THE EFFECT OF PROBLEM-BASED LEARNING ON THE ELEMENTARY SCHOOL STUDENTS' ACHIEVEMENT IN GENETICS

A THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF SOCIAL SCIENCES
OF
MIDDLE EAST TECHNICAL UNIVERSITY

BY

GÜLSÜM ARAZ

IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR
THE DEGREE OF MASTER OF SCIENCE
IN
ELEMENTARY SCIENCE AND MATHEMATICS EDUCATION

JUNE 2007

Approval of the Graduate School of Social Sciences

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ABSTRACT

THE EFFECT OF PROBLEM-BASED LEARNING
ON THE ELEMENTARY SCHOOL STUDENTS' ACHIEVEMENT
IN GENETICS

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June 2007, 193 pages

The purpose of the study is to investigate the relative effect of problem-based learning (PBL) and traditionally designed science instruction (TDSI) on students' academic achievement and performance skills in the unit of genetics after controlling for students' prior knowledge, prior performance skills, reasoning ability, and learning approach.

The sample consisted of 192 eight grade students from a public elementary school in Ankara. Four classes instructed by two science teachers were randomly assigned as experimental and control groups. The experimental group students were taught the subject through PBL, while the control group students received the TDSI. Students in experimental group dealt with ill-structured problems based on real-life working in small groups and individually. On the other hand, students in control group received an instruction based on teacher explanations and textbooks.

Genetics Achievement Test, Test of Logical Thinking, and Learning Approach Questionnaire were administered as pre-tests to students in both groups to determine their prior knowledge and prior performance skills, reasoning ability, and learning approach, respectively. After the treatment, Genetics Achievement Test was administered again as a post-test to compare the effectiveness of PBL and TDSI on students' achievement and performance skills in Genetics.

Multivariate Analysis of Covariance (MANCOVA) was used to investigate the effect of problem based learning and traditionally designed science instruction on students' academic achievement and performance skills in Genetics when students' prior knowledge, prior performance skills, logical thinking abilities and learning approaches are controlled. Results of the study revealed that students in PBL classes had higher mean scores on Genetics Achievement Test developed to measure academic achievement and performance skills in the unit of genetics. Therefore, the PBL students appeared to be better compared to the TDSI students in terms of genetics understanding and at using relevant information in addressing the problem, articulating uncertainties, organizing concepts, and interpreting information.

Keywords: Problem Based Learning, Traditionally Designed Science Instruction, Genetics, Academic Achievement, Performance Skills

ÖZ

PROBLEME DAYALI ÖĞRENME MODELİNİN İLKÖĞRETİM ÖĞRENCİLERİNİN GENETİK KONUSUNDAKİ BAŞARILARINA OLAN ETKİSİ

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Haziran 2007, 193 sayfa

Bu çalışmanın amacı, öğrencilerin ön bilgi ve ön performans becerileri, mantıksal düşünme yetenekleri ve öğrenme yaklaşımları kontrol altındayken probleme dayalı öğrenme modeli (PDÖ) ve geleneksel fen öğretim yönteminin (GFÖ) öğrencilerin akademik başarısına ve performans becerilerine olan etkisini incelemektir.

Çalışmanın örneklemini Ankara ilinde bir ilköğretim okulunda okuyan 192 sekizinci sınıf öğrencisi oluşturmaktadır. Deney ve kontrol grupları 2 ayrı öğretmenle eğitim gören 4 sınıftan rasgele seçilmiştir. Konular deney grubunda probleme dayalı öğrenme modeli ile işlenirken, kontrol grubunda geleneksel fen öğretim yöntemi ile işlenmiştir. Deney grubundaki öğrenciler konuları iyi yapılandırılmamış, gerçek hayata dayalı problemler doğrultusunda grup içersinde ve aynı zamanda bireysel çalışarak öğrenirken, kontrol grubundaki öğrenciler konuları öğretmen açıklamaları ve ders kitaplarına dayalı olarak öğrenmişlerdir.

Öğrencilerin ön bilgilerinin ve performans becerilerinin, mantıksal düşünme yeteneklerinin ve öğrenme yaklaşımlarının belirlenebilmesi için ön test olarak sırasıyla Genetik Başarı Testi, Mantıksal Düşünme Yetenek Testi ve Öğrenme Yaklaşımı Ölçme Testi uygulanmıştır. Uygulamalardan sonra PDÖ ve GFÖ yöntemlerinin öğrencilerin akademik başarılarına ve performans becerilerine olan etkisini karşılaştırabilmek için Genetik Başarı Testi son-test olarak tekrar uygulanmıştır.

Probleme dayalı öğrenme modelinin ve geleneksel fen öğretim yönteminin öğrencilerin Genetik konusundaki akademik başarılarına ve performans becerilerine olan etkisini incelemek için Ortak değişkenli çok yönlü varyans analizi (MANCOVA) kullanılmıştır. Öğrencilerin ön bilgi ve ön performans becerileri, mantıksal düşünme yetenekleri ve öğrenme yaklaşımları analize ortak değişkenler olarak atanmıştır. Çalışmanın sonuçları öğrencilerin akademik başarısının ve performans becerilerinin ölçülmesini amaçlayan Genetik Başarı Testinde PDÖ öğrencilerinin GFÖ öğrencilerinden daha yüksek bir ortalamaya sahip olduklarını göstermiştir. Bu durum, PDÖ öğrencilerinin genetik konularını GFÖ öğrencilerine kıyasla daha iyi öğrendiğini ve verilen problemdeki gerekli bilgilerin kullanımı, belirsizliklerin ortaya konması, kavramların organize edilmesi ve bilgilerin yorumlanması gibi beceriler açısından daha başarılı olduğu ortaya çıkmıştır.

Anahtar Sözcükler: Probleme Dayalı Öğrenme Modeli, Geleneksel Fen Öğretim Yöntemi, Genetik, Akademik Başarı, Performans Becerileri.

To My Parents

ACKNOWLEDGMENTS

The completion of my master degree and this thesis represents the work of many people to whom I am very thankful for their encouragement, support and help.

First of all, I would like to express my deepest gratitude to my supervisor Assist. Prof. Dr. Semra SUNGUR for her invaluable advices, patience, guidance and assistance during my research.

I am very thankful to my family members for their encouragement and moral support through the process. Special thanks to my parents; their life long devotion to education became my major inspiration to be an educator and they never stopped trusting me. I would like to thank to my brothers Kürşad, for his help and support, and Kadir for his moral support. Their existence means much more to me than I will ever be able to express.

Special heartfelt thanks to my fiancé Ali GÖK for his help, support, continuous encouragement and sensibility. He was with me in every step of the process and where I need help. I feel very fortunate that I have someone like you.

Thanks are also extended to my officemates Asiye PARLAK-RAKAP, Savaş PAMUK, Murat AYDEMİR and Mustafa Sami TOPÇU for their valuable friendship, help and patience during the entire process. They have never turned me back when I need their help.

Sincere gratitude is extended to 8th grade students of Hacı Mustafa Tarman İlköğretim Okulu who participated in this study and also their science teachers, Belgin MURAT and Nurhayat KAYATURHAN who agreed to apply my instructional materials fastidiously. I also extend my gratitude to Dr. İlker ÇİÇEK for fruitful discussions and his suggestions related to my thesis.

Finally, I express my sincere thanks to my committee members for their willingness to serve in my committee and their invaluable comments.

Thank you all very much indeed.

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LIST OF SYMBOLS

PBL : Problem Based Learning

TDSI : Traditionally Designed Science Instruction

GAT : Genetics Achievement Test

TOLT : Test of Logical Thinking

LAQ : Learning Approach Questionnaire

LAQ-M : Learning Approach Questionnaire - Meaningful

LAQ-R : Learning Approach Questionnaire - Rote

LSI : Learning Style Inventory

EG : Experimental Group

CG : Control Group

CHAPTER 1

INTRODUCTION

> "…learning needs to be conceived of as something a learner does, not something that is done to learner." (Fosnot, 1989, p.5).

In recent decades, there has been a shift in science education towards more student-centered teaching approaches. Indeed, relevant literature has shown that when students are involved in the learning process actively; meaningful learning, understanding and retention can be enhanced (Ausubel, 1963; Lord, 1994). According to Debacker and Nelson (2000), classroom environments which focus on students' effort and strategy use instead of their ability, encourage students to compare and realize the difference between their past and present performance, and reduce the emphasis on grade and social comparisons can improve student learning. Moreover, as Torp and Sage (2002) points out, "students need to understand at deeper levels, and to understand at deeper levels they need to engage in sustained thinking about topics or issues-to crawl inside ideas and expose misconceptions while making multiple connections" (p.31).

Problem-based learning (PBL) is a constructivist method in which students learn the course content by dealing with messy, open-ended problems in small groups and individually with the guidance of the teacher. Educators worked on this method over than 40 years, since PBL was firstly integrated in medical curriculum in McMaster University. PBL attracted attention in medical fields as it contributes usage of the knowledge in the relevant situations, and in education as it has several advantages in motivation, meaningful learning, retention, and social and performance skills.

There are studies in the literature which aimed at adapting problem-based learning for use in elementary and high school settings (Achilles & Hoover, 1996; Gallagher, Stepian, Sher, & Workman, 1995; Gordon, Rogers, Comfort, Gavula, & Mcgee, 2001; McBroom & McBroom, 2001; Sage, 1996; Savoie & Hughers, 1994; West, 1992). Results, in general, revealed that the PBL creates an environment in which students actively participate in the learning process, take responsibility for their own learning, and become better learners in terms of time management skills, ability to define topics, ability to access different resources, and ability to evaluate validity of these resources. Moreover, it was found that PBL appears to improve critical thinking, communication, mutual respect, teamwork, interpersonal skills and increase students' interest in the course and make students apprentice scientists. Furthermore, it was suggested that PBL encourages students to identify knowledge deficiencies, coordinate actions and people, realize goals and continuously monitor understanding (Galand, Bentein, Bourgeois & Frenay, 2003; Karabulut, 2002; Paris & Paris, 2001).

