.

c. The salt will enter the vacolue.
d. Salt solution outside the cell cannot effect the vacuole inside the cell.

21. Suppose you killed the plant cell in Figure 4 with poison and immediately placed the dead cell in a 25% saltwater solution.

a. Osmosis and diffusion would not occur.
b. Osmosis and diffusion would continue.
c. Only diffusion would continue.
d. Only osmosis would continue.

22. The reason for my answer in question 21 is because:

a. The cell would stop functioning.
b. The cell does not have to be alive.
c. Osmosis is not random, whereas diffusion is a random process.
d. Osmosis and diffusion require cell energy.

23. All cell membranes are:

a. selective permeable
b. permeable

24. The reason for my answer in question 23 is because:

a. They allow some substances to pass.
b. They allow some substances to enter, but they prevent any substance from leaving.
c. The membrane requires nutrients to live.
d. They allow all nutrients to pass.

APPENDIX C

DIFFUSION AND OSMOSIS ACHIEVEMENT TEST

1. The cell membrane is selectively permeable. This means that it
   a) has many layers
   b) allows all materials to pass through
   c) allows only biologic molecules to pass through
   d) allows only certain materials to pass through

2. Simple diffusion is defined as the
   a) movement of molecules from a region of high concentration to a region of low concentration
   b) movement of molecules from a region of low concentration to a region of high concentration
   c) Movement of water by diffusion
   d) Movement of molecules across cell membrane using energy

3. Movement of substances across the cell membrane from a region of lower concentration to a region of higher concentration is called
   a) Simple diffusion
   b) Facilitated diffusion
   c) Osmosis
   d) Active transport

4. What is essential for diffusion?
   a) Concentration gradient
   b) A selectively permeable membrane
   c) A source of energy
   d) A protein

5. Diffusion <u>does not</u> require the cell to use ATP. Therefore, diffusion is considered as a type of

a) Passive transport

b) Active transport

c) Bulk transport

6. The term *osmosis* refers to the diffusion of

a) Water

b) Energy

c) Positive electric charges

d) Glucose

7. Which of the following is required for osmosis to occur?

a) An enzyme

b) A fully permeable membrane

c) ATP

d) A solute concentration gradient

8. A plant cell placed in pure water will probably:

I. be plasmolysed

II. gain water by osmosis

III. burst

IV. lose water by osmosis

a) Only I   b) Only II   c) II and III   d) III and IV

9. Which of the following <u>does not</u> move freely (without energy or a carrier protein) across the plasma membrane?

a) CO_2

b) H_2O

c) Ether

d) Glycogen

10. Oxygen passthrough the plasma membrane by

a) Osmosis

b) Active transport

c) Facilitated diffusion

d) Simple diffusion

11. Which of the followings does not increase the rate of diffusion?

a) Increasing concentration gradients of the molecules

b) Incresing the temperature of the fluid

c) Decreasing size of the molecules

d) Decreasing lipid solubility of the molecules

12. If you place an animal cell in pure water, which of the followings will happen?

a) Water molecules will move out of the cell, and it will shrink and die from lack of water

b) There will be no change

c) Water molecules will move into the cell, it will swell and may burst

d) All the cell’s energy will be used to prevent the movement of molecules into the cell

13. If placed a plant cell in tap water it will not undergo lysis.What is the reason of this?

a) Removal of water by the plant cell's central vacuole

b) The impermeability of the plant cell membrane to water

c) The impermeability of the plant cell wall to water

d) The strength of the plant cell wall

14. When the fluid outside a cell has a greater of a given molecule than the fluid inside the cell, the fluid outside is

a) Isotonic

b) hypertonic

c) hypotonic

d) ultratonic

15. Small, non-polar, hydrophobic molecules such as fatty acids

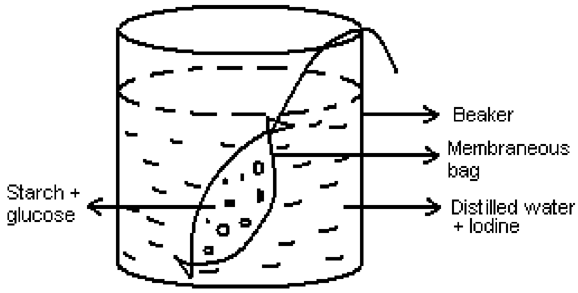
a) easily pass through a membrane's lipid bilayer

b) very slowly diffuse through a membrane's lipid bilayer

c) require transport proteins to pass through a membrane's lipid bilayer

d) are actively transported across cell membranes

16. A membraneous bag is filled with ½ full of starch solution and 5 ml of glucose solution. As seen in the figure below, the bag is put into a 250 ml beaker filled only with water and iodine solution.



Which one (s) of the below molecule (s) can pass through the sac?

I-Starch

II-Glucose

III-Water

IV-Iodine

a) I and II   b) II and III   c) I, II and IV   d) II, III and IV

17. In which of the following conditions the diffusion rate will be <u>the highest</u>?

a) At low pressure

b) At low temperatures

c) With small sized molecules

d) At low concentration gradient

18. A cell that neither gains nor loses water when it is immersed in a solution is

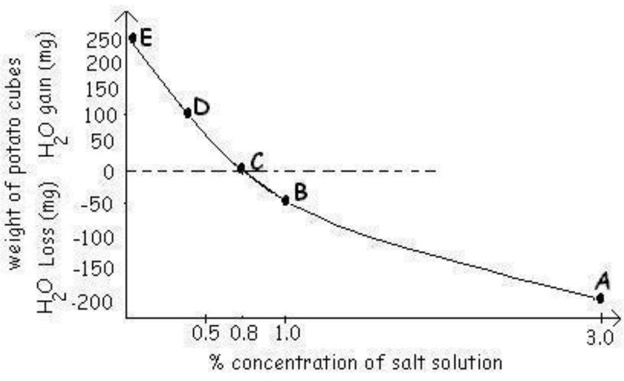
a) isotonic to its environment

b) hypertonic to its environment

c) hypotonic to its environment

d) metabolically inactive

19. Five potato cubes (labeled as A, B, C, D and E) of equal size and weight were placed in five different concentrations of salt solutions. The potato cubes were weighed again after they are put in salt solutions for 30 minutes, and the following graph was obtained.



What is the name the solutions in which the potato cubes A, C, and D?

	Cubes A	Cube C	Cube D
a)	isotonic	hypertonic	hypotonic
b)	hypotonic	isotonic	hypertonic
c)	hypertonic	isotonic	hypotonic
d)	hypotonic	hypertonic	isotonic

20. In lab, you use a special balloon that is permeable to water but not sucrose to make an "artificial cell." The balloon is filled with a solution of 20% sucrose and 80% water and is immersed in a beaker containing a solution of 40% sucrose and 60% water. Which of the following will occur?

a) Water will leave the balloon

b) Water will enter the balloon

c) Sucrose will leave the balloon

d) Sucrose will enter the balloon

APPENDIX D

BİLİMSEL İŞLEM BECERİ TESTİ

AÇIKLAMA: Bu test, özellikle Fen ve Matematik derslerinizde ve ilerde üniversite sınavlarında karşınıza çıkabilecek karmaşık gibi görünen problemleri analiz edebilme kabiliyetinizi ortaya çıkarabilmesi açısından çok faydalıdır. Bu test içinde, problemdeki değişkenleri tanımlayabilme, hipotez kurma ve tanımlama, işlemsel açıklamalar getirebilme, problemin çözümü için gerekli incelemelerin tasarlanması, grafik çizme ve verileri yorumlayabilme kabiliyetlerini ölçebilen sorular bulunmaktadır.

Her soruyu okuduktan sonra kendinizce uygun seçeneği yalnızca cevap kağıdına işaretleyiniz.

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

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

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

a. Arabaların benzinleri bitinceye kadar geçen süre ile.

b. Her arabanın gittiği mesafe ile.

c. Kullanılan benzin miktarı ile.

d. Kullanılan katkı maddesinin miktarı ile.

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

a. Arabanın ağırlığı.

b. Motorun hacmi.

c. Arabanın rengi

d. a ve b.

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

a. Evin çevresindeki ağaç sayısı ne kadar az ise ısınma gideri o kadar fazladır.

b. Evde ne kadar çok pencere ve kapı varsa, ısınma gideri de o kadar fazla olur.

c. Büyük evlerin ısınma giderleri fazladır.

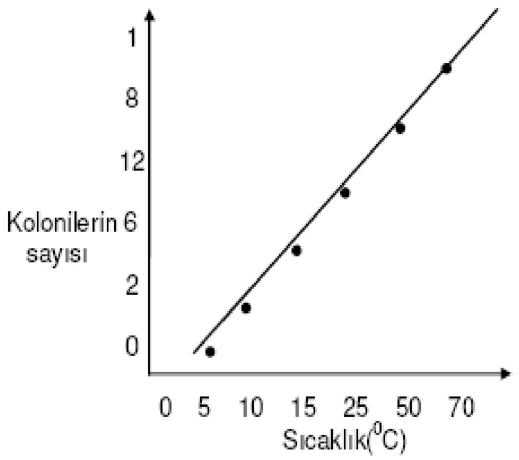
d. Isınma giderleri arttıkça ailenin daha ucuza ısınma yolları araması gerekir.

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

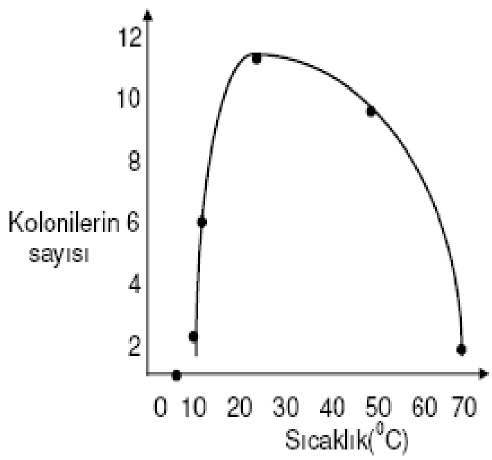
Deney odasının sıcaklığı (^{0}C)	**Bakteri kolonilerinin sayısı**
5	0
10	2
15	6
25	12
50	8
70	1

Aşağıdaki grafiklerden hangisi bu verileri doğru olarak göstermektedir?

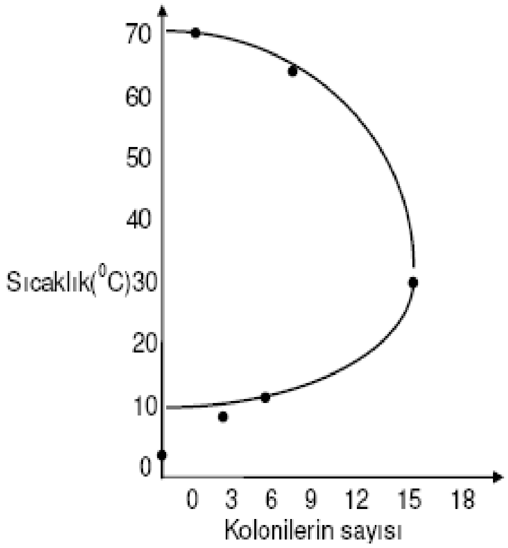
a.



