THE EFFECT OF PROJECT BASED LEARNING ORIENTED INSTRUCTION ON STUDENTS' UNDERSTANDING OF HUMAN CIRCULATORY SYSTEM CONCEPTS AND ATTITUDE TOWARD BIOLOGY

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ABSTRACT

THE EFFECT OF PROJECT BASED LEARNING ORIENTED INSTRUCTION ON STUDENTS' UNDERSTANDING OF HUMAN CIRCULATORY SYSTEM CONCEPTS AND ATTITUDE TOWARD BIOLOGY

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The purpose of the study is to examine the effect of project based learning oriented instruction (PBLOI) on 11th grade students' achievement in human circulatory system concepts and their attitudes toward biology as a school subject when compared to traditional designed biology instruction (TDBI). Seventy two 11th grade students from two classes in a public high school in Ankara participated in this study in the second semester of 2008-2009. These classes were randomly assigned as control and experimental groups. In the experimental group PBLOI was used while in the control group TDBI was used.

Human Circulatory System Achievement Test and Attitude Scale toward Biology were given to the control and experimental groups as pre-tests and post-tests in order to assess students' achievement in human circulatory system and their attitudes toward biology, respectively. In addition, Science Process Skills Test was administered to both groups at the beginning of the study in order to assess students' science process skills.

In order to test the hypotheses of the study, Analysis of Covariance (ANCOVA) and Two-Way Analysis of Variance (ANOVA) were used. The results show that PBLOI caused a significantly better acquisition of scientific concepts related to human circulatory system than TDBI. However, there was no significant effect of PBLOI on students' attitudes toward biology. In addition, there was no significant effect of gender on both students' achievement in human circulatory system and their attitudes toward biology.

Keywords: Project Based Learning Oriented Instruction, Human Circulatory System, Attitude toward Biology, Models, Science Process Skill

ÖZ

PROJE TABANLI ÖĞRENMEYE DAYALI ÖĞRETİM METODUNUN ÖĞRENCİLERİNİN İNSAN DOLAŞIM SİSTEMİ KAVRAMLARINI ANLAMALARINA VE BİYOLOJİ DERSİNE KARŞI TUTUMLARINA ETKİSİ

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Bu çalışmanın amacı proje tabanlı öğrenmeye dayalı öğretim metodunun geleneksel biyoloji öğretimine kıyasla 11. sınıf öğrencilerinin insan dolaşım sistemi kavramlarını anlamalarına ve biyoloji dersine karşı tutumlarına etkisini incelemektir. Bu çalışmaya 2008-2009 öğretim yılının ikinci döneminde Ankara'da bulunan genel bir lisedeki iki kimya sınıfında öğrenim gören yetmiş iki on birinci sınıf öğrencisi katılmıştır. Bu sınıflar kontrol ve deney grubu olarak rastgele seçilmiştir. Kontrol grubunda geleneksel biyoloji eğitimine dayalı öğretim metodu kullanılırken deney grubunda proje tabanlı öğrenmeye dayalı öğretim metodu kullanılmıştır.

Öğrencilerin insan dolaşım sistemi ile ilgili kavramları anlamalarını değerlendirmek için İnsan Dolaşım Sistemi Başarı Testi ve biyolojiye karşı tutumlarını değerlendirmek için Biyolojiye Karşı Tutum Ölçeği kontrol ve deney grubundaki öğrencilere ön test ve son test olarak uygulanmıştır. Ayrıca öğrencilerin bilimsel işlem becerilerini belirlemek için çalışmanın başlangıcında her iki gruptaki öğrencilere Bilimsel İşlem Beceri Testi uygulanmıştır.

Çalışmanın hipotezlerini test etmek için Kovaryans Analizi (ANCOVA) ve İki Yönlü Varyans Analizi (ANOVA) kullanılmıştır. Sonuçlar, proje tabanlı öğrenmeye dayalı öğretimin geleneksel biyoloji öğretimi ile kıyaslandığında insan dolaşım sistemi ile ilgili kavramların anlaşılmasında daha etkili olduğunu göstermiştir. Bununla birlikte, bu öğretimin öğrencilerin biyolojiye karşı tutumlarında anlamlı bir etkisinin olmamıştır. Ayrıca, cinsiyetin hem öğrencilerin insan dolaşım sistemi kavramlarını anlamalarına hem de onların biyolojiye karşı tutumlarına anlamlı bir etkisinin olmadığı belirlenmiştir.

Anahtar Sözcükler: Proje Tabanlı Öğrenmeye Dayalı Öğretim, İnsan Dolaşım Sistemi, Biyolojiye Karşı Tutum, Modeller, Bilimsel İşlem Becerisi.

To my family...

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TABLE OF CONTENTS

LIST OF TABLES

TABLES

LIST OF ABBREVIATIONS

PBL : Project-Based Learning

PBLOI : Project Based Learning Oriented Instruction

TDBI : Traditionally Designed Biology Instruction

HCSAT : Human Circulatory System Achievement Test

ASTB : Attitude Scale toward Biology

SPST : Science Process Skill Test

EG : Experimental Group

CG : Control group

CHAPTER I

INTRODUCTION

Students experience difficulties in comprehending the fundamental concepts and principles, applying them into different contexts, link their school knowledge to real life (Finn, 1991). This fact is also an important concern among science educators (Ladewski, Krajcik & Harvey, 1994). To overcome these problems, science educators develop authentic and context-rich activities for students to help them cognitively engage in school tasks (Brown, Collins & Duguid, 1989). The project-based learning (PBL) serves this purpose by activating students in learning tasks during the investigation of meaningful questions. Tyler explained it as (1949, as cited in Yam & Rossini, 2010*) "learning takes place through the active behavior of the student, it is what he does that he learns, not what the teacher does" (p.63)*. In sum, in PBL classrooms, students construct their own knowledge in active learning atmosphere. Krajcik, Czerniak, and Berger (1999) declare four gains of PBL: (1) integrated understanding of materials is enhanced, (2) collaborative studying is learned during problem solving process, (3) independent learning is promoted since students take more responsibility in their learning, and (4) different types of learning are satisfied due to diverse kind of tasks involvement.

Although, different definitions of PBL exist in the literature, they include the following characteristics in common: "the use of driving questions", "a community of inquiry" and "the employment of cognitive tools" (Krajcik, Blumenfeld, Marx, & Soloway, 1994; Marx et al., 1998). "Authentic content", "authentic assessment", “teacher’s assistance without direction”, “explicit educational goals” (Moursund, 1999); “cooperative learning”, “reflection”, and “integration of adult skills” (Diehl, Grobe, Lopez, & Cabral, 1999) are other defining features of PBL. PBL is based on the principle that students work on real life issues in small groups or individually to produce concrete products (Moursund, 1999). Through projects, students solve authentic and interdisciplinary problems. They ascertain how to approach an issue and what kind of activities and actions to perform. Data are collected from numerous sources, then the findings are analyzed/synthesized and new information is created. Afterwards, students present the information they reached. Finally, they are evaluated in terms of how well they exhibit what they have learnt from their cooperative attempts (Solomon, 2003). In PBL situations, students are asked to construct their own knowledge. Hence, PBL focuses on learning by doing things (Moursund, 1999). In this respect, PBL confirms more effective, fruitful and generative courses by allowing students to contribute in the learning process actively and to create in association with others.

In PBL classrooms, students learn through active engagement in projects. Projects are initiated by a driving question or sub-questions related to it, required use of problem-solving and decision making skills, are designed by students, and include deep inquiry activities. Therefore, students learn while working on authentic and challenging tasks. Additionally, in PBL classrooms students have an opportunity to work independently, projects last over an extended period of time and end with realistic artifacts. Other defining features of PBL classrooms include the authenticity of the content, use of authentic assessment techniques, scaffolding, explicitly stated educational goals, cooperative learning, reflection on the learning process and outcomes, and development of new skills. Moreover, students construct their knowledge by investigating and transform knowledge to different domains and real life situations (Bereiter & Scardamalia, 1999; Diehl et al., 1999; Jones, Rasmussen, & Moffitt, 1997; Krajcik and Cizerniak, 2007; Krajcik et al., 1994; Marx et al., 1994; Moursund, 1999; Thomas, 2000; Thomas, Mergendoller, & Michaelson, 1999). In conclusion, students learn concepts and principles through engaging in scientific investigation like scientists. Therefore learning science and specifically biology by PBL is important.

In heterogeneous classrooms, teachers can implement PBL instruction and benefit from the diversity among students and support contribution of each student to the project in line with his/her expertise. Additionally, PBL helps students become independent learners by the use of relevant and interesting projects for the students (Bolotin & Svinicki, 2000). Therefore, In PBL classrooms learning in other words construction of knowledge occurs in social constructivism learning environment (Boaler, 2000). Accordingly, in PBL classrooms students develop mutual respect with their peers and an improvement in student-student and student-instructor interactions is observed.

Generating driving questions that trigger students' curiosity, which in turn support their engagement in learning process is a critical issue in PBL instruction. Therefore, driving questions should allow for open-inquiry, be challenging and attainable for students, be achieved using available facilities, link project to the curriculum, integrate science concepts, be contextualized in students' daily life, be meaningful for students, and consider ethical issues during students' inquiry process (Krajcik & Czerniak, 2007). As a result, in PBL instruction learning occurs outside the classroom as well as inside the classroom. Teachers provide scaffolding and feedback to their students while they are designing and performing their inquiry (Tal, Krajcik & Blumenfeld, 2006).

The aforementioned characteristics of PBL promote meaningful learning. Thus, learners build their knowledge to understand the world around them. Fortunately students are familiar with the many biology concepts from their daily lives by means of printed and visual media, and their environment. The rapid improvement in biotechnology, genetics and pharmaceutical industry keep attention to the biology science. For these reasons, biology is introduced as "life science"; therefore, students can make sense of biology as a field of science.

In elementary level, scientific topics are taught under science course. It is divided into its fields as chemistry, biology, and physics in high school. Students begin the biology course in high schools with positive attitudes. Unfortunately, their interest to the biology course decrease over time (Kablan, 2004). Results of her study revealed that students could not connect biology course content to their real life and they complained about the overloaded content of the curriculum. In addition, she found that students perceived some concepts as abstract such as genes, chromosomes and photosynthesis, and they could not visualize these concepts. Besides, students stated that biology required rote memorization. They iterated that the topics were not related with each other, thus they easily forgot the previous subjects. In addition, they found some contents were unnecessary such as transportation in invertebrates. Moreover, students mentioned that they were not active in the lessons due to the dominance of didactic instruction. For the aforementioned reasons, PBL is one of the best ways to use as instructional method in the biology courses to activate students in their learning (Kablan, 2004).

Biology involves concepts and subjects with different difficulty levels. Students find some topics more difficult such as; biotechnology and genetic engineering, hormones, photosynthesis, genes, protein synthesis, reproductive systems, excretory system etc. (Kablan, 2004). Within these concepts circulatory system is one of the difficult topics to learn even among undergraduate students (Michael et al., 2002). In the following statement, Kitano (2002) provided suggestions for better understanding biological systems:

> Shift our notion of “what to look for” in biology from a mere examination of the system’s components, to an understanding of its structure and dynamics. This is due to the fact that a system is not just an assembly of genes and proteins; its properties cannot be fully understood merely by drawing diagrams of their interconnections. (p.1662)

In addition, in order to understand circulatory system concepts like blood pressure students need to integrate their knowledge in physics, chemistry, and biology (Sungur, Tekkaya & Geban, 2001; Yip, 1998). PBL is assumed to overcome students' learning difficulties in concepts of circulatory system. Thus, in the present study PBL oriented instruction is implemented in human circulatory system topic.

Attitude is an important affective construct associated with students' achievement in science education. It has influence on the process of knowledge construction and the students' engagement in learning process (Shrigley, Koballa, & Simpson, 1988). Therefore, understanding students' attitudes are important in order to understand the ways that students learn scientific concepts. Students' with positive attitudes toward science also possess higher academic achievement in the course (Simpson, Koballa, Oliver, & Crawley, 1994). Therefore, this study also examines the influence of PBL instruction on students' attitudes toward biology course.

1.1 Purpose of the Study

The purpose of the study is to examine the effect of PBL instruction on students' achievement in human circulatory system concepts and their attitudes toward biology as a school subject when compared to traditional designed biology instruction.

1.2 Significance of the Study

Many studies have confirmed the efficiency and benefits of PBL in both science and biology (Krajcik et al., 1998; Lehrer, Schauble & Petrosino, 2001; Wright & Boggs, 2002). However, considerable body of the work in the literature focuses on the theoretical issues in the implementation of PBL. In other words, the research studies conducted on PBL focus on how to carry out the PBL applications (e.g., Barron et al., 1998; Jarmon, Traphagan, & Mayrath, 2008; Thomas, 2000; Thomas, Mergendoller, & Michaelson, 1999). Accordingly, what comes into prominence by the ongoing literature is that there are not enough studies investigating the effects of PBL on different learning outcomes in the actual classroom context (Han, Capraro & Capraro, in press; Panasan & Nuangchalerm, 2010; Wu & Krajcik, 2006). These issues were not explored much in Turkish school context either (Altun Yalçin, Turgut & Büyükkasap, 2009; Gültekin, 2005, 2007; Korkmaz & Kaptan, 2002). Moreover, little is known about how the PBL affects students' learning outcomes in the biology topics as well and there could not be any study found in the human circulatory system topic in biology. As the significance of this fact is obvious, in the current study, PBL was implemented in the high school biology course in the human circulatory system topic and its effect on 11th grade students' biology achievement and attitudes towards biology as a school subject was explored.

Most of the earlier studies investigated the teachers and/or pre-service teachers and research focus on the implementations and administrations of PBL (e.g., Barron et al., 1998; Shome & Natarajan, 2013). Therefore, there is a gap in the existing literature that the application of PBL with K-12 students is a concern among science educators. Hence it is believed that the effects of PBL on students' achievements and attitudes should also be addressed. Thomas (2000) suggests that more research is required to investigate how PBL affects students' learning outcomes such as achievement and attitude in different domains based on his review of previous research. Besides, he recommended conducting studies with students at different age groups. Considering this, the current study is conducted in a less frequently studied context, high school biology course.

In Biology, the understanding of circulatory system topic is important since it affects the understanding other systems such as excretory system, respiratory system and digestive system. Additionally, it is pre-requisite for learning the homeostasis concept (Alkhavaldeh, 2007). Although there has been substantial research on students' understanding of systems in living organisms such as the respiratory system, there is limited research related to students' understanding of the human circulatory system (e.g. Arnaudin, 1983; Barnett, 1989; Chi, Chiu, & de Leeuw, 1991; Sungur, & Tekkaya, 2003). Despite the importance of human circulatory system concepts, the improvement of students' achievement on this topic has not been investigated very frequently in educational literature. Therefore, the human circulatory topic was investigated in this study.

Meanwhile, attitude is an important construct in affective domain. Therefore, its relationship with academic achievement has been substantially investigated in earlier studies, in science education literature as well (e.g., Cheung, 2009; Dhindsa & Chung, 2003; Freedman, 1997; George, 2000; Pehlivan & Köseoğlu, 2010; Uşak et al., 2009). These studies present evidence that students with positive attitudes towards biology as a school subject possess higher academic achievement compared to the students with negative attitudes. Additionally, PBL instruction is found to improve students' achievement in science and result in students' positive attitudes towards biology as a school subject when compared to traditional biology instruction (Kaldi, Filippatou & Govaris, 2011; Pichayakul, 2013). Therefore, this study aimed to extend previous research on students' attitudes towards biology as a school subject in the human circulatory system unit.

1.3 Definition of the Key Terms

The key terms used in the current research are defined below:

Project based learning instruction: A type of constructivist instructional approach in which students engaged in inquiry process to find solutions to driving questions which are authentic for them. Additionally, the project is directed by the students in cooperation with peers and their teacher. In this instruction, students use different skills such as asking questions, making predictions, designing investigations, using technology, constructing artifacts, and sharing their ideas with their peers. In the present study, "PBL instruction" and "PBL oriented instruction" are used interchangeably.

Traditionally designed biology instruction: Teacher centered instruction in which the biology teacher chiefly employs lecturing. Students passively listen to their teacher and write down the information dictated by her to their notebooks. In the current study, "traditional instruction" and "traditionally designed biology instruction" are used interchangeably.

Science process skill: Ability of somebody when solving complex science problems. It is measured using Science Process Skill Test.

Achievement: It indicates students' success on the unit of Human Circulatory System in biology. It is assessed using Human Circulatory System Achievement Test developed by the researcher.

Attitude toward biology: The feelings of students such as prefer, like-dislike, and interest toward biology. Attitude Scale toward Biology is used to measure it.

CHAPTER II

REVIEW OF THE RELATED LITERATURE

This chapter consists of four sections reviewing the related literature. First, PBL was explained in terms of its definition, historical development, basic features, and advantages and disadvantages on learning are presented in order. Next, research on students' attitudes toward science and biology in association with the literature on gender differences is given. Following, the definition of model and its classification are presented. Finally, the findings of prominent research on circulatory system subject are shared.

2.1 Project Based Learning (PBL)

The project is considered to be one of the best and most appropriate methods of teaching throughout the history. The idea of using a project as a learning material comes before the definition of PBL: even in 1870s the term "Sloyd" which refers producing crafts in Swedish educational system existed. Even though they are not pedagogically labeled as PBI, there are other well-known early examples of use of projects in diverse disciplines: "wood and metal shop" in agriculture class and "homemaking and cooking" in domestic science class (Horn, 1922; as cited in Capraro & Slough, 2009). Researchers mentioned the term "project" differently as a "methodical device" (Pütt, 1982 as cited in Knoll, 1997), as a "didactic conception" (Stubenrauch, 1971 as cited in Knoll, 1997) and also as a "contrafactic idea" (Suin de Boutemard, 1976 as cited in Knoll, 1997).

The roots of PBL as a pedagogical approach date back to early 1900s to Dewey who is known as the father of progressive education. He emphasized active participation of learner in the learning process, which referred to "*learning by doing*" or "*student-directed learning*" in the related literature (Dewey, 1916). In his book, "Experience and Education", Dewey assigns teachers a new role that teachers provide students access to meaningful learning experiences on which the current PBL classroom is built. In that sense, the following statement explains John Dewey (1910)'s description of teachers' role in the classroom:

> "Teachers are the agents through which knowledge and skills are communicated and rules of conduct enforced…[teachers] must…have that sympathetic understanding of what is actually going on in the minds of those who are learning…any experience…that has the effect of arresting or distorting the growth of further experience [is miseducative]…every experience enacted and undergone modifies whether we see it or not, the quality of subsequent experiences…The most important attitude that can be formed is that of desire to go on learning." (p. 3-4)

Kilpatrick (1921) also proposed one of the earliest definitions in which he underlined that for improving students' skills, the best way is their engagement in the activities. In 1918, William Kilpatrick wrote an article, "The Project Method", in which he extended the original ideas of Dewey. In this initial formulation, PBL was the idea of the purposeful activity taking place in a social environment. In the following statement, Kilpatrick (1921) defined term project as dominated by a *purpose* and related it to students' *daily life*: "The project does may refer to any kind or variety of life experience which is in fact actuated by a dominating purpose." (p.283).

Similarly, Hosic and Chase (1924) mentioned active engagement of students in projects which are *meaningful* to them as stated below:

> "[T]he Project Method means providing opportunity for children to engage in living, in satisfying, worth-while enterprises—worth-while

> to them; it means guiding and assisting them to participate in these enterprises so that they may reap to the full the possible benefits." (p.7)

Nevertheless, social constructive theories of learning developed mainly from the work of Lev Vygotsky, proposes that students learn by constructing knowledge and by thinking and doing in social context (Vygotsky, 1986). Therefore, individuals take an active role in constructing knowledge. According to Vygotsky, development depends on social and cultural factors as well as biological factors. Additionally, for Vygotsky, learning takes place in the social context: gradually, children become more independent and autonomous through social interactions with others. This social constructivist viewpoint also has been widely studied in science education (e.g. Brown & Campione, 1994; Driver, 1989; Roth, 1995). Lorsbach and Tobin (1992) put it forward that teaching science with a constructivist approach means that teachers teach science more like scientist really does science by active engagement of children in the social process of experiences.

The zone of proximal development, ZPD, is one of the most famous notions of Vygotsky's theory. This concept, ZPD, is used to identify the 'zone' at which a learner is able to succeed in her/his own and work collaboratively with his/her peers to improve himself/herself. Actually, when learning a new concept, learner benefit from his/her peers' or teacher's assistance. Bruner (1977) called this assistance as 'scaffolding.' Since PBL also emphasizes the role of collaboration and scaffolding to empower projects, Vygotsky's conceptions support PBL. A competent teacher in PBL assists students constructing projects in light of their interests and competencies (Moursund, 1999). Additionally, determination of instructional strategies and methods creating suitable social and cultural conditions to increase student learning has been the focus of many research studies accepting Vygotsky as theoretical framework (Dixon-Krauss, 1996). To conclude, PBL can be considered as embedded in Vygotskian theory.

Today's understanding of PBL differs little from Dewey's view of inquiry (Levin, 2001). In PBL, projects are generally embedded in problem-based learning context, students construct projects to suggest solutions to the problems that they potentially encounter in real life. The problems may be chosen by students themselves or given by the teacher. Usually projects are designed to support group oriented learning. In PBL, students learn through engaging in problem solving process and constructing a project. Especially during presenting their work, students recommend potential solutions to the problem to a real audience (Levin, 2001). As Dewey suggested, the teacher facilitates students' learning, rather than directly presenting the information. Capraro and Slough (2009) explain the scope of as "a spectrum ranging from brief projects of one to two weeks based on a single subject in one classroom; to yearlong, interdisciplinary projects that involve community participation and adults outside the school" (p.4). Considering this, Dewey's view of inquiry evolved from short-term projects including a few class hours to long-term projects lasting almost a semester or a year. Since PBL provide students opportunities to work on the problems from the environment in which they live, the definition of PBL changes as the world continues to change (Krajcik, Czerniak, & Berger, 2002).