The main characteristic of PBL that differentiate it from other constructivist methods is the ill-structured problems. Students construct the knowledge base while dealing with ill-structured, messy, and open-ended problems that include cases from real-world situations with no single right solution. Ill-structured problems poss multiple solutions and multiple criteria for evaluating solutions and require learners' personal opinions

(Jonassen, 2000). The problem requires scientific thinking, reasoning skills and personal decisions that are based on prior experiences. In a PBL classroom after meeting the problem, students determine what they know and generate hypotheses to solve the problem, decide what they need to know to test the hypotheses and to reach the solution, search the sources about the subject and share their ideas and information with their peers, get a conclusion for the best solution, and lastly summarize their process and present their solution. During the PBL teachers are the facilitator who guide students in the process and help to reach the sources. The teacher must check on the students in each group and their progress and help groups eliminate their misconceptions or help them keep going to learning in true way (McKeachie, 2002). Therefore, students are active learners and problem solvers and teachers are the guides (Torp & Sage, 2002).

In PBL classes, students are responsible for their learning and they learn how to learn instead of receiving the information from teacher. The benefits of PBL include improvement in students' motivation, higher-order thinking skills and learning how to learn skills by making learning relevant to the real world, encountering the students with authentic situations. In addition, learners' endeavor for finding a solution and generation the strategies to the problems provide self-regulated learning and learning how to learn (Torp & Sage, 2002). Moreover, the real-world problems connect the knowledge with students' world and support their perception of subjects as important to learn since they may use them in their real life (Uyeda, Madden, Brigham, Luft & Washburne 2002; Plucker & Nowak, 1999; Levin, 2001; Gordon et al., 2001). Therefore, in PBL environments ill structured problems are used as guides for student learning and teachers are expected to keep students on track while deciding on what directions to follow in their investigations, what information to collect, and how to evaluate the information (Chin & Chia, 2005; Hmelo-Silver, 2004; Song, Grabowski, Koszalka, & Harkness, 2006).

In fact, one of the primary goals of research in education and educational psychology is to help students apply scientific concepts to real life problems (Chin & Chia, 2005). According to Ausubel (1968), such meaningful learning is encouraged whenever students relate new knowledge to relevant concepts they already know. For meaningful learning to take place, however, students should not acquire isolated facts; they should construct new knowledge by drawing relationships among several different concepts, both new and old. Therefore, it should be noted that regardless of which instructional approach is employed in the classrooms, students' prior knowledge has great influence on their further learning. The studies in the literature showed that prior knowledge is a significant predictor of achievement (Johnson & Lawson, 1998; Williams & Marek, 2000).

Meaningful learning is also associated with a meaningful learning approach (Entwistle & Ramsden, 1983), which refers to an intention to understand the material. The predominant strategies of this approach are use of evidence and the relating of different ideas, and its predominant motive is an interest in the ideas presented (Diseth, Pallesen, Hovland, & Larsen, 2006). Entwistle and Ramsden (1983) reported that students who adopt a meaningful learning approach are likely to find the task more interesting and easier to understand. In general, a meaningful approach is found to be associated with a deep level of understanding. In contrast, the rote approach to learning involves both rote memorization and the syllabus boundness. In this approach, the student's intention is to meet the minimum course requirements and their external motive is to avoid failure by simple recall (Diseth et al., 2006). Cavallo, Rozman and Potter (2004) suggested that the rote approach to learning is not sufficient to achieve a sound understanding of scientific concepts. Cavallo (1992) found a significant positive relationship between the student's approach to learning, their prior knowledge, and their level of meaningful understanding after completing a genetics course. In a similar study, Cavallo (1996) later reported that a meaningful approach to learning is the best predictor of meaningful understanding. On the other hand, students relying on the rote approach appeared to need help in applying the concepts, indicating a lack of meaningful understanding.

However, learning approach or prior knowledge may not be sufficient to explain the observed variations in students' science understanding especially in abstract concepts like Genetics. Therefore, it is essential to consider the students' native reasoning abilities as well. In fact, many studies have shown that reasoning ability is also a strong predictor of achievement for several biological concepts, including genetics (Cavallo, 1996; Johnson & Lawson, 1998; Lawson & Thompson, 1988). Students at higher formal reasoning levels are more successful in genetics and solving genetic problems than students at lower reasoning levels. Additionally, reasoning ability is a contributor of achievement for inquiry based instructions (Johnson & Lawson, 1998).

Previous studies showed that students have difficulty, many misconception, confusion and incoherency knowledge in genetic topics which include many abstract concepts hard to understand, to learn and to remember (Bahar, Johnstone, & Hansell, 1999; Cavallo, 1996; Esiobu & Soyibo, 1995; Lewis, & Leach, 2004; Lewis, & Wood-Robinson, 2000; Lewis, Leach, & Wood-Robinson, 2000a, b, c; Wood-Robinson, Lewis, & Leach, 2000; Knippers, Waorlo & Boersma, 2005). The researchers of the studies suggested that meaningful understanding of Genetics concepts can be increased by integrating methods that actively involves students in the learning process with the guidance of the teacher and enhancing students-students interactions by small group discussions and dealing with open-ended problems. Ausubel (1963) points out that, to achieve a meaningful learning for abstract concepts, learners need to discover them by their own concrete, empirical, problem-solving experience.

In Turkish curriculum, students meet with the Genetics concepts first time at 8th grade, when they are at the age of 14-15 years. Tobin and Capie (1982) suggested that the majority of students at these ages have difficulty in learning to use integrated process skills, and the teaching strategies should be designed to improve these skills. Otherwise, students may have difficulty in understanding abstract concepts like genetics. The intricacy in genetics concepts may be overcome and students process skills may be improved by implementing PBL since it encourage meaningful understanding through confronting students with ill-structured problems, activating their prior knowledge, and improving their higher order thinking skills as well as their performance skills. However, since there are a few empirical studies involving the implementation of PBL in elementary science education, more studies are needed to reveal the effectiveness of PBL on achievement, performance skills and some other important variables such as motivation in elementary schools (Sage, 1996; Savery, 2006). Majority of the studies in the literature, on the other hand, have focused on the effectiveness of PBL without making a comparison with other instructional methods. Related studies in elementary and high school levels were mainly descriptive. As a result of this, the number of empirical studies which compared effectiveness of PBL with other instructional methods was very limited. In order to fill this gap in the literature, the present study aimed at comparing the effectiveness of PBL and traditional lecture-based instruction on elementary school students' academic achievement and performance skills in a science unit on genetics. Moreover, students' prior knowledge, prior performance skills, reasoning ability and learning approach were used as covariates to control the variance in achievement and performance skills scores due to these variables. The findings of the present study are imperative since the appropriateness of PBL for elementary students and its effectiveness in terms of student learning, understanding, higher order thinking skills, and performance skills can be determined.

CHAPTER 2

REVIEW OF LITERATURE

This chapter includes the review of the literature relevant with problem-based learning, students' difficulties in understanding genetics, reasoning ability, and meaningful learning.

2.1. Problem-Based Learning

In today's world, one of the main goals of science education is to help students develop scientific thinking. In order to accomplish this end, there is need for creating rich learning environments in which students are involved in inquiry based tasks requiring cognitive processes used by scientists while conducting research. As suggested by Chin and Chia (2005) such scientific thinking processes can be developed in students with the integration of the problem based learning (PBL) into the curriculum. In fact, the PBL provides students with guided experience in learning through dealing with ill-structured problems based on real life. Ill-structured problems are complex problems that have multiple solutions instead of having a single correct answer, and to generate a solution and support their ideas students need to consider alternatives by using personal opinions and provide a reasoned argument (Hmelo-Silver & Barrows, 2006; Jonassen, 2000). Actually, three major components of a PBL environment include presence of ill-structured problems, teachers as facilitators, and changed students' role in learning (Curry, 2002). Firstly if we take a look at the problems we can see that unlike well-structured problems which focus on conclusion with straightforward solutions, ill-structured problems incline students in a messy situation with no one right answer and allow creation of several hypotheses and solutions (Levin, 2001; Sage, 1996). These problems play a role as a "content and knowledge organizer, learning environment contextualizer, thinking reasoning stimulator, and learning motivator" in the PBL process (Hung, 2006, p.56). Therefore, since the problems are ill-structured, the PBL students are to define the problem and determine what they need to know. Moreover, ill structured problems based on real life situations help students make connections with real world and realize that what they learn in the classroom can be used in their daily lives (Levin, 2001). Additionally, these problems allow students to take the responsibility of learning and increase their activity in the learning process by giving roles, to play according to scenario. This situation is not only enjoyable but also helps students define the problem.

Therefore, in PBL environments ill-structured problems are used as guides for student learning, and teachers, who are no longer considered as dispensers of knowledge, are expected to keep students on track while they decide on what directions to follow in their investigations, what information to collect, and how to evaluate the information (Chin & Chia, 2005; Hmelo-Silver, 2004; Song, Grabowski, Koszalka & Harkness, 2006).

Accordingly, in a typical PBL class, lesson starts with meeting the problem but the students are to be prepared for PBL process. In fact, the steps of PBL was specified by Torp and Sage (2002, p.36) in the following order; prepare the learners, meet the problem, identify what we know, what we need to know, and ideas, define the problem statement, gather and share information, generate possible solutions, determine the best fit of solutions, present the solutions, and lastly debrief the problem. More specifically, in a PBL class the students need to know how a PBL lesson runs on and what they are going to do in this process. When they meet the problem they take the roles to play and identify what they know, generate ideas, hypothesis and determine learning issues (Hansen, 2006). They conduct independent study after lesson. They revise their hypothesis and ideas in line with new information (Robins, 2005). Based on information and ideas, they generate possible solutions to the problem and choose the best one. Because of the problems are ill-structured they need to generate plural hypothesis. The important point is not to find a correct answer; but to learn the content while acquiring the information individually, sharing and exchanging and integrating them with peers. All groups present their solution and explain their process through PBL lesson. During these processes, the teachers guide students to reach right sources and try to keep them on track (Robins, 2005).