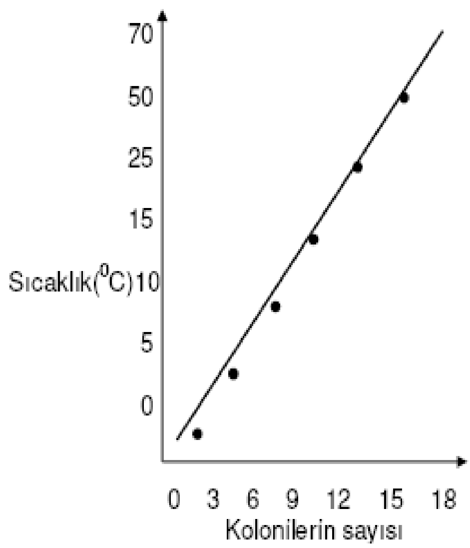
b.



c.



d.



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

a. Daha genç sürücülerin daha hızlı araba kullanma olasılığı yüksektir.

b. Kaza yapan arabalar ne kadar büyükse, içindeki insanların yaralanma olasılığı o kadar azdır.

c. Yollarde ne kadar çok polis ekibi olursa, kaza sayısı o kadar az olur.

d. Arabalar eskidikçe kaza yapma olasılıkları artar.

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

a. Her deneyde arabanın gittiği toplam mesafe ölçülür.

b. Rampanın (eğik düzlem) eğim açısı ölçülür.

c. Her iki deneyde kullanılan tekerlek tiplerinin yüzey genişlikleri ölçülür.

d. Her iki deneyin sonunda arabanın ağırlıkları ölçülür.

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

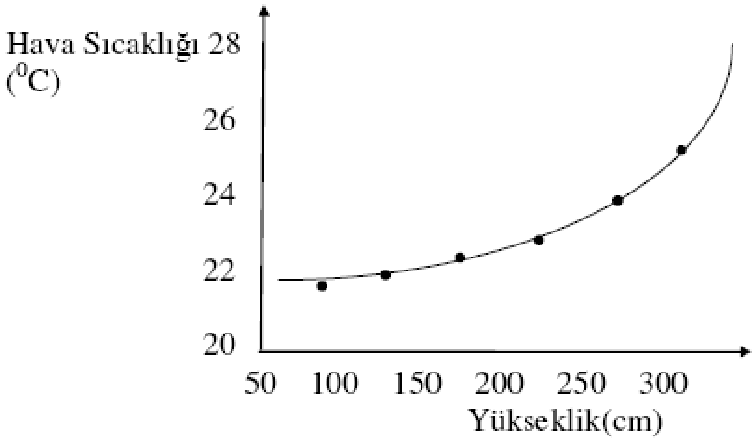
a. Tarlaya ne kadar çok gübre atılırsa, o kadar çok mısır elde edilir.

b. Ne kadar çok mısır elde edilirse, kar o kadar fazla olur.

c. Yağmur ne kadar çok yağarsa , gübrenin etkisi o kadar çok olur.

d. Mısır üretimi arttıkça, üretim maliyeti de artar.

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



a. Yükseklik arttıkça sıcaklık azalır.

b. Yükseklik arttıkça sıcaklık artar.

c. Sıcaklık arttıkça yükseklik azalır.

d. Yükseklik ile sıcaklık artışı arasında bir ilişki yoktur.

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

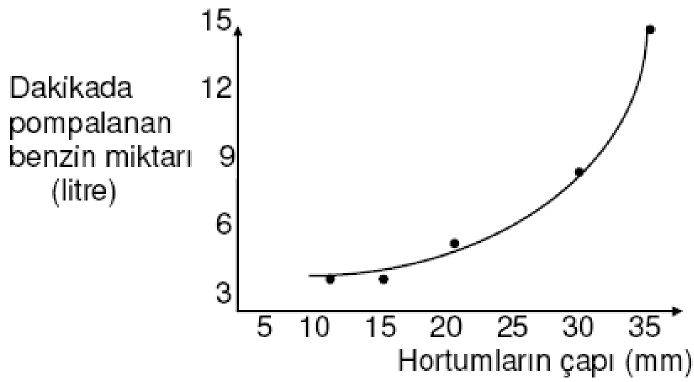
a. Topları aynı yükseklikten fakat değişik hızlarla yere vurur.

b. İçlerinde farlı miktarlarda hava olan topları, aynı yükseklikten yere bırakır.

c. İçlerinde aynı miktarlarda hava olan topları, zeminle farklı açılardan yere vurur.

d. İçlerinde aynı miktarlarda hava olan topları, farklı yüksekliklerden yere bırakır.

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi açıklamaktadır?

a. Hortumun çapı genişledikçe dakikada pompalanan benzin miktarı da artar.

b. Dakikada pompalanan benzin miktarı arttıkça, daha fazla zaman gerekir.

c. Hortumun çapı küçüldükçe dakikada pompalanan benzin miktarı da artar.

d. Pompalanan benzin miktarı azaldıkça, hortumun çapı genişler.

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

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

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

12. Araştırmada aşağıdaki hipotezlerden hangisi sınanmıştır?

a. Toprak ve su ne kadar çok güneş ışığı alırlarsa, o kadar ısınırlar.

b. Toprak ve su güneş altında ne kadar fazla kalırlarsa, o kadar çok ısınırlar.

c. Güneş farklı maddeleri farklı derecelerde ısıtır.

d. Günün farklı saatlerinde güneşin ısısı da farklı olur.

13. Araştırmada aşağıdaki değişkenlerden hangisi kontrol edilmiştir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Her bir kovanın güneş altında kalma süresi.

14. Araştırmada bağımlı değişken hangisidir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Her bir kovanın güneş altında kalma süresi.

15. Araştırmada bağımsız değişken hangisidir?

a. Kovadaki suyun cinsi.

b. Toprak ve suyun sıcaklığı.

c. Kovalara koyulan maddenin türü.

d. Her bir kovanın güneş altında kalma süresi.

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

a. Hava sıcakken çim biçmek zordur.

b. Bahçeye atılan gürenin miktarı önemlidir.

c. Daha çok sulanan bahçedeki çimenler daha uzun olur.

d. Bahçe ne kadar engebeliyse çimenleri kesmekte o kadar zor olur.

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

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

17. Bu araştırmada sınanan hipotez hangisidir?

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

18. Bu araştırmada kontrol edilebilen değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.
b. Her bardağa konulan su miktarı.
c. Bardakların sayısı.
d. Suyun sıcaklığı.

19. Araştırmanın bağımlı değişkeni hangisidir?

a. Her bardakta çözünen şeker miktarı.
b. Her bardağa konulan su miktarı.
c. Bardakların sayısı.
d. Suyun sıcaklığı.

20. Araştırmadaki bağımsız değişken hangisidir?

a. Her bardakta çözünen şeker miktarı.
b. Her bardağa konulan su miktarı.
c. Bardakların sayısı.
d. Suyun sıcaklığı.

21. Bir bahçıvan domates üretimini artırmak istemektedir. Değişik birkaç alana domates tohumu eker. Hipotezi, tohumlar ne kadar çok sulanırsa, o kadar çabuk filizleneceğidir. Bu hipotezi nasıl sınar?

a. Farklı miktarlarda sulanan tohumların kaç günde filizleneceğine bakar.

b. Her sulamadan bir gün sonra domates bitkisinin boyunu ölçer.

c. Farklı alanlardaki bitkilere verilen su miktarını ölçer.

d. Her alana ektiği tohum sayısına bakar.

22. Bir bahçıvan tarlasındaki kabaklarda yaprak bitleri görür. Bu bitleri yok etmek gereklidir. Kardeşi "Kling" adlı tozun en iyi böcek ilacı olduğunu söyler. Tarım uzmanları ise "Acar" adlı spreyin daha etkili olduğunu söylemektedir. Bahçıvan altı tane kabak bitkisi seçer. Üç tanesini tozla, üç tanesini de spreyle ilaçlar. Bir hafta sonra her bitkinin üzerinde kalan canlı
bitleri sayar. Bu çalışmada böcek ilaçlarının etkinliği nasıl ölçülür?

a. Kullanılan toz ya da spreyin miktarı ölçülür.

b. Toz ya da spreyle ilaçlandıktan sonra bitkilerin durumları tespit edilir.

c. Her fidede oluşan kabağın ağırlığı ölçülür.

d. Bitkilerin üzerinde kalan bitler sayılır.

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

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

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

c. 10 dakika sonra alevin sıcaklığını ölçer.

d. Bir litre suyun kaynaması için geçen zamanı ölçer.

24. Ahmet, buz parçacıklarının erime süresini etkileyen faktörleri merak etmektedir. Buz parçalarının büyüklüğü, odanın sıcaklığı ve buz parçalarının şekli gibi faktörlerin erime süresini etkileyebileceğini düşünür. Daha sonra şu hipotezi sınamaya karar verir: Buz parçalarının şekli erime süresini etkiler.

Ahmet bu hipotezi sınamak için aşağıdaki deney tasarımlarının hangisini uygulamalıdır?

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

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

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

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

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

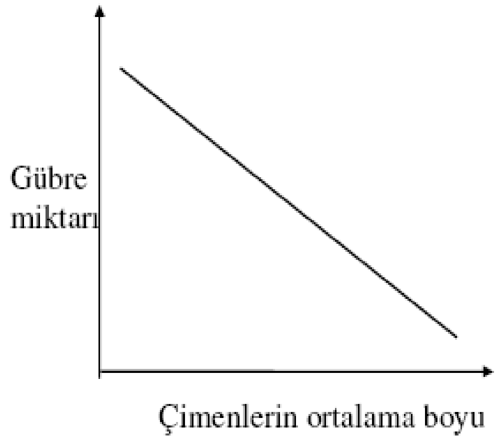
Ölçüm sonuçları aşağıdaki tabloda verilmiştir.

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

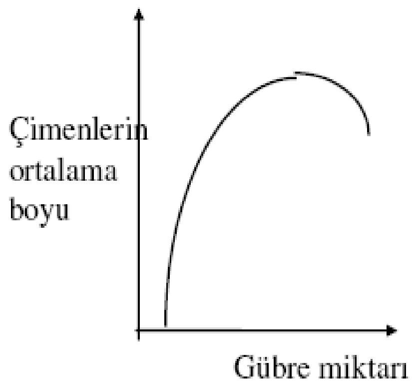
Tablodaki verilerin grafiği aşağıdakilerden hangisidir?

a.