In the current literature, there is no single structured definition of PBL, in this study PBL is described in terms of the following attributes. It is a student-centered instructional approach used in which students construct their knowledge through engagement in open inquiry related to real life problems and phenomena in a collaborative learning setting (Yam & Rossini, 2010). In PBL students are engaged in authentic driving questions which are significant and meaningful for them (Krajcik et al., 2002). Moreover, PBL is a learning approach that arranges learning process through investigation of projects. The project started with a driving question that requires students' involvement in designing the learning activity under teacher's guidance that includes investigative activities, problem-solving, and decision making; hence, it gives students the opportunity to learn real world around them (Jones et al., 1997; Marshall, Petrosino & Martin, 2010; Marx et al., 1994; Prince & Felder, 2006; Thomas, 2000). Accordingly, students use science process skills such as asking questions, making predictions, designing their inquiry, gathering and analyzing data, making conclusions, using technology, constructing products, and sharing their ideas with a real audience (Krajcik et al., 1999; Thomas, 2000). Projects can be seeking for solutions to interdisciplinary problems as well as domain specific problems; therefore, learning is extended beyond school environment (Holubova, 2008). Consequently, students build their own knowledge by being active in their own learning, interacting with their real world around them and working independently and/or collaboratively in line with the constructivist approach. During students' investigation, the teacher directs and guides to his/her students through asking open-ended questions (Frank & Barzilai, 2004; Thomas, 2000).

2.1.1 Basic Features of PBL

Based on the definitions stated in PBL handbooks, "project-based instruction" is founded on driving questions, they are complex tasks, and they provide students opportunities to involve in designing, problem-solving, and decision making processes in investigative activities. Moreover, students are given the chance to take the responsibility of learning activity and create realistic products (Jones et al., 1997; Thomas et al., 1999). Some other defining features of PBL include presenting authentic task to students to work on, using authentic assessment tools, defining clear educational goals, providing cooperative learning environment, reflection on learning process and products, and supporting development of skills (Diehl et al., 1999; Moursund, 1999). Moreover, project-based instruction reinforces the use of technology (Krajcik et al., 1994; Marx et al., 1994).

Even though there is no single acknowledged definition of PBL; fortunately, researchers describe several fundamental features of it and provide guidelines for the implementation in the classroom. Current study is led by the following unique features of PBL: centrality, driving question, constructive investigations, collaboration among communities of learners, realism, use of technology, and creation of artifacts (Krajcik & Czerniak, 2007; Railsback, 2002; Thomas, 2000). These features are explained below.

Centrality: Centrality feature means that PBL projects form the curriculum. According to this defined characteristic, project is the central teaching strategy in PBL; students form their conceptual understanding through engaging in projects.

Conducting a project without an emphasis on concepts in the related domain cannot be given as an example of PBL instruction considering centrality feature. As a consequence of centrality criterion, projects covering outside curriculum things are not considered as PBL either. In conclusion, including outside curriculum demands to a project for the purpose of enriching it is not accepted as PBL.

1) *Driving question:* PBL oriented science classes should encourage students explore solutions for challenging questions which is related to their lives. These questions are referred to driving questions in PBL literature. The driving question is the "central organizing feature of project-based science" (Krajcik & Czerniak, 2007; p.67); that is, driving question directs the following inquiry. Since it also supports all other features of PBL instruction, driving question is the key element of PBL.

An appropriate driving question should be meaningful and important to the learners (Blumenfeld et al., 1991; Krajcik et al., 1994. A good driving question should capture the essential features of the project in a clear language; that is, it should apparently define the purpose of the project. Besides, the driving question should be challenging that encourages students' creativity. The questions should be stated open-ended which allows students investigate in depth and promote students' deep understandings. In view of that, students continue working on the task and create a variety of products. It also should be linked to real world situations; that is, questions emerge from students' daily lives. Therefore, students are highly motivated to learn and generate put high effort on the project. Moreover, the driving question should provide opportunity to development of a product as a result of students' investigation of the question.

There are some common activities in schools that require hands-on engagement of students and creating a craft. In these activities students are informed about the time of the activity, where to undertake the investigation and/or the concepts related to it. However, this traditional approach cannot be considered as a PBL instruction since it does not provide meaningful learning experience to students and students have difficulty to understand why they are undertaking a project. In PBL instruction by the help of the driving question the students embrace the project, get motivated to find a solution to the question, sustain their effort on the project during the investigation and after the investigation.

An important issue is the source of the questions being asked and investigated. The teachers can determine meaningful and important questions for their students and students may identify sub-questions. Teachers may also set up a learning setting in which students can develop their own questions. It is also possible that the questions can be generated by students as a consequence of their daily experiences.

2) *Constructive Investigations:* The constructive nature of PBL means that the activities that students conduct for the purpose of finding solutions to driving question should encourage students transform and construct knowledge as a result of their inquiry (Bereiter & Scardamalia, 1999). In PBL classrooms, students construct their own knowledge through planning and designing, collecting data, analyzing data, making conclusions, asking and improving other questions, constructing products, and communicating findings with others.

During construction of a project, students make choices in several ways: the topic to be studies guided by a general driving question, design of the project, creation of the product, use of different resources, arrangement of time, and presentation of project etc. However, teachers can also provide options to guide their students considering the difficulties that students experienced while conducting a project. By time, as students get more experienced with PBL instruction, they could even select the topic of the project and/or propose a good driving question. Thus, teachers should provide students opportunities to make choices on their inquiry.

3) *Collaboration among communities of learners:* According to Vygotsky's ZPD, learning occurs within a socio cultural context. PBL provides opportunities for the involvement of members of society while investigating solutions for the questions in addition to the involvement of the students and the teachers. Accordingly, coloration occurs in different forms. Students form *a community of learners*: they collaborate with their peers and with their teacher during

conducting the project, making sense of information, developing conclusions, and presenting their findings.

The *audience* that the project is presented may include peers, parents, and different members of the community such as government organizations. When students present their work to a real audience, they gain more ownership of their project and assign a meaning to their inquiry. The projects might also find solutions to the problems of the society. As a consequence, project becomes more important to the students.

Advancement in *telecommunication* allows students to share their projects with a wider community of knowledgeable individuals, access a variety of resources, and communicate and cooperate with other individuals in other parts of the world. As a consequence, the use of telecommunication supports the collaborative environment.

5) *Realism:* Projects can be authentic in terms of the topic chosen, the tasks designed, the roles of students, the context in which the project is constructed, collaborators who work with students, designed products, “audience” for the products, or “criteria” by which the products are evaluated. In PBL instruction, the problems emerged from real life situations and the solutions have possible applicable in reality.

6) *Use of Technology:* As the expense of technology has been decreased since 1980s, the use of technology has speeded up as a result. Therefore, technological tools have become more feasible for the use of instructional purpose. Learning technologies may include computers, educational software programs, and electronic devices etc. As a result, science classrooms can turn into a more authentic learning environment in which students actively construct products as well as their construct knowledge (Linn, 1997; Tinker & Papert, 1989; White & Fredrickson, 1995). “The Web Integrated Science Environment” (Linn & Slotta, 2006) and “the Center for Learning Technology in Urban Schools” (Krajcik & Blumenfeld, 2006) are two examples of use of technology in PBL classrooms.

Technology can be used as a thinking tool in PBL classrooms to support different phases of students’ inquiry such as data collection and analysis, accessing real data on the internet, information gathering, interaction and collaboration via varied networks, use of different visualization tools, and sharing their project with community. It can also enhance students' motivation in the learning process. Moreover, the use of technology can support understanding of complex ideas such as the use of educational simulations. For example, a simulation can help students visualize the blood flow from heart to the vessels in biology classroom.

Teachers role also change from being a lecturer to the facilitator. As a consequence, teachers are not the center of attention anymore and become a guide to support students' learning (Dwyer, 1994).

7) *Creation of artifacts:* Artifacts can be used as a measurement of students' understanding of science since they reflect what students have learned (Marx, Blumenfeld, Krajcik & Soloway, 1997). In PBL classrooms, diverse forms of artifacts may be produced such as models, posters, reports, video-types, and computer programs. These artifacts address the question to be investigated, the solutions students produced, and the concepts they have learnt. Frequently students share their artifacts with an audience such as their peers, teachers, parents, and members of the community.

The artifacts can support students learning in several ways. To begin with, artifacts are real and therefore motivating for students. Creating and sharing artifacts help students experience nature of science. Students represent their ideas to the community by presenting their artifacts as scientists often do at conferences. Next, artifacts promote development of students' understanding on scientific concepts. Since artifacts are concrete products reflecting students' inquiry, students can get feedback from their peers and teachers about the artifacts and improve their understanding. This feedback is a useful tool for students to assess and revise their work. To finish, the artifacts can be used as an assessment tool to measure development of students' understanding over the time.

2.1.2 Benefits and Challenges of PBL

As with all learning theories, there are benefits and challenges when designing and implementing PBL instruction. Research has showed that in PBL classrooms students also improve their academic achievement depending on how much they engaged in the project and how well they produced the artifacts. A variety of benefits to PBL are identified in the literature in line with the empirical studies (Krajcik & Czerniak, 2007; Railsback, 2002; Thomas, 2000):

- Since PBL instruction provides students meaningful questions that are relevant to their real lives, it makes school more like a real life context. The deep investigation of real-world topics enhance students' motivation to learn. This in turn helps students put high effort on the project, continues in case of difficulties, and pursues their inquiry after the project.

- Since PBL is a process of inquiry, it supports students' science process skills such as asking problem, stating hypothesis, gathering and analyzing data, making inferences. As these processes progressed, students take responsibility for their own learning process which is guided by the teacher. In the end students become self-directed learner.

- PBL classrooms develop use of different cognitive and metacognitive strategies such as critical thinking, awareness of purpose of the project, decision making, thinking on alternative solutions, scientific reasoning, monitoring learning process, and evaluation of learning experience and outcomes.

- In PBL students engage in authentic questions that require use of fundamental academic skills such as reading, writing, and solving problems.

- PBL supports the use of technology.

- PBL instruction also gives students opportunities to work and learn collaboratively. Commonly, in PBL classrooms students work in group while conducting their projects; thus, they develop communication skills and effective and productive collaboration with peers and community members.

- As a consequence of improvements in technology today's world is knowledge-based which requires development of new-skills. Then, learning continues beyond school. PBL also serves these purposes and in turn promotes lifelong learning for students and teachers who applied PBL in their classrooms as well.
- Projects in PBL classrooms are long-term, interdisciplinary, and student-centered.
- In PBL, the role of students shifts from being passive learner to actively constructing conceptual understanding and artifacts.
- Additionally, PBL allows students manage time and different resources.
- PBL enables students and teachers communicate with the members of the community.
- PBL supports diversity among students in terms of learning styles and/or abilities since students can contribute to the project in line with their strengths. Since students engage in different type of tasks while conducting a project, PBL meets needs of students from different cultural backgrounds, races, academic abilities or genders.
- In addition, using authentic assessment practices, teachers can evaluate different aspects of learning process and outcomes. Teachers can use a variety of assessment techniques to follow students' progress while they are working on the project.

Even though, there are various benefits of PBL, there are also some challenges which must be taken into consideration while designing the classroom applications (Krajcik & Czerniak, 2007; Marx et al. 1997; Railsback, 2002; Thomas, 2000):

- Since there is not a universally accepted model or theory of PBL; it becomes difficult to define what PBL is and what PBL is not. PBL is a relatively new and still developing instructional approach. For that reason, teachers have difficulty in designing PBL instruction and hesitate to implement it in their classrooms. Luckily, there are several sources on the web that teachers can access for free. For example; Buck Institute for Education (BIE, 2014) provides a large database of successful examples of PBL instruction in diverse grade levels and diverse disciplines for practitioners. Similarly, West Virginia Department of Education (2014) shares their database which includes the sample projects developed by the teachers in diverse disciplines and grade levels for public. Teachers can use these and several other web sources for free as a guide to design their instruction.

- In PBL classrooms, there should be a balance the degree of control that students have on their learning process and the amount of feedback provided by the teacher. However, teachers had difficulties in counterbalance between the amount of independence of students and the amount of scaffolding. Workshops can be organized to help teachers experience good examples of PBL and develop their pedagogical skills in PBL. By time, as they implemented, they are assumed to improve their ability to manage PBL classrooms.

- One of the most important challenges of PBL implications is the time. In PBL classrooms, the highly loaded curriculum makes it challenging for teachers to apply a good PBL intervention. The implementation of projects often takes longer than it is expected since it required in depth inquiry. An important aspect of PBL is its interdisciplinary nature that can help teachers manage time and curriculum effectively. Researchers suggest that teachers in diverse disciplines can collaboratively develop PBL interventions that one project cover several domains.

- In addition to time management difficulties, teachers also have worries about the counterbalance between maintaining classroom order and supporting students' independent and self-directed learning process.

- Another question about PBL is teachers desire to control the flow of information. Teachers feel more confident when they provide information; however, students are engaged in open-ended questions in PBL classrooms and construct their own knowledge.

- Although the use of educational technologies in the classrooms increased over time, teachers still have troubles in the effective use of technology.

- While conducting projects, students and teachers benefit from several resources. However, it is problematic for teachers as well as for students to access and manage different resources.

- PBL interventions required authentic assessment techniques. Teachers can use various authentic techniques such as portfolios, rubrics, concept maps, and journals to evaluate students' projects. However, the development, implication and interpretation of these techniques are challenging for teachers.

- Connecting the link between daily life problems and the underlying subject matter concepts is also challenging for teachers.

- Teachers do not feel confident in implementing PBL in their classrooms. Administrators and curriculum makers can support teachers' development of new skills required for PBL instruction, and encourage and motivate them to implement PBL in their classrooms.

- The teachers who do not feel confident in their domain knowledge and do not trust their science background are unwilling to implement PBL in their classrooms.

- In traditional classroom tasks mostly require use of memorizing strategy. However, PBL interventions require use of several cognitive, metacognitive and science process skills as stated while explaining benefits of PBL. Students are not accustomed to use of these strategies and resist using them.

> Learning new strategies needs more effort and cognitive engagement. Teachers may encourage their students to employ new strategies, provide them feedback about the implementation of the strategies, and emphasize that errors are also a part of learning.

If these challenges are evaluated critically by educational researchers and solutions are provided for teachers, PBL could be implemented successfully by many teachers across diverse disciplines and at different grade levels.

2.1.3 Classroom Applications of PBL on Academic Achievement

There is plentiful research conducted about PBL in different types such as experimental research, action research; developing and evaluating activities in Project-Based Learning. Similarly, there are several forms of research on project-based learning. For example, many researches make evaluation about the effectiveness of PBL; some of them determine the degree of accomplishment in implementation of PBL. In addition, some researches find out the effect of student characteristics on PBL effectiveness or modify PBL and others test the quality of proposed modification of PBL. In this part of literature review, research on PBL is undertaken in two main parts. The ones considering the effects of PBL on students' achievement are placed in the first phase and then attitude toward biology and gender are placed in detail in the second phase.

Panasan and Nuangchalerm, (2010) applied project-based and inquiry-based learning activities to the fifth grade level as instructional method. In this study, science process skills, analytical thinking skills and learning achievement of 88 students from two particular classrooms were compared. The data was collected from the School of Muang Nakhon Ratchasima at 2008, in the first semester of the academic year. Eight lesson plans prepared as research instruments were used in the study. These plans could be considered as moderately effective according to having effectiveness indices of almost 0.68 for both. Accordingly, there were no significant difference determined in learning achievement, science process skills and analytical thinking between the students of PBL and inquiry-based learning activities. The students in two groups did not show different learning achievement, science process skills and analytical thinking. Therefore it was concluded that these lesson plans developed in this study were properly competent and successful. Science teachers were advised to use both of these instructional methods in group of activities for their learners to achieve in the future.

Jarmon, Traphagan, and Mayrath (2008) explained how an effective project based can be applied in graduate interdisciplinary communication course in the concept of Second Life. Observations during the instructions, classroom setting and students experiences were the main data sources in this study. In this article, there were two levels in assessment; evaluating for understanding the effects of using SL in general and context specific. In the first level, six issues were addressed about using SL for general teaching. For example, students' reactions to the SL activities, attitudes toward using SL, and students' perceptions about using SL on their learning and participation were addressed. In the second level, using SL in a definite context was taken under consideration deeply. A content analysis was conducted to students' journals, photos of classroom setting, all document collected during the study. According to analysis, students considered the use of SL as effective. They regarded using SL is enjoyable, engaging, increasing learning and expanding their own research ideas. Based on results, the use of SL substantially improved the quality and involvements of student learning. It entirely has room for student experiential learning that is why it is strongly recommended by researchers.

Bas (2011) employed a quasi-experimental study to explore the effectiveness of PBL instruction on ninth grade students' academic achievement and their attitudes toward the course in English class. While the students in the experimental group took PBL instruction, the students in the control group received their regular instruction based on their textbooks. The implementation took four-week period. Results revealed that the students in the experimental group performed better in terms of their academic achievement and showed more positive attitudes towards the English course compared to their peers in the control group.

Gültekin (2005) investigated the effects of PBL on students' learning in the course of social studies. The level of participated students in the study is fifth grade. Both quantitative and qualitative methods were used in the study, a pre-test and-post-test control group design was used and the effects of PBL on the learners' success were determined in the quantitative phase. A semi-structured interview was used, in the qualitative phase, in order to reveal the views of students and teachers participated in the study. The findings showed that PBL is an effective method for academic success of students' in the social sciences course in primary education. In addition, students and teachers indicated that PBL increased the achievement of students with various skills. They stated that PBL is enjoyable, entertaining, and meaningful. There were some problems occurred during instruction; they are for example arguments between group members and difficulties in carrying out the project. Although a few problems reported in the article, it is strongly suggested to be used in the Social Studies class as well as in other disciplines of the primary school curriculum.

Barron et al. (1998) not only designed but also implemented and evaluated problem-based and project-based curricula in his study. That has come out of a long-term teamwork with teachers. Four designed principles had been defined in the study. First of all, learning goals were defined. Then, scaffolds were offered; for example type of teaching, tools, sets of cases, and activities for projects. Thirdly, assessment tools were presented for self-assessment and revision. Lastly, participants were encouraged for developing social structures of being a group. The most emphasized way to scaffold projects in the article was to help teachers and students regularly consider about how the activities are related to the goals by taking account the reasons. Although the research was called as "design experiment", the aim was to collect information from both teachers and students that would help improve the learning environment. Moreover, since all teachers wanted to be in experimental group there was not any control group in the research. Five teachers and 111 students were participated in the study. Instructions took place 4 days per week in 45 minutes. It took 5 weeks on the problem and projects components of the lessons for students. According to research findings, positive effects were determined on 5th grade students' learning and students' experiences. However this positive effect was based on only qualitative research, not an experimental research.

Apedoe, Reynolds, Ellefson, and Schunn (2008) claimed that design-based learning approach could be used in both K-12 and engineering in order to meet their goals according to the results of their study. In this study, the central and difficult chemistry concepts in engineering were taught in high school. It lasted eight weeks. Field trials for Heating/Cooling system unit were conducted for 3 years to 1,400 students. It is mentioned in the article that these successful field trials showed the power of design-based approach for teaching difficult chemistry concepts to high school students. According to teachers' reports and observations conducted in classrooms, many students showed high level of engagement during the instructions. Pre-test and post-test were conducted besides the observations. ANOVA and Cohen's d were used to compute effect size. The results showed that students' had a 13 percent accuracy gain for 24 questions related to the unit concepts. Accuracy increased for all concepts included in the study. It was concluded that design-based learning is effective for teaching complicated concepts in chemistry. Moreover, it is considered as increasing awareness and interests of students in engineering.

In science education, it is important to study the interrelationships between attitude and achievement (Weinburgh, 1995). The significance of attitude examination becomes more important, particularly when studies represent disturbingly students' low interest toward science (Ramsden, 1998; Stark & Gray, 1999). Similarly; the development of positive attitudes toward biology is an important goal of biology education.

Giving attention to students' attitudes is important since individuals' decision making and action taking can also be predicted from their attitudes (Glasman & Albarracin, 2006; Kraus, 1995). For instance, Kelly (1988) stated it can be predicted which science subject British students choose according to their attitudes toward each subject. In addition, there is a meaningful correlation between science achievement and attitude toward science indicated in meta-analyses for both females and males (Weinburgh, 1995). Moreover, Freedman (1997) supported the result of Weinburgh's meta-analyses finding a moderate correlation for treatment group in his study. Linear relationships between attitude and achievement were also reported by Bennett, Rollnick, Green and White (2001). So, it can be stated that generally strong relationships are found between attitude and achievement according to these studies (Weinburgh, 1995; Freedman, 1997; Dhindsa & Chung, 2003).

Several studies conducted on students' attitudes toward science in general, there are many studies focusing a specific science subject like chemistry, biology. For instance, the result of Salta and Tzougraki's study (2004) are similar to mentioned studies in the previous paragraph. The only difference is that this study observed the correlation between chemistry achievement and attitudes toward chemistry. There is a moderate correlation found between students' own perception of difficulty of chemistry and achievement.