The other major features of PBL contain a change both in teacher and student role in learning. In a PBL environment, students are challenged to understand the problem situation, identify important points to be investigated, formulate hypothesis for a solution, access a variety of resources to gain new knowledge, think about how this new knowledge can be used to deal with the problem, and reflect on their understanding. Moreover, in a PBL class students participate in social interactions working in groups and the teacher acts as a facilitator. Therefore, in PBL classrooms, students' role changes from passive knowledge receivers to active learners and teachers' role changes from knowledge transmitter to facilitator in learning process. In other words, instruction is students centered not teacher directed in the PBL (Levin, 2001). Actually, Torp and Linda (2002) suggested that in the PBL classrooms, students become active learners and problem solvers and teachers' role is to act like a coach. Likewise, Greenwald (2000) explains the PBL as a constructivist process that is shaped and directed primarily by the students, with the instructor as the "thinking" coach. The control of the direction of learning is on students as they decide what they need and want to know to construct a solution to the problem (Uyeda, Madden, Birgham, Luft & Washburne, 2002), and the teachers questions aimed at to challenge students' thinking, help shape learning (Greeanwald, 2000) and asses depth of knowledge and understanding (Uyeda et al., 2002). The PBL teacher as a facilitator scaffolds students' learning by clearing misapprehensions and gives clues through questions, and produces good strategies for learning and thinking rather than giving the subject directly (Hymelo-Silver & Barrows, 2006). Moreover, teachers are expected to make students more responsible for their learning (Archilles & Hoover, 1996). They are to follow up the students' progress and guide them. Rather then transferring knowledge, they facilitate the learning (Fyrenius, Bergdahl & Silén, 2005). In addition, feedback to students as well as facilitation required from teachers. The teacher checks on the students in each group and help groups clear up misconceptions or help them keep continue to learn in the right way (McKeachie, 2002). According to Torp and Linda (2002), "as teachers model and coach strong cognitive and metacognitive behaviors and dispositions, students learn how to learn and become excited about learning through problem solving." (p.34). In addition it should be noted that, implementation of the PBL involves both cooperative learning and independent learning. Cooperative learning, which provides students with opportunity to learn while working in small groups, is one of the best ways for active learning (Silberman, 1996). Similarly, Rivarola and Garcia (2000) consider that team work is the best way to encourage student participation and interaction, discussion, corporation and conceptual communication. PBL favors learners to work with group peers and share their findings and ideas to reach the solution. Besides, it develops students' skills to become self-directed learners by requiring students to work in a group cooperatively to get information to decipher the problem. On the other hand, while learning on their own independently, students take the responsibility of learning and are expected to assess their performance in order to determine what they need to learn (Burgess, 2004). Searching information and deciding what is going to be learned becomes personal construction of the learner. In a PBL classroom, after defining the problem and determining the needed information for finding them, students search the resources like library, books, internet, e-sources individually then share the information in their group.

Savery and Duffy (1995) supports the claim that PBL is a constructivist approach and is agreed with the principles of constructivist instructions. The principles are as follows. Firstly, the purpose of the learning activities should be clearly perceived and accepted by the learner. Since the goals of the learners determine what they learn, a task should be established in a way that learners may adopt it as their own. Secondly, similar to the first principle, students should be encouraged to take on the ownership of the process used for the task. Thirdly, authentic tasks and complex environments should be generated for students. These tasks and learning environments should be challenging for learners' thinking skills. Fourthly, teachers' roles in instruction should be to support effective functioning of learners in complex environments, to encourage their alternative views, their discussions in the collaborative learning groups, and to encourage testing their ideas and hypotheses. Lastly, the evaluation should be based on learning process as well as the knowledge learned.

Suvery and Duffy suggested that abovementioned characteristics are all relevant to PBL instruction.

In fact, according to Arambula-Greenfield (1996), PBL is an instructional format that requires students to participate actively in their own learning by researching and working through real-life problems to arrive at a best solution. In the PBL process, the problems are the center of the learning. The problem is given students at the beginning of the process and learning occurs by doing the problem solving (Burgess, 2004). Problems aim at to motivating students to learn and providing a real world context to examine the related issues (Savoie & Hughes, 1994). The problem is ill-structured that is unclear and open-ended and that raises questions about what is known, what needs to be known, and how the solution can be found (Greenwald, 2000). Problems have many solutions ways and individuals solve them by influencing their vantage point and experience (Greenwald, 2000). Since the problem is unclear, students need to redefine the problem as new information is gathered (Greenwald, 2000) and to eliminate some of the hypothesis or to generate new ones. In typical classroom problem solving approaches, students encounter problems after they learn the required content knowledge (Uyeda et al., 2002) and when all information needed for solution building is available (Greenwald, 2000). On the contrary, in PBL approach learning begins at the introduction of problem to students. The process is regulated by students as generating hypotheses to the problem based on the information in the problem, their prior knowledge and research.

In PBL instruction, what students will construct from a learning environment depends on teaching context, teaching/learning activities and student factors such as prior knowledge, ability and motivation (Spronken-

Smith, 2005). Additionally, Raine and Collett (2003) claim that prior knowledge is the most important factor in learning and it is a valid contribution to the group effort in PBL. Doig and Werner (2000) suggested that creation of a common base of knowledge for students from diverse academic backgrounds enables students to create meaningful constructs on which PBL can build. Indeed, one of the aims of PBL procedure is to increase the interaction between new information to be learnt and knowledge already present in the learner (De Grave, Schmidt & Boshizen, 2001). De Grave et al. (2001) consider that PBL discussions have an influence on the integration of new information in the knowledge already available in the student. According to Doig and Werner (2000), although problems are the focus for learning, integration and application students need to have sufficient science knowledge background in order to deal with problems effectively and learn underlying basic science. In fact, students rely on their prior knowledge to formulate tentative hypotheses to the problem (Burgess, 2004).

The origin of PBL as an educational approach was in medical education in the 1960s (Torp & Sage, 2002). In the nineteen century the cases were used in Harvard Medical School but firstly in 1969 traditional lectures in first-year basic science courses were replaced with courses that started with problems presented by patients' cases in McMaster University (McKeachie, 2002). The researchers realized that using traditional lecture approach was sufficient to provide theoretical knowledge; however, it was defective to provide enough skills to use in practical exercises. Whereupon, the necessity of having learning approach that is not only based on theoretical framework but also profitable for clinical application was realized. Within a following decade PBL became widespread to be accepted as instructional approach in many other medical schools in North America and Europe (Blight, 2000; Norman & Schmidt, 2000; Salvatori, 2000; Savery, 2006). The main question, which is if the PBL was as much adequate as in terms of conventional test of knowledge like in traditional lectures, was examined by many researchers and the results showed that PBL provided comparable scores with traditional approaches in medical examinations (Vernon & Blake, 1993), and PBL graduates performed as well and sometimes better in clinical examinations and faculty evaluations (Albanase & Mitchell, 1993). There are many other studies which investigated the effectiveness of implementation of PBL in engineering education (Dahlgren, 2000; Fink, 2002) and in law education (Driessen & van der Vleuten, 2000; Mackinnon, 2006). Now there are universities in which PBL is implemented in many courses (Eck & Mathews, 2000). In addition, PBL has been implemented in elementary and secondary school because of its potential to enhance higher order thinking skills and communication skills (Archilles & Hoover, 1996) and to make students more active and highly motivated (Hmelo-Silver, 2004).

There are some studies conducted to identify the effect of PBL on learning and to compare its effectiveness with traditional instruction. Vernon and Blake (1993) conducted a meta-analysis study for 22 studies to compare PBL with traditional methods in medical education and they pointed out that the superiority of the PBL approach over the traditional methods with respect to students' clinical performance, attitudes and opinions about their program while both methods are not differ on knowledge. Arambula-Greenfield (1996) stated that, collage students preferred PBL instruction to the traditional lecture-discussion-presentation format for both learning academic content and for practicing independent learning and critical thinking.

A study by Gordon, Rogers, Comfort, Gavula and McGee (2001) focused on the effectiveness of PBL on middle school students. They conducted a study on low-income minority middle school students who received PBL. Before the lectures more than thirty staff members of the school were trained for PBL. The experimental group consisted of two classrooms that included sixty six students from different levels and all students were grouped according their grade level. Groups of eight to ten students were formed. The control group consisted of two similar classrooms with students of different levels. There was no difference in the classes in terms of the grade level of the students so classes were grouped heterogeneously. The same advisors and teachers of each grade remained with the experimental and the control group classes. PBL scenarios were developed in accordance with goals of the curriculum in health science issues in order to develop students' self-directed learning skills and critical thinking. Problems that are relevant with issues were given to the sixth, seventh, and eighth grades. The topics in the eighth grades were domestic violence, target-marketing and advertising, sickle-cell anemia and aneroxia-endocrinology. On the first day the PBL group met the problem, generated learning issues and recorded their discussion results on a sheet of paper under the categories of "data", "analysis", "hypothesis" and "learning issues". They used the school library, the internet and expert opinions as source of information on subsequent days. The teachers and a librarian helped students with their research. The next day they started to share and discuss their findings and to apply the things they learned with each other. They made a concept-map of their solutions and learning. The facilitator provided feedback at end of each lesson. At the end a self-assessment instrument which contained a list of what they learned, ideas about group success and suggestions for group improvement was completed by all PBL students. The findings showed that not only students but also facilitators had a positive perception of PBL and responded positively PBL activity. While the teacher thought PBL promoted students' critical thinking, communication skills, group work and information seeking, the students also valued the active learning, information seeking, the high level of challenge, team work and the personal relevance of the material. Moreover, a significant improvement in their science grades was observed at the end of the study and it was concluded that PBL increased the performance of low-income minority middle school students in the science subject.