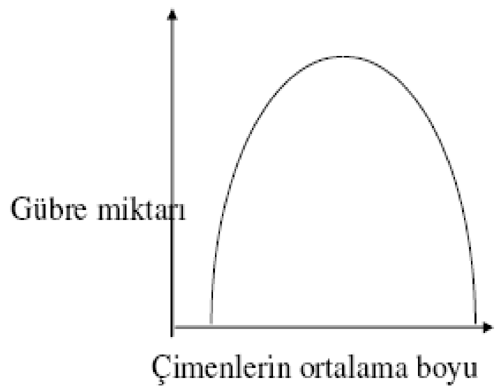
b.



c.



d.



26. Bir biyolog şu hipotezi test etmek ister: Farelere ne kadar çok vitamin verilirse o kadar hızlı büyürler.

Biyolog farelerin büyüme hızını nasıl ölçebilir?

a. Farelerin hızını ölçer.

b. Farelerin, günlük uyumadan durabildikleri süreyi ölçer.

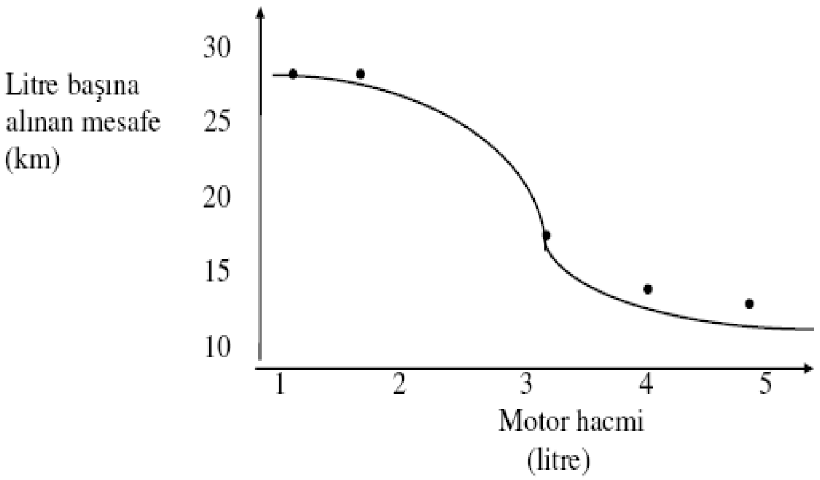
c. Her gün fareleri tartar.

d. Her gün farelerin yiyeceği vitaminleri tartar.

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

a. Daha fazla şekeri çözmek için daha fazla su gereklidir.
b. Su soğudukça, şekeri çözebilmek için daha fazla karıştırmak gerekir.
c. Su ne kadar sıcaksa, o kadar çok şeker çözünecektir.
d. Su ısındıkça şeker daha uzun sürede çözünür.

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



Aşağıdakilerden hangisi değişkenler arasındaki ilişkiyi gösterir?

a. Motor ne kadar büyükse, bir litre benzinle gidilen mesafe de o kadar uzun olur.
b. Bir litre benzinle gidilen mesafe ne kadar az olursa, arabanın motoru o kadar küçük demektir.
c. Motor küçüldükçe, arabanın bir litre benzinle gidilen mesafe artar.
d. Bir litre benzinle gidilen mesafe ne kadar uzun olursa, arabanın motoru o kadar büyük demektir.

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

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

29. Bu araştırmada sınanan hipotez hangisidir?

a. Bitkiler güneşten ne kadar çok ışık alırlarsa, o kadar fazla domates verirler.

b. Saksılar ne kadar büyük olursa, karıştırılan yaprak miktarı o kadar fazla olur.

c. Saksılar ne kadar çok sulanırsa, içlerindeki yapraklar o kadar çabuk çürür.

d. Toprağa ne kadar çok çürük yaprak karıştırılırsa, o kadar fazla domates elde edilir.

30. Bu araştırmada kontrol edilen değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki toprak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

31. Araştırmadaki bağımlı değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

32. Araştırmadaki bağımsız değişken hangisidir?

a. Her saksıdan elde edilen domates miktarı

b. Saksılara karıştırılan yaprak miktarı.

c. Saksılardaki torak miktarı.

d. Çürümüş yapak karıştırılan saksı sayısı.

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

a. Kullanılan mıknatısın büyüklüğü ile.

b. Demir tozlarını çeken mıknatısın ağırlığı ile.

c. Kullanılan mıknatısın şekli ile.

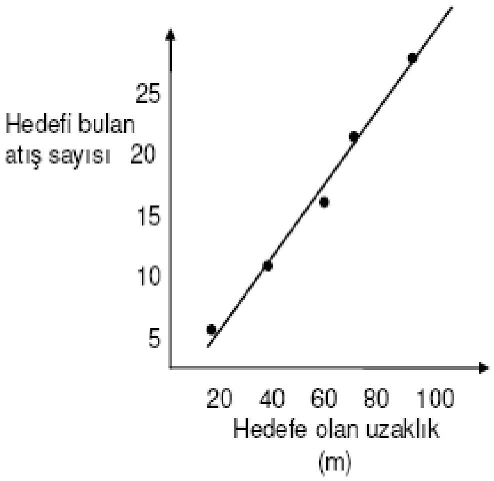
d. Çekilen demir tozlarının ağırlığı ile.

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

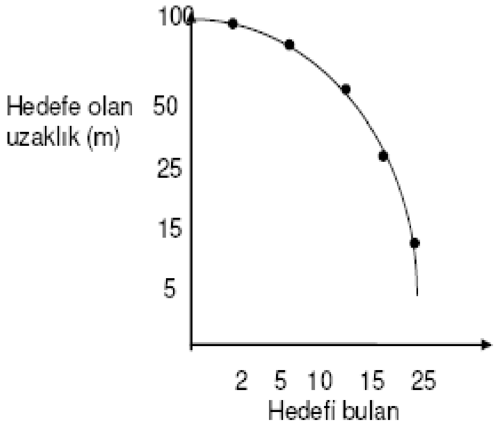
Mesafe(m)	**Hedefe vuran atış sayısı**
5	25
15	10
25	10
50	5
100	2

Aşağıdaki grafiklerden hangisi verilen bu verileri en iyi şekilde yansıtır?

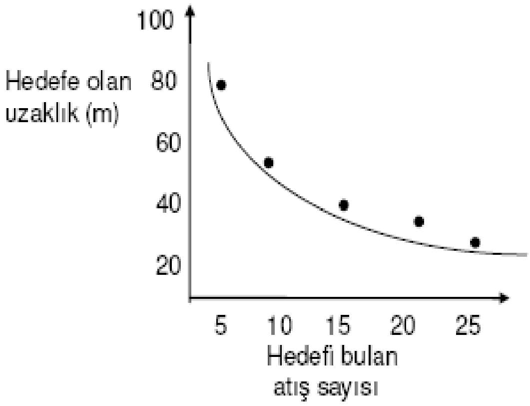
a.



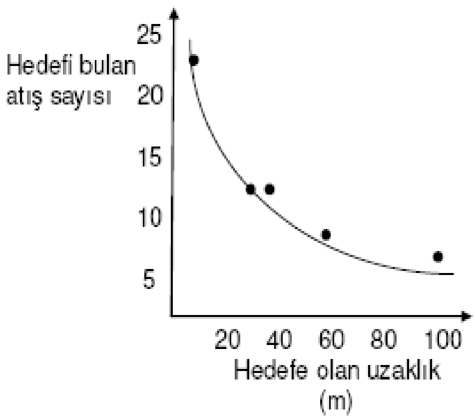
b.



c.



d.



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

a. Balıklara ne kadar çok yem verilirse, o kadar çok yeme ihtiyaçları vardır.

b. Balıklar ne kadar hareketli olursa o kadar çok yeme ihtiyaçları vardır.

c. Su da ne kadar çok oksijen varsa, balıklar o kadar iri olur.

d. Akvaryum ne kadar çok ışık alırsa, balıklar o kadar hareketli olur.

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

a. TV nin açık kaldığı süre.

b. Elektrik sayacının yeri.

c. Çamaşır makinesinin kullanma sıklığı.

d. a ve c

APPENDIX E

BİYOLOJİ DERSİ TUTUM ÖLÇEĞİ

AÇIKLAMA: Bu ölçekte, Biyoloji dersine ilişkin tutum cümleleri ile her cümlenin karşısında "Tamamen Katılıyorum", " Katılıyorum", "Kararsızım", "Katılmıyorum" ve "Hiç Katılmıyorum" olmak üzere beş seçenek verilmiştir.
Her cümleyi dikkatle okuduktan sonra kendinize uygun seçeneği işaretleyiniz.

		Tamamen Katılıyorum	**Katılıyorum**	**Kararsızım**	**Katılmıyorum**
1	Biyoloji çok sevdiğim bir alandır				
2	Biyoloji ile ilgili kitapları okumaktan hoşlanırım				
3	Biyolojinin günlük yaşantıda çok önemli yeri yoktur				
4	Biyoloji ile ilgili sorular çözmekten hoşlanırım				
5	Biyoloji konularıyla ile ilgili daha çok şey öğrenmek isterim				
6	Biyoloji dersine girerken sıkıntı duyarım				
7	Biyoloji derslerine zevkle girerim				
8	Biyoloji derslerine ayrılan ders saatinin daha fazla olmasını isterim.				
9	Biyoloji dersini çalışırken canım sıkılır				
10	Biyoloji konularıyla ilgili günlük olaylar hakkında daha fazla bilgi edinmek isterim				
11	Düşünce sistemimizi geliştirmede Biyoloji öğrenimi önemlidir				
12	Biyoloji çevremizdeki doğal olayların daha iyi anlaşılmasında önemlidir				
13	Dersler içinde Biyoloji dersi sevimsiz gelir				
14	Biyoloji konularıyla ilgili tartışmaya katılmak bana cazip gelmez				
15	Çalışma zamanımın önemli bir kısmını Biyoloji dersine ayırmak isterim				