In biology, there are also many studies investigating correlation among biology achievement, attitude, and gender. Many countries included Biology separately from other science subjects like chemistry and physics (e.g. Prokop, Prokop, & Tunnicliffe, 2007a; Prokop, Tuncer, & Chuda, 2007b). These studies focus on relation between gender and attitude toward biology. According to results, it is determined that compared to males, females consider biology as more attractive and entertaining (Jones, Howe, & Rua, 2000; Keeves & Kotte, 1992; Lamanauskas, Gedrovics, & Raipulis, 2004; Prokop, Leškova, Kubiatko, & Diran, 2007c; Prokop et al., 2007a; Stark & Gray, 1999; Warrington & Younger, 2000). Based on results of these studies, the most attractive concepts to females are botany and human biology (Baram-Tsabari & Yarden, 2005; Dawson, 2000; Hong, Shim, & Chang, 1998; Prokop et al., 2007a; Prokop et al., 2007b). However, the study of Prokop et al. (2007a, 2007b) showed that females' positive attitude to special concepts like botany and human biology are valid in only some grades. It can be re-stated that attitudes towards biology is related to gender and grade level. The concepts students like in biology can differ accordingly to not only gender but also grade level. Therefore the results of these studies are examined well when the grade level are taken into account. For instance, the grade level in the study of Prokop et al., (2007a) was elementary school.

Although many studies about achievement and attitude are mentioned previously, this relation concerning biology has not been extensively studied in Turkey. Weak but statistically significant association between attitudes and achievement of university students were stated in the research study by Usak et al., (2009). In this study, neither achievement nor attitudes toward biology were influenced by gender. However, according to study results Turkish university students have relatively positive attitude toward biology (Usak et al., 2009; Pehlivan & Köseoğlu, 2010). In addition, Turkish students accept the significance of biology for human life so they are eager to understand biology.

The aim of PBL is not only to gain knowledge to students but also to develop system thinking, practical skills, and positive attitudes towards what they learned (Forman, 2003). However students' attitudes may become barriers toward their acceptance of PBL. The attitude in PBL has also been widely studied in engineering studies. For instance Fowler, Grabowski, and Fowler (2013) tried to introduce attitudes towards engineering gradually in their study with engineers. Besides, positive attitudes of university engineering students towards project based learning and their consideration of the teamwork to be successful were determined in the study of mobile robot developing (Lin, Yueh & Chou, 2014). Moreover, Cheung (2013) determined that PBL supported positive attitudes, in the quantitative study with university students about the use of smart phones. Additionally, positive attitude development of university engineering students was found to be supported by the PBL design (Dzan, Chung, Lou, & Tsai, 2013).

In the area of environmental studies under the title of 'sea animals', PBL is found to help primary school students develop positive attitudes towards peers (Kaldi, Filippatou & Govaris, 2011). Besides, it was found that the secondary school students gained benefits of PBL in terms of their attitudes towards learning English language (Okumuş & Konca, 2013). Moreover, middle school teachers' attitudes towards projects were examined and it was found that teachers felt burdened with work for conducting the projects within school hours (Shome & Natarajan, 2013). In a study by Alkan and Erdem (2013) contrarily it was found that self-directed learning originated by PBL did not have an effect on attitude towards chemistry pre-service teachers' laboratory skills in chemistry. Additionally, junior mathematics students' attitudes towards mathematics were not found to improve in a study using the effects of PBL (Wade, 2013).

2.2 Attitude

Research studies in science education revealed that affective factors should be taken into account (Koballa & Glynn, 2004; Pintrich, Marx & Boyle, 1993) and among the affective variables, attitude is an important one. One of the crucial goals for science educators is that to educate students with scientific literacy, in order to get this purpose meaningful learning rather than rote memorization plays an important role in transferring science learning from school to everyday life; and in developing a meaningful learning, interest and attitudes toward science are efficient factors (Nieswandt, 2007). Student learning is affected by attitudinal constructs and it has been a very hot-topic in science education since 1980's for understanding the cognitive area and the relation of these attitudinal constructs on students' learning. In addition, research studies have mainly focused on determining the attitudinal constructs which have an effect on student learning (Koballa & Glynn, 2004). Based on the similar reasons, the studies have also conducted in science education in order to investigate the relation of attitudes and achievement since attitudes can take role as facilitators and are the products of science learning as well. Pintrich et al. (1993) described attitudinal constructs as moderators of a student's conceptual change and suggest that they may influence science learning in the short-term and over long-term periods of time.

In the literature, various definitions of attitude have been given, each of which underline a different aspect of the attitude. In social science, attitude term is defined as the 'posture of the mind'. Furthermore, science educators pursue their researches based on the theories which were proposed by social psychologists. In this study, the following definition by Fishbein and Ajzen (1975) was taken into account: “Attitude is a predisposition to respond positively or negatively to things, people, places, events, or ideas” (Simpson et al., 1994). It includes feelings (such as prefer, like-dislike, interest, value, etc.) toward objects. In this study the object was determined as biology course and the students’ attitude towards biology was aim to be assessed.

On the other hand, the other definitions of attitude could also be found in the literature; such as “a condition of readiness for a certain type of activity” (Warren, 1934), “mental or neural state of readiness, organized through experience, exerting a directive or dynamic influence upon the individual’s response to all objects and situations with which it is related” (Allport, 1935) “a general and enduring positive or negative feeling about some person, object, or issue” (Petty & Cacioppo, 1981), etc. The notion that attitude is a predisposition for action is associated with the type of consistency interpretation one adopts, since attitudes cannot be observed directly and have to be inferred from the observed consistency in behavior. The meaning of attitude had shifted from physical to mental posture and gained psychological meaning based on individuals' cognitive structures over the time (Shrigley, Koballa, & Simpson, 1988). Although there is a wide range of attitude definitions, there is an agreement about the theory of attitude has three dimensions: affective (feelings or emotions toward an attitude object), behavioral (actions toward an attitude object), and cognitive (ideas or beliefs toward to an attitude object). These three dimensions evolved over time and the term attitude has been called only affectively stating favorability toward an object, as cognitive aspect ‘beliefs’ has been labeled and as behavioral dimension ‘behavioral intensions’ has been labeled.

Although there is a disagreement on the definition of “attitude” concept, researchers also agree on that attitudes can be learnt. Therefore, students form and change their attitudes as a result of their experiences. One of the common features of attitudes is that they are enduring in nature and attitude change is a long-lasting and hard process. Although attitudes have an enduring nature, it is also possible to change them throughout people’s lives and many factors affect the acquisition process; but this process is not very easy. For that reason, it is very important to facilitate this process for the humankind's benefits (Koballa, 1992). Various attitude changes have been proposed in the study of Triandis (1971). This attitude change in the cognitive area can be through new information taken from other people around or mass media; then the reflections of these change could be seen in the affective and behavioral components as well. Therefore, the attitude change is firstly taken place in cognitive area (for instance, with new information), then in affective (for instance, positive or negative experiences in the occurrence of attitude object) or in behavioral areas (for instance, by performing toward the object). Since these components are closely related to each other the change on one of them affects also the others.

Persuasive communication is one of the ways which is commonly used in order to change attitudes (Simpson et al., 1994). Persuasive communication is one of the ways that is commonly used in attitude change programs. It is believed that the change in attitudes will result with a change in behavior. A persuasive message including arguments about the topic is presented to the receiver by the source and the receiver creates a response either processing the arguments or relying on the peripheral cues. Attitude change occurs after generating a response or thoughts similar to the source of the message as a result of following either central or peripheral route.

During 1970s and 1980s the studies focused on attitudes toward science, and proposed many theories in order to explain attitude-behavior consistency. Some of them are, "theory of reasoned action", "theory of planned behavior" (Ajzen & Fishbein, 1980), and "cognitive response or self-persuasion approach" (Petty & Cacioppo, 1981; Shrigley et al., 1988). In addition, during this period, attitudes were viewed as both "facilitator" and "product" of learning (Koballa & Glynn, 2004).

Literature states that some teaching methodologies were to be found effective, for example, the involvement of students on the tasks (Sungur, 2004), the support that students taken, the negotiation among peers, using different strategies during teaching (Atay, 2006; Chang, 2002; Freedman, 2002; Papanastasiou & Papanastasiou, 2004; Parker, 2000; Sungur, 2004), unusual teaching activities

(Myers & Fouts, 1992), variety as a key feature (Piburn & Baker, 1993; Scottish HMI report, 1994, as cited in Monk & Osborne, 2000), kind of science teaching students experience (Ebenezer & Zoller, 1993), significance of teacher (Sundberg & Dini, 1994; Piburn & Baker, 1993). The study of Mordi (1991) investigated the factors affecting students' attitudes toward science and the results of the study revealed that student and home characteristics, teaching and learning variables (found as the most important factor affecting their attitudes) and school factors were effective in students' attitudes toward science.

Many studies have found a positive correlation between student learning outcomes and attitude expressing that students' with higher attitudes toward science would be more successful in scientific issues (e.g., Atay, 2006; Kesamang & Taiwo, 2002; Osborne & Collins, 2000; Simpson & Oliver, 1990). There is powerful evidence that students' attitudes toward science is linked to their ability to learn. Students with a positive regard for their own abilities in science develop a greater overall positive attitude (e.g., Atay, 2006; Mattern & Schau, 2002; Oliver & Simpson, 1988; Simpson & Oliver, 1990; Sungur, 2004). In the study of Atay (2006) students' achievement in genetics concepts and also their attitude towards science were investigated; the results stated that attitude towards science was one of the predictors of achievement in genetics. Oliver and Simpson (1988) investigated the relationship between the subcomponents of attitude and achievement, attitude toward science, achievement motivation, and science self-concept. Their results revealed a positive and significant relationship between achievement motivation and science self-concept. The similar finding were found by the same researchers in the investigation of the factors which affect student attitudes; a positive relation in student achievement and attitudes toward science (Simpson & Oliver, 1990). Weinburgh (1995) in a meta-analysis study found quite high correlation score between students' attitudes toward science and their science achievement; this score for female students was .55 and for male ones was .50. Similarly, Steinkamp and Maehr (1984) reported a correlation between attitudes toward science and science achievement was .19 considering 66 studies; and Willson (1983) investigated 43 studies and reported the correlation score as .16. The aforementioned studies in science education stated the significant relations between achievement and motivation and also with science self-concept. The similar findings have been also found in the Third International Mathematics and Science Study (TIMSS) showing that science achievement is affected by students' attitudes toward science (Webster & Fisher, 2000). A study conducted by Mattern and Schau (2002) conducted a similar study to find a structural equation model between scientific attitudes and achievement in science and their results revealed a cross-effect between attitude and achievement while investigating the causal relation of attitudes toward science and science achievement; suggesting instructional strategies that enhance science learning and scientific attitudes as well for higher achievement in science.

As the studies in the science education literature revealed that student attitude towards science is crucial factor in their science achievement, many studies in science education have been focused to develop students' attitude toward science (e.g., Atay, 2006; McBroom & McBroom, 2001; Myers & Fouts, 1992; Sungur, 2004). In addition, the development of student attitudes towards science is also important for their career choice (Cavallo & Laubach, 2001; Glasman & Albarracin, 2006; Simpson & Oliver, 1990). The study of McBroom and McBroom (2001) studied the effect of problem based learning on biology students' knowledge level, attitude, and self-confidence; and the results revealed that the students scored higher in the instructor assessment and completed the PBL experience with a more positive attitude favoring the experimental group students. In addition, in the study conducted by Myers and Fouts (1992) revealed that various teaching strategies, unusual learning activities, collaboration with peers, and involvement affect student attitudes toward science positively. Therefore, it has been also revealed that the quality of instructional strategies used in science courses were crucial factors which affected student attitudes in science education (Ebenezer & Zoller, 1993; Gibson & Chase, 2002; Osborne, Simon, & Collins, 2003; Wong, Young, & Fraser, 1997). For instance, Adesoji and Raimi (2004) stated that students attitudes were positively affected when laboratories was used in science classes.

2.2.1 Gender differences

There has been a deeply rooted belief that science related fields are more suitable for males; in fact gender differences studies have been one of the most popular investigation area in science education research. As indicated in the following sentences, studies related to gender differences in science achievement have led inconsistent results. Most of the studies reporting significant differences claimed that male students are more successful than female students especially in physical science topics (Brynes, 1996; Francis & Greer, 1999; Lee & Burkam, 1996; Linn & Hyde, 1989; Steinkamp & Maehr, 1984) whereas there are also studies reporting higher achievement of girls than boys (Anderman & Young, 1994; Britner, 2008; Britner & Pajares, 2006). Some studies also reported gender differences favoring boys (Meece, Glienke, & Burg, 2006) and particularly, in favor of boys in physical sciences and in favor of girls in biological science and chemistry (Schibeci, 1984; Steinkamp & Maehr, 1984). Learning style differences between males and females are proposed to be a potential reason for their differences in science learning in the study conducted by Wapner (1986), since usually females are considered as passive learners while males as active thinkers.

Boys and girls do not differ only in their science achievement but also they differ in terms of their attitudes toward science. Regarding to his review between 1970 and 1991, Weinburgh (1995) pointed out that the attitudes of learners and academic achievement were correlated to each other and they favor male students more than they do females. Additionally, several researches showed that girls are reluctant to choose science related fields, as a career choice, than boys do (Jones et al., 2000; Kahle & Lakes, 2003; Weinburgh, 1995). Actually, females and males are faced with different cultural expectations from their social environment, correspondingly they are provided with different experiences (Jones et al., 2000; Koballa & Glynn, 2004). Moreover, Francis and Greer (1999) reported that younger students possessed more positive attitudes toward science than older students did, as well as, boys had more favorable attitudes toward science than girls did. Similarly, George (2000) investigated the change in students' attitudes toward science over the middle and high school years, and found that boys have more positive attitudes toward science than girls at the middle school years and the rate of decline in attitudes was greater for the boys because of the courses students take.

2.3 Models

Models have been defined in broad range in the literature by different researchers. However, the everyday usage of the term "model" constrains its meaning and hence may cause the misinterpretation (Treagust, Chittleborough, & Mamiala, 2002). Models can represent intangible and conceptual theoretical construction like energy pyramids in ecosystems or unattainable direct observation such as the interior of the earth (Windschitl, Thompson, & Braaten, 2008). Gilbert (1993) explained models as they are essential for thinking and working scientifically and science and its explanatory models are always together since models are outputs and ways of science and key learning and teaching tools. Moreover, models are representations of thoughts, entities, events, mechanisms and systems (Gilbert & Boulter, 2000). Besides, Jackson, Trebitz, & Cottingham (2000) defined that models are representation of specific entities, thoughts, or circumstances that facilitate realities by simplifying and used often by scientist to investigate systems or processes they cannot operate straightforwardly. Moreover, models can be relatively numerical, deterministic, theoretical, and experimental and can be both simple such as verbal statement about a topic or linked boxes by an arrow to symbolize various connections and particularly complicated and comprehensive such as mathematical depiction of nitrogen changes in ecosystems via pathway. Additionally, models assist to identify problems and concepts more accurately, produce hypotheses, help in testing the hypotheses, and make predictions (Turner, Gardner, & O'Neill, 2001).

In the literature researchers categorized different types of models employed in science such as "mental models", "expressed models", "consensus models", "scientific models", "historical models", and "teaching or curricular models". *Mental models* are the mental entities that are produced cognitively (Gentner & Stevens, 1983; Johnson-Laird, 1983; Ritchie, Tobin, & Hook, 1997) and cannot be directly observed or obtained just figured out from the ways of person' interaction like body language, discourse, scripts (Justi & Gilbert, 2000). Expressed *models* are the form of mental models which are uttered in community realm by means of act, conversation, writing or other representational construct (Gilbert & Boulter 2000; Gobert &Buckley, 2000). Expressed models turn out to be *consensus models* when expressed models are tested and accepted by professional scientist society. Consensus models which are utilized currently at the boundary of science may be labeled *scientific models* (Gilbert, 2008; Gilbert & Boulter 2000; Justi & Gilbert, 2000; Silva, 2007; Treagust et al., 2002). Moreover, some phenomena cannot be observed directly due to their inaccessibility and so these events can be explained by the observed entities by using *conjectural models* (Windschitl et al., 2008).

All the models mentioned above may be *historical models* which were constructed particular historical stage but later were replaced by new one or have been superseded. T*eaching models* (Gobert & Buckley 2000; Justi & Gilbert, 1999) or *curricular models* (Justi & Gilbert, 2000) are built and utilized by teachers and curriculum developers in order to help the comprehension of a target system.

Greca and Moreira (2000) typified the models as *mental models* and *conceptual models*. Conceptual models are external representations of the mental models. These are generated to make easy the understanding or the teaching of phenomenon or systems by experts such as scientists or teacher. Although mental models are specific to person cognition, uncompleted, changeable and functional, conceptual models are external representations that are approved by the society due to the consistency of the scientific knowledge of this society. The external representations can be embodied in mathematical equation or symbols, analogies, or human-made objects. An object that shows working of water pump, an analogy between cell membrane and sandwich, or the mathematical formulation of universal gravity are examples of conceptual models.

Mental models have been studied by diverse disciplenes from cognitive psychology to philosophy of science and science education (Franco & Colinvaux, 2000). Since the definitions of mental models reflect different point of views, descriptions have varied in the literature. While Johnson-Liard (1983) defines the mental models as sensed or comprehended world's structural analogues, Gertner and Stevens (1983) affirm that mental models are "concerned with understanding human knowledge about the world" (p.1). These two pioneering edited collections concentrated on nature of representations differently (Nesessian, 2008). Whereas, Johnson-Liard's offered theoretical approaches to mental models such as deductive reasoning or discourse comprehension, the authors in the book edited by Gertner and Stevens focused on instructional approaches especially knowledge on physical phenomena and technological devices (Greca & Moreira, 2000). Present studies on mental models arise mainly from cognitive psychology, artificial intelligence and human machine interfaces (Norman, 1983), and from science education (Buckley, 2000; Harrison & Treagust, 1996; Treagust et al., 2002).

The notion of mental models has been tried to conceptualize by different areas. However, mental models cannot be directly observed or retrieved (Franco & Colinvaux, 2000; Justi & Gilbert, 2000). To provide evidence about mental models, researchers have analyzed artifacts like notebooks, texts, devices, drawings, or human actions and communications. Therefore, mental models can study by means of expressed models. The relation between the expressed models and the things in the mind of the individuals who announced these models is tried to be understood. However, there is always difference between persons' mental models and examination that researchers perform concerning these models (Norman, 1983). Although there is no specific and commonly approved approach to capture mental models, some methods have been developed (Gilbert & Boulter, 2000). In these circumstances some data sources are more trustworthy than the others (Franco & Colinvaux, 2000). For example, the process of reasonable rebuilding of scientists' production is more enlightening than the idea in their mind before the decision of preparing a document to the literature. Thus, some researcher studying on mental models prefer to examine scientists' notebooks or archetypes of inventions. Since collecting data by way of interviews can be suspicious for complicated for relation between the idea in the mind and expressed statements as well, researchers have developed some methods to complement the data from interview. For example, in problem solving activities on-line protocols are produced so these provide pictures of activities which are more reliable (Norman, 1983).

Norman (1983) generalized his observations about mental models of people. According to Norman, mental models are uncompleted, changeable (people cannot remember all aspects of their system, in particular these aspects have been used for some time), do not have definite borders, are not scientific (people beliefs influence mental models), are thrifty (people prefer to make additional physical actions that necessitate more energy in swap for diminished mental complexity).

Johnson-Liard (1983) stated some characteristics of mental models in his theory. One of the most prominent features is that mental models are analogical representations of reality. When people encounter to a specific situation, models are selected to understand this situation along with comprehended relations between the model and the situation to choose an internal representation which will function as a "substitute" for the situation (Greca & Moreira, 2000). Recursiveness qualifying mental models as active and functioning representations is the other significant characteristic of mental models. Mental models are incomplete and maintain to be extended and progressed whilst new information is integrated into it.

The role of mental models and expressed models are quite significant in research and transfer of knowledge so science does not progress without the application to models (Dagher, 1994; Ogborn & Martins, 1996; Treagust, 1993). For example, model of atom or DNA provided new momentums to the understanding of the micro-world's phenomena. However, our insight of phenomenon and comprehension of representation are influenced by mental models. The interaction between the phenomena and their representations affects our mental models as well (Gentner & Stevens 1983; Johnson-Laird 1983).

Analogies that are accepted as a subset of models since they entail the similarities between two entities are frequently employed to clarify abstract science concepts by scientist besides when they are improving the complication of their mental models

(Coll, France, & Taylor, 2005). Like scientists, experienced teachers utilize analogy while explaining the complicated abstract thoughts and phenomena (Ault, 1998).

Hesse (1966) asserted that analogies have dyadic relations namely *horizontal* and *vertical*. Horizontal relations are related to identity and dissimilarity usually to similarity, whereas vertical relations are concerned with the causality. Analogy argument necessitates the specific relation between the horizontal phrases of the analogy and the specific kind of vertical relation (Hesse, 1966). To attract the students' awareness to the employment and worth of analogies (BouJaoude & Tamim, 2000), and to be familiar with the role of analogies (Coll et al., 2005) are important in model development processes.

Analogical models that they can be “concrete”, “abstract” or “theoretical” such as scaled and inflated “objects", “symbols”, “equations”, and “graphs simulations” contingent on the necessity of the people improve scientific thought and work (Harrison & Treagust, 2000). Thus, they can be range from concrete such as models cars, plants, or animals to extremely “abstract” theoretical models such as magnetic fields or chemical equilibrium. Similar to analogy, Curtis and Reigeluth (1984) categorized analogical model as simple, enriched, and extended. Simple analogical models as “atom is like a ball”, do not necessitate explanation because the shared features between the analogue and the target are evident (Harrison & Treagust, 2000). To enlighten when and how the target resembles to the analogue provides enrichment. If multiple enriched analogical models demonstrate one target or multiple targets are explained by an enriched analogical model, the analogue is “extended”. For example between eye and camera (Glynn, 1991) or solar system and atom (Harrison & Treagust, 2000) there is multiple analogue-target matching.

Harrison and Treagust (2000) classified analogical models under the four main groups. These are; “scientific and teaching models”, "personal models of reality, theories and processes”, “pedagogical analogical models that build conceptual knowledge”, and “models depicting multiple concepts and/or processes”. According to their typology of the models each main group contain categories.