A similar study was carried out by Sage (1996) to describe the characteristics of PBL as a curriculum development and instructional strategy in the K-8 level and to determine the effects of PBL on students' thinking skills. To this purpose $1^{st}/2^{nd}$, $3^{rd}/4^{th}$ and 8^{th} grade students participated in the study. Teachers involved in the study had experience in PBL implementation. During the implementation, $1^{st}/2^{nd}$ and $3^{rd}/4^{th}$ grade students studied the same problem which was about the failure of planted flowers in a garden to grow. The teacher prepared the students for the PBL by making them to conduct several plant experiments and making them familiar with the strategy of recording what they know, what they need to know. The teacher also brought some books to the class to help students access related information. However, students were not informed about the fact that they would be doing PBL. After being prepared for the PBL, students met with the problem about plant problems. While they were dealing with the problem, the teachers took the role of coach who keeps students focus on the problem, guides their efforts, provides active learning opportunities and helps students to express their prior knowledge, recognize facts, pursue and research about ideas and knowledge. They worked also at home and shared their information with other groups. Students did more experiments with the help of the teacher about plants to determine what affects on plants' growth. Students were encouraged about using library and online resources. In the last part they asked for help from their art teacher and librarian to prepare a presentation on their solutions. The criteria for presentation were that it had to be understandable, attractive and concise. 8^{th} grade students, on the other hand, worked on a problem related to a prairie on their campus. After meeting the problem students were allowed to examine the plants outside. The teacher collected relevant resources that students used in class. The students also presented their solutions. $1^{st}/2^{nd}$ grade's teacher stated that PBL improved students' complex thinking and problem solving. According to her, PBL helped students realize the reason behind using a skill or strategy which improves retention. $3^{rd}/4^{th}$ grade's teacher mentioned that students learned many things about not only plants but also food chains and ecosystem by actively involving the learning process, not just by relying on textbooks. The opinions of 8^{th} grade students' teachers on PBL showed also that PBL develops students' problem solving and presentation ability. Additionally, they stated that PBL helps teachers to redefine the aim of education and science and change their perspective from "students need to know this" to "what is important for kids to know". Overall, the opinions of teachers, in all grade levels, about PBL were all positive.

In other study, PBL was implemented in a Molecular Genetics unit (McBroom & McBroom, 2001). Six high school juniors were selected for the control group which would be instructed by a traditional lecture method while five sophomore students were selected for the experimental group to be instructed by PBL method. Each group was taught by the same instructor. An interesting and practical problem about genetic similarity on common daisy's weed control on campus was given to the experimental group. The experimental group spent more time on the unit than the control group. In the first week, students were introduced the problem, and students defined the problem and identified where they could find the necessary information about possible solutions to the problem. The instructor did not teach related concepts directly but helped them as a learner-coach. In following lessons, they did research on these concepts and class discussion controlled by the instructor was made. In the last week they presented their project. A questionnaire, which was developed to measure knowledge of students, was administered as pre and post test. Independent samples t-test of the pre and post tests scores showed that at the end of the unit, the PBL group scored significantly higher then the traditional lecture group. Moreover, PBL students completed the unit with a positive attitude and an apparent gain in self confidence differently from other group.

In addition, the result of the study conducted by Cerezo (2004) showed an increase in students' motivation, self-regulated learning and self-efficacy. The researcher studied on at-risk female students in middle grades math and science classrooms to determine the effectiveness of PBL and changes in students learning and self-efficacy. More specifically, 14 female students, who were in danger of failing from math or science lessons, from 6^{th}, 7^{th} and 8^{th} grades were lectured with PBL and interviewed to collect data. Data on self-regulated learning and self-efficacy were collected depending on the use of the library, concentration in school, homework deadlines, and ability to be outspoken or participate in class discussions. The results showed that participants' performance positively changed and all of the participants liked PBL and working in a group, also they benefited from PBL for learning. Additionally, PBL made students have more willing for school work, increased the students' self efficacy by providing them with interaction with other students in problem-solving situations and contributed to understanding of the concepts deeply.

Indeed, PBL engages students in learning and students take their responsibilities, it increases students' motivation. According to Savoie & Hughes (1994), students become highly motivated and eager to share their thoughts about problem, both inside and outside of the classroom. They also reports that they observed their students changed from individuals who struggled to remember even the simplest information in their regular classes to discussers of a broad range of information, not just from the case description but from their personal experiences as well. Additionally, PBL gives answers to students about their dilemmas on 'Why do they need to learn?' or 'Where will they use this information in real world?', so they can find out the real reasons to learn. PBL makes learning relevant to the real world by dealing with real-life problems. According to Uyeda et al., (2002) the main benefit of PBL is developing an awareness of the connection between science and society by presenting the importance of using concepts from specific science disciplines to explain collected data to solve the problem. These ill-structured scenarios encourage students to use and improve their critical thinking and creativity. Moreover, PBL increases self-regulated and metacognition skills and induce students to learn how to learn (Torp & Sage, 2002). Independent learning skills are developed through PBL process (Doig & Werner, 2000) and when the learning constructed by the learner it is more meaningful and long-lasting (Rivarola & Garcia, 2000). The result of the study conducted by De Grave et al. (2001) revealed that PBL discussions encourages elaboration based on prior knowledge, thereby causing integration of new information into existing knowledge as well as accessibility and memorization of such knowledge. Moreover, thinking about problem and possible solutions improve the formal reasoning ability, and working together to solve the problem increases students communication. Likewise, Xiuping (2002) maintains that, PBL produces strong reasoning and team building skills. Additionally, students' presentation of their works in teams improves their oral communication skills (Rivarola & Garcia, 2000).

Although PBL has many positive yields, during the implementation of PBL some problems may be encountered, because in a PBL lesson students are expected to work on ill-structured real world problems that they are not familiar with (Plucker & Nowak, 1999). In other words, students must be experienced in dealing with ill-structured problems while working in groups and conducting independent study. The preparation of students to the PBL process and encouraging students to use their critical thinking and self-regulated learning skills are some of the roles of teachers. A paper presented by Ngeow and Kong (2001) to prepare teachers and students for PBL noticed the challenges in PBL implementation like difficulty of group management, lack of experience with inquiry learning and insufficient feedback from instructors. Moreover, during the implementation of PBL it is recommended that cooperative learning skills, inquiry skills, reflection skills are emphasizes; and in order to asses these skills, teachers make use of presentations or final projects. In fact, teachers' assessment and evaluation of the PBL are not only based on the final learning product like PBL project or knowledge based tests but also students' performance during the whole PBL process (Ngeow & Kong, 2001). Because the goals of PBL are both knowledge-based and process-based the examinations must be considered students progress towards these goals (Savery, 2006).

2.2. Students' Difficulties in Understanding Genetics

Considerable research has demonstrated that Genetics is one of the most important yet difficult topics to teach and learn in school science (Rotbain, Marbach-Ad & Stavy, 2006; Kindfield, 1991; Tsui & Treagust, 2003; Tsui & Treagust, 2004). These studies, indeed, showed that students have difficulty in understanding genetics concepts and hold variety of misconceptions with incoherent knowledge structure. Actually, genetics include many abstract concepts hard to understand, learn and remember such as inheritance, reproduction, and meiosis (Bahar, Johnstone, & Hansell, 1999; Cavallo, 1996; Knippers, Waorlo & Boersma, 2005; Lewis, & Leach, 2004; Lewis, & Wood-Robinson, 2000; Lewis, Leach, & Wood-Robinson, 2000a, b, c; Wood-Robinson, Lewis, & Leach, 2000). Law and Lee (2004) pointed out that understanding of genetics requires understanding of both not observable and abstract conceptual entities and interactions among these entities. However, it is easier for young students to deal with the organisms that are more visible than the invisible ones to the naked eye (Gilbert, Osborne & Fensham, 1982).

The study of Wood-Robinson (1994) (as cited in Lewis &Wood-Robinson, 2000) showed that understanding of genetics and inheritance was poor at all age groups. Bahar et al. (1999) reported that even students in higher education, who passed the university exam successfully, had difficulty in understanding genetics related concepts. Authors suggested that some similarities between topics like meiosis and mitosis may lead to difficulties experienced by the students. In addition, Lewis and Wood-Robinson (2000) found that students could understand probability well however, the ability to apply relevant knowledge within the context of inheritance showed variability among students. Additionally, dominance and recessiveness of alleles was found to be one of the commonly misunderstood concepts in genetics (Heim, 1991).

Furthermore, the study conducted by Lewis, Leach and Wood-Robinson (2000) revealed that although students were familiar with genetics related concepts, they knew little about scientific explanations of these concepts. Accordingly, they had difficulty in providing explanations for the questions asking for meaning of these concepts. It was also found that also it was difficult for students to realize the links among different concepts and apply their knowledge into new areas.

Further aspects of the abovementioned study were reported by Lewis, Leach and Wood-Robinson (2000b). The study was carried out on students aged 14-16 to determine their' understanding of continuity of genetic information between the cells of a single organism, which is the fundamental subject to understand inheritance. The results showed the lack of scientifically correct understanding in the related subject which results in difficulties in meaningful understanding. Students knew the related concepts but had difficulty in explaining meaning of these concepts. A few students were found to achieve a meaningful understanding of the distinction between a gene and genetics information that the gene carries out.

Additionally, Lewis, Leach and Wood-Robinson (2000c) studied with the same students to investigate their understanding of cell division and fertilization. Analysis of results revealed that students were confused with respect to these topics and showed limited, and inconsistent understanding of cell division. Some students were aware of function of mitosis, meiosis and basic features of fertilization however they appeared to have little understanding of related processes. The researchers suggested that the sources of these difficulties were lack of the understanding of the relationship among gene, chromosome and genetics information.

A similar study was investigated by Wood-Robinson, Lewis & Leach (2000). They studied with 35 students in nine groups, aged 15-16.

Students were asked to draw a check cell of an animal that include three pairs of chromosomes as well as nerve, sperm, egg, fertilized egg and cells from early embryo. While they were drawing the cells, some questions were asked to students such as what is DNA, and discussions were made about their drawings in order to better understand what they know about the related concepts ad to explore their ideas deeply. The result of the study showed that overall 11/35 students draw number of chromosomes correctly while remaining students had confusions about relationships among chromosomes, genes and DNA. In addition they have an opinion about if the function of a cell or the gender of organism is different the genetic information also changes.

In addition, the study of Lewis and Kattman (2004) focusing on understanding of the process rather than knowledge of the rules and patterns of inheritance, showed that 14-16 aged students had little understanding of the difference between a gene and its expression as a trait, and little awareness of basic processes of genetics.

Moreover, the study conducted by Tatar and Cansungu-Koray (2005) revealed the prevalence of the knowledge deficiency and misconceptions among 8th grade students on basic genetics concepts like gene, DNA and chromosome. They proposed that students' tendency to memorize the concepts without an attempt to understand deeply is the main cause of the difficulties that they experience. In line with this proposition, the authors suggested that different teaching methods including models, experiments or educational games should be integrated into regular classroom instruction. They also added that small group discussions should be encouraged to promote understanding of relationships among the concepts.

However, Knippers et al. (2005) stated that there is not enough empirical research focusing on kind of strategies that can promote learning and teaching of Genetics related concepts, which have been described as difficult subjects to achieve. They recommended that instructional strategies should help students identify the interrelationships among different concepts by actively involving in the learning process with the guidance of the teacher. Instruction should not just concentrate on solving crossing problems.