APPENDIX F

OBSERVATION CHECK LIST

	Evet	Hayır	Kısmen
1. Öğretmen öğrencilerin katılımını artrırmak için ilgi ve merak uyandıracak yöntemler kullandı mı?			
2. Öğretmen öğrencilerin konu hakkında bildiklerini ortaya çıkaracak fırsatlar sağladı mı?			
3. Öğretmen öğrencilerin konu hakkında ön bilgilerini açıklamalarına fırsat verdi mi?			
4. Öğretmen öğrencilerin kafaları karıştıracak sorular sordu mu? (kafalarında dengesizlik yarattı mı?).			
5. Öğretmen öğrencilerin konuya farklı yaklaşımlarını tartıştırarak bu kavramların yetersizliğini/ yanlışlığını fark etmelerini sağladı mı?			
6. Öğrenciler konuyu öğrenme ihtiyacı hissetmeye başladılar mı?			
7. Öğretmen öğrencilere günlük hayattan örnekler verdi mi?			
8. Öğretmen öğrencilere düşündürücü sorular sordumu?			
9. Öğrenciler aktif olarak derse katıldılar mı?			
10. Öğretmen öğrencilerin grup olarak çalışmalarına fırsat sağlayacak ortamlar oluşturdu mu?			
11. Öğretmen bilgisayar animasyonlarını etkili bir şekilde kullandı mı?			
12. Öğretmen öğrencilerin deney malzemlerini aktif olarak kullamana bilecekleri ortamlar oluşturdu mu?			
13. Öğretmen öğrencilerin deney çalışmaları sonucunda ulaştıkları verileri sunabilecekleri ve tartışabilecekleri ortamlar yarattı mı?			
14. Öğretmen öğrencilerin çaluşmaları sonucunda ulaştıkları sonuçları dinleyip onlarlara tartışarak, gereken açıklamaları yaptı mı? eksiklerini ya da yanlışlarını giderdi mi?			
15. Öğretmen kavramları açıklarken öğrencilerin ön bilgilerini göz önünde bulundurdu mu?			
16. Öğretmen öğrencilerin mevcut kavramları diğer alanlarla veya diğer kavram/konularla ilişkilendirmelerine rehberlik etti mi?			
17. Öğretmen öğrencilerin öğrendikleri kavram ve becerileri yeni durumlara uygulamaları için cesaretlendirip gerekli ortamı oluşturdu mu?			
18. Öğretmen öğrencilerin kendi öğrendiklerini ve grup işlem becerilerini değerlendirmelerine izin verdi mi?			
19. Sınıfın fiziksel ortamı (sıcaklık, aydınlatma, oturma düzeni, vb.) dersin planlandığı gibi işlenmesine uygun mu?			
20. Öğrenciler dersin işlenişinden hoşlandılar mı?			

APPENDIX G

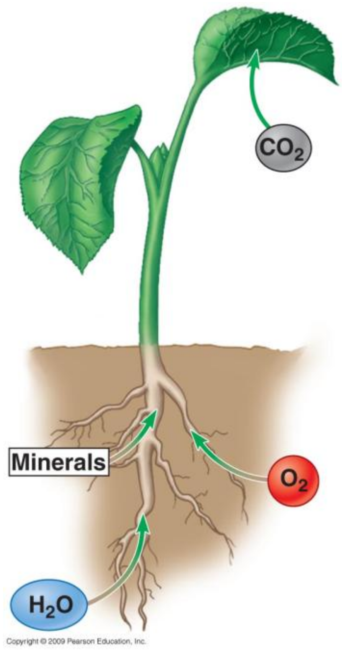
SAMPLE LESSON BASED ON 7E LEARNING CYCLE ABOUT DIFFUSION AND OSMOSIS CONCEPTS

1. ELICIT:

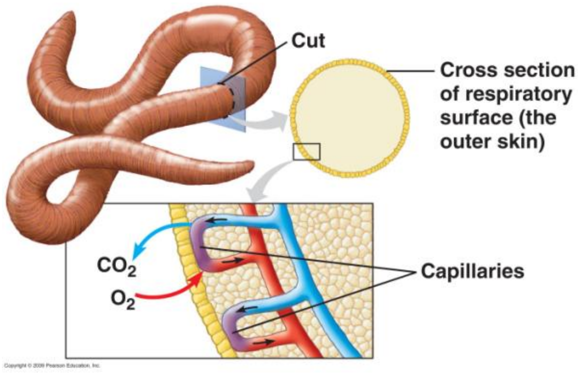
Students are expected to discuss and answer the following questions by using their prior knowledge. During the discussion of each question teacher showed a related picture on the screen from projector machine.

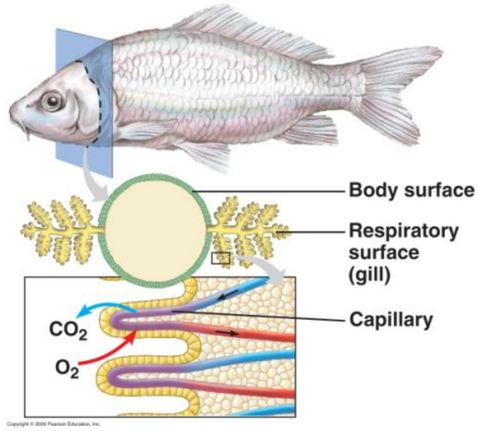
By this way she teacher tried to identify students' prior knowledge and misconceptions about the concepts related to diffusion and osmosis.

For question "How do plants can take water and minerals from soil?", she used shown figure and asked students to discuss what is happening on the picture and how these molecules move into the plant structures.



For question "How does the gas exchange occur at our lungs of mammals, gills of fish, skin of earth worms, etc?", she used a short simple animation about the exchange of oxygen and carbon dioxide taking place at mammalian lungs (Appendix H). Through this animation she wanted students think about the name of the mechanism by which this gas exchange process takes place and how these molecules moved from one area to another. Just after the animation she showed following two pictures and wanted students to notice what is the common process that they can notice for two pictures and he process in animation.





Then she called one student to go one of the corners of the class and spray a given perfume and waited for other student to smell the odour. Then she asked the question “What makes these perfume molecules reach you and so that you fee the odour?” Then she took a beaker of water prepared before the lesson and asked students that “What will happens when I dropped this crystal of a dye into this beaker full of water? At the end she wanted asked students give similar other examples about diffusion and osmosis concepts from daily life. Some students can give example as “a lump of sugar dropped into a glass of tea”. After each question she attempted to create a discussion environment, gave opportunities for students to share their ideas. After each question she attempted to create a discussion environment, gave opportunities for students to share their ideas. By this way she tried to explore students’ prior knowledge about the concepts and revealed their misconceptions about diffusion and osmosis.

2. ENGAGEMENT: At this stage teacher tried to get attention of students into the subject matter. For this purpose, she made a demonstration to show the movement of molecules across a differentially permeable membrane. Before starting main demonstration, she took 2 test tubes and placed equal amount of starch and phenolphthalein (colorless) solutions and then placed 5 drops of iodine into starch containing tube and 5 drops of NaOH into phenolphthalein containing test tube and wanted students to record color changes and to discuss the reason for using this demonstration. (Starch containing suspension changed from original color of iodine (red) into blue-black, phenolphthalein containing suspension changed from colorless form into pink). Then she took two pieces of water-soaked dialysis tubing approximately 15 cm long and tightly tied at one end. The first tube was filled with 10 mL of water and 3 drops of phenolphthalein and the second tube wass filled with 10 mL of starch suspension as seen in Figure G1.

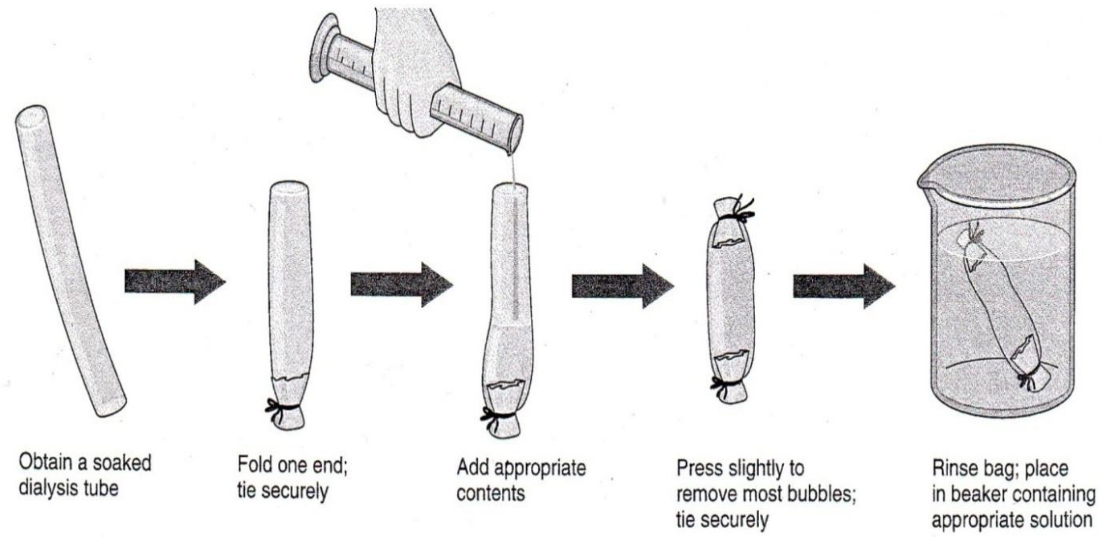


Figure G1 Preparation of dialysis tube for the process of diffusion and osmosis

NOTE: Students were given a sheet having two figures that illustrated the demonstration process and a list of discussion questions below.

Then both of the bags were placed into two different 250 mL beaker containing 200 mL tap water. For the beaker (labeled as "a"), in which the bag containing 3 drops of phenolphthalein was submerged, 10 drops of 1 M NaOH were added and for the beaker (labeled as "b"), in which the bag containing starch suspension was submerged, 20-40 drops of iodine were added. The bags were then placed on the bench for 15 minutes so that students can observe any color change. During this time period students were asked to discuss the below questions on their sheets:

1- What do you think that what will happen to the molecules inside or outside of the dialysis tube?

2- In what direction they will move? Can they go out of the bags?

3- Which one(s) can go out of or inside the bags? And Why?"

She wanted students discuss the answers of these questions together. And then she used an animation about the movement of particles through the pores of a membrane by the process of diffusion (see Appendix I).

After waiting a given period of time students realized some colour changes in both beakers. This time teacher asked students to discuss the below questions:

1- How can you describe the colour changes in the two bags and their surrounding solutions?
2- For which molecules and ions did this demonstration provide evidence for passage through the selectively permeable membrane?
3- What characteristic distinguishes those molecules and ions passing through the membrane from those that do not pass through the membrane?

NOTE: This phase of the cycle was related to Particulate Nature and Random Motion of Matter and Concentration and Tonicity concepts. During this phase, teacher acted as a facilitator for students' discussions and therefore supported students to realize that their present conceptions were not enough to explain some of these phenomena. In other words, a kind of disequilibrium was created in the students.