Scientific and teaching models include *scale models* and *pedagogical analogical models*. Scale models are the miniature of the objects so illustrate carefully external shape, form and colors of the objects. These models hardly ever demonstrate internal structure, properties and functions of the target (Black, 1962). Toys and toy-like (Grosslight, Unger, Jay, & Smith, 1991) objects are thought as scale models and this fact may make unclear the implicit model - target dissimilarities (Harrison & Treagust, 2000). Pedagogical and analogical model embraces all analogical models used in education. Since the target information is shared by the model (Glynn, 1991), it is identified as "analogical" and also this type of model called as pedagogical since these models developed by teachers and used to enhance understanding of students in non-observable unit like atom.

Harrison and Treagust (2000) stated that to emphasize conceptual features, analogue attributes frequently are understated or overstated and so analogue and target similarities are indicated point-by-point such as "atoms are solid balls, bonds are sticks joining balls" . Therefore, they called these types of model as *Pedagogical* analogical *models that build conceptual knowledge.* They categorized these models as *iconic and symbolic models*, *mathematical,* and *theoretical models*. Compound compositions and chemical reactions are modeled by chemical formulas and equations so these models are symbolic models (Feynman, 1994). However, students and the teachers who are not professional in chemistry may misinterpret the formulas and equations when they are explanative and communicative models since they are implanted in chemistry language intensively (Harrison & Treagust, 2000). Therefore, formulas and equations require to be interpreted according to the context.

Mathematical equations and graphs can depict physical laws such as Boyle's Law (k=PV). Although mathematical models are the most abstract one, these are the most precise and prognostic of all models (Kline, 1985). Harrison and Treagust (2000) suggested that since models like F=ma that valid function in frictionless condition and are hardly ever exist in classrooms, the best appropriate features of these models should be identified. Moreover, students form verbal or written explanations for mathematical models for themselves (Hewitt, 1987). Theoretical models express the theoretical structure such as representation of gas volume, temperature and pressure of kinetic theory (Harrison & Treagust, 2000). In specific event theoretical and mathematical features may exist together (Black, 1962).

Harrison and Treagust (2000) gathered maps, diagrams and tables, concept process models, and simulations under the *Models depicting multiple concepts and/or processes* category. Design, pathways and relationships can be illustrated by maps, diagrams and tables so students can easily envisage these. Some examples of these models are periodic table in chemistry, blood circulation in biology, and circuit diagrams in physics. Making simple or complicated features of all or pieces of these diagrams provide these being two dimensional models. These may cause misinterpretation by students for example students suppose that blood enriched with oxygen is blue and blood which carry carbon dioxide is red.

Concept-process models are used to explain the process of science concepts such as oxidation and refraction of light which are not objects. In physics, concept process models as balls, wheels or marching soldier moving from hard to soft or soft to hard plane are used to explain the refraction of light effectively (Harrison, 1994; Hewitt, 1987). Since the majority of students think concrete level, explaining the abstract concept processes produces explanatory contradiction (Harrison & Treagust, 2000). For example, teachers can introduce oxidation by using model with reverse event as loss of hydrogen instead of the gain of oxygen. Therefore students can confuse and tend to learn by rote the rules (Garnett & Treagust, 1992a; Garnett & Treagust, 1992b). They are unwilling to examine the grounds to typify oxidation as both gain and loss.

Harrison and Treagust (2000) highlighted the simulations as peerless division of multiple dynamic models. Complicated and advanced processes such as aircraft flight and global warming are modeled by simulation, which is peerless unit of multiple dynamic models. Simulations allow learners and researchers by making feel in “virtual reality” to improve abilities without putting in jeopardy their life and goods. Practically, students generally imagine the simulation as real because of hidden analogical features of simulations.

Mental models and *synthetic models* were grouped under the *personal models of reality, theories and process* by Harrison and Treagust (2000). Mental models are unique category of mental representation that persons produce throughout cognitive performance (Vosniadou, 1994). Synthetic models used by Vosniadou (1994) to explain the alternative conceptions. When students synthesize their mental models with the teachers' scientific models alternative conceptions may arise.

2.4 Research on Circulatory Systems

Studies on circulatory system mainly conducted about preconception and misconception on circulatory system, and the conceptual change aproaches in the field of education (Alkhawaldeh, 2007; Arnaudin, 1983; Arnaudin & Mintzes, 1986; Barnett, 1989; Chi, Chiu & de Leeuw, 1991; Chi, de Leeuw, Chiu, & LaVancher, 1994; Kurt, Ekici, Aksu, Aktas, 2013; Sungur, Tekkaya, & Geban, 2001; Yip, 1998)

One of the important studies about the students' alternative conceptions on the human circulatory systems was carried out by Arnaudin (1983). The researcher studied with the students of various age groups (grade 5 to college level) to identify their alternative conceptions. This study was conducted in two phases as constructive and validation. In the constructive phase, 25 elementary (grade 4) and 25 college students participated the study and each of them formed concept maps using eight circulation concepts ("hearth", "blood", "vessels", "oxygen", "food", "cells", "lungs", "carbon dioxide") and was interviewed about his/her ideas of human circulatory system. After getting insight of participants' understanding of the system by analyzing the data obtained from concept maps and interviews, in the validation phase, the researcher wrote the instrument which included open ended and multiple choice questions based on the findings of constructive phase. The instrument was administered to 495 students: fifth grade, eight grade, tenth grade, college non-biology majors, and college biology majors. This cross-age data were used to determine which alternative conceptions remain stable through education levels. The data suggested that accurate knowledge rate on cardiovascular concepts increased throughout educational levels in most of the concepts whereas alternative conceptions prevented acquisition of specific concepts such as; double circulation, closed circulation, respiratory/circulatory relationships; blood structure, the cellular environment. For example, the most persistent alternative conception held by students was the thought of a partially open circulatory system. About 30% of the students from all education levels considered that blood went out the vessels and washed the cells. Another alternative conception stayed robust through levels was the idea that air went to the hearth by means of the air tubes and it blended with the blood in the hearth.

Another study about misconceptions of the circulatory system was carried out by Yip (1998). Yip studied with 26 biology teachers who joined in-service teacher training program. These teachers graduated with majors in biological science. The researcher developed test questions containing short statements to identify misconceptions of the teachers about specific biological concepts such as “enzyme action”, “photosynthesis”, “animal nutrition”, “reproduction and genetics”, “gaseous exchange”, and “circulatory system”. The participants were supposed to read every statement and to indicate whether it was “correct”, “partially correct”, or “incorrect”. Then, they needed to highlight section that they thought to be incorrect and they required to validate their answer. However, the results of just two items related to misconceptions about circulatory system were reported in this article. The researcher revealed that most of the teachers indicated important misunderstandings of the circulatory system. They did not comprehend the link between flow rate, blood pressure, and vessel diameter. For example, in the first item on the circulatory system was: “In the mammalian circulatory system, the blood flow rate is lowest at the capillaries because the very narrow capillaries offer great resistance to blood flow.” (p. 208)

The first part of this statement (i.e. “the blood flow rate is lowest at the capillaries”) was thought as correct by the most of the teachers but the cause of the low flow rate in their opinion was differed. Although, almost half of the teachers’ (46 percent) opinion was that the statement was reasonable, some of them proposed different explanation such as: “this is due to a rapid drop in blood pressure along the narrow capillaries” (p. 209). Moreover, some teachers supposed that “high resistance to blood flow in the capillaries causes the blood pressure in the capillaries to drop below that of the arteries and veins” (p.209) . Besides, a few teachers thought that since the capillaries are particularly thin, blood moves fastest through them. The researcher asserted that all these explanations showed defective ideas of the teachers about the subject. This situation was attributed that teachers’ weak cognizing of physical relationship among flow rate, blood pressure, and vessel diameter. The researcher claimed that teacher candidates are not adequately taught science courses in the universities. Moreover, the possible misconceptions generated in secondary schools are not investigated and remedied in physiology unit.

Michael and his friends (2002) surveyed 1076 undergraduate students from 8 different institutions to detect prevalence conceptual difficulties on cardiovascular function. They wrote specific 13 multiple-choice diagnostic questions based on existing conceptual or reasoning difficulties in circulatory system. They also developed questions matched cardiovascular diagnostic questions to test the students’ ability to reason about general models. Each question, which necessitated implementation of universal principle to a particular cardiovascular phenomenon, identified nonphysical system about pressure/flow/resistance, elastic structures, and mass balance. The students who enrolled 12 courses such as human physiology, introductory biology, and mammalian physiology took cardiovascular diagnostic survey at the beginning of the course or just earlier than the beginning the topic of cardiovascular physiology. The researchers found that the most prevalent cardiovascular difficulty about cardiac output and resistance was showed by 81% of students while the least about hemorrhage and venous pressure was showed by 20% of the participants. Moreover, the results of pairs matched questions confirmed that students who could answer general models correctly were more likely to be able to answer correctly a related cardiovascular question. Thus, the researchers argued that some difficulties in understanding cardiovascular physiology resulted from the students' incapability to implement specific general models to particular physiological phenomenon.

Sungur, Tekkaya, and Geban (2001) performed a study to examine the role of "conceptual change texts accompanied by concept mapping instruction" on students' understanding of concepts in the human circulatory system topic. They conducted a quasi-experimental study with 49 tenth-grade students. The researchers developed the concepts test by conducting interview with the students and administered the test after the instruction. They found that experimental group students showed better achievement on the test than the control group students. Although some misconceptions still were held by the students of both groups, more students in the experimental group chose the selected desired answers that were scientifically correct. The researchers claimed that the misconceptions that were determined in the study were prevalent among students because of interdisciplinary nature of these concepts. For example, to understand blood pressure and velocity of blood concepts, students need to use their physics and chemistry knowledge (Yip, 1998).

Another study was performed by Alkhawaldeh (2007) to explore the efficiency of conceptual change text oriented instruction on students' understanding of the human circulatory system Moreover, the researcher also investigated that students' retention of understanding of human circulatory system concepts one month later. Two intact biology classes including 73 ninth grade female students were assigned as control and the experimental groups in 2005-2006 school-year in Jordan. While the control group students received traditional biology instruction, the experimental group students were instructed with the conceptual change text. Human Circulatory System Concept Test was implemented before and after the treatment to measure students' understanding of human circulatory concepts. The researcher found that there was no difference between the control and the experimental groups before the treatment in terms of understanding of the human circulatory system. Although the students in both groups indicated improvement with respect to the achievement in the concepts, the students in the experimental group had statistically significant score on the posttest. 70.27% of the experimental group and 19.44% of the students in the control group chose covetable answer. Moreover, the retention test result showed that there was a statistically significant difference between the groups in favor of experimental group. However, some misconceptions stay stable in both groups after the treatment. For instance, students still had the idea that blood pressure was lowest in veins since blood velocity is lowest in veins. Moreover, the results of this study revealed that the most prevalent misconception held by the control group students was that “the brain sends stimulus to the sinoatrial node (SA) to initiate hearth contraction” (p. 377).

Sungur and Tekkaya (2003) conducted another study to examine the impact of gender and reasoning ability on the human circulatory system concepts achievement and attitude toward biology. Two intact classes consisting of forty seven 10^{th}-grade students (26 boys and 21 girls) attended the study. The researchers administered Group Assessment of the Logical Thinking (GALT), the Attitude toward Biology Scale (ATBS), and the Human Circulatory System Concepts Test (HCSCT) to assess students’ reasoning ability, attitude toward biology, and achievement, correspondingly. The students received GALT at the beginning of the human circulatory system unit. They were administered ATBS and HCSCT after regular classroom instruction. The results showed that although the attitude toward biology mean score of the girls (mean=57.20) was higher than the mean score of the boys (mean=51.61), it was not found statistically significant mean difference between boys and girls. Moreover, boys and girls did not differ significantly with respect to achievement. Also statistically significant mean difference was found between concrete and formal students in terms of achievement and attitude toward biology. According to the findings, reasoning ability affected significantly on students’ achievement ($p < .05$). Students at the formal level showed significantly better performance than students at the concrete level on the Human Circulatory System Concepts Test. In addition, this study indicated that the increase in students’ reasoning ability affects positively their attitude toward biology.

Bahar, Ozel, Prokop, and Usak (2002) studied with science student teachers to reveal their understanding level about the internal structure of heart. This study was conducted with 120 third year science student teachers at the Faculty of Education in a University in Turkey. All participants took biology courses through 5 terms and the circulatory system was taught in students' 2nd and 3rd year. The researchers conducted the study in two phases. In the first phase, the pre-service teachers made some drawings about the structure of the animal cell and the place of some human organs and organ systems. Then, they were expected to interchange their drawings and make up deficient parts of one another. After that, the participants changed their drawings again and presented finished pictures by comparing their own drawings with them. Therefore, the deficiencies of pre-service teachers in these subjects were underlined. In the second phase, the participants drew to indicate their personal ideas about the heart. At the end of the study, each researcher independently scored every drawing. The researchers identified three levels of conceptual understanding as nonrepresentational drawings, partial drawings, and comprehensive representation drawings. According to the results of this study, in all categories remarkable proportion of the science pre-service teachers held several misconceptions as well as inadequate knowledge with regard to heart internal structure whereas number of students in the non-representational drawings level was low. Moreover, total number of pre-service students in comprehensive representation drawings was low.

Kurt et al. (2013) used "content analysis" technique to determine senior biology student teachers' conceptual structures about the concept of "blood". They used the "free word association test" and the "draw-write technique" both of which were open-response techniques. Results of the free word association test revealed nine conceptual categories explaining the senior biology student teachers' conceptual structures about the concept of blood: (1) "blood cells", (2) "blood fluid, its content, and its task", (3) "description of blood, its color, and its proteins", (4) "blood and its transport system", (5) "blood groups and determination of the blood groups", (6) "blood and its circulation system", (7) "blood-immunity", (8) "blood diseases", and (9) "the reminders of blood". Draw-write technique also produced similar categories except for the "blood diseases" category. Additionally, the "blood cells" category was dominant category in the free word association test, while the "blood groups and determination of the blood groups" was dominant in the draw-write technique. However, the biology student teachers were found to have shallow knowledge about the “blood” concept and they could not relate biological systems in macro and micro levels. Moreover, students teachers had inadequate and inappropriate knowledge on the “blood cells”, “blood fluid, its content and its task”, and “blood and its circulation system” categories.

Cardak, Dikmenli, and Saritas (2008) investigated the effect of 5E Learning Cycle Model on 6th grade students’ achievement in the circulatory system unit in elementary science course. Totally 38 students, 19 students in each class, were participated in the study. They used quasi-experimental study as a research method; the experimental group was instructed with 5E Learning Cycle Model; whereas, the control group received traditional instruction. The instruction took four-week period. The researchers used the “circulatory system achievement test” to measure students’ concepts in the circulatory system unit. They found significant differences among the groups in terms of circulatory system achievement test scores in favor of experimental group.

Similarly, Cakmak, Gurbuz, and Kaplan (2012) also studied the circulatory system unit with 6th grade students in science and technology class and employed a quasi-experimental study. The researchers examined the effect of concept map oriented instruction on students’ academic achievement in the circulatory system unit. Two classes, each composed of 40 students, were participated in the study. Students in the experimental group were taught using concept map oriented instruction; while, students in the control group took traditional method in five-week period. Likewise, a circulatory system achievement test was implemented to measure the success of the students on the circulatory system concepts. It was found that concept map oriented instruction improved students achievement. Additionally, use of concept maps increased their participation to the classroom activities.

CHAPTER III

PROBLEMS AND HYPOTHESES

This third chapter presents the main problem and the sub-problems related to the main problem in the first section and the hypotheses used to test each sub-problem in the second section.

3.1 The Main Problem and Sub-Problems

In this first section the main problem and six sub-problems associated to the main problem are given.

3.1.1 The Main problem

1. What is the effect of PBL instruction over TDBI on 11th grade students' achievement in the unit of human circulatory system and their attitudes toward biology as a school subject when their science process skills are controlled as covariate?

3.1.2 The Sub-problems

1. Is there a significant mean difference between the students instructed with PBL instruction and the students instructed with TDBI with respect to their achievement in the unit of human circulatory system when their science process skills are controlled as covariate?

2. Is there a significant mean difference across gender groups with respect to students' achievement in the unit of human circulatory system when their science process skills are controlled as covariate?

3. Is there a significant interaction between gender of students and treatment with respect to students' achievement in the unit of human circulatory system when their science process skills are controlled as covariate?

4. Is there a significant mean difference between the students instructed with PBL instruction and the students instructed TDBI with respect to their attitudes toward biology as a school subject?

5. Is there a significant mean difference across gender groups with respect to students' attitudes toward biology as a school subject?

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

3.2 The Hypotheses

In this second section, the hypotheses used to test each sub-problem are listed as follows:

Ho1: There is no significant mean difference between the students instructed with PBL instruction and the students instructed with TDBI with respect to their achievement in the unit of human circulatory system when their science process skills are controlled as covariate.

Ho2: There is no significant mean difference across gender groups with respect to students' achievement in the unit of human circulatory system when their science process skills are controlled as covariate.

Ho3: There is no significant interaction between gender of students and treatment with respect to students' achievement in the unit of human circulatory system when their science process skills are controlled as covariate.

Ho4: There is no significant mean difference between the students instructed with PBL instruction and the students instructed with TDBI with respect to their attitudes toward biology as a school subject.

Ho5: There is no significant mean difference across gender groups with respect to students' attitudes toward biology as a school subject.

Ho6: There is no significant interaction between gender of students and treatment with respect to students' attitudes toward biology as a school subject.

CHAPTER IV

DESIGN OF THE STUDY

4.1 The Experimental Design of the Study

Since the school administration formed the classes at the beginning of the semester, students were not assigned to experimental and control groups randomly in this study. Thus, nonequivalent control group design as a branch of quasi experimental design was used (Gay & Airasian, 2000; Tuckman, 1999). However, one of the classes was randomly assigned as control group (CG) and one of the classes was randomly assigned as experimental group (EG) in the same school.

While traditionally designed biology instruction was used in control group, project based learning oriented instruction was implemented in the experimental group. The 20-year experienced biology teacher instructed both groups. Before the treatment, the teacher was informed about the purpose of the study, PBL instruction and models in science education. The treatment was performed over five weeks. There were three 40-minute sessions per week for each group.

Human Circulatory System Achievement Test and Attitude Scale toward Biology were given to both groups before the treatment to check whether the groups were equal in understanding of human circulatory system concepts and attitude toward biology. In addition, at the beginning of the treatment, Science Process Skill Test was also distributed to both groups in order to assess students' intellectual abilities. Table 4.1 presents the design of the study.

Table 4.1 Research design of the study

Groups	Pre-test	Treatment	Post-test
EG	HCSAT ASTB SPST	PBLOI	HCSAT ASTB
CG	HCSAT ASTB SPST	TDBI	HCSAT ASTB

The meanings of the abbreviations in the table are presented below:

EG: Experimental Group

CG: Control group

HCSAT: Human Circulatory System Achievement Test

ASTB: Attitude Scale toward Biology

SPST: Science Process Skill Test

PBLOI: Project Based Learning Oriented Instruction

TDBI: Traditionally Designed Biology Instruction

4.2 Population and Subjects

All eleventh grade students in Ankara, the capital city of Turkey, were described as target population of the study. Since to reach target population was not easy, it was reasonable to define an accessible population. All eleventh grade students in Çankaya districts in Ankara were identified as accessible population. Therefore, the results of this study would be generalized to accessible population.

In Çankaya district Sokullu High School was chosen and two intact classes of a biology course that was taught by the same teacher were randomly selected from 5 possible classes in the second semester of 2008-2009 academic year. The classes were randomly assigned as control and experimental group. Seventy two eleventh grade students (42 female and 30 male) participated to this study. The experimental group which received project based learning oriented instruction consisted of 35 students (21 female and 14 male), while the control group which was instructed with traditional methods involved 37 students (21 female and 16 male). Students' ages varied from 16 to 17 years old.

4.3 Variables

4.3.1 Independent variables

The independent variables of this study were two different types of instruction which were project based learning oriented instruction and traditionally designed biology instruction, gender, and science process skills test scores. Types of instruction and gender were processed as categorical variables that do not differ in degree or quantity but vary qualitatively (Fraenkel & Wallen, 2006). Science process skills test score was taken as quantitative variable which stays in some degree and is assigned continuous numbers to assess individuals (Fraenkel & Wallen, 2006).

4.3.2. Dependent Variables

The dependent variables in this study were students' achievement of human circulatory system concept and students' attitudes toward biology as a school subject. Students' achievement of human circulatory system concept was measured by Human Circulatory System Achievement Test and students' attitude toward biology as a school subject was measured by Attitude Scale toward Biology. These variables were taken as quantitative variable.

4.4 Instruments

Human Circulatory System Achievement Test (HCSAT), Attitude Scale toward Biology (ASTB), and Science Process Skill Test (SPST) were instruments used in this study. SPST and HCSAT were administered to control and experimental groups in order to check the difference that existed before the treatment. Thus, SPST and HCSAT were identified as covariates to inhibit the probability of any differences which could arise from the characteristic of the groups. To assess students' achievements on of human circulatory system concept, HCSAT was administered again to both groups after the treatment. Moreover, ASTB was administered to both groups before and after the treatment to evaluate whether a change would occur about students' attitudes toward biology as a school subject.

4.4.1 Human Circulatory System Achievement Test

This test was improved by the researcher in order to measure students' achievement in the subject of human circulatory system. The instructional objectives of the unit of circulatory system, eleventh grade biology textbooks, and the questions in university entrance exam were taken into consideration while developing the questions of this test. Moreover, some questions were taken from Arnaudin (1983) and Sungur (2004). The Human Circulatory System Achievement Test consisted of 17 multiple-choice items (see Appendix A). Each item included four alternatives and four of them were distracters and one of them was true answer. The correct answer was coded as "1" point while the wrong answers were coded as "0". Thus, the maximum score of the students was 17. Higher scores of students in HCSAT can be interpreted as better learning regarding to human circulatory system subject.