Indeed, findings of a study conducted by Esiobu and Soyibo (1995) showed that small heterogeneous cooperative groups improve students' individual attention and performance more than traditional intrapersonal competitive groups. They also suggested that an approach that focuses on ways of enhancing students-students interactions may be used to improve students understanding and performance in genetics and other science aspects.

Moreover, Orcajo and Aznar (2005) investigated the effectiveness of problem-solving methodology to teach Genetics and human inheritance in secondary education students. Students in the experimental group dealt with 13 open problems in an environment based on investigation-action paradigm. The control group students, on the other hand, worked with traditional methodology receiving teacher centered instruction, following textbooks and solving closed problems at the end of the unit. Both qualitative and quantitative techniques of analyses showed that working on open problems improved problem-solving abilities, which is an important goal in science education (Slack & Stewart, 1990), and metacognitive skills like classroom discussions, annotated drawing, and keeping diary included all steps that followed on the process. Moreover, meaningful learning was promoted through open problems than traditional methodology.

Similarly, Şahin and Parim (2002) compared the effectiveness of problem solving methodology and traditional lecture method on 8^{th} grade students' understanding of genetics. Students' understanding was measured by asking 40 open ended and 40 multiple choice items. Alternative of multiple choice Items included a total of 63 misconceptions. The result of study showed that problem solving method was more effective than traditional lecture method in terms of meaningful understanding of genetics.

According to Thomson and Steward (2003), scientific inquiry that is consistent with practice of science, promote student thinking and learning. Therefore, student-centered inquiry methods that can encourage student learning should be used to teach genetics. In accordance with this idea, Okebukola (1990) noted the necessity of discouraging rote learning and encouraging higher-level understanding while teaching genetics. The researcher further suggested that since genetics is a fundamental subject, inquiry methods providing students with opportunity to learn meaningfully should be used in the classrooms.

Likewise, Rotbain et al. (2006) recommended use of classroom activities that can enable students to study at their own pace until they believe that they have assimilated the necessary information. According to Saka, Cerrah, Akdeniz and Ayas (2006), different teaching methods that encourage active student involvement in the learning environment must be used to support students learning of abstract concepts such as genetics. Furthermore, to teach genetics, Slack and Stewart (1990) proposed an instruction that engages students to generate and test hypotheses to solve problems and to interpret the results. Moreover, they add that expressing a solution to problems must be emphasized instead of giving an answer. Additionally, Keles, Usak and Aydogdu (2006) found that in 8^{th} grade students modeling, role playing, and games were more effective than traditional lecture methods with respect to understanding of genetics. This finding supported the idea that student centered instructional strategies integrated with scientific methodology are effective in learning and teaching of genetics concepts.

According to Lewis and Wood-Robinson (2000), school curriculum provides 14-16 aged students with neither a firm basis for future training as a scientist nor a useful preparation for personal interactions with science. In fact, using mostly verbal and textual explanation will not be sufficient to promote students' interest in and motivation to understanding of scientific concepts including genetics (Tsui & Treagust, 2004; Tsui & Treagust, 2003). Parallel to this idea, Lewis and Wood-Robinson (2000) suggested that students should be provided with opportunities to gain basic knowledge and skills and use these knowledge and skills in order to effectively deal with social issue. Therefore students should have ability to evaluate scientific information and use it to propose solutions to real life problems.

To sum up, research indicates that although genetics is an important subject in science education due to its abstract nature it is hard to understand related concepts meaningfully. In our national science curriculum, students are expected to learn basic genetics concepts like DNA, gene and chromosome at the elementary school level. It is clear that, if they learn these concepts meaningfully at this level, they may learn related advance concepts in the following years in a meaningful way (Saka et al., 2006). To promote meaningful learning researchers suggested that it is necessary to create learning environments that requires students to deal with ill-structured problems by generating hypotheses and ideas to propose solutions, testing these hypotheses and ideas through interacting with their environment and accessing different resources, and exploring the relationships among concepts and topics by themselves. Problem based learning is an instructional method that encourages active student participation in the learning process through dealing with ill-structured problems in small groups. In PBL environments, students learn the concepts and subjects while they search for information to find a solution by themselves and share their ideas and information with group members. Indeed, according to Şenocak and Taşkesengil (2005), PBL is an effective method in meeting the goals of the science education such as improving students' ability to use scientific processes like scientists, to propose solutions to a given problem and to express personal ideas in a positive manner. Thus, it is suggested that the PBL may improve students' understanding of genetics while dealing with ill-structured authentic problems, participating in social interactions, being guided by teachers and peers (Song et al., 2006).

2.3. Research on Formal Reasoning Ability

Gerber, Marek and Cavallo (1997) explain reasoning ability as stages in the development of thinking process. According to Valanides (1996), Piaget's works increased the attention on reasoning ability as an important objective in education. Piaget's theory about formal reasoning ability and its effects on education have been tested in many studies. General conclusion in these studies was reasoning ability is an important variable for the ability to do science, learning and achievement. An individual at high formal reasoning operation had the five reasoning modes, which are important for science learning; controlling variables, proportional, probabilistic, correlational and combinational reasoning (Lawson, 1982; Bitner, 1991). These people are able to use logical operations to hypothetical situations (Williams & Cavallo, 1995) and able to assimilate abstract instructional materials (Ehindero, 1979). On the other hand, Piaget states that to understand and learn, concrete operational level students need tangible and concrete objects or situations (Williams & Cavallo, 1995). While formal students has the ability of analyzing data systematically, learning from generated ideas and considering the reasons, concrete students tend to learn concepts concretely without generating any ideas or hypotheses. Indeed, Fuller (2001) suggested that concrete reasoning students need experienced actions, concrete objects and observable properties to understand, and step-by-step explanations in a lengthy procedure. They are able to use classification, conservation and seriation reasoning patterns. They tend to memorize the worlds, phrases or procedures and use them without understanding meaningfully. The researcher appends that concrete students are not aware of their own reasoning. On the other hand, formal reasoning students are able to reason with concepts, relationships and abstract properties. They express their ideas by using symbols and plan a lengthy procedure with goals and resources. They are also able to use combinational, proportional, probabilistic, correlational, and controlling reasoning in addition to concrete reasoning individuals. Differently from concrete students, they are aware of their reasoning ability and test their conclusions by incorporate new knowledge with existing ones. Additionally, they can work about an unfamiliar subject manner in a new area. Lastly, the researcher stated that self-regulated learning methods are needed to advance concrete reasoning people to formal reasoning.

Students use reasoning abilities in science to collect, to interpret and to analyze data for problem solving, to formulate responses to questions and to explain procedures (Tobin & Capie, 1982). Studies showed that, reasoning ability is an essential skill for science learning (Gerber et al., 1997). Students in high level of cognitive development get higher scores in science (Vass, Schiller & Nappi, 2000). More specifically, Bitner (1991) showed that reasoning ability is a statistically significant predictor of students' achievement in mathematics and science, explaining 62% and 29% of the variance respectively. Similarly, Lawson, Banks and Logvin (2007) stated the reasoning ability is primary factor that predict the variance of achievement and is a strong predictor of self-efficacy. A study conducted by Mwamwenda (1993) reported a correlation between university students' intellectual development and their academic achievement. Students at formal operational level had a better performance in the courses. Similarly, Baker and Lawson (2001) found a significant difference between the performances of students with more reasoning skills than less skilled ones. Additionally, Harwood and McMahon (1997) suggested that students with higher logical thinking ability may benefit more from visual and auditory images and videos.

Johnson and Lawson (1998) found that in inquiry based instructions students' reasoning ability was the best predictor of the achievement. The sample consisted of 366 college students in biology course. While reasoning ability was the better predictor in achievement in inquiry based learning cycle instruction classes, the prior knowledge was the better predictor in expository based classes. Moreover, pre and post formal reasoning ability tests revealed that students in inquiry classes showed greater improvement in formal reasoning ability than in expository classes.

According to Sungur, Tekkaya and Geban (2001), tenth grade students' reasoning ability has a significant effect on their achievement in human circulatory system concepts. Moreover, a significant mean difference for achievement and attitude in biology was found between formal and concrete students (Sungur & Tekkaya, 2003). Likewise, Oliva (2003) analyzed 10^{th} grade students reasoning ability with respect to conceptual change. The researcher reported that students at high level formal reasoning ability changed their previous conceptions more easily as a result of better initial structuralization.

A review of the literature conducted by Smith and Sims (1992) showed that formal reasoning ability is conductive to success in genetics problem solving. Similarly, Cavallo (1996) investigated the relationship between students' meaningful learning approach, reasoning ability, understanding of genetics and solving genetics problems. One hundred and eighty nine 10^{th} grade biology course students were instructed by laboratory-based learning cycle instruction, which was the schools' teaching procedure for K-12 education. To determine students' cognitive operational level, which ranges from concrete to formal, Classroom Test of Scientific Reasoning was administered. Students' genetics knowledge was measured through Test of Genetics Meanings and Test of Genetics Problems. The tests aimed to determine students' understanding of Punnet square diagrams and using these diagrams to solve and interpret genetics problems. The results of the both test showed that students' meaningful learning approach and reasoning ability were significantly predicted students understanding of meiosis and Punnet square diagrams and using them to solve genetics problems. While the reasoning ability explained more variance for problem solving, meaningful learning explained more variance of understanding of genetics. The researcher concluded that higher reasoning ability is the most important variable to solve genetics problems and second important variable to understand genetics.

Furthermore, Lawson and Thomson (1988) studied on 131 seventh-grade students' misconceptions concerning genetics and natural selections and the relative effect of formal reasoning ability, mental capacity, verbal intelligence and cognitive style. Open-ended essay questions were asked to students to determine their misconceptions related to principles of genetics and natural selection after the lecture-textbook instruction. Students' formal reasoning ability was determined by Lawson Classroom Test of Formal Reasoning. A negative and strong relationship was found between misconceptions, and reasoning ability and mental capacity. To explain, the results showed that better reasoning ability and larger mental capacity are compensatory of misconceptions. The study concluded that formal reasoning ability is necessary to overcome misconceptions in Genetics.