3. EXPLORATION: A laboratory investigation was organized for students to explore the new knowledge and solve related problems by themselves. For this purpose, she gave a brief introduction about the aim of this investigation then she divided class into 4 groups. Each group was given by letter as Group A, Group B, Group C, and Group D. Students in each group carried out similar investigation with different solutions. Each group was informed about what materials they were going to use and what procedure they were going to apply. Each group was supposed to record their observations on a “Data Collection Tables” given with their lab sheets. Each group discussed the questions given by the teacher considering their observations. At the end of the activity they were expected to share their data with other members of the class.

NOTE: This phase of the cycle was also related to Particulate Nature and Random Motion of Matter and Concentration and Tonicity concepts. With this activity teacher let the student manipulate materials to actively explore concepts, processes or skills and by this way a kind of equilibration was initiated by the teacher. The teacher was the facilitator. She observed and listened to students and suggested approaches, provided feedback, and assessed their understandings.

Each group followed the below procedure:

1. Wear your safety goggles, plastic gloves, and laboratory apron. Work in a team. You will eventually share your data with other members of the class.
2. Obtain a decalcified egg, provided by your teacher. Gently blot it on a paper towel and determine the mass of it, using the correct procedure as instructed before (See Figure G2).

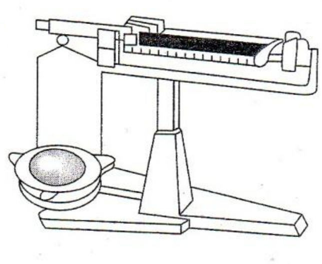


Figure G 2 Measuring the initial mass of a decalcified egg

3. Record the initial mass of your egg in the space provided on data table for your own group.

4. Place your egg in the beaker as seen in figure G3, cover it with the solution assign for your group and record the time.
5. Place your egg in a 250 mL beaker. Fill this beaker with 150 mL of the solution assigned for your group to just cover the egg. On data table of your group, record the time the egg placed in the solution. Note the appearance of the water at this time and record your observation.
6. After 10 minutes have elapsed; use a plastic spoon to remove each egg from its beaker.
7. Carefully blot the egg with a paper of towel and determine the mass of it.

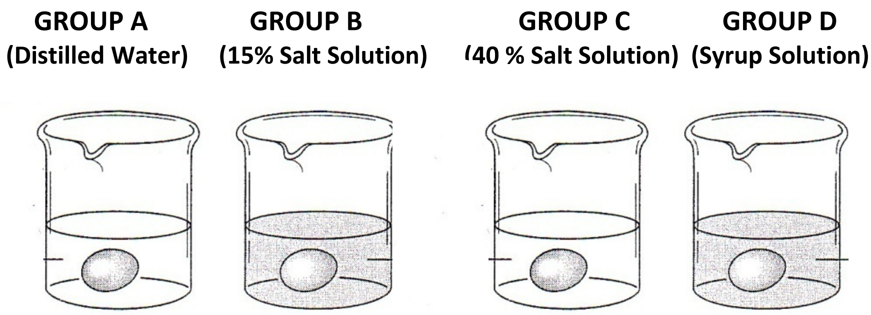


Figure G 3 Contents of the beakers having decalcified eggs for Group A, Group B, Group C and Group D

8. Record in data table of your group the mass of the egg that was immersed in water.
9. Gently return your egg to the beaker. Note the time again.
10. Repeat steps "6" every 10 min., as long as time permits. Record the mass of the egg for each 10-minute interval on data table of your group.
11. After you have completed the last mass determination of the egg, record the appearance of the solution in the beaker on Table E 5.
12. Determine the percentage change in mass of your egg for each 10-minute interval by using the following formula:

$$\frac{\text{(mass after immersion – initial mass) X 100}}{\text{initial mass}}$$

13. Record this percent mass change on data table of your group.
14. Calculate the mean of the % mass change of your egg at the end.
15. Share your data with other members of the class by using data on table G 5
16. Graph the percent change in mass of each egg versus time using the graph paper given by your teacher. Use different symbol or color for each egg.

Table G 1 Measuring the change in mass of decalcified egg ***in distilled water***

Time (minutes)	**Mass (grams)**	**% Mass change**
In ______ Out______	Initial mass ________	
In ______ Out______	After 10 min. ________	
In ______ Out______	After 20 min. ________	
In ______ Out______	After 30 min. ________	
In ______ Out______	After 40 min. ________	
In ______ Out______	After 50 min. ________	
Mean of the % Mass Change		

Table G 2 Measuring the change in mass of decalcified egg ***in 15% Salt Solution***

Time (minutes)	**Mass (grams)**	**% Mass change**
In ______ Out______	Initial mass ______	
In ______ Out______	After 10 min. ________	
In ______ Out______	After 20 min. ________	
In ______ Out______	After 30 min. ________	
In ______ Out______	After 40 min. ________	
In ______ Out______	After 50 min. ________	
Mean of the % Mass Change		

Table G 3 Measuring the change in mass of decalcified egg ***in 40% Salt Solution***

Time (minutes)	**Mass (grams)**	**% Mass change**
In ______ Out______	Initial mass ________	
In ______ Out______	After 10 min. ________	
In ______ Out______	After 20 min. ________	
In ______ Out______	After 30 min. ________	
In ______ Out______	After 40 min. ________	
In ______ Out______	After 50 min. ________	
Mean of the % Mass Change		

Table G 4 Measuring the change in mass of a decalcified egg ***in Syrup Solution***

Time (minutes)	**Mass (grams)**	**% Mass change**
In ______ Out______	Initial mass ________	
In ______ Out______	After 10 min. ________	
In ______ Out______	After 20 min. ________	
In ______ Out______	After 30 min. ________	
In ______ Out______	After 40 min. ________	
In ______ Out______	After 50 min. ________	
Mean of the % Mass Change		

Table G 5 Initial and final **a**ppearances of solutions of four different groups

		Initial appearance	Final appearance	Mean of % Mass Change
Egg placed in	**Distilled water**			
	15% Salt Solution			
	40%Starch Solution			
	Syrup Solution			

At the end of the investigations **s**tudents in each study groups were asked to study the below conclusion and discussion questions:

1. Did any egg gain mass over time? If so, which one (s)? Explain your answer.
2. Did any egg loss mass over time? If so, which one (s)? Explain your answer.
3. Describe any changes in the appearance of 4 different solutions.
4. Explain why there were changes in the mass of the eggs either a loss or gain.
5. Explain any changes you observed in the appearance of 4 different solutions.
6. Using the terms isotonic, hypotonic, and hypertonic explain the changes in mass of the eggs.
7. Were the results consistent throughout the class? If not, explain the sources of error that may have affected the results.

4. EXPLANATION: In this phase, teacher allowed students to share and explain their findings and ideas that they gained in the previous stages. So, she tried to guide students to modify and enhance their concepts. Teacher clarified the answer of the questions asked in the previous phases and clearly connected these explanations with students' gained experiences by the use three computer animations. So that she provided an interactive, visual, and clear explanation. In the first animation, the process of osmosis and concepts related to concentration and tonicity were explained (see Appendix J). In the second animation the structure of the cell membrane was shown and briefly explained at first, then passive transport mechanism as simple diffusion, facilitated diffusion and diffusion of water (osmosis) were animated with an explanation of each (see Appendix K). The third animation was about the mechanism for the uptake of water and minerals from soil into plant root cells (see Appendix L).

Before giving an explanation, she teacher listened to each group's answer at first. Then she explained the concept using students' previous experiences. She gave examples from daily life in order to make concepts more concrete. For the answer of the question asked in "engagement" phase, she explained the reason of color changes for each bag and their surrounding solutions and clarified this demonstration provide evidence for passage of molecules and ions (phenolphthalein, iodine, starch, Na^+, OH^-) through the selectively permeable membrane and also explained what characteristic distinguishes those molecules and ions passing through the membrane from those that do not pass through the membrane.

Students were expected to explain their own data and the data of other groups. They discussed which egg gained or lost mass over time and why. They described if there was any changes in the appearance of the solutions in which eggs were suspended for the investigation of each group. They had determined and listed important concepts on the board. Teacher helps students to find out an explanation for each of these concepts by considering the data they had found.

NOTE: This phase of the cycle was related to Particulate Nature and Random Motion of Matter, Concentration and Tonicity, and Processes of diffusion and osmosis, Membrane, and Kinetic Energy of Matter. During this phase, the role of the teacher was to give an explanation for the following concepts: passive transport mechanisms, simple diffusion, diffusion of water (osmosis), selective permeability, concentration gradient, hypotonic solution, isotonic solution, plasmolysis, deplasmolysis, turgor pressure, osmotic pressure, factors affecting the rate of diffusion.

5. ELABORATION: During this phase, teacher provided students with further investigations to extend or elaborate the concepts, processes, or skills gained during the previous stages. For this purpose she let students explore how osmosis and the rate of diffusion were affected by free-energy gradient. She aimed at finding out where students had difficulties and provided help to overcome them. Students in groups of 4 carried out an investigation in order to observe how the speed at which a substance diffuses from one area to another depends on the free-energy gradient between those areas. For example, if concentration of a diffusing substance at the two areas differs greatly, the free-energy gradient was steep and diffusion was rapid. By this way they could also observe what happens to a cell is a hypertonic, hypotonic and isotonic solution. During this phase, teacher used formal assessment methods to evaluate instructional objectives and misconceptions.

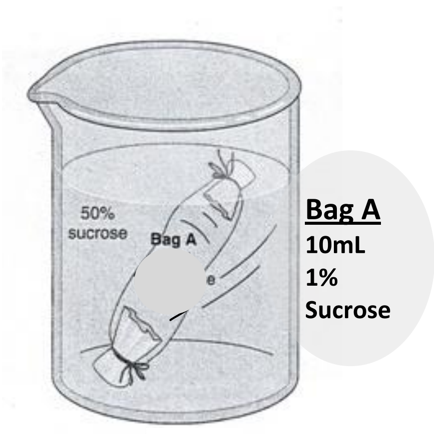
NOTE: This phase of the cycle was related to Particulate Nature and Random Motion of Matter, Concentration and Tonicity, and Processes of diffusion and osmosis, Membranes.

Each study group was given by a dialysis bag, as a model of a cell. Then each group placed their own bags (cells) in different solutions as hypotonic, hypertonic or isotonic.