The items of this test were examined by the two biology education professors and two biology teachers to provide content validity of the test. The test was revised by the researcher related to experts' recommendations. At the beginning of the development of the test, there were 25 items. The test was implemented as a pilot test to eleventh grade students in another high school. The cronbach alpha reliability of the test was found as .70. After finishing the validity and reliability studies of this test, it was administered to both EG and CG students before the treatment as a pretest to evaluate their knowledge of human circulatory system concept. After the treatment this test was administered to the both groups as a post-test in order to verify PBL oriented instruction on students' achievement on human circulatory concept test

4.4.2 Attitude Scale toward Biology

Attitude Scale toward Biology (ASTB) was used to measure students' attitudes toward biology. Geban et al. (1994) developed Attitude Scale toward Science. The scale was adapted to biology by Binzat (2000) and its reliability was found as .93. The scale consisted of 15 items with 5 point likert type scale: strongly agree, agree, neutral, disagree, and strongly disagree (see Appendix B). Since scale included both positive and negative statements, the negative statements were translated to the scores of positive statements. Therefore, higher scores showed positive attitudes toward biology and total possible scores of ASTB could range from 15 to 75. This scales was administered both pretest and posttest to all subjects and it took about 10 minutes to complete for students.

4.4.3 Science Process Skill Test

Science Process Skill Test was developed by Okey et al. (1982). It was translated and adapted into Turkish by Geban et al. (1992). The test contained 36 four-alternative multiple choice questions with five subdivisions (see Appendix C) conceived to assess the different facets of science process skills such as identifying variables, identifying and stating hypothesis, defining operationally, designing investigations, graphing data. The reliability of the test was found to be as 0.85. The test was administered to both experimental and control groups before the treatment to measure intellectual abilities of students. Since, each correct answer was assigned 1 point, the possible total score was 36. This test was assigned to the students before the instruction.

4.5 Treatment

This study was performed throughout 5 weeks in the spring semester of 2008-2009 academic year at a high school in Ankara. Two classes including 72 students taught by the same biology teacher participated in this study. One of the classes was designated as control group and other was designated as experimental group. While the experimental group received project based learning oriented instruction, traditionally designed biology instruction was implemented in the control group.

Both groups were instructed three 45 minute sessions per week. The researcher trained the teacher about project based oriented instruction and clarified the lesson plans for each topic. Moreover, the teacher was provided information about what she should do and what she should not do in both groups.

Human circulatory system topics were covered as part of regular classroom curriculum in the biology course. The topics comprised of transportation in the living system, structure and function of heart, structure and function vessels, circulation of blood, lymphatic system, blood pressure, the elements of blood, and health of the circulation system. The same biology textbook was used by the students in both groups.

In order to decide whether there was any difference between control and experimental groups in terms of understanding of human circulatory system, students' attitude toward biology as a school subject, and their science process skills as the pretests were administered at the beginning of the study. Human Circulatory System Achievement Test, Attitude Scale toward Biology, and Science Process Skill Test were used as pretests. The teacher was informed how the tests were administered as well.

In the control group, traditionally designed biology instruction was implemented. Lecturing and discussion method were used primarily by the teacher. Teaching strategies depended on teacher explanation and textbooks. Sometimes, the students were expected to read related subject from the textbook before the class hour. The teacher started lesson announcing the topic to the class. After explanation of the concepts, the teacher had students write definition of the concepts on their notebooks. The related figures were drawn on the board and some explanations were made through these figures. For example, the teacher drew an amoeba on the board and then indicated how oxygen and food were transferred in and out to the cell. After explaining the mechanism of the cellular transportation, she asked how multicellular organisms might transport materials. Students gave different answers related to the structure of the organisms. For example, while a student talked about the veins and blood of the human body, another student gave an example from plants. After giving little information about transportation in the plants, she wrote “circulation system” on the board. During the instruction, the teacher wrote some title and definitions on the board to highlight them. When explaining the subject she drew some tissue and organ pictures relevant to circulatory system by labeling their important parts. Moreover, she sometimes had students write on their notebooks what she said about them. To motivate students learning, she emphasized the importance of these subjects in the university exam. She gave examples from these questions. After explaining the subject, she asked related question to the students. At the end of the lesson, the teacher briefed the topic to clarify it for students. In addition, before coming to next class hour students were asked to study next subtopics. At the beginning of next class hour, the students were wanted to tell what they learned in the previous lesson.

In the experimental group, project based learning instruction was used. Before applying the project based learning, seven groups were formed and each of them involved 5 students. There were 2 males and 3 females in each group. The students were grouped by considering their biology grades in the previous semester. Therefore, academic performance and gender were optimized for each group. At the beginning of the study, the researcher trained the teacher about project based learning (PBL). The teacher explained the students what PBL was and what were expected from them during the instruction.

The first lesson started with directing a driving question to the students. This question, which was how material exchange occurred in a cell at a human body, was asked in a scenario to provide the students a real world situation (see Appendix D). According to this scenario, the professor wanted his/her students in the Biology Department at a university to show a trip of the molecules in our body to high school students. The university students needed to mark some molecules such as oxygen and glucose in a radioactive way. They were expected to track these molecules from entry to exit the body by using a technology like X-ray computed tomography. After determining the whole trip of the molecules, the students were expected to produce a model of this whole system. Then, they would explain the structure and the function of this system by using the model. According to this scenario, the experimental group students were expected to assume themselves as those university students. Based on the scenario, each group would produce a model by studying collaboratively.

Then, the students in the experimental group started to discuss what their method would be when searching the modeling question. The teacher toured around the groups and observed their discussions. Moreover, the teacher gave support to the students by asking additional questions. The students made their drafts and started to search about transportation in the living systems from the textbooks provided by the teacher. At the next meeting, all groups were invited to the computer laboratory. The students continued their investigations from the internet. The teacher proposed related pages to the students as well.

The teacher opened a class discussion regarding what kind of information they reached from their exploration about the transportation of living systems. The teacher asked the students what were important parts of the human circulation system. The students from different groups gave answers such as hearth, blood, and vessels. The teacher told that they would investigate the structure and the function of human hearth. Each group studied on this subject by using the referenced book in the classroom. She also advised the groups to develop the draft of their models while they were searching on the subject. Moreover, the teacher monitored each group and guided the students when they did not understand the concept. For example, the students in a group did not decide how they would design the valves between chambers, and between ventricles and arteries. Since the students saw just two dimensional pictures of the human hearth on the textbooks, they had difficulty in making valves on three dimensional models. In these cases, the teacher asked some sub-questions such as “Think about the blood flows and used your hands like valves. Suppose below of your hand is ventricle and above of your hand is atrium. If blood comes from below of your hand (from ventricle), how would be your hand position to prevent blood from flowing back in to the atria when the ventricles contract?” Two students used their hands as valves and tried to decide the position of the valve.

Then, the teacher offered the students to go to the computer laboratory and to continue their study through use of the internet. In this laboratory session, they had a chance to watch animations about the structure and function of the human hearth.

In the experimental group, all students proceeded to evolve the models over searching the subject. Within this period, some groups changed their initial models. The groups mainly used materials such as paper, colored cardboard, play dough, plastic pipe, aluminum folio, and crayon in the models. At the last two hours of the instruction, each group presented their models in front of their classmates (Appendix E). The presenters did self-evaluation of their products and expressed their difficulty about making those models. Moreover, all students criticized positive and negative aspects of the models, and they argued how weak parts of the models would be resolved.

After the treatment, the Human Circulatory System Achievement Test and Attitude Scale toward Biology as post-tests were administered to both experimental and the control groups in order to measure the effect of the treatment on students' achievement of human circulatory system and their attitudes toward biology.

4.6 Treatment Fidelity and Treatment Verification

Treatment fidelity enable researcher to confirm that any other parameter beyond treatment is not a reason for the difference in the dependent variable before research conducted (Borrelli et al., 2005; Hennessey & Rumrill, 2003). To be sure of treatment fidelity, first criterion list was prepared to be aware of what should be performed and what should not be performed in both experimental group (EG) and control group (CG). For instance, project based learning oriented instruction accompanied with model construction was used in the experimental group. Each phase of the instruction and how these phases would be performed were designated for EG and CG group in the criterion list. Therefore, this method was accomplished for project based learning oriented instruction accompanied with model construction group (EG) and traditionally designed biology instruction group (CG). In addition, specified lesson plans regarding to the criterion list and instructional objectives on the subject of human circulatory system were formed. Three experts in biology and biology education and two biology teachers evaluated these lesson plans and the instruments whether they were fitted for the purpose of the study. Depends on experts' and teachers' feedback, the materials were revised and improved. After all, the teacher who would implement the instruction in EG and CG was trained to clarify project based learning oriented instruction to her.

Treatment verification provides evidence to researcher whether the treatment was fulfilled as planned in the study (Shaver, 1983). To meet treatment verification, observation checklist involving the phases of the instruction to be implemented in the EG and CG was prepared. 15 items with 3 point likert-type scale (yes, moderately, no) were included in this checklist. The experts explained above examined the phases of the instruction with respect to the purpose of the study. Then, the groups were observed with reference to the checklist by the researcher throughout the treatment. Moreover, the researcher had an interview with the teacher and some students to evaluate whether the implementation met the purpose of the study. All evaluation results provided evidence to the researcher that treatment was implemented as designed before the instruction.

4.7 Ethical Issues

The ethic committee that consisted of five professors from education faculty examined to evaluate the proposal of the study, the instruments, and the lesson plans before carrying out the research. The study was approved by the committee that there was not any potential harm to participants. Moreover, instead of the names of the subjects, numbers were assigned to students for each instrument so as to guarantee confidentiality. The researcher informed students that the tests would not include their names and the data would be collected in confidence as well. Additionally, no one but the researcher accessed the data.

4.8 Threats to Internal Validity

Attributing the change occurred in dependent variable particularly to independent variable instead of any unintended extraneous variables is known as internal validity

(Frankel & Wallen, 2006). Subject characteristics, mortality (loss of subject), location, maturation, instrumentation, testing, history, attitude of subjects, regression, and implementation are threats to internal validity.

Difference among individuals in the sample corresponding with such as age, maturity, socioeconomic status, knowledge background on specific topic, intelligence, science process skill and so forth are some examples of subject characteristic threat (or selection bias) (Frankel & Wallen, 2006). The students' age in both EG and CG were close to each other (16-17 years old) and they were on the same grade level (11^{th} grade). At the beginning of the study, previous knowledge about human circulatory system and science process skills of the participants were evaluated by implementing the Human Circulatory System Achievement Test and Science Process Skill Test. These variables were employed as covariate whether prior differences influence observed differences on the posttest at the end of the study. In respect to the analyses of the pretest, insignificant difference was observed between EG and CG. Moreover, the researcher was informed that students' socioeconomic status was similar to each other.

Mortality threat is that some participants may give up the study for some reasons such as sickness, relocation, necessity of other events, and thus, subjects may be nonexistent throughout data gathering (Frankel & Wallen, 2006). In this study, loss of subjects was not a problem since no missing data was in all pretests and posttests.

This study was conducted in the students' usual classrooms at their school and the schedule was stuck. Therefore, location threat which arises from influence of specific location on outcome of a study was under control. Moreover, this study took just five weeks it was thought that maturation threat did not occur.

Frankel and Wallen (2006) state that instrumentation threats are instrumentation decay, data collector characteristics, and data collector bias. Instrumentation decay is related to scoring procedure and characteristics of the instruments. In this study, the items in the instruments were formed as multiple choice (HCSAT, SPST) and likert type (ASTB). Thus, different interpretation of the response and exhaustion of the scorer due to extended or difficult to score were eliminated. Moreover, data collector characteristics such as gender, age, and ethnicity of the data gatherer may influence the result. This problem was got over by administered same data collector (the teacher) in both EG and CG. Furthermore, to overcome data collector bias, the teacher was trained about the implementation of the instruments regarding to standardized procedures.

In intervention studies, research are conducted in a period of time and during the study data are collected. It is common that participants take tests before and after the study. The substantial improvement may result from the use of the pretest, which is known as testing threat. For this study, adequate time (5 weeks) was allocated for intervention thus testing threat was controlled.

History threat is that the possibility of effect of unexpected and unplanned occasions on the students' responses. The researcher observed all classrooms sessions and any extraordinary event did not happen during the intervention and testing. Therefore, the researcher concluded that there was no history effect.

Subjects' point of view in a study and their involvement may cause attitude of subject threat. In intervention studies, the participants of the control group may become dejected and offended, and thus they indicate less achievement than the members of the treatment group (Frankel & Wallen, 2006). To minimize this threat, students were convinced that the treatment in the experimental group was not a novel situation and it was an ordinary component of the instruction. Moreover, the teacher told the students in the control group that they would make models for different subject matter later.

Regression threat may occur if change is assessed in a group that performs particularly low or high before the intervention (Frankel & Wallen, 2006). Since the students were not selected corresponding with their pre-intervention performance, regression threat was under control.

Someone such as a researcher, a teacher, or a counselor administers the treatment or method in any experimental study. Therefore, the possibility of that experimental group was treated unintended way, which provides them sort of an advantage increases. This fact is known as implementation threat. In order to remedy this threat, the teacher instead of the researcher employed the instruction in both EG and CG. In addition, the researcher trained the teacher about how the method would be implemented. Beside these, the researcher observed the groups whether the treatments were practiced in the groups as planned.

4.9 Assumptions and Limitations

4.9.1 Assumptions

1. The teacher was not biased and kept the instructions as the researcher intended in both EG and CG.

2. The students answered the instruments caringly and honestly.

3. The testing was completed under standard conditions.

4. The students in the control group and experimental group did not affect each other.

4.9.2 Limitations

1. This study was limited to 72 eleventh grade students at a high school in Çankaya district in the spring semester of 2008-2009 academic year.

2. The individuals were not randomly selected since the students had been placed at the beginning of the academic year.

3. This study only includes “human circulatory system” unit in biology.

4. The students required to work cooperatively in the experimental group. Thus, one of the assumptions which is independency of observations in two-way ANCOVA may be violated.

CHAPTER V

RESULTS AND CONCLUSIONS

In this chapter, the results of the descriptive statistics and the results of the inferential statistics are presented.

5.1 Descriptive Statistics Analyses

Descriptive statistics such as minimum (min), maximum (max), mean, standard deviation (SD), skewness, and kurtosis related to the students' scores from all instruments used in the study were analyzed. Table 5.1 presents descriptive statistics regarding pre and post human circulatory systems achievement test scores, pre and post attitude scale toward biology scores, and science process skill test scores.

Table 5.1 Descriptive Statistics Related to Human Circulatory Systems Achievement Test (HCSAT), and Science Process Skill Test (SPST), Attitude Scale toward Biology (ASTB)

Descriptive Statistics								
Group	Test	N	Min	Max	Mean	SD	Skewness	Kurtosis
CG	Pre-HCSAT	37	1.00	9.00	3.971	1.951	.399	-.293
	Post-CSAT	37	5.00	15.00	11.318	2.253	-.848	1.380
	SPST	37	11.00	26.00	18.261	2.983	-.298	1.551
	Pre-ASTB	37	1.53	5.00	3.787	.708	-.768	1.567
	Post-ASTB	37	1.07	5.00	3.887	.779	-1.564	3.632
EG	Pre-HCSAT	35	1.00	8.00	4.765	1.941	.226	-.721
	Post-CSAT	35	11.00	17.00	14.080	1.304	-.336	.977
	SPST	35	11.00	27.00	20.891	3.713	-.439	.646
	Pre-ASTB	35	1.27	5.00	4.026	.744	-1.710	4.851
	Post-ASTB	35	2.00	5.00	3.998	.696	-1.166	1.451

As seen in Table 5.1, Pre-Human Circulatory Systems Achievement Test (pre-HCSAT) scores ranged from 1 to 9 with the mean value 3.97 in control group while the experimental group students' pre- HCSAT scores ranged from 1 to 8 with the mean value of 4.77. The post- Human Circulatory Systems Achievement Test (post-HCSAT) scores of control group students ranged from 5 to 15 with the mean of 11.32 whereas the experimental group students' post-HCSAT scores ranged from 11 to 17 with the mean 14.08. Therefore, in terms of HCSAT, the mean value increased more in experimental group (14.08-4.77 = 9.31) than the mean value in control group (11.32-3.97 = 7.35).

The mean value of the control group students' Science Process Skill Test (SPST) scores was 18.26 and their scores ranged from 11 to 26 while the mean value of the experimental group students' SPST was 20.89 and their scores ranged from 11 to 27. Even though, the experimental group students' mean scores was higher than the control group students' mean scores, no statistically significant difference was found from the t-test analysis which is presented in the inferential statistics analyses section.

The control group pre-ASTB scores ranged from 1.53 to 5.00 with the mean value of 3.79 while the pre-ASTB scores of the experimental group ranged from 1.27 to 5.00 with the mean value of 4.03. Post-ASTB scores in control group ranged from 1.07 to 5.00 with the mean value 3.89 in control group and those in the experimental group ranged from 2.00 to 5.00 with the mean value of 4.00. As seen in Table 5.1, the attitude scores in both groups did not show important changes after the instruction.

5.2 Inferential Statistics Analyses

The hypotheses were tested by using Analysis of Covariance (ANCOVA) and two-way analysis of variance (ANOVA) at a significance level of .05. Before testing hypotheses, independent t-test analyses were conducted in order to check whether there was a significant mean difference between the experimental and the control group regarding students' achievement in human circularity system measured with pre-HCSAT, their attitudes towards biology measured with pre-ASTB, and their science process skills measured with SPST.

The results of independent t-test analyses show that there was no significant mean difference between the scores of the students in the experimental group and those in the control group in terms of students' achievement in human circularity system ($t\ (70) = -1.729$, $p = .088$) and their attitudes towards biology ($t\ (70) = -1.397$, $p = .167$). However, there was a significant mean difference between the groups in terms of their science process skills ($t\ (70) = -.3.323$, $p = .001$). Therefore, students' science process skill test scores were assigned as covariate when Analysis of Covariance was used.

5.2.1 Null Hypothesis 1

The first hypothesis was that there is no significant mean difference between the students instructed with project based learning oriented instruction and the students instructed with traditionally designed biology course with respect to their achievement in the unit of human circulatory system when their science process skills are controlled as covariate. This hypothesis was tested by using Analysis of Covariance (ANCOVA).

The assumptions of ANCOVA are independence of observations within and between groups, normality of sampling distribution, equal variances, no custom interaction between independent variable and covariate, and significant correlation between dependent variable and covariate. The first assumption, which is independence of observations, was met because all tests were administered to all students in the standard conditions and there was no interaction within and between groups while administering the tests. The second assumption, which is normality of sampling distribution, was met because the skewness and kurtosis values show that Human Circularity System Achievement Test scores are normally distributed. The third assumption, which is equal variances, was checked by Levene's Test of Equality. The result of this test ($F(3, 68) = 4.697$, $p<.05$) shows that the variances of the post-HCSAT scores of the students were not equal (Table 5.2). Even though this assumption was not met, the ANCOVA was conducted.

Table 5.2 Levene's Test of Equality of Error Variances for Post-HCSAT

	F	df1	df2	Sig.
Post-HCSAT	4.697	3	68	0.005

The fourth assumption, which is no custom interaction between independent variable and covariate, was met because the results (Table 5.3) show that there is no custom interaction between treatment and students' science process skill test scores ($F(1, 1) = 0.620$, $p>.05$).

Table 5.3 Test of Between-Subjects Effects for Post-HCSAT (Treatment-SPST)

Source	df	SS	MS	F	p
Treatment	1	10.669	10.669	3.082	0.084
SPST	1	3.949	3.949	1.141	0.289
Treatment & SPST	1	2.146	2.146	0.620	0.434

The fifth assumption, which is significant correlation between dependent variable and covariate, was met because the result (Table 5.4) shows that there was a significant correlation between students' human circularity system achievement test scores and science process skill test scores (r = .306, p<.05).

Table 5.4 Correlation between Post- HCSAT Scores and SPST Scores

		Post-HCSAT	SPST
Post-HCSAT	Pearson Correlation	1	0.306*
	Sig.		0.009
	N	72	72
SPST	Pearson Correlation	0.306*	1
	Sig.	0.009	
	N	72	72

*significant at .05

After checking the assumptions, ANCOVA was run. As given in Table 5.5, the results show that there was a significant mean difference between post-test scores of the students instructed with project based learning oriented instruction and the students instructed with traditionally designed biology course with respect to their achievement in the unit of human circulatory system when their science process skills are controlled as covariate (F (1, 67) = 33.801, p<.05). The students instructed with project based learning instruction scored significantly higher than the students instructed with traditionally designed biology course ($\overline{X}$ (EG) = 13.999, $\overline{X}$ (CG) = 11.283).

Table 5.5 ANCOVA Summary of Post- HCSAT

Source	df	SS	MS	F	P
Covariate (SPST)	1	2.887	2.887	0.919	0.341
Gender	1	11.404	11.404	3.628	0.061
Treatment	1	106.234	106.234	33.801	0.000
Gender & Treatment	1	13.091	13.091	4.165	0.045
Error	67	210.579	3.143		

5.2.2 Null Hypothesis 2

The second hypothesis was that there is no significant mean difference across gender groups with respect to students' achievement in the unit of human circulatory system when their science process skills are controlled as covariate. This hypothesis was tested by using Analysis of Covariance (ANCOVA).

The assumptions of ANCOVA are independence of observations within and between groups, normality of sampling distribution, equal variances, no custom interaction between independent variable and covariate, and significant correlation between dependent variable and covariate. The first assumption, which is independence of observations, was met because all tests were administered to all students in the standard conditions and there was no interaction within and between groups while administering the tests. The second assumption, which is normality of sampling distribution, was met because the skewness and kurtosis values show that Human Circularity System Achievement Test scores are normally distributed. The third assumption, which is equal variances, was checked by Levene's Test of Equality. The result of this test (F (3, 68 = 4.697, $p<.05$) shows that the variances of the post-HCSAT scores of the students were not equal (Table 5.2). Even though this assumption was not met, the ANCOVA was conducted.