Ehindero (1979) found out a significant correlation between high school students' brightness and cognitive development precocity, especially at the formal operational level. Additionally, Lawson (1982) suggested that reasoning ability, different form intelligence, is an effective contributor to general achievement. As reported in his paper, several science curriculum development projects revealed that reasoning ability is related to both problem solving abilities and achievement. Moreover, his study with 72 ninth grade students investigating the relationship between students' reasoning ability and general achievement in reading, language art, mathematics, social studies and science revealed that students' formal reasoning ability was not only correlated with achievement in science (r=.69) and mathematics (r=.70) but also in social studies (r=.72).

Moreover, Williams and Cavallo (1995) examined the relationship between reasoning ability, meaningful learning and students' understanding of Newtonian Physics. 41 university students were involved in the study. Correlational analyses and regression lines showed that reasoning ability and meaningful learning was correlated with understanding of physics concepts. Students who had higher reasoning ability had more physics understanding and fewer misconceptions while concrete level students had more misconceptions in the relevant subject.

In other study, Williams and Marek (1999) examined the relationship between collage students' understanding in Physics subjects and their reasoning abilities and prior knowledge. The results demonstrated reasoning ability was best predictor for understanding of heat concept and second best predictor, after the prior knowledge, of forces and density concepts understanding. In addition, reasoning ability was found to be a significant predictor of problem solving in Physics concepts.

In middle schools, Chiappetta and Russel (1982) found out reasoning ability was related with the achievement of 8^{th} grade students. In the study, the effects of reasoning ability and instructional methods, as traditional and problem solving, on students achievement in earth science subject were investigated. While logical reasoning ability explained more variation than instructional method in achievement, no interaction was found between instructional methods and reasoning ability.

Moreover, the results of a study conducted by Tobin and Capie (1982) indicated that formal reasoning is important for achievement in science at middle schools. The researchers found that formal reasoning was the strongest predictor, as explains 36% variance, of process skill achievement and retention in science at 6^{th}, 7^{th} and 8^{th} grades and, it was related with generalizing and comprehending.

The review of the research revealed that students' formal reasoning ability is positively associated with achievement, performance skills and problem solving in science and more specifically in Genetics. Indeed, understanding of Genetics requires abstract level of thinking. Therefore, formal reasoning abilities are necessary for meaningful understanding of related concepts. Inquiry based methods, such as PBL, requires the reasoning ability to understand the subjects. In the present study, students' reasoning ability will be used as a covariate to remove the error variance on students' academic achievement and performance skills scores in genetics arising from this variable.

2.4. Research on Meaningful Learning

Science education primarily aims at facilitating acquisition of conceptual knowledge about the world (Cavallo, 1992). In order to have a conceptual understanding, it is necessary for students to realize the interrelationships among different concepts and processes of science (Cavallo & Rozman, 2004). According to Ausubel (1963), meaningful learning refers to processes whereby students relate new concepts and information to relevant existing knowledge and at the end learn in a meaningful manner. He explains that, to achieve the meaningful learning students need to have a meaningful learning set which is used to relate new concepts, information or situations to existing cognitive structure. In addition, the material to be learned must be potentially meaningful to them. A potentially meaningful material refers to the learning that is relatable with relevant concepts in cognitive structure and with the specific cognitive structure of an individual. Parallel to this proposition, Taber (2004) suggested that meaningful learning involves an integration of new knowledge with previous experiences.

On the other hand, when students strive to memorize the information as isolated pieces of knowledge, instead of associating with information that already known it is described as rote learning. Novak (as cited in Cavallo, 1994) defined rote learning as memorization of facts instead of relating information, concepts and ideas with previous experiences. Rote learners employ their meaningful learning sets to ascertain a solution to the problem or assimilate material verbatim (Ausubel, 1963). Cavallo (1992) suggested that students should prefer acquisition of knowledge by formulating relationships among ideas, rather than by rote memorization to be able to create new ideas. The researcher also proposed that rote learning is not sufficient to subsume the concepts by existing ones, as a result new understanding does not occur because of the lack of conceptual framework for understanding. On the other hand, majority of the students have a belief that learning in science occurs only by rote memorization (Cavallo, Rozman, Blickenstaff &Walker, 2003). The research investigating students' learning orientation and its effects on their meaningful understanding was examined in the following paragraphs.

In one of the relevant research, Cavallo (1994) studied with 140 high school biology students (70 males, 70 females) to examine their tendency to learn biological concepts either by rote memorization of facts or by formulating relationships between ideas on information. The researcher also investigated effect of students' approaches to learning on their performance in biology. Learning Approach Questionnaire and teachers' ratings were used to determine students' approaches. The data concerning students' performance were obtained from two sources: open-ended questions about meiosis and genetics and multiple-choice final exam. The teachers' ratings revealed that girls tended to learn biological concepts by rote memorization more than boys. However, students' responses to self report questionnaires showed that there was no significant difference between boys and girls with respect to their approaches to learning. Moreover, results of the study concerning students' performance indicated that while there was no difference between boys and girls in open-ended questions, boys who were rated as meaningful learners by teachers outperformed on multiple choice exam.

In other study, BouJaoude and Giuliano (1994) found that, among 220 collage students, students who had an intention to learn concepts meaningfully succeeded in chemistry course slightly higher than those having an intention to reproduce the learning material. The best predictor of achievement was found to be prior knowledge, followed by reasoning ability. Furthermore, a significant relationship between achievement and meaningful learning orientation was found. However, the researcher emphasized the importance of having a balance of both rote and meaningful learning orientations in chemistry course which is necessary for both acquiring concepts and understanding the relationships meaningfully.

Similarly, Cavallo and Schafer (1994) found that meaningful learning orientation is necessary to attain meaningful learning, as well as prior knowledge. In their study, the researchers explored the factors that predict students' meaningful understanding of meiosis and Punnet-square method. Meaningful learning orientation was investigated as if it was a distinct variable on meaningful understanding of topics independent form prior knowledge, aptitude and achievement motivation. The possible predictive influences of interaction between meaningful learning orientation and prior knowledge on meaningful understanding were also examined. Students' learning approaches were determined by administering Learning Approach Questionnaire and making observations to validate the findings from this self-report questionnaire. The sample consisted of 163 10^{th} grade students. The results showed that meaningful learning orientation was a factor that uniquely predicted students' attainment of meaningful understanding. Moreover, meaningful learning orientation and prior knowledge in meiosis were found to be significant predictors of students' meaningful understanding of meiosis, Punnet-square method and relationship between these topics. Results also revealed that for the understanding of relationship between meiosis and Punnet-square method, meaningful learning orientation alone was a predictor variable. In addition interaction between prior knowledge and meaningful learning orientation was found to be a significant predictor of students' understanding in meiosis and Punnet-square method. Results showed that meaningful learning orientation was less effective in meaningful understanding of meiosis in students who had high level of prior knowledge. However, meaningful understanding of relationship among topics was high when students were meaningfully oriented and had high prior knowledge of meiosis. It was concluded that meaningful learning orientation explained a unique portion of the variance in students' acquisition of meaningful understanding. More meaningful understanding was attained by students oriented toward meaningful learning with high prior knowledge Thus, meaningful learning orientation interacted with prior knowledge in predicting students' meaningful understanding and students with higher levels of meaningful learning orientation appeared to have meaningful conceptual understanding. In a separate study, Cavallo (1992) also found that meaningful learning was a significant predictor of the students' retention of meaningful understanding of the meiosis topic but not Punnet-square method. The researcher concluded that meaningful learning orientation was essential for retaining meaningful understanding of abstract topics like meiosis.

Similarly, BouJaoude (1992) conducted a study to determine the relationship between high school students' learning approach, prior knowledge attitudes and their misconceptions in chemistry. The researcher also examined misconceptions of the students with different learning approaches in detail. A multiple-choice test was used to explore students' misconceptions. After each multiple choice item, students were asked to provide an explanation for their responses. Students' learning approach was determined by Learning Approach Questionnaire. Explanations provided by students regarding their responses in multiple choice test revealed that meaningful learners developed more consistent understanding. Meaningful learners had a significantly better performance than rote learners and they were better able to use the information to correct their misconceptions. The number of correct answers in both multiple-choice and explanation parts of each question was higher for meaningful learners. It was concluded that rote learning may leads to development of misconceptions

Furthermore, Cavallo, Rozman, Blickenstaff and Walker (2003) investigated the relationships between collage students' learning approaches, reasoning abilities, motivational goals and epistemological beliefs relative to science concept understanding and course achievement. The possible differences in students' learning approaches and its relationship between conceptual understanding and achievement in an inquiry based physics course, an expository based physics course and biology course was also examined. Majority of biology students were found to adopt rote learning orientation, yet it did not contribute their grades in the course. These students appeared to study for the reason of getting external approval or high grades rather than learning for their own sake. In inquiry based physics course designed in accordance with constructivist course format, rote learning negatively predicted achievement. In expository base physics course, on the other hand, only formal reasoning ability was found to be a significant predictor of achievement

Moreover, BouJaoude, Salloum and Abd-El-Khalick (2004) examined the relationship between 11^{th} grade students' performance on conceptual and algorithmic problems in chemistry and their learning orientation, reasoning ability and mental capacity. Students were more successful in conceptual problems than algorithmic problems. While meaningful learners outperformed rote learners in conceptual problems, there was not a significant mean difference in algorithmic problems with respect to students' learning orientations. Moreover, the researchers commented that meaningful learners were likely to develop coherent conceptions than rote learners. Meaningful learning and mental capacity were predictors of 8% variance of performance on conceptual test, while 18% of the variance was predicted by reasoning ability.

A study conducted by Cavallo, Rozman and Potter (2004) ascertained that meaningful learning encourage students in the process of physics learning. They also suggested that rote learning did not help students' success in the physics course since it is a negative predictor for achievement. Similarly, Reap and Cavallo (1992) found that for high school females, to achieve meaningful understanding and achievement, meaningful learning orientation was important.

Although above mentioned studies showed that learning approach is important for conceptual understanding, BouJoude and Barakat (2003) found no relationship between learning approach and conceptual understanding. In their research, they employed a qualitative descriptive study to compare high school students' problem solving strategies in stoichiometry with different learning approaches and conceptual understanding levels. Results showed that learning approach did not have effect on problem solving approach and was not correlated with students' conceptual understanding.