MATERIALS

FOR GROUP A:

-2X strings 15 cm long
-1X250 mL beaker
-1X water-soaked dialysis tubing 15 cm long
-balance
-10 mL, 1% sucrose solution
-200 mL 50% sucrose solution



(a)

<u>FOR GROUP B:</u>

-2X strings 15 cm long

-1X250 mL beaker

-1X water-soaked dialysis tubing 15 cm long

-balance

-10 mL, 1% sucrose solution

-200 mL 1% sucrose solution

(b)

<u>FOR GROUP C:</u>

-2X strings 15 cm long

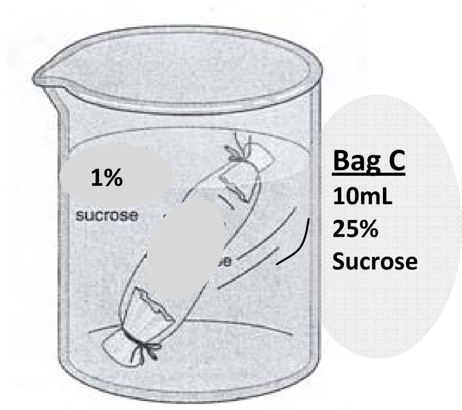
-1X250 mL beaker

-1X water-soaked dialysis tubing 15 cm long

-balance

-10 mL, 25% sucrose solution

-200 mL 1% sucrose solution



(c)

<u>FOR GROUP D:</u>

-2X strings 15 cm long

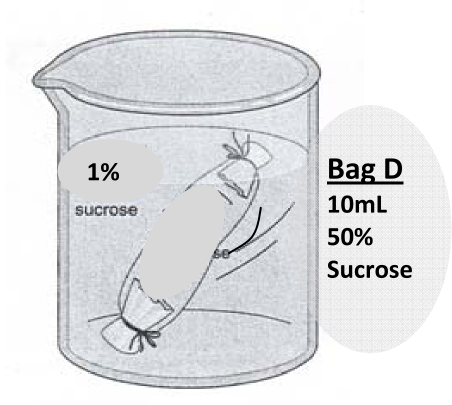
-1X250 mL beaker

-1X water-soaked dialysis tubing 15 cm long

-balance

-10 mL, 50% sucrose solution

-200 mL 1% sucrose solution



(d)

Figure G4 Dialysis bags in different sucrose solutions (a), (b), (c), and (d) as a model of a cell

PROCEDURE:

<u>Observation of Osmosis along a free-energy gradient</u>

1- Obtain 2 pieces of string and a piece of water-soaked dialysis tubing 15 cm long
2- Open the other end of the tube by rolling it between your thumb and finger
3- Fill the bags with the contents shown in the above figures for your own group above
4- To label your group write your group letter (as A, B C, or D) on the surface of your beaker
5- For your bag, loosely fold the open end and press on the sides to push the fluid up slightly and remove most of the air bubbles
6- Tie the folded ends securely, rinse the bag, and check for leaks
7- Blot excess water from the outside of the bag and weigh each bag to the nearest 0.1g
8- Record this initial weights of your bag in the first column of the Data Collection Table
9- Bags B, C, and D of the other groups are separately placed in a 250 mL beaker filled 200 mL 1% sucrose to cover the bags. Record the time
10. Bag A of Group A is placed in an empty 250 mL beaker and fill the beaker with 200 mL 50% sucrose to cover the bag. Record the time.
11- Remove your bag from the beaker at 15 min. intervals for the next hour, bolt it dry, and weigh it to nearest 0.1 g
12- Handle your bag to avoid leaks and quickly return it to its beaker
13- During the 15 min. intervals, use your knowledge of osmosis to make hypothesis about the direction of water-flow in each system (i.e., into or out of the bag) and extend of water flow in each system (i.e., in which system will osmosis be most rapid?)
14- For each 15 min. interval record the total weight of each bag and its contents in the table
15- Calculate and record on the Table E 6 the change in weight since the previous weighing

Table G 6 The change in weight of dialysis bags used as cellular models

CHANGE IN WEIGHT OF DIALYSIS BAGS USED AS CELLULAR MODELS										
	0 min	15 min.		30 min.		45 min.		60 min.	
BAGS	Initial Weight	Total Weight	Change in Weight	Total Weight	Change in Weight	Total Weight	Change in Weight	Total Weight	Change in Weight
A									
B									
C									
D									

<u>Graphing of Osmosis</u>

1- Use a graph paper at the end of the investigation to construct a graph of *Total Weight (g)* vs. *Time (min)* by using the data of all groups

2-Plot the data for total weight at each time interval from Data Collection Table

3-Use separate curves for the data of each group on the same graph

DISCUSSION QUESTIONS:

1-Which solution (s) in the beakers is (are) an isotonic/ hypertonic/ hypotonic solution?

2-Did water move across the membrane in all bags containing sucrose solutions?

3-In which bags did osmosis occur?

4-A free energy gradient for water must be present in cells for osmosis to occur. Which bag represented the steepest free-energy gradient relative to its surrounding environment?

5-The steepest gradient of free energy should result in the highest rate of diffusion. Examine the data in your Data Collection Table for Change in Weight during the 15' and 30 min intervals. Did the greatest changes in weight occur in cells with the steepest free-energy gradients? Why or why not?

6-Refer to your graph. How does the slope of a segment of a curve relate to the rate of diffusion?

7-Components of free energy causes the curves for Bags C and D eventually to become horizontal (i.e., have a slope = 0)?

EXPLANATION: Students share their answers to the previous questions. They used their observations and recordings in their explanations. The teacher listened critically to all of them. She explained some other important concepts as plasmolysis, deplasmolysis, lysis,

6. EXTENSION

In this phase students discussed the forces that act on water within a plant in terms of the water's potential energy. Teacher provided information about water potential and states that water in a plant possesses potential energy for two reasons: 1) Pressure exerted by the atmosphere (pressure potential),

2) Pressure exerted by diffusion forces (solute potential).

The sum of these two potentials is known as water potential.

Then students were asked to discuss water potential in different locations of a plant such as water potential in leaves and roots. They needed to remember direction of diffusion in accordance with a gradient in water potential. They were expected to relate that water flows through a plant from the higher water potential of the root tissues toward the lower water potentials of leaves.

With the following investigation they measured the concentration of solutes in potato cells and relate this concentration to water potential.

Five beakers with different concentration of salt (NaOH) solutions (0%, 1%, 5%, 10%, 15%) prepared by the teacher were located on the front bench of the laboratory. Five equal sized (i.e., same in length and weight) potato cylinders were placed into each of these solutions. The students were divided into 5 study groups. Each group was assigned with one of these beakers as Group A, Group B, Group C, Group D and Group E. Groups measured the weight of potato cylinders for 15 min. intervals. They carried out 3 measurements and each group recorded their data on the Table G7 provided by the teacher on the board.

NOTE: The purpose of this experiment was to transfer of students' knowledge about diffusion and osmosis to the new concept of as the effect of different solute concentrations on living plant cells, which is related to plant transport unit of eleventh grade biology curriculum.

CHANGE IN THE WEIGHT OF POTATO CYLINDERS						
GROUPS	**Concentration of Salt Solutions**	**Initial Weight of Potato Cylinders (g)**	**Weight of Potato Cylinders (I. 15' interval) (g)**	**Weight of Potato Cylinders (II. 15' interval) (g)**	**Weight of Potato Cylinders (III. 15' interval) (g)**	**AVERAGE CHANGE IN WEIGHT (g)**
Group A	0%					
Group B	1%					
Group C	5%					
Group D	10%					
Group E	15%					

Table G7 Change in the weight of potato cylinders placed into different concentration of salt solutions

DISCUSSION QUESTIONS

1-Which potato cylinders increased in size? Why?

2-Which solution (s) contained a higher concentration of solutes than in potato cells? Explain your answer.

3-Which salt solution best approximated the concentration of solutes in the potato cells?

4-Does this concentration of solutes in potato cells creates a water potential?

5-How would this affect the movement of water in the plant? What does this imply about the solute concentration of water in the soil?
6-What might be some sources of errors in this experiment?
7-How could a graph help you estimate the solute concentration of potato cells?

7. EVALUATION: In this phase, the purpose of the teacher was to encourage students to assess their understanding and abilities; and evaluate their understanding and skills acquired during previous phases. For doing this, students were given a list of questions and shown with the figures of animal and plant cells and then teacher asked students to discuss what is happening to these cells placed in different solutions for each figure. Students were expected to compare plant and animals in each of these solutions by using the concepts of osmosis, hypertonic, isotonic, hypotonic solutions, or other related concepts they had learnt. Teacher collected students answer and then gave feedback about their understanding and skills.

Below figures of animal and plant cells can be used to start this phase.

Figure G 5 Osmosis in animal cells

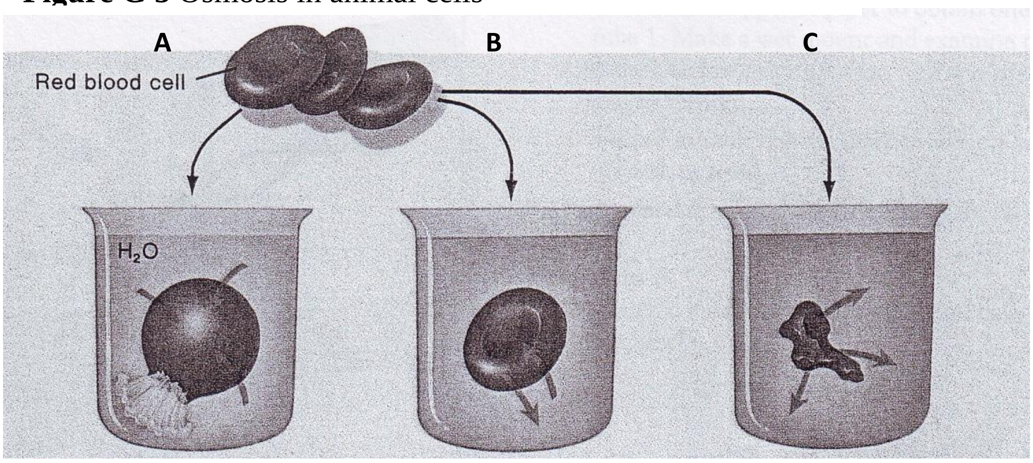
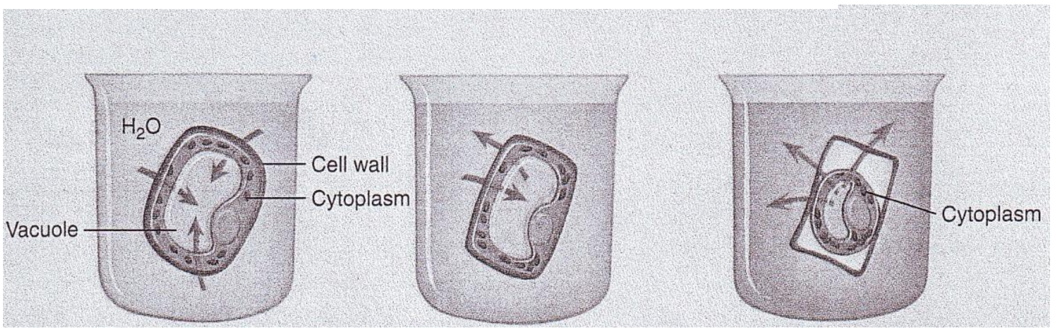


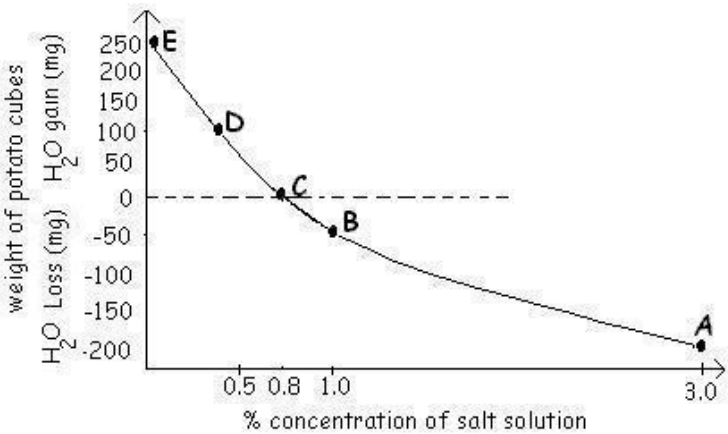
Figure G 6 Osmosis in plant cells



Teacher listened answers of the students, tried to recognize their missing and mistakes and then explain these concepts.