The fourth assumption, which is no custom interaction between independent variable and covariate, was met because the results (Table 5.6) show that there is no custom interaction between gender and students' science process skill test scores ($F (1, 1) = 3.574$, $p>.05$).

Table 5.6 Test of Between-Subjects Effects for Post-HCSAT (Gender-SPST)

Source	Df	SS	MS	F	P
Gender	1	23.065	23.065	5.189	0.026
SPST	1	53.056	53.056	11.937	0.001
Gender & SPST	1	15.886	15.886	3.574	0.063

The fifth assumption, which is significant correlation between dependent variable and covariate, was met because the result (Table 5.4) shows that there was a significant correlation between students' human circularity system achievement test scores and science process skill test scores ($r = .306$, $p<.05$).

After checking the assumptions, ANCOVA was run. As given in Table 5.5, the results show that there was no significant mean difference between post-test scores of males and females with respect to their achievement in the unit of human circulatory system when their science process skills are controlled as covariate ($F (1, 67) = 3.628$, $p>.05$). While the post-test mean score of males was 12.224, the post-test mean score of females was 13.059.

5.2.3 Null Hypothesis 3

The third hypothesis was that there is no significant interaction between gender of students and treatment with respect to students' achievement in the unit of human circulatory system when their science process skills are controlled as covariate. This hypothesis was tested by using Analysis of Covariance (ANCOVA). Since the p value for the interaction between treatment and gender was 0.045, this can be accepted as 0.05. Thus, this result shows that there was no significant interaction effect between gender and treatment on students' achievement in the unit of human circularity system (F (1 ,67) = 4.165, p= .05).

5.2.4 Null Hypothesis 4

The fourth hypothesis was that there is no significant mean difference between the students instructed with project based learning oriented instruction and the students instructed with traditionally designed biology course with respect to their attitude toward biology as a school subject. This hypothesis was tested by using two-way Analysis of Variance (ANOVA).

The assumptions of ANOVA are independence of observations within and between groups, normality of sampling distribution, and equal variances. The first assumption, which is independence of observations, was met because all tests were administered to all students in the standard conditions and there was no interaction within and between groups while administering the tests. The second assumption, which is normality of sampling distribution, was met because the skewness and kurtosis values show that post-ASTB scores are normally distributed. The third assumption, which is equal variances, was checked by Levene's Test of Equality. The result of this test (F (3, 68 = .032, p>.05) shows that the variances of the post-ASTB scores of the students were equal (Table 5.7).

Table 5.7 Levene's Test of Equality of Error Variances for Post-ASTB

	F	df1	df2	P
Post-ASTB	0.032	3	68	.992

After checking the assumptions, ANOVA was run. As given in Table 5.8, the results show that there was no significant mean difference between post-test scores of the students instructed with project based learning oriented instruction and the students instructed with traditionally designed biology course with respect to their attitude toward biology as a school subject (F (1, 68) = 0.826, p>.05).

Table 5.8 ANOVA Summary of Post-ASTB

Source	Sum of Squares	df	Mean Square	F	P
Group	0.421	1	0.421	0.826	.367
Gender	1.688	1	1.688	3.309	.073
Group*Gender	1.835	1	1.835	3.597	.062
Error	34.692	68	0.510		

5.2.5 Null Hypothesis 5

The fifth hypothesis was that there is no significant mean difference across gender groups with respect to students' attitude toward biology as a school subject. This hypothesis was tested by using two-way Analysis of Variance (ANOVA).

The assumptions of ANOVA are independence of observations within and between groups, normality of sampling distribution, and equal variances. The first assumption, which is independence of observations, was met because all tests were administered to all students in the standard conditions and there was no interaction within and between groups while administering the tests. The second assumption, which is normality of sampling distribution, was met because the skewness and kurtosis values show that post-ASTB scores are normally distributed. The third assumption, which is equal variances, was checked by Levene's Test of Equality. The result of this test (F (3, 68 = .032, p>.05) shows that the variances of the post-ASTB scores of the students were equal (Table 5.7).

After checking the assumptions, ANOVA was run. As given in Table 5.8, the results show that there was no significant mean difference between post-test scores of males and females with respect to their attitude toward biology as a school subject (F (1, 68) = 3.309, p>.05). While the post-test mean score of males was 3.766, the post-test mean score of females was 4.077.

5.2.6 Null Hypothesis 6

The sixth hypothesis was that there is no significant interaction between gender of students and treatment with respect to students' attitude toward biology as a school subject. This hypothesis was tested by using two-way Analysis of Variance (ANOVA). Table 5.8 shows that there was no significant interaction effect between gender and treatment on students' attitudes toward biology as a school subject ($F(1, 68) = 3.597$, $p > .05$).

CHAPTER VI

DISCUSSION, IMPLICATIONS, AND RECOMMENDATIONS

In this chapter, initially the summary of the study is presented. Next, the results are discussed. Following, the educational implications are given. Finally, recommendations for further research are listed.

6.1 Summary of the Study

This study investigated the effect of PBLOI over TDBI on 11th grade students' achievement in the unit of human circulatory system and their attitudes toward biology as a school subject. Before conducting the study, the PBL literature was reviewed. Secondly, the Human Circulatory System Achievement Test (HCSAT) was developed to measure students' achievement on human circulatory system. Thirdly, Attitudes Scale toward Biology (ASTB) and Science Process Skill Test (SPST) were chosen as instruments. Finally, lesson plans and the instructional activities were planned for 11th grade students.

This study took place for five weeks at a high school in Ankara. Two intact classes involving 72 students taught by the same biology teacher participated in this study. One of the classes was assigned as control group and the other as experimental group. The experimental group was taught by PBLOI and the control group received TDBI. At the beginning of the treatment, HCSAT, ASTB, and SPST as pre-tests were administered to both groups to examine if there was a significant difference between two groups before the treatment.

In order to determine whether there was a significant mean difference between students' achievement in human circulatory system concepts, their attitudes toward biology as a school subject, and their science process skills, t-tests were run. The results of these analyses point out that there was not any significant mean difference between two groups in terms of their biology achievement and attitude scores. However, a significant mean difference in SPST scores was found between two groups so that SPST was used as a covariate for the inferential analysis. After the treatment, both experimental and control groups were given the HCSAT and ASTB as post-tests. In order to determine the effect of treatment and gender on students' biology achievement and their attitudes toward biology course, two-way ANCOVA and two-way ANOVA were used respectively.

6.2 Discussion of the Results

Circulatory system is one of the most difficult phenomena for students in a biology class (Buckley, 2000; Chi, 2001; Chi et al., 1991). It involves different structures categorized from macro structures such as heart and blood vessels to micro structures such as blood cells and capillaries. Although macro structures are visible to naked eye, micro structures cannot be seen without visualization tools. Moreover, in order to comprehend circulatory system concepts, students need to know related chemistry and physics concepts. For example, to understand "flow of the blood through the vessels", students should know "fluid dynamics". In addition, this system is placed into the body; it cannot be seen directly and it functions out of sight (Buckley, 2000). However, children experience some concepts related to human circulatory system in daily life. For example, they feel their pulse via their senses and they observe measurement of blood pressure using blood pressure monitor. Sometimes, these experiences may be a source of misunderstanding. For example, students possess the misunderstanding of "pulse is an object", since they can feel their pulse (Gellert, 1962). Therefore, teachers need to be aware of the difficulties that their students possibly have and implement constructivist teaching methods to support students' conceptual understanding. In the current study, PBL as one of the constructivist teaching methods was preferred in order to overcome the problems mentioned above.

PBL enables students to learn through experience. This method provides an environment to the students in order to construct their knowledge with meaningful understanding. Throughout PBL implementation, students develop artifacts or products while trying to find solutions to driving questions. Moreover, students comprehend the phenomena and represent their understanding by means of artifacts (Krajcik & Czerniak, 2007).

In this study, students in the experimental group were given PBL instruction. Initially, the study groups were formed to support students work collaboratively. Each group involved two males and three females. The students were given a driving question presented in a scenario which is related to their own lives. Moreover, the students searched for the answers from the textbooks and internet and each group generated a model simultaneously during the PBL instruction. Meanwhile, the teacher monitored the groups, asked some questions to guide them when they needed help, and encouraged the students to generate and ask questions throughout their inquiry. The students had a chance to study in the computer laboratory as they continued their investigations. In addition, they watched some animations related to the circulatory system. Throughout the study, while the students were searching the subject, they generated, revised, and improved their circulatory system models as their projects. At the end of their projects, all groups made presentations to their classmates, and they discussed the deficiencies and the strengths of their models.

On the other hand, the students in the control group received TDBI. In this group, the teacher used lecturing as a teaching approach predominantly. Teacher's explanations and textbooks formed the source of information. Usually the students were responsible for reading the oncoming topic from their textbooks as homework. The lessons began with the teacher's announcement of the topic and continued with the teacher's explanations of the concepts. Then, the students needed to write the definitions of the concepts on their notebooks. The teacher also drew related figures on the board and made explanations related to the figures. Meanwhile, she asked some questions to the students throughout the lessons.

As stated earlier, this study aimed to explore the effect of PBL on students' understanding of human circulatory system concepts and their attitudes toward biology as a school subject. According to ANCOVA results which is based on post-HCSAT scores, students in the experimental group showed higher achievement scores than the students in the control group, indicating that the statistically significant difference between the groups might be due to the treatment-PBL. The results of this study supports the findings of the previous studies by confirming the significant effect of PBL on students' academic achievement (Barron et al., 1998; Frank & A. Barzilai, 2004; Gultekin, 2005; Jarmon et al., 2008; Korkmaz & Kaptan, 2002; Özdener & Özçoban 2004; Panasan & Nuangchalerm, 2010; Thomas, 2000; Usak et al., 2009).

Previous research shows that in a classroom environment where the instruction is traditionally designed, students are passive learners. They mostly listen what the teacher says, take notes, and passively receive the information, which is perceived boring among the students (Tomlinson, 2002). Since conventional teaching methods are routine, students' motivation to learn the subject matter and their personal interest to the subject matter decreases over time. However, PBL provides learning environments to the students that they can be more active, perceive biology learning entertaining, and in turn become more successful in biology courses (Nasr & Soltani, 2011). Likewise, the researcher also observed that students in the experimental group were more interested in the course material compared to the students in the control group and even did not use their break time to continue working on their models.

In this study, experimental group students construct their knowledge by using different resources and media. For example, students searched the topics from additional textbooks which were provided by the researcher. They continued their investigation on the web in the computer laboratory, as well. During the study, they had a chance to see some animations and simulations. However, the traditional instruction in control group did not involve solutions to students' daily life problems. Moreover, students generally asked the teacher why they learned the concept in the curriculum since they found many subjects meaningless. According to the classroom observations of the researcher, the teacher explained the human circulatory system concepts without considering her students' daily experiences. She just gave the definition of the terms, and the structure and function of the elements of human circulatory system. Thus, students did not show any curiosity to learn the concepts. On the other hand, PBL allows students to construct their knowledge via real life problems (Panasan & Nuangchalerm, 2010). In the PBL classroom, the teacher provided the questions based on students' lives. For example, the teacher asked a question as; "Do any of you have a hole in your heart congenitally or do you know anyone who has one?" One of the students held his hand and shared his experience with his classmates. Then, the teacher asked the students: "What do you think about blood flow in the heart and blood pressure of a child who has a hole in her/his hearth?" In the classroom, the students were familiar with the notion of "cyanosis-blue baby- a hole in your heart", but they did not know the structure of a cyanotic heart and how it functioned. Then, students made an investigation about a cyanotic heart. When searching for this topic, the students reinforced their knowledge about the structure and the function of a healthy heart. In addition, the students in the experimental group constructed a model of the human circulatory system throughout the treatment. Constructing a model is a kind of hands-on activity and students enjoyed this activity. These observations were in line with the previous research that PBL provides enjoyable and meaningful learning experience to the students and thus enhances their academic success (Barron et al., 1998; Boaler, 1997; Girgin Balkı, 2003; Gultekin, 2005).

Earlier studies also suggest that in order for biology understanding to take place, micro and macro relatedness among concepts should be emphasized (Cimeri, 2012; Jones & Rua, 2006; Kurt et al., 2013; Lazarowitz & Penso, 1992; Lukin, 2013; Seymour & Longdon, 1991; Simpson & Marek, 1988). If it is not done, students have difficulty in comprehending particularly complex systems such as circulatory system. Moreover, circulatory system as a biology subject includes dynamic processes such as blood flow and function of the heart. The relationship between macro and micro structures and functions cannot be provided to the students in straight structure of a traditional instruction. PBL allows students to make connections between the concepts. When trying to find out an answer to the driving question, searching for the subject, and developing the project, students deeply investigate the subject matter. Therefore, they realize the relationships between the concepts through the dynamic setting of PBL. For example, in this study the students searched for the structure and the function of the heart; however, they had difficulty in designing the valves while they were constructing their models. They overcame this difficulty; by the help sub-questions about the hearth and valves provided by the teacher and discussion with peers. After that, they continued their investigation and revised their models.

PBL provides a collaborative learning environment to students, as well. Brown, Collins, and Duguid (1989) stated that “Knowledge is...in part a product of the activity, context, and culture in which it is developed and used” (p.32). This idea also supported Vygotsky’s theory that, learning happens in social contexts such as playtime with friends and conversations with others. Thus, individual interiorizes knowledge in these contexts (Vygotsky, 1986). Moreover, Vygotsky used the term “zone of proximal development” which means “the difference in performance between what a learner can accomplish unassisted and what he could accomplish with the assistance of a more knowledgeable and capable other” (Krajcik & Czerniak, 2007, p.199). As a result, the group studies in the classroom support learning if the groups are arranged properly. The literature supports the positive effect of collaboration on learning. Accordingly, in this study, study groups were formed in the PBL class. The group members were chosen from different academic success levels and different gender groups. Therefore, the students had a chance to learn from each other. In addition, learning takes place best when individual can speak out and share her/his opinions with others. Working in a study group and presenting their models provided students a discussion environment in collaboration with their peers in the PBL classroom in this study. However, in the traditional classroom, the students were passive listeners. They seldom stated their ideas and communicated with their class-mates. It is suggested that these circumstances might have created the statistically significant difference in the achievement in favor of the students in PBL classroom.

Gender was another independent variable in this study. Gender has been studied from diverse sides for a long time in science education (Anderman & Young, 1994; Bektas, 2011; Byrnes, 1996; Ceylan, 2008; DeBacker & Nelson, 2000; Dimitrov, 1999; Greenfield, 1996; Lee & Burkam, 1996; Linn & Hyde, 1989; Nowell & Hedges, 1998; Pajares, 1996; Steinkamp & Maehr, 1984; Sungur & Tekkaya, 2003; Thomson, 2008) and inconsistent results were reported. For example, some studies found that boys are higher achievers than girls in science courses (Byrnes, 1996; Lee & Burkam, 1996; Linn & Hyde, 1989; Steinkamp & Maehr, 1984; Wang & Staver, 1997); whereas, other studies reported that girls are much more successful than boys (Anderman & Young, 1994; Britner, 2008; Britner & Pajares, 2006). Becker (1989) conducted a meta-analysis study and reported that with small effect size males perform better than girls in “biology”, “general science”, and “physics”. On the other hand, no significant differences were found in “mixed science content”, “chemistry”, “geology”, and “earth science”. Greenfield (1996) did not find any significant gender differences in terms of science achievement. Similarly, Sungur and Tekkaya (2003) examined the effect of gender and reasoning ability on students’ achievement in the human circulatory system concepts. Although, they found significant difference between “concrete” and “formal” students, there was no significant effect of gender difference in terms of biology achievement. Consistent with these results, the findings of the current study showed that there was no statistically significant mean difference between girls and boys with regards to their achievement in the human circulatory system topic. In conclusion, the PBL instruction did not favor any gender groups in the present study which is a desired outcome, since it supported both genders’ understanding of human circulatory system concepts.

The results of this study also shows that PBL oriented instruction do not have an effect on students’ attitudes toward biology as a school subject. This finding is also supported by a various number of previous studies (e.g., Atay, 2006; McBroom &

McBroom, 2001; Myers & Fouts, 1992). Similarly, there are studies in the biology education literature which report that the experimental methods have not been affective on students' attitudes toward biology as a school subject (e.g., Kaynar, 2007). These findings offer an implication for biology teachers that affective domains such as attitudes are not easy to be changed. Therefore, attitudinal change could be enhanced by increasing the length of the study period. In the current study, the length of the intervention in the experimental group might not be enough to determine the transformation in student attitudes. Moreover, the findings are limited by testing only a small number of students.

The present study revealed no gender difference in students' attitudes toward biology course in the human circulatory system. It is not surprising since previous research also reported similar findings for gender on students' attitudes toward biology course (e.g., Balci, 2005; Greenfield, 1997; Nasr & Soltani, 2011; Sungur & Tekkaya, 2003). Therefore, the current study suggests that the instructional approaches of either PBL oriented instruction or TDBI in the human circulatory system does not include any gender difference that would affect student attitudes towards biology as a school subject.

6.3 Educational Implications

Based on the findings of the current study, several implications with respect to learning and teaching of biology, and curriculum applications are proposed:

- The centralized high school curriculum in Turkey was planned to revolutionize in 2004. The new curriculum encouraged teachers to implement student centered instructions in their classrooms. PBL was one of the constructivist instructional approaches proposed in the curriculum. Thus, the result of this study may contribute curriculum designers while making revisions in the biology curriculum.

- When teaching complex systems, teachers can benefit from PBL approach which enhances students' meaningful understanding of biological concepts.

Therefore, teachers should be encouraged to implement PBL in their classrooms.

- Students become enthusiastic when they are learning and gain some social and cognitive skills such as using language in discussions, organization, problem solving, critical thinking etc. That's why schools' administrations should support teachers for applying PBL.

- Implementing PBL properly requires one to be well informed and experienced. For this reason, pre-service teachers should be trained about PBL in teacher education programs at their universities.

6.4 Recommendations for Further Research

Based on the results of the present study, several recommendations for further studies are proposed:

- The efficiency of PBL can be examined at different grade levels.

- The effectiveness of PBL with respect to students' achievement and understanding of other biological concept can be explored.

- To be able to generalize the results to a larger population, additional studies can be conducted with larger sample sizes.

- To be able to see the effect of PBL on students' attitude, long term studies should be conducted.

- Further studies can be conducted in order to examine other constructs in affective domain such as self-efficacy, anxiety, and motivation of students.

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APPENDIX A

THE HUMAN CIRCULATORY SYSTEM ACHIEVEMENT TEST

İNSAN DOLAŞIM SİSTEMİ BAŞARI TESTİ

Yukarıda sizden istenen bilgileri eksiksiz yazdıktan sonra aşağıdaki sorularda lütfen size en doğru gelen cevabı daire içine alarak işaretleyiniz. Bu sorulara verdiğiniz cevaplar herhangi bir şekilde okul notlarınızı etkilemeyecektir. Sonuçlar bu konuda yapılan bir araştırma için kullanılacak olup isimlere yer verilmeyecektir.

Bu konudaki yardımlarınız için teşekkür ederiz.

1. Eğer kan basıncı kılcal damarlarda normal seviyenin üzerine çıkacak olursa aşağıdakilerden hangisi gerçekleşir?

A) Dokular daha az besin alırlar
B) Hücrelerde karbondioksit birikir
C) Kılcal damarlardan dışarı verilen oksijen miktarı artar
D) Kana daha az doku sıvısı geçer

2. Toplardamarlar diğer damarlarla kıyaslandığında en düşük kan basıncına sahiptir çünkü________

A) toplardamarlar en ince damar duvarına (çeperine) sahiptir
B) damarlar kan hareketine direnç gösterir
C) yerçekimi kan akışına engel olur
D) kanın hızı toplardamarlarda en düşüktür

3. I. Aort
II. Böbrek atardamarı
III.Sol kulakçık
IV.Sol karıncık
V. Akciğer toplar damarı

Oksijenin akciğer kılcal damarlarına alınmasından sonra, böbreklere gelene kadar izlediği yol, aşağıdakilerden hangisinde doğru olarak verilmiştir?

A) I-IV-III-V-II **B)** III-V-IV-I-II **C)** V-I-III-IV-II **E)** V-III-IV-I-II

4. İnsanda atardamarları toplardamarlara bağlayan kılcal damarlar boyunca kan basıncı azalmayıp sabit kalsaydı, aşağıdaki durumlardan hangisinin gerçekleşmesi beklenirdi?