In the light of related literature it can be said that, students' learning orientation is a significant predictor of their meaningful understanding of science and achievement. In many studies meaningful learning approach was positively associated with achievement while rote learning approach was negatively associated. It is possible that learning approach may have differential effect on achievement depending on concept being taught. For example, it is expected that understanding genetics may require meaningful learning approach because it includes many abstract concepts which are closely linked with each other. Therefore, meaningful learning can be achieved when students can realize the relationship among different concepts which are abstract in their nature. For this reason, in the present study, students' learning approach will be used as a covariate to remove the error variance on students' academic achievement and performance skills scores in genetics arising from this variable.

To sum up, the literature review revealed that PBL is a constructivist method that encourages active student participation in the learning process. Considerable research demonstrated that PBL has positive effect on motivation, performance skills, social skills, meaningful learning and higher order thinking skills while it has little or no effect on knowledge. Accordingly, PBL was suggested to be an effective method in promoting students' understanding of science concepts like genetics which is abstract in its nature. Additionally, research showed that students' prior knowledge, meaningful learning approach, and reasoning abilities significantly contribute to their understanding of science concepts. In the present study, contribution of these three variables to collective dependent variables was statistically controlled using them as covariates.

CHAPTER 3

PROBLEMS AND HYPOTHESIS

This chapter introduces main research problem, sub problems of the study and the hypothesis tested in results chapter.

3.1. The Main Problem and Sub-problems

3.1.2. The Main Problem

What is the relative effect of problem based learning and traditionally designed science instruction on students' academic achievement and performance skills in the unit of genetics after controlling for their prior knowledge, prior performance skills, reasoning abilities, and learning approaches?

3.1.2. Sub-Problems

1. Is there a significant population mean difference between the control group, exposed to traditionally designed science instruction, and experimental group, exposed to problem based learning, with respect to students' academic achievement in the unit of genetics when students' prior knowledge, prior performance skills, logical thinking abilities, and learning approaches are controlled?

2. Is there a significant population mean difference between the control group, exposed to traditionally designed science instruction, and experimental group, exposed to problem based learning, with respect to students' performance skills in the unit of genetics when students' prior knowledge, prior performance skills, logical thinking abilities, and learning approaches are controlled?

3.2. Hypothesis

There is no statistically significant mean difference between the control group, exposed to traditionally designed science instruction, and experimental group, exposed to problem based learning, with respect to students' academic achievement and performance skills in the unit of genetics when students' prior knowledge, prior performance skills, logical thinking abilities, and learning approaches are controlled in the population of all the 8th grade students in Ankara.

CHAPTER 4

METHOD

This chapter includes information about design of the study, sample, variables, instruments, treatment, analysis of data, assumptions and limitations.

4.1. Design of the study

The quasi-experimental design was implemented in this study (Fraenkel & Wallen, 1996). Following table summarizes the design of the study:

Table 4.1: Research Design of the Study

Groups	**Pretests**	**Treatment**	**Posttest**
EG	GAT	PBL	GAT
	LAQ		
	TOLT		
CG	GAT	TDSI	GAT
	LAQ		
	TOLT		

In this table, EG refers to experimental group taught by problem-based instruction and CG refers to control group taught by traditional science instruction. GAT is the Genetics Achievement Test, LAQ is the Learning Approach Questionnaire, and TOLT is the Test of Logical Thinking. PBL refers to Problem Based Learning while TDSI represents Traditionally Designed Science Instruction.

Before the instruction, GAT was administered to both experimental and control groups to determine students' prior knowledge and prior performance skills in a science unit on Genetics. Moreover, before the treatment, students' learning approach and reasoning ability were measured by LAQ and TOLT, respectively. After the treatment the GAT was administered again to compare the effectiveness of PBL and TDSI on students' achievement and performance skills in a science unit on Genetics. Moreover, the experimental group students' opinion about the PBL was determined by the instrument called Problem Based Learning Feedback after the treatment.

4.2 Definition of Variables

1. Academic Achievement: Students' performance on multiple choice part of the Genetics Achievement Test developed by the researcher.

2. Performance Skill: Students' ability to use relevant information in addressing a problem, to articulate uncertainties, to organize concepts, and to interpret information as measured by essay type items in the Genetics Achievement Test developed by the researcher.

4. Logical Thinking Ability: Formal thought or intellectual abilities of students as determined by TOLT.

5. Learning Approach: Students' tendency of learning concepts meaningfully or rote as measured by LAQ. Meaningful learning takes places when students put effort to achieve deep understanding of the complex ideas or relationship among concepts, while rote learning is associated with memorization of information.

6. Traditionally Designed Science Instruction: The science instruction based on the teacher explanations and textbooks.

7. Problem-Based Learning: An instructional strategy with the following basic characteristics (Sungur, 2004).

<u>Reliance on problems to drive the curriculum</u> – students learn the subjects through problems while they assess what they know, identify what they need to know, search information, and collaborate on the evaluation of hypotheses and ideas based on the data they collected.

<u>The problems are ill-structured</u> – students deal with problems that do not have only one correct answer. The nature and definition of the problem may change as students' work on the problem.

<u>Students solve the problems</u> – students take the responsibility of their learning and teacher acts as a facilitator.

4.3. Sample of the study

The target population of this study was all eighth grade students in Ankara and the accessible population was all eighth grade students attending public schools in Keçiören. Accordingly, sample of the study consisted of 192 eight-grade students (91 boys and 101 girls) attending a public elementary school in Ankara. Students were from six intact classes of two teachers and intact classes were randomly assigned to one of two modes of instruction namely, PBL instruction and traditional instruction. Each teacher had both PBL classes (n = 101) and traditional classes (n = 91). Students in both types of classes received identical syllabus-prescribed learning content. The mean age of the students was 14.07 years (SD=.355, range 13 to 15). Students were from middle-class families.

Learning Style Inventory Test (Kolb, 1985) (see Appendix A) was administered to the experimental group students to form heterogeneous groups with respect to learning styles as converger, diverger, assimilator or accommodator.

In the school where study was conducted, there were two science laboratories, one computer laboratory with internet connection, and one multi-media room. In addition, there was a library with books on different disciplines. All students had access to these resources.

4.4. Variables

Variables of this study can be categorized as Independent Variables, Covariates, and Dependent Variables.

4.4.1. Independent Variable

Independent variable of this study was the treatment being implemented.

4.4.2. Covariates

Covariates of this study were prior knowledge and prior performance skills as measured by GAT, learning approach as measured by LAQ, and reasoning ability as measured by TOLT before the treatment.

4.4.3 Dependent Variables

Dependent variables of this study were the scores on the post-GAT which measures students' academic achievement and performance skills in the unit of Genetics.

4.5. Instruments

4.5.1. Genetics Achievement Test (GAT)

Genetics achievement test includes 20 multiple-choice items and one essay type item to measure students' academic achievement and performance skills respectively (see Appendix B). Items in the test were related to Mendelian Genetics. Essay type item prepared in accordance with a problem-based learning approach aimed at measuring students' performance skills such as ability to use relevant information in addressing the problem, articulate uncertainties, organize concepts, and interpret information. Students' responses to essay type item were evaluated by using a modified version of a rubric (Sungur, 2004) (see Appendix C) which was originally developed by Lynch and Wolcott (2003). The scoring for this item was done by two raters.

Genetic achievement test was developed by the researcher. Content validity of each item in the test was determined by a group of experts in biology, biology education, and measurement and evaluation. The classroom teachers also analyzed the relatedness of the test items to the instructional objectives. Internal consistency reliability coefficient for multiple choice items was found to be .64 by conducting Kuder-Richardson-20 formula, and inter-rater reliability was found to be .91 for the essay type item. The GAT was administered to students in both experimental and control groups to measure their knowledge and performance skills before and after treatment.

4.5.2. Learning Approach Questionnaire (LAQ)

It is a 22-item-questionnaire developed to measure students' approaches to learning (Cavallo, 1996; Cavallo et al., 2003). It was translated into Turkish by Yenilmez (2006) (see Appendix D). The LAQ includes two subscales, namely Meaningful Learning Approach (LAQ-M) and Rote Learning Approach (LAQ-R) which determine the degree of meaningful and rote learning orientations, respectively. In this study, rote items were reversed and the mean of the items were used in the analysis. Students responded to items on each subscale on a four point scale ranging from always true to never true. A response of 'Always True' was assigned a value of 4, 'More True than Untrue' was 3, 'More Untrue than True' was 2, and 'Never True' was assigned 1. The alpha coefficient for the whole scale was found to be .60.

4.5.3. Test of Logical Thinking (TOLT)

Students' reasoning abilities were measured by TOLT that was developed by Tobin and Capie (1981) and translated into Turkish by Geban, Aşkar and Özkan (1992). The test consists of 10 items. Students respond to each item by selecting a response and a reason for selecting that response. For an item to be scored correct, the student must check the best answer and the best justification. The Cronbach alpha internal consistency for the test was found to be $r = .85$ (see Appendix E).

4.5.4. Problem Based Learning Feedback Form

Adapted version of the Problem Based Learning Feedback Form (Sungur, 2004), which was originally developed by Mierson (1998) as a course evaluation form, was used to get students' opinion regarding PBL. It included seven open-ended questions to obtain an in-depth understanding of students' opinions (see Appendix F). The form was administered to the experimental group students after the treatment.

4.6. Treatment (PBL vs TDSI)

This study was conducted over a five week period during the 2005-2006 spring semester in a public elementary school in Ankara. Genetic concepts were covered as part of the regular curriculum in the eighth grade science courses. 192 students from six intact classes of two science teachers were involved in the study. Classes were randomly assigned as experimental and control groups. Students in the control group were taught by the traditionally designed instruction, which was based on teachers' explanations, questioning method, discussion and textbook. On the other hand, experimental groups were instructed with Problem-based Learning. Problem based learning was based on the presence of ill-structured problems posed as cases from real life, small group work in the classroom, independent study outside the classroom, and involvement of the teacher as a guide. Prior to instruction, the teachers were trained about implementation of PBL. The students of experimental group were also trained about PBL by presentations and distribution of handbooks prepared by Sungur (2004) (see Appendix G). The science lessons were three times per week and each lesson was 40 minutes.