Teacher wanted each student to answer the questions below:

1- Five potato cubes (labeled as A, B, C, D and E) of equal size and weight were placed in five different concentrations of salt solutions. The potato cubes were weighed again after they are put in salt solutions for 30 minutes, and the following graph was obtained.



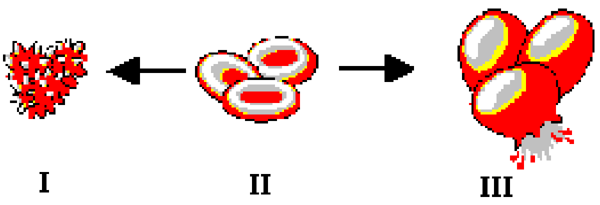
a) Name the solutions in which the potato cubes are placed either hypotonic, hypertonic or isotonic for each of the potato cubes.

Potato A: Potato B: Potato C:

Potato D: Potato E:

b) Why were potato cube A and B below their original weights?

2- Answer the below questions by using the following figures.



a) In figure I, cell is in ……………………………. condition

b) Osmotic pressure is the highest at figure …………………………….

c) The cell is placed into ……………………………. solution in figure I

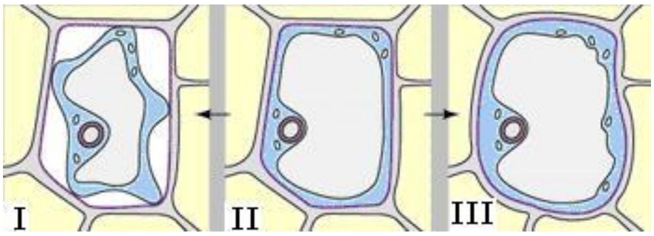
d) The name of the event shown in figure III is ....

e) The event shown in figure III occurs because the amount of water in the solution is ………… than the amount of water in the cell.

3- Fill in the below table by comparing two types of transport mechanisms in terms of given criteria.

	Facilitated Diffusion	**Osmosis**	**Simple Diffusion**
Energy requirement			
Carrier protein requirement			
Direction of movement			

4- Answer the below questions by using the following figures.



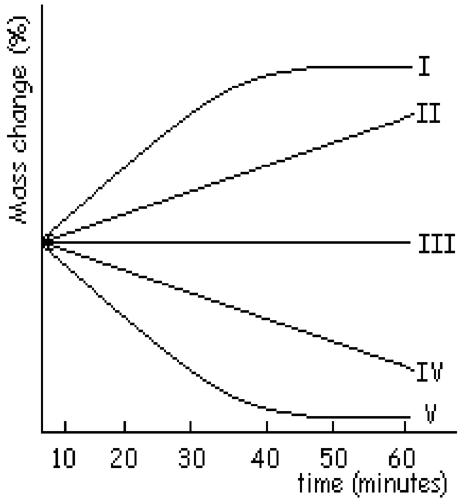
a) In figure I, cell is in ……………………………. condition

b) Turgor pressure is most at figure …………………………….

c) The cell is put into ………………………………. solution in figure II

d) The osmotic pressure is the highest in figure …………………………….

5- Read the following information and refer to figure below to answer the following three questions.



Five dialysis bags, impermeable to sucrose, were filled with various concentrations of sucrose and then placed in separate beakers containing an initial concentration of 0.6 % sucrose solution. At 10-minute intervals, the bags were weighed and the percent change in mass of each bag was graphed.

a) Which line represents the bag with the highest initial concentration of sucrose? Why?

b) Which line represents the bag with the lowest initial concentration of sucrose? Why?