A) çözünen maddelerin kılcaldamardan doku sıvısına daha kolay geçmesi

B) metabolizma atıklarının kılcaldamarlara daha kolay geçmesi

C) doku sıvısının kılcaldamarlara daha kolay geçmesi

D) doku sıvısının miktarının azalması

5. Kılcal damarlarda kan akış hızının düşüklüğünün nedeni _________

A) kılcalların büyük kesitsel alana sahip olmalarıdır

B) kılcalların çaplarının küçük olmasıdır

C) kılcallar boyunca madde tranferi olmasıdır

D) kalbe olan mesafenin uzaklığındandır

6. Aşağıdakilerden hangisi serumun doğru tanımıdır?

A) Hastaya verilmesi gereken besinleri içeren kan plazmasıdır

B) Kan plazmasının depolanmış halidir

C) At kanından elde edilen plazmadır

D) Kan plazması pıhtılaştıktan sonra kalan kısımdır

7. Atardamarların duvarının kalın ve esnek (elastik) olmasının faydası nedir?

A) Yüksek kan basıncının korunmasını sağlar

B) Isı kaybını önler

C) Kanın dokulara doğru akışını sağlar

D) Yüksek basınç altında kanı pompalar

8. Kalp kasılmasıyla ilgili hangisi doğrudur?

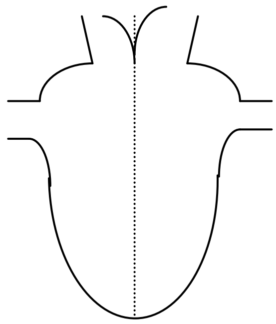
A) Kalp atımı bir reflekstir

B) Beyin kalp atımını başlatmak için Siniatrial düğüme (SA) uyarı gönderir

C) Kalp atımı nefes aldigimizda gerceklesir

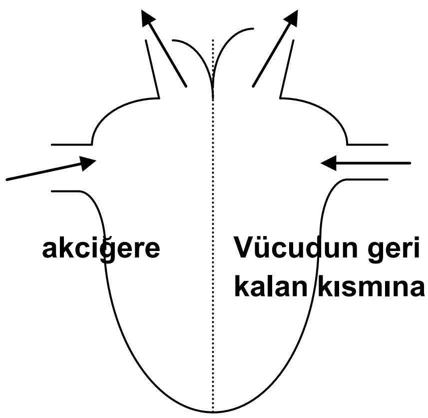
D) Oksijence zengin ve oksijence fakir kan aynı kalp atımı sırasında kalpten ayrılır

9. İnsan kalbinin ortasından aşağıdaki gibi çizgi geçirdiğimizi varsayın

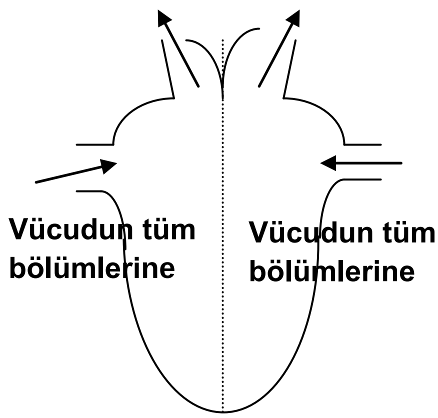


Aşağıdakilerden hangisinin kalp içindeki kan akışını simgelediğini düşünürsünüz

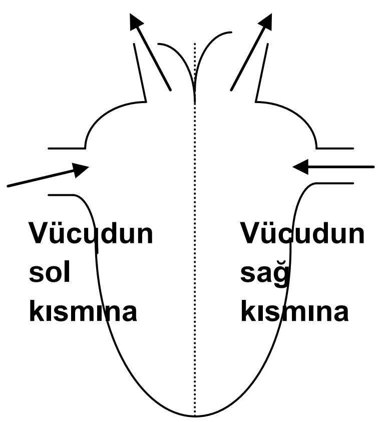
A) Kalbin bir bölmesindeki kan sadece akciğerlere gider. Kalbin diğer bölmesindeki kan vücudun geri kalan ksımlarına gider



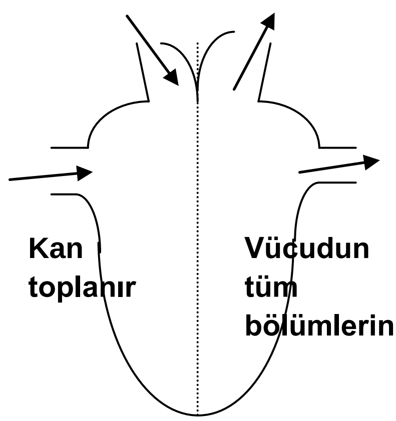
B) Kalbin her iki bölmesindeki kan vücudun tüm bölümlerine gider



C) Kalbin bir bölmesindeki kan vücudun sağ tarafına, kalbin diğer bölmesindeki kan vücudun sol tarafına gider



D) Kan kalbin bir bölmesine gelir, kalbin diğer bölmesinden kan ayrılıp vücudun tüm bölümlerine gider.



10. Glikoz kılcal damarlar içindeki kanı başlıca hangi yolla terkeder

A) Endotel hücrelerinden difuzyonla

B) Atardamar sonundaki endotel hücrelerinden sıvı hareketiyle

C) Endotel hücreleri arasindaki küçük açıklıklardan (porlar) difüzyonla

D) Entodel hücrelerinden aktif taşımayla

11. Kalpte karıncığın kanla dolması ______________sırasında gerçekleşir

A) kulakçıkların kasılması

B) karıncıklardan kanın gönderilmesi

C) karıncığın gevşemesi

D) atrioventrikuler (AV) düğümünün kasılması

12. Ortam ısısı yükseldiginde cildimiz kızarır çünkü________________

A) kanın akış hızı artar

B) kılcaldamarlar genişler

C) kılcallara gelen kan miktarı artar

D) kan basıncı yükselir

13. Kulakçıklardaki kan karıncıklara geçerken kulakçık ve karıncığın basınç değişimi nasıl olmaktadır.

A) Kulakçıkta basınç artar karıncıkta azalır

B) Kulakçıktaki basınç azalır, karıncıktaki basınç artar

C) Kulakçıktaki basınç artar, karıncıktaki basınç değişmez

D) Her iki bölmedede bir değişim olmaz

14. Normal fizyolojik koşullarda tüm plazma proteinleri _________

A) Kan basıncının korunmasına yardım eder

B) Hücrelerin amino aside ihtiyacı olduğunda kullanılırlar

C) Kılcallar boyunca madde transferinin gerçekleşmesine yardımcı olur

D) Kandaki reaksiyonları katalizler

15. I. Kan basıncı artınca doku sıvısının toplardamara dönüşü yavaşlar.

II. Kan basıncı azalınca kandan doku sıvısına madde geçişi yavaşlar.

III. Kanın ozmotik basıncı arttıkça doku sıvısının kılcal damarlara dönüşü yavaşlar.

İnsan dolaşım sistemi ile ilgili yukarıdakilerden hangisi ya da hangileri yanlıştır?

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

16. Aşağıdaki seçeneklerden hangisi yemeği yuttuktan sonra izlediği yolu doğru biçimde anlatmıştır?

A) Yemek mideye ve ince bagırsağa gittikten sonra sindirilmiş besinin bır kısmı besini taşıyan bir boru aracılığı ile kalbe gider ve burada kanla karışır. Besinin geri kalan atık kısmı vücuttan atılır.

B) Yemek mideye ve ince bagırsağa gittikten sonra sindirilmiş besinin bır kısmı besin taşıyan bir boru aracılığı ile vücudun çeşitli bölgelerine taşınır. Besinın geri kalan atık kısmı vücuttan atılır.

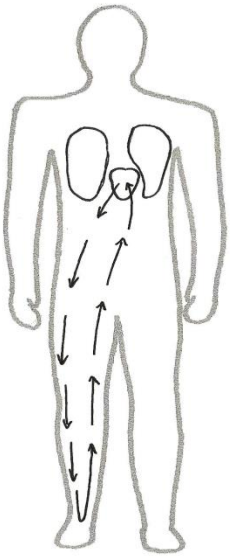
C) Yemek önce mideye sonra ince bağırsağa gittikten sonra sindirilmiş besinin bır kısmı kan damarları aracılığıyla kalbe taşınır. Besinın geri kalan atık kısmı vücuttan atılır.

D) Yemek önce mideye sonra ince bağırsağa gidip sindirildikten sonra dışarı atılır.

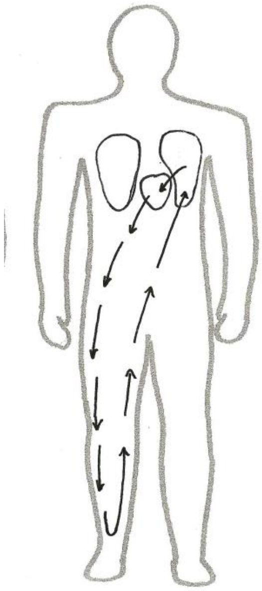
LÜTFEN ARKA SAYFADAKİ SORUYU BOŞ BIRAKMAYINIZ

17. Aşağıdaki seçeneklerde beş farklı öğrencinin bir damla kanın kalpten ayrıldıktan sonra ayak başparmağına doğru yolculuğu sırasında izlediği yol için görüşleri yer almaktadır. Sizin görüşünüze en yakın görüş hangisidir?

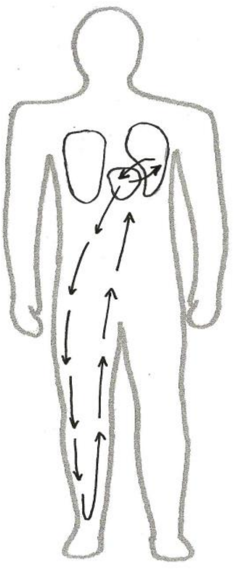
A) Kan damlası doğruca ayak baş parmağına gider ve oradan doğruca kalbe döner



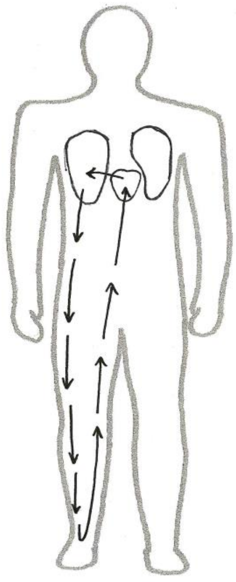
B) Kan damlası doğruca ayak baş parmağına gider sonra akciğere oradan kalbe tekrar döner



A) Kan damlası doğruca ayak baş parmağına gider ve sonra kalbe geri döner sonra akciğere gider ve sonra kalbe tekrar gelir



D) Kan damlası once akciğere sonra ayak baş parmağına gider ve sonra kalbe geri döner



APPENDIX B

ATTITUDE SCALE TOWARD BIOLOGY

BİYOLOJİ DERSİ TUTUM ÖLÇEĞİ

Bu ölçekte, Biyoloji dersine ilişkin tutum cümleleri ile her cümlenin karşısında TAMAMEN KATILIYORUM, KATILIYORUM, KARARSIZIM, KATILMIYORUM ve HIÇ KATILMIYORUM olmak üzere beş seçenek verilmiştir. Her cümleyi dikkatle okuduktan sonra kendinize uygun seçeneği işaretleyiniz.

SORU NO	SORULAR	Tamamen Katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Hiç Katılmıyorum
1	Biyoloji çok sevdiğim bir alandır.					
2	Biyoloji ile ilgili kitaplar okumaktan hoşlanırım.					
3	Biyolojinin günlük yaşantıda çok önemli yeri yoktur.					
4	Biyoloji ile ilgili ders problemlerini çözmekten hoşlanırım.					
5	Biyoloji ile ilgili daha çok şey öğrenmek istiyorum.					
6	Biyoloji dersine girerken sıkıntı duyarım.					
7	Biyoloji derslerine zevkle girerim.					
8	Biyoloji derslerine ayrılan sürenin daha fazla olmasını isterim.					
9	Biyoloji dersine çalışırken canım sıkılır.					
10	Biyoloji konularını ilgilendiren 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 konuları ile ilgili tartışmaya katılmak bana cazip gelmez.					
15	Çalışma zamanının önemli bir kısmını biyoloji dersine ayırmak isterim.					

APPENDIX C

SCIENCE PROCESS SKILL TEST

BİLİMSEL İŞLEM BECERİ TESTİ

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 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 antrenman süresini.
d. Yukarıdakilerin hepsini.

2. Arabaların verimliliğini inceleyen bir araştırma yapılmaktadır. Sınanan hipotez, benzine katılan bir katkı maddesinin arabaların verimliliğini artırdığı 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.

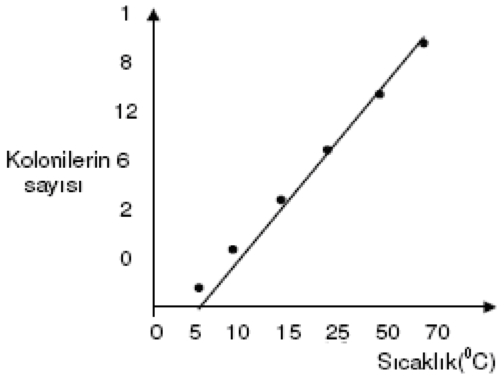
d. Isınma giderleri arttıkça ailenin daha ucuza ısınma yolları araması gerekir.

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

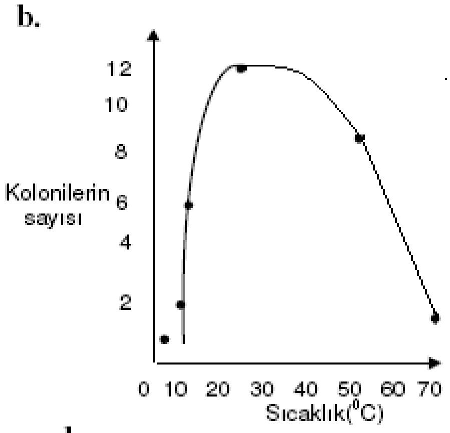
Deney odasının sıcaklığı (^{0}C)	Bakteri kolonilerinin sayısı
5	0
10	2
15	6
25	12
50	8
70	1

Aşağıdaki grafiklerden hangisi bu verileri doğru olarak göstermektedir?

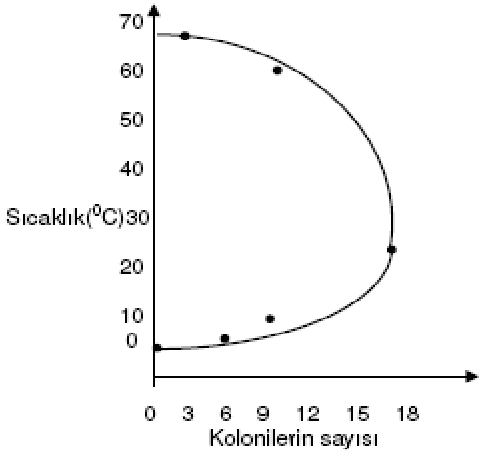
a.



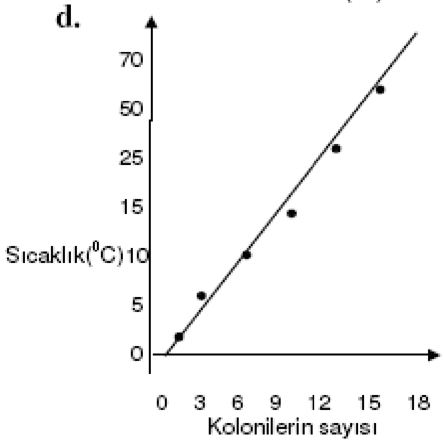
b.



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.

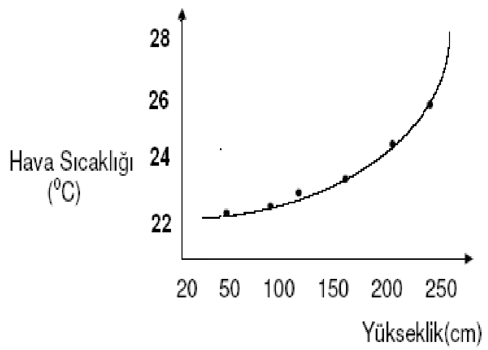
c. Yollarda ne kadar çok polis ekibi olursa, kaza sayısı o kadar az olur.

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 sıcaklıklarıylala 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?

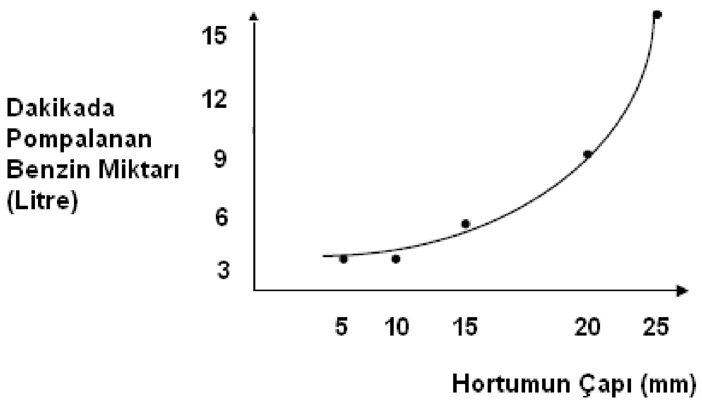
a. Topları aynı yükseklikten fakat değişik hızlarla yere vurur.

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. Bunlardan 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 inci 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 ^{0}C de, diğerine de sırayla 50 ^{0}C, 75 ^{0}C ve 95 ^{0}C 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 yada spreyin miktarı ölçülür.
b. Toz yada 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.

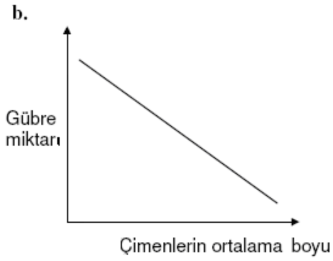
25. Bir araştırmacı yeni bir gübreyi denemektedir. Çalışmalarını aynı büyüklükte beş tarlada yapar. Her tarlaya yeni gübresinden değişik miktarlarda karıştırır. Bir ay sonra, her tarlada yetişen çimenin ortalama boyunu ölçer. Ölçüm sonuçları aşağıdaki tabloda verilmiştir.

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

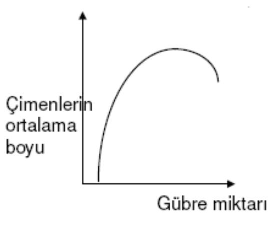
Tablodaki verilerin grafiği aşağıdakilerden hangisidir?

a.

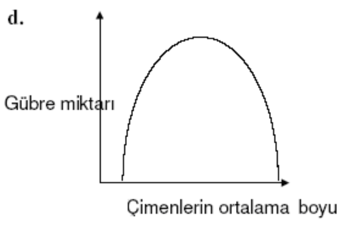
b.



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?

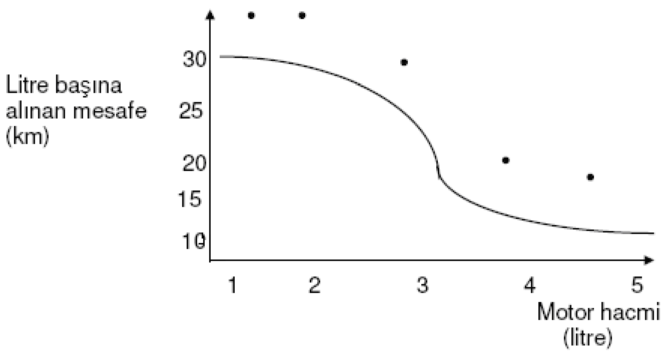
a. Daha fazla şekeri çözmek için daha fazla su gereklidir.

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 inci soruları aşağıda verilen paragrafı okuyarak cevaplayınız.

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

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

30. Bu araştırmada kontrol edilen değişken hangisidir?
a. Her saksıdan elde edilen domates miktarı
b. Saksılara karıştırılan yaprak miktarı.
c. Saksılardaki toprak miktarı.
d. Çürümüş yaprak karıştırılan saksı sayısı.

31. Araştırmadaki bağımlı değişken hangisidir?
a. Her saksıdan elde edilen domates miktarı
b. Saksılara karıştırılan yaprak miktarı.
c. Saksılardaki toprak miktarı.
d. Çürümüş yaprak karıştırılan saksı sayısı.

32. Araştırmadaki bağımsız değişken hangisidir?
a. Her saksıdan elde edilen domates miktarı
b. Saksılara karıştırılan yaprak miktarı.
c. Saksılardaki toprak miktarı.
d. Çürümüş yaprak 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.

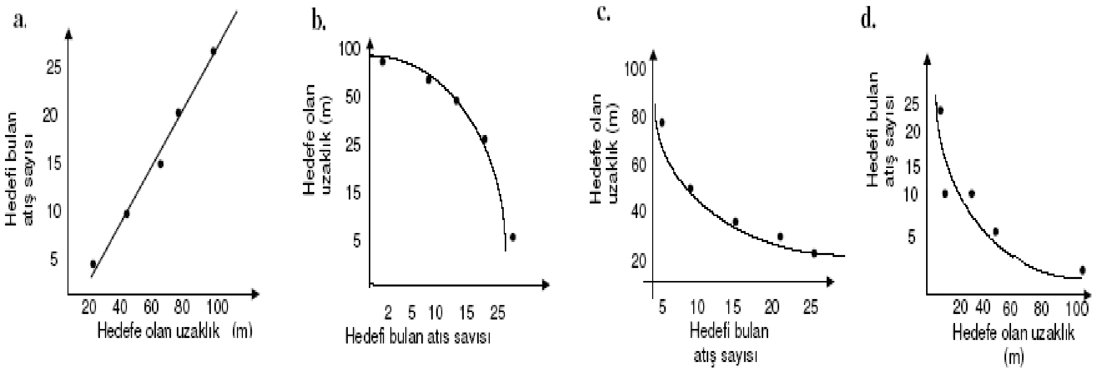
c. Kullanılan mıknatısın şekli ile.

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?



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 makinasını kullanma sıklığı.

d. a ve c.

Bilimsel İşlem Beceri Testinin Yanıt Anahtarı

1-d	10-b	19-a	28-c
2-b	11-a	20-d	29-d
3-d	12-c	21-a	30-c
4-d	13-d	22-d	31-a
5-b	14-b	23-a	32-b
6-a	15-c	24-c	33-d
7-a	16-c	25-c	34-d
8-a	17-c	26-c	35-d
9-b	18-b	27-d	36-d

APPENDIX D

SAMPLE LESSON PLAN

D-1. WE ARE UNIVERSITY STUDENTS

ÜNİVERSİTE ÖĞRENCİLERİYİZ

Sure: 40 dk.

Kazanımlar:

- Grup arkadaşlarının fikirlerine saygı duyar.
- Grup çalışmalarında duygu ve düşüncelerini paylaşır.
- Bir fikre katılıp katılmadığını nedenleriyle ortaya koyar.
- Uygulanabılır plan yapar.

Dersin İşlenişi:

Öğretmen sınıfı selamladıktn öğrencilerine sonra bu derste bir projeye başlayacaklarını bildirir ve öğrencilerin grup oluşturmalarını söyler. Gruplar öğretmenin daha önceden planlamış olduğu şekilde düzenlenir (grupların birbirine yakın özellikler taşıması için; gruplarda kız –erkek öğrenci dağılımının dengeli olması, daha önceki biyoloji dersi notlarına göre grupların başarı ortalamalarının yakın olması gibi özellikler göz önüne alınır). **(10 dk.)**

Öğrenciler grup düzeni aldıktan sonra, öğretmen insan hücresinde madde transferinin nasıl gerçekleştiği ile ilgili soruyu senaryo eşliğinde öğrencilere sorar.

Senaryoya göre öğretmen üniversite biyoloji bölümü profeserünü, öğrenciler ise o bölümde okuyan öğrencileri temsil edeceklerdir.

Öğretmen: "Arkadaşlar, geçen ay Sokullu Mehmet Paşa Lisesi biyoloji dersi öğretmeni Zeynep hanımdan bir e-mail almıştım. Bu maili sizlerle paylaşmak istiyorum."

Bu arada öğretmen geldiği varsayılan e-maili öğrencilerine okur.

Öğretmen: "Arkadaşlar ben Zeynep öğretmenimize bu konuda destek vermek istiyorum. Sizden isteğim öncelikle bu konuda geniş çaplı bir araştırma yapmanız. Bunun için üniversitemizdeki tüm labaratuvarları kullanabilirsiniz. Ayrıca tıp fakültelerindeki tüm labaratuvar ve ünitelerde gözlemci olarak çalışabilirsiniz. Bunun için gerekli izinler alındı. Radyoaktif olarak işaretlenmiş şeker gibi moleküllerin insan vücudundaki doku ve hücrelere taşınmasına ait verileri bu lavaratuvarda yapılan çalışmalardan ve çekilen filmlerden toplayabilirsiniz. Verileri topladıktan sonra, ince bağırsağımızdan emilen moleküllerin ve akciğerimize çektiğimiz oksijenin vücudumuzda yaptığı yolculuktan elde ettğiniz bilgiler ışığında bir model geliştireceksiniz. Modelinizi geliştirmeniz için 5 hafta süreniz var. 5 hafta sonra Sokullu Mehmet Paşa Lisesine hep birlikte gideceğiz. Her bir grup modelleri üzerinden 9. Sınıf öğrencilerine maddelerin vücudumuzda nasıl taşındığı ile ilgili bir sunum yapacak ve bu konuyu öğrencilere anlatacak." **(10 dk.)**

Öğretmen öğrenci gruplarının modellerinin ilk taslağını tartışarak çalışmalarına başlamalarını söyler. Bu arada öğretmen gruplar arasında dolaşarak tartışmaları gözlemler. **(20 dk.)**

D-2. I FEEL MY HEART ON MY ARM

KOLUMDA KALBİMİ DUYUYORUM

Sure: 2x40 dk.

Materyal: Tansiyon ölçme aleti

Kazanımlar:

- Kalp ve damarların sağlıklı yapısının korunması için çıkarımlarda bulunur.
- Nabız ve tansiyon ölçebilir ve bunların arasındaki ilşkiyi kurar.
- Kalp ve damarların yapı, görev ve işleyişini kavrar.

Dersin İşlenişi:

Öğretmen öğrencilerine projelerinin nasıl gittiğini sorar ve öğrencilerin anlamadıkları bir nokta varsa sorularını cevaplar **(5 dk.)**

Öğretmen sınıfa yeni bir soru sorar:

Öğretmen: "Çocuklar nabız nedir?

Öğretmen öğrencilerden gelen cevaplara doğru ya da yanlış olduklarına dair herhangi bir geri dönüt vermez. Öğrencilerin bu aşamada nabız ile ilgili ön bilgileri yoklanmış olur. Öğretmen sınıfa nabzımızı nasıl ölçtüğümüzü sorar. Sonra her gruptan bir öğrencinin nabzının ölçülüp not edilmesini söyler. Nabzı ölçülen öğrencinin dışarı çıkıp 5 dakika koştuktan sonra sınıfa gelmesi söylenir. Dışarıda koşup gelen öğrencinin nabzı grup üyeleri tarafından ölçülüp tekrar not edilir. Bu esnada öğretmen sınıf içinde dolaşarak öğrencileri gözlemler. Nabız ölçmede hata yapan öğrencilerin arkadaşlarından yardım almasını sağlayacak yönlendirmeler yapar. Daha sonra bir öğrenciyi görevlendirilerek tüm sınıftan nabız ile ilgili gelen verilerin sınıf tahtasında bir tabloda yazılması sağlanır. **(20 dk.)**

Öğrenciler senaryoya göre öğrencilerin data toplaması ve gözlem yapması için tıp fakültelerinden izin alınmış olduğu hatırlatılır.

Öğretmen: "Gazi Üniversitesi Tıp Fakültesi Genel Cerrahi Bölümünde yatan bir hastanın bir günlük tansiyon değerelerini size veriyorum. Bu hastanın tansiyon değerleri ile kendi tansiyon değerlerinizi karşılaştırınız.

Öğretmen ekteki (D-2A. PULSE TABLE**)** tabloyu çoğaltarak öğrenci gruplarına dağıtır. Öğret***m***en sınıfa getirmiş olduğu tansiyon aletlerini gruplara dağıtır ve nasıl tansiyon ölçümü yapıldığını bir öğrenci eşliğinde sınıfa gösterir. Sonra gruptaki öğrencilerin birbirlerinin tansiyonunu ölçmesini ve verilen tabloya bu değerlerin yazılmasını ister. **(15 dk.)**

Öğretmen tansiyon aletinde tansiyona ait neden iki farklı değer okuduklarını ve bunların ne anlama geldiğini sınıfa sorar. Hastanede yatan hastanın değerleri ile kendi değerelerini karşılaştırtırıp bu değerlerin neden farklı olabileceğini tartışmalarını sağlar.

Öğretmen sınıfa daha önceden getirmiş olduğu dolaşım sistemini içeren farklı kaynakları öğrencilere gösterir ve bu kaynaklar dışında farklı kaynaklarıda kullanabileceklerini söyleyerek nabzın ve tansiyonun ne olduğunu araştırmalarını ister. Bu arada öğretmen yine gruplar arasında dolaşarak öğrencileri ve öğrencilerin gruba katılımını ve bilgi toplama süreçlerini gözlemler. Öğrencilerin bilgi toplama sürecinde bilişsel ve yöntem olarak zorlandıkları bir durum olursa öğrencilerin doğru bilgiye ulaşmalarını kolaylaştıracak alt sorular sorar. Bu araştırma sırasında öğrencilerö kalp ve damarların yapısı hakkında da bilgi toplamış olacaklar. **(20 dk.)**

D-2A. PULSE TABLE

NABIZ TABLOSU

HASTA ADI: Müzeyyen ......

Tarih \ Saat	**6:00**	**12:00**	**18:00**	**24:00**
25.04.2008	8/13	9/15	9/14	8/13
26.04.2008	8/12	9/13	8/13	8/12
27.04.2008	7/1	8/13	8/12	7/11
27.04.2008	6/10	8/12	7/11	7/11

Grup Adı	
isim	Tansiyon

APPENDIX E

COLLABORATION RUBRIC

İşbirliği Çizelgesi

Grup Adı:			
Proje Adı:		Gün	

Yeni bir göreve baslarken grup üyeleri…				
Gözlemlenen Davranış	**Tüm üyeler**	**Çoğu üye**	**Bazı üyeler**	**Az üye**
Bir planı kabul etme	†	†	†	†
Hemen çalışmaya başlama	†	†	†	†
Proje malzemelerini hazırlama	†	†	†	†
Öğretmenin pek yardımı olmadan olayları anlama	†	†	†	†
Sorumlulukları paylaşma ve/veya görev dağılımı	†	†	†	†
Son tarihleri gözden geçirme	†	†	†	†
Görevde kalma	†	†	†	†

Grup üyeleri ile çalışırken...				
Gözlemlenen Davranış	**Tüm üyeler**	**Çoğu üye**	**Bazı üyeler**	**Az üye**
Konuşma yapma	†	†	†	†
Yeni bilgiyi değerlendirme	†	†	†	†
Birbirlerine öğretme	†	†	†	†
Birbirlerinin görevlerini gözden geçirme	†	†	†	†
Ev/hafta sonu görevi verme	†	†	†	†
İştirak etme	†	†	†	†
Temizleme ve yerleştirme	†	†	†	†
Gerektiğinde yârdim isteme	†	†	†	†
Görevde kalma	†	†	†	†

Projeyi tartışırken grup üyeleri....				
Gözlemlenen Davranış	**Tüm üyeler**	**Çoğu üye**	**Bazı üyeler**	**Az üye**
İyi sorular sorma	†	†	†	†
Konuşmada bulunma	†	†	†	†
Ortak karar alma	†	†	†	†
Planları kayıt etme	†	†	†	†
Bilgiyi paylaşma	†	†	†	†
Son tarihleri gözden geçirme	†	†	†	†
Görevde kalma	†	†	†	†

APPENDIX F

TEAM WORK RUBRIC

GRUP ÇALIŞMASI PUANLAMA ÇİZELGESİ

İsim: ____________________ Öğretmen: ____________________

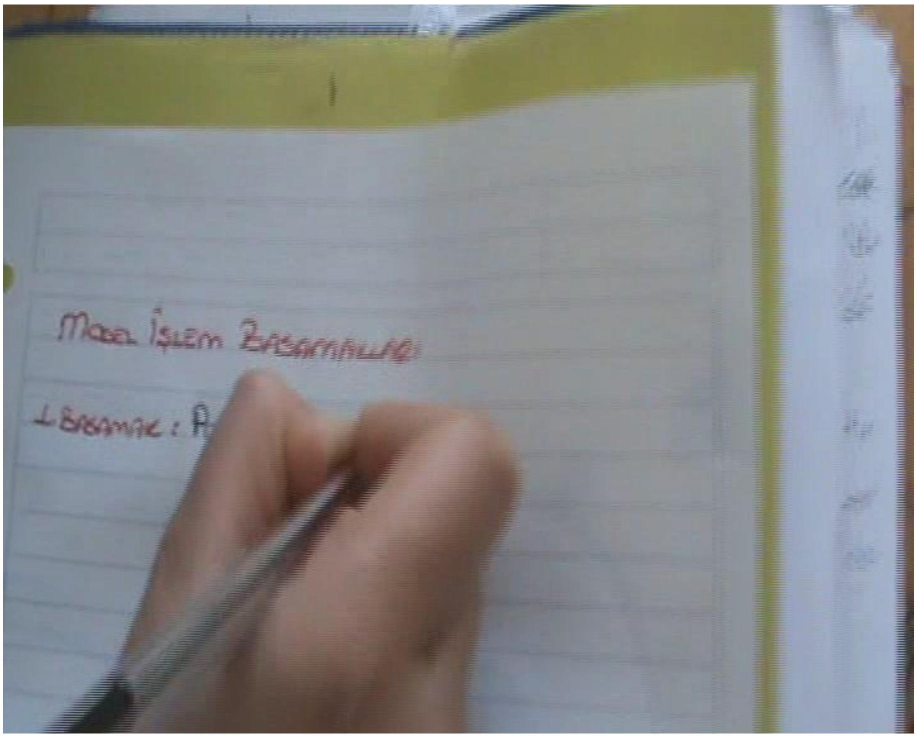
Tarih: ____________________ Çalışma Başlığı: ______________

Beceriler	Ölçüt				Puan
	1	2	3	4	
Yardım etme: Öğretmen birbirine destek olan öğrencileri gözlemledi.	*Hiçbir zaman*	*Bazen*	*Çoğu zaman*	*Her zaman*	____
Dinleme: Öğretmen birbirlerinin fikirlerinden çalışan öğrencileri gözlemledi.	*Hiçbir zaman*	*Bazen*	*Çoğu zaman*	*Her zaman*	____
Katılım: Öğretmen projeye katkıda bulunan her öğrenciyi gözlemledi.	*Hiçbir zaman*	*Bazen*	*Çoğu zaman*	*Her zaman*	____
İkna etme: Öğretmen fikir alışverişi yapan, savunan ve fikirleri yeniden düşünen öğrencileri gözlemledi.	*Hiçbir zaman*	*Bazen*	*Çoğu zaman*	*Her zaman*	____
Sorgulama: Öğretmen ekibin bütün üyeleriyle etkileşim halinde olan, tartışan ve soru soran öğrencileri gözlemledi.	*Hiçbir zaman*	*Bazen*	*Çoğu zaman*	*Her zaman*	____
Saygı duyma: Öğretmen başkalarının fikir ve çabalarını teşvik eden ve destekleyen öğrencileri gözlemledi.	*Hiçbir zaman*	*Bazen*	*Çoğu zaman*	*Her zaman*	____
Paylaşma: Öğretmen fikirler sunan ve bulgularını birbirlerine rapor eden öğrencileri gözlemledi.	*Hiçbir zaman*	*Bazen*	*Çoğu zaman*	*Her zaman*	____
				Toplam Puan	____

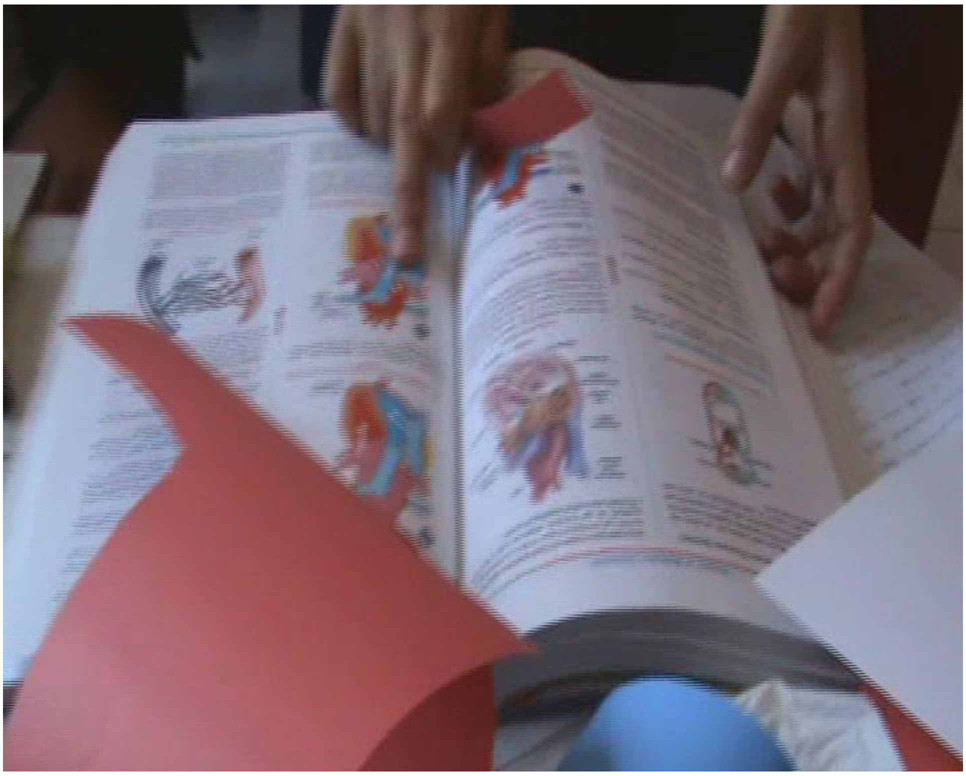
APPENDIX G

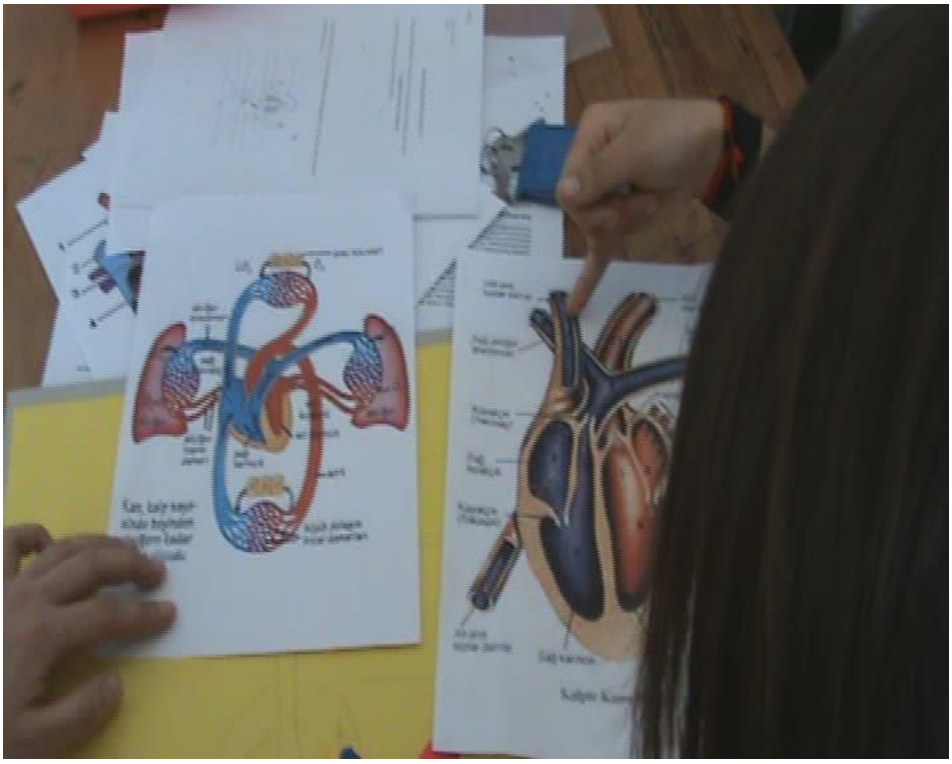
SAMPLE STUDENTS STUDY IN THE PBL CLASSROOM

G-1. PLANNING THE MODEL



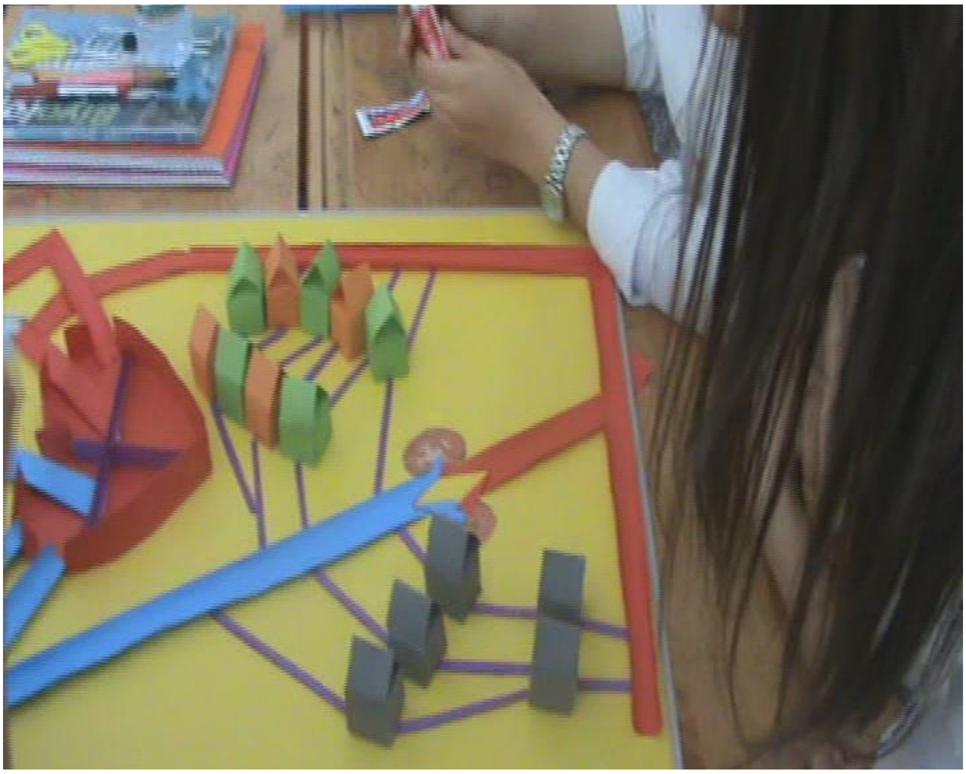
G-2. INVESTIGATING FROM DIFFERENT SOURCES





G-3. STUDYING IN THE GROUPS

G-4. CONSTRUCTING THE MODEL



G-5. PRESENTING THE MODEL

CURRICULUM VITAE

PERSONAL INFORMATION

Surname, Name: Cömert, Gülsüm Gül

Nationality: Turkish

E-mail: gulcomert@gmail.com

EDUCATION

Degree	Institution	Year of Graduation
MA	The Ohio State University Faculty of Education, Science Education	2003
BS	Hacettepe University Faculty of Art and Science, Department of Biology	1996

WORK EXPERIENCE

Year	Place	Enrollment
1996-1997	Private Baran School Bursa, TURKEY	Biology and Science Teacher
1997-2000	Private Tan School Bursa, TURKEY	Biology and Science Teacher
2001-2003	The ohio State University Family Housing Buckeye Village Office Columbus, OHIO/USA	Official
2003-2004	Antalya City Directorate of Education, Cultural Service Office Antalya, TURKEY	Official

2004-2005	Akdeniz University, Faculty of Education Antalya, TURKEY	Research Assistant
2005-	Middle East Technical University, Faculty of Education, Department of Secondary Science and Mathematics Education Ankara, Turkey	Research Assistant
2010-2011	Texas A&M University, Department of Teaching, Learning, and Culture Antalya, TURKEY	Visiting Scholar