The students were administered the Genetics Achievement Test (GAT) , Learning Approach Questionnaire (LAQ), Test of Logical Thinking (TOLT), Learning Style Inventories (LSI) in the first week to determine their prior knowledge, prior performance skills, approaches to learning, reasoning ability, and learning styles, respectively. In each class, students were informed about the purpose of each instrument and procedure for completing it.

In the control group, traditionally designed science instruction (TDSI) was implemented. Before the instruction, the control group students prepared sheets that include a list of genetics related concepts, and their definitions. They kept the sheets through the implementation and used them when they needed during the lessons. In the first session of TDSI, the teachers asked the concepts to randomly selected students, they gave definitions and the teachers corrected or repeated their answers. Following session students and the teachers discussed about the effect of genes on the similarity and variation of the species, and the teachers gave some examples about human traits. After that, the teachers explained how the genes are represented by the symbols on the blackboard and students took notes. At the end of the session a reading assignment about Mendel's laws was given to students. The last session of the first week started with the summary of the previous sessions by the teachers. The teachers also gave information about following session's content and started to explain Mendel's laws on the blackboard. All explanation of the laws took 3 sessions. The teachers gave an example for each law and explained the examples again when required. Next session the teacher started to solve the crossing problems. These problems, about the peas and human traits, were all knowledge based and did not require higher order thinking skills. First two problems done by the teachers and other problems were done by the students. The teacher gave enough time to students to solve the problems on their seats and called voluntary students to the blackboard. The homework of students for next week was searching about the genetic diseases. First session of the third week started with the discussion of the students' findings about the diseases and the summary of the previous session. Students said the name of the diseases and the teachers explained them. The teachers asked to students why the relative marriage is not recommended. Some of the students said that the children of the parents can be sick. After that, the teacher clarified that recessive illnesses can be observed on the offspring even the parents are healthy. Next session started with the summary of the previous session, and then the teachers explained how to determine the probability of the offspring in the crossing problems. At the end of this session, students were given a crossing problem as a homework assignment. Last session of the third week started with solving the homework problem. Afterward, the teachers explained that sex is also determined by genes and there are some sex-linked diseases. Finally, the teachers solved two problems about sex linked inheritance and allowed to students to solve two other problems on the blackboard.

Therefore, in the control group, the lessons were based on teachers' explanations, textbooks, questioning and discussions. Majority of the lessons started with the summary of the prior lesson and teacher-directed questions. Students were required to take notes while the teachers explain the subjects and solve problems related to monohybrid crosses. In addition, at the end of each lesson, the teachers asked students to study to the related topics of the next lesson from their textbooks. In short, traditionally designed science instruction was a teacher-centered instruction where teacher was considered as a dispenser of knowledge and students were passive receiver of information.

In the experimental group, before the treatment, a presentation was made to inform students about what PBL is and how the PBL lessons proceeds. Moreover, handbooks about PBL implementation were prepared and distributed to students to guide them during the implementation.

Then, during the first week, two posters prepared by the researcher were brought to the PBL classes. These posters (see Appendix H) included some pictures related to human genetic characteristics such as brown haired person, freckled face, etc. One of the posters included pictures of dominant characters while the other included recessive characters. However, students were not informed about this information. The teachers attached the posters to the blackboard. Then, they requested students to examine the posters and to put a tick under the picture showing the character that they had. When all of the students put a tick under the pictures showing their characters, they realized that number of tick in one of the posters is much greater than that of the other poster. After that the teacher started a discussion about the possible reasons for this situation. At the end of the discussion students realized that some of the characters are observed more commonly than others. The students searched this subject on the books and they explained the meaning of “dominant” and “recessive” using the examples given on the posters.

Next lesson, the teachers introduced an activity to prepare students to PBL implementation (see Appendix I). For this purpose, the teacher gave a list of key words related to Genetics such as phenotype, genotype, homozygote, heterozygote to students. Then, they requested them to search for these key words and find the meanings of them. In addition students were supposed to prepare a unit plan on Genetics. Students were asked to prepare a very well designed and clear unit plan so that a primary school student can learn from it. Moreover, students were expected to search for news related to Genetics and find out some pictures which will help visualization of some concepts. The students worked individually on this activity and prepared a report including definitions of important terms, a unit plan, news and pictures about the subject. The related concepts were discussed in the class and the teachers never provided explanations or gave direct answers to questions. They just encouraged discussion, helped the students learn correct definitions of concepts, and tried to eliminate formation of misconceptions.

Second week, PBL implementation was started. Before the implementation, heterogeneous groups with respect to academic performance, gender and learning style were formed. There were 5 to 7 students in each group. First case was prepared based on Mendel’s experiments and the pages were prepared in such a way that reflects steps of his research. The case, which included information about pea crossings in

Mendelian Genetics, was implemented throughout 3 class hours. Each group was given a sheet which included a table with columns titled as, “what we know,” “hypothesis/ ideas,” “learning issues,” and “resources.” Some roles such as writer and reader were assigned to students. The case was distributed over 9 pages and distributed one at a time (see Appendix J). First page included information about a farmer: “He raises peas in his farm and sells them in the bazaar. He wants to have more smooth peas because they are more popular for the customers than the wrinkled ones.” After the reader read this page, the writer wrote what were known, what were needed to be known and listed the ideas generated to help the farmer. In next pages the farmer starts to test different fertilizations and students starts to generate new ideas and revise previous ones. For example, in the third page students had an idea that the farmer is going to have wrinkled peas if he fertilizes two wrinkled peas. When they took the fourth page they realized that this idea is true and then they thought that if he crosses two smooth peas he can obtain smooth peas. However, following pages showed that when the farmer crossed two smooth peas, he did not have only smooth peas but also wrinkled ones. In this page, students tried to find out possible reasons for this. They searched their books and groups decided to make research out of the school independently until next lesson. When the lesson was over, many of the groups have been reached the fifth page and some others were on sixth page.

At the beginning of the next lesson, a student from each group was selected by lottery to summarize their group work and to mention about his/her findings obtained from independent study. These presentations revealed that students realized the fact that recessive traits can only be expressed in homozygous condition while dominant traits can be expressed in heterozygous condition as well as homozygous condition. In fact, they mentioned that this is the reason why wrinkled peas can be obtained when two smooth peas are crossed. When they continued on the next pages, they also recognized that in the given situation, when wrinkled and smooth peas are crossed smooth peas are obtained. Therefore, they concluded that dominant characters dominate corresponding recessive ones. At the end, all groups tried to explain the reason for the results of crossing situations and what the farmer needs to do to have always smooth peas. Then the teacher gave the last page including the information about monohybrid crosses provided by a friend of the farmer who was an agriculture engineer. After that the teacher asked students to make crossings on each pages of the case by using symbols for genotypes. The groups achieved this goal by the guidance of the teacher and the help of the books.

Next week, a guest speaker from science education department at a university was invited to provide students with an opportunity to share their knowledge with an expert from the field and to discuss some points which are not clear in their minds. In this way, it was intended that students become aware of important learning issues and what they learned during PBL. After the discussion between students and the guest speaker, a worksheet was given to students containing several problems related with monohybrid crosses (see Appendix K). Students completed the sheet individually but discussions within groups were allowed. The teacher and the guess speaker provided feedback for each student. Then, the teacher asked students to write problem situations involving monohybrid crosses A volunteer from each group shared his/her problem with the rest of the class and another volunteer solved the problem. At the end, students prepared a report that summarizes their process, ideas and understanding of crossings. The sample of final reports submitted by students is presented in Appendix L.

Second case was implemented through next three class hours. Before starting the case, the teachers asked students when they go to a doctor and what the doctor does. Most of the students said that the doctor makes a physical examination. At this point, the teacher asked it is really what a doctor does first when a patient visits him/her. After this question, students thought for a while and said that the doctor first asks what their complaints are and then makes a physical examination and requests some laboratory tests, X-ray, or tomography etc. Students further mentioned that the doctor makes a diagnosis based on the information obtained from talks with them, physical examination and laboratory test results and start treatment. After this discussion, the second case related with sickle-cell anemia and negative consequences of relative-marriage was introduced to students (see Appendix M). Information about the complaints of a 4-year-old boy and the results of the physical examination and blood tests were distributed over 6 pages. Students were assigned some volunteer roles as doctor, parent, writer and reader. First page included brief information about the patient and it was given to all group members. The teachers gave the second page only to the student who role played parent. The reader read the case information given on the page to other group members. The case was about a 4-year-old boy living in Hatay. His parents brought him in hospital complaining of frequent fever, weakness, and fatigue. They suspected delayed growth in their child and mentioned that he sometimes suffers from palpitation. The writer took the necessary notes then the doctor and other members discussed about what can be the reason of this situation and what they need to ask to the parent to get further information on the sheet. A sample of sheet filled by writer is presented in Appendix N. Meanwhile, group members stated that this illness can be the result of some genetic problems and they decided to ask for other complaints such as if there is another family member showing similar symptoms. Then, the doctor asked questions determined as a result of the group discussion to the parent. The parent tried to answer the questions based on the information provided on the second page. If there was no information addressing a question the parent said “I do not know”. Talks with the parent revealed that the parents were close relatives and symptoms similar to those of patient were present among some of their family members. At this point, the teacher asked them whether they had any other questions to ask the patient. The doctors in each group decided to start the physical examination and they wanted the results from the teacher. So, third page providing information about physical exam results was given to students. The reader read the page to the group and the writer wrote the summary of the information. Information given on this page showed that he looked pale, he had abdominal swelling, yellow skin and eyes, and prominent cheek bone. In addition, information given on the page revealed that he suffered from delayed growth, structural abnormalities of bones, and shortness of breath. After getting this new information, students thought that he may have hit somewhere and the swollen may have occurred because of internal bleeding. Another idea arisen from the groups was that he had jaundice so his skin looked pale. However, they had no idea about the symptoms of jaundice so the group members agreed to use internet to find information about jaundice. The writer wrote their decision on the ‘what wee need to know’ column. In addition, some of the groups proposed that his shortness of breath could be due to a problem in the respiratory system. Another idea arising as a result of group discussions was that he could be suffering from rickets because he had problems related to bones. Each group generated ideas similar to ones which have been mentioned so far. Accordingly, groups decided to make search related with their ideas on the internet using the computer present in the class. They took notes about their findings about the symptoms of the diseases that they proposed such as rickets. Then, they compared these symptoms with the symptoms