APPENDIX H

PROCESS OF DIFFUSION

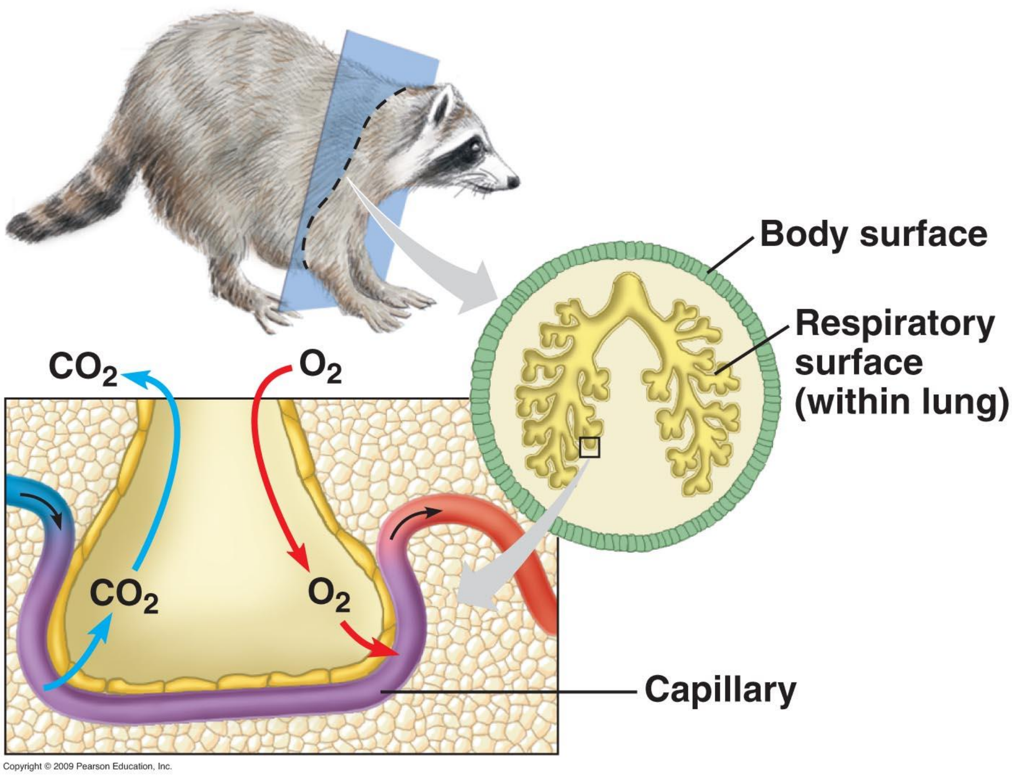


Figure H.1 Exchage of respiratory gases between air in the lungs and blood

APPENDIX I

PARTICULATE AND RANDOM NATURE OF MATTER

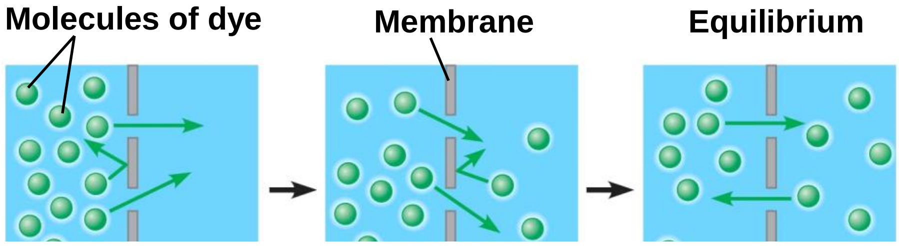


Figure I.1 Diffusion of dye particles through a membrabe

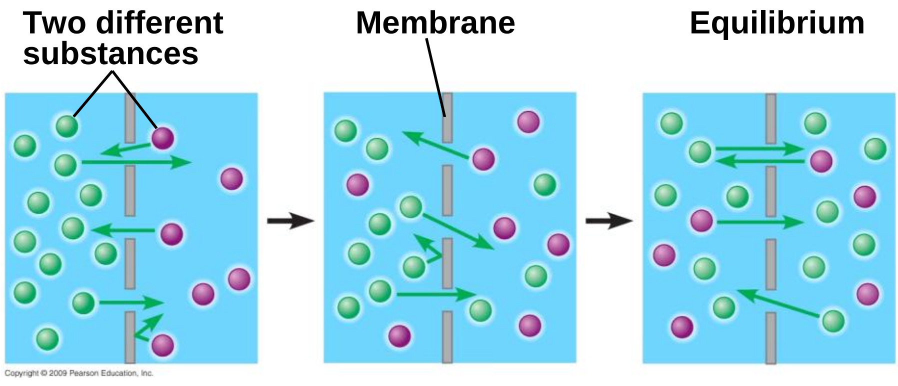


Figure I.2 Diffusion of two different particles through the pores of a membrabe

APPENDIX J

CONCENTRATION AND TONICITY

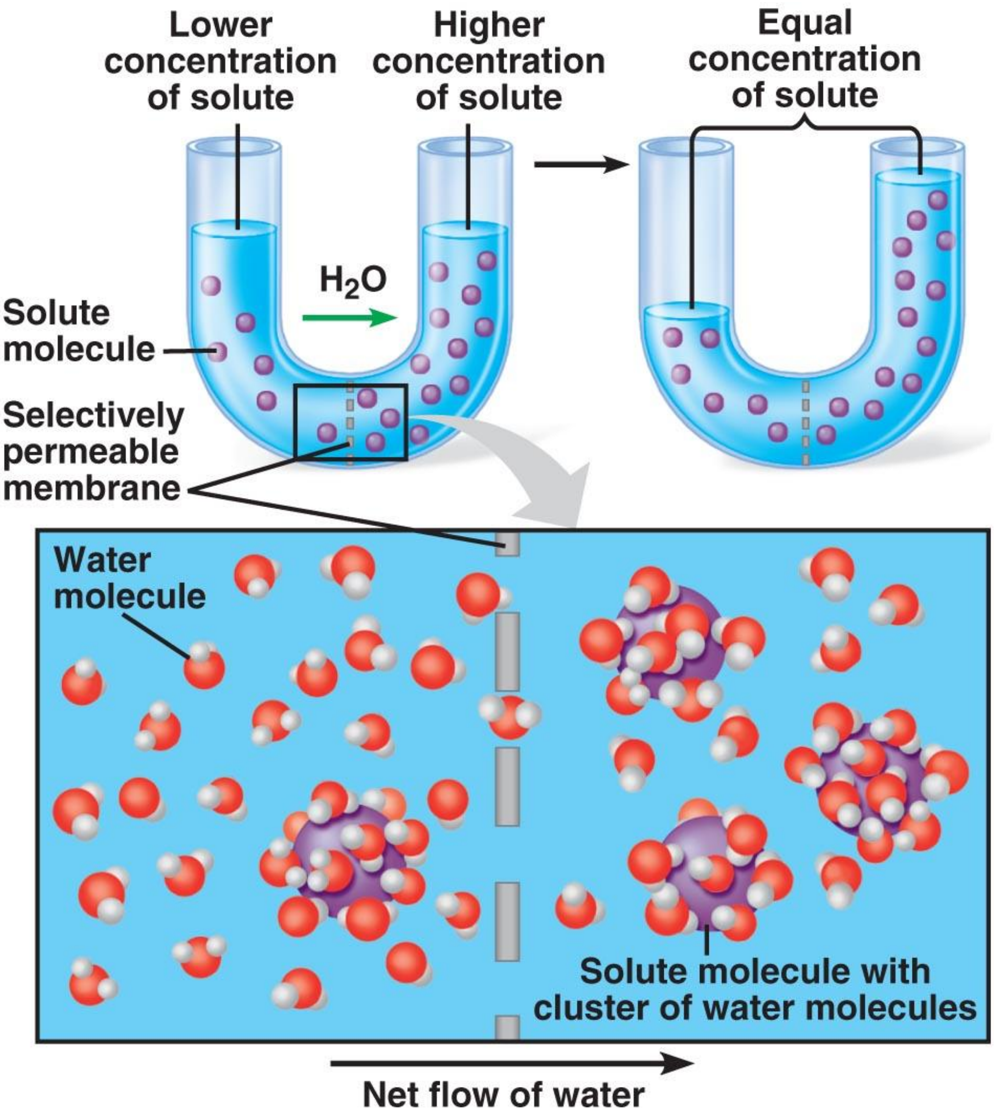


Figure J The process osmosis through a slectively permeable membrane

APPENDIX K

MEMBRANE

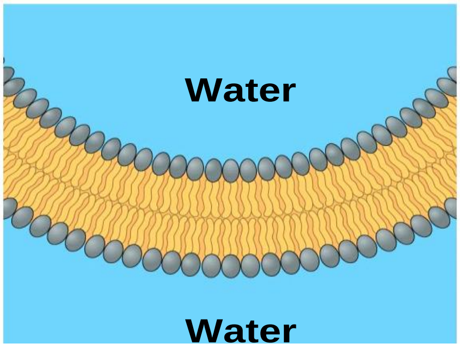


Figure K.1 Structure of the cell membrabe

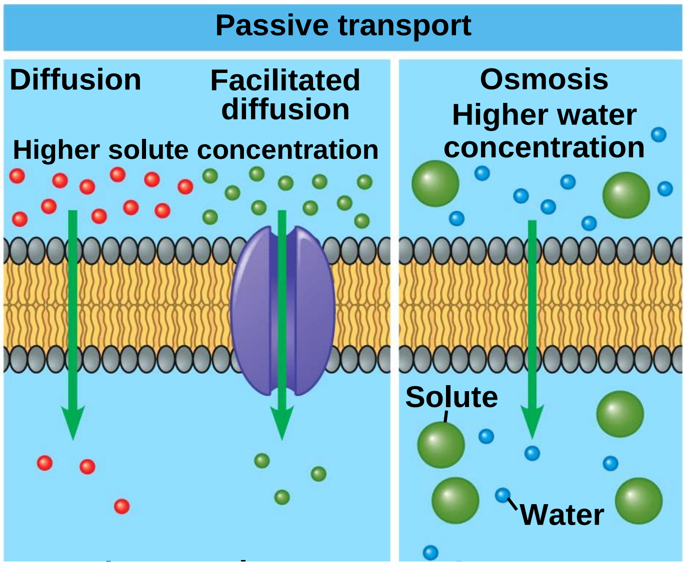


Figure K.2 Types of diffusions

APPENDIX L

INFLUENCE OF LIFE FORCES ON DIFFUSION AND OSMOSIS

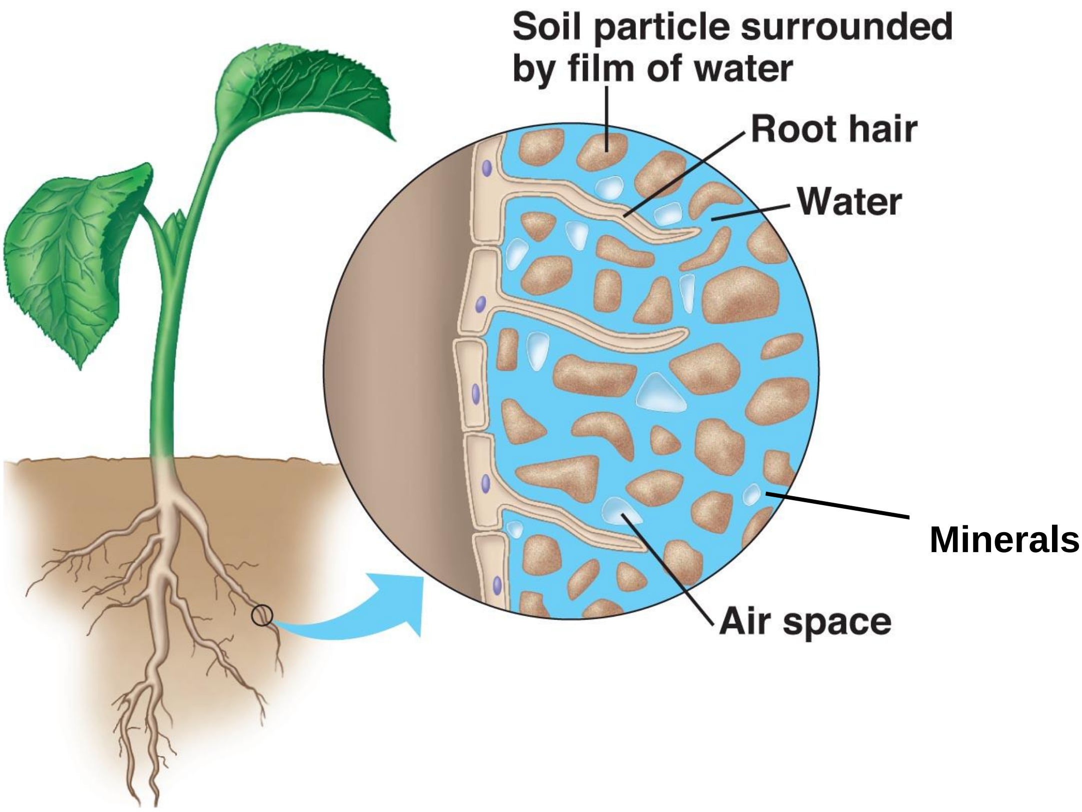


Figure L Mechanism for the uptake of water and minerals from soil into plant root cells

CURRICULUM VITAE

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EDUCATION:

Degree	Institution	Year of Graduation
MS	METU, Science Faculty	1994
BS	METU, Science Education	1998

RESEARCH INTEREST

Conceptual Change Approach, 7E Learning Cycle Model, Constructivism

FOREIGN LANGUAGES

Advanced English

HOBIES

Reading, Skiing, Playing tennis

WORKING EXPERIENCE

1994 – 1996: Karabük Anatolian Lycee/ Karabük, TURKEY

1996 – 2006: TED Ankara College Foundation High School/ Ankara, TURKEY

2006 – 2009: Enka Private High School/ Istanbul, TURKEY

2009 – 2010: VKV Koç High School/ Istanbul, TURKEY

Related teaching duties:

1- University Preparatory Courses
2- Academic Improvement Programs
3- Developing Science Education Project
4- Supervisor of the High School Students for TUBITAK Project
5- Integration of IB Biology Curriculum into the National Biology Curriculum
6- Biology Coach of the TUBITAK Science Olympiads
7- Extended Essay Supervisor of IB students
8- IB Examiner for SL Paper 2
9- Preparation of Question Bank for the Biology Department (SOBIS)
10- Project Leader for the “Young Reporters for The Environment Project”
11- Project Leader for “Youth for Habitat”
12- Mentor to new teachers
13- Science Fair Project
14- Teacher-in-charge of First Aid
15- Leading Eco-school Club
16- Leading Innovation Club

PROFESSIONAL TRAINING

1- IB Summer Workshop: June 2000, Zagreb/ Croatia (participant)

2- 5th Annual IB Day: March 2003, Ugur College, Istanbul, Turkey (presenter)

3- Education and Science Seminar: October, 2003, Ankara, Turkey (presenter)

4-7th Annual Autumn Teachers’ Conference: October 2003, VKV Koç High School, Istanbul, Turkey (presenter)

5- 6th Annual IB Day: March 2004, Yüzyıl Işıl Schools, Istanbul, Turkey (presenter)

6- Differentiated Instruction Course: October 2007, Istanbul, Turkey

7- 8th EMBO/EMBL Joint Conference on Science and Society- The future of our Species Evolution, Diseases and Sustainable development: 2-3 November 2007, EMBL Heidelberg, Germany

8- IB Internal Assessment Workshop- 15th October- 16th November, 2007

9- IB Extended Essay Workshop- 5th March- 10th April, 2008

10- XX. International Genetic Workshop in Berlin- 12th -17th July, 2008

11- Training workshop for the use of Smart board- 2008

12- Training workshop for Blog preparation- 2008

13- AIE Conference 2008: October 2008, Istanbul, Turkey (as a presenter)

14- IBO Examiner training workshop: April 2009, IBO

15- IBO SCORIS Assessment training workshop- April 2010, IBO

16- Teacher Training Workshop: ELLS Learning LAB: Colors of Life: New Frontiers in Microscopy: 1st-3rd March, 2010 – EMBL Monterotondo, Italy

PUBLISHED ARTICLE(s) and AWARD(s):

1- Regeneration of *Agrobacterium* mediated Transformation Studies in Tomato (*Lycopersicon esculentum* Miller), Turkish Journal of Botany, 2 (5), 1999

2- TUBITAK High School Students' Project Competition- Second Place, 2004

3- The European Society of Human Genetics, DNA Day Essay Contest for High School Students: June, 2010- Second, 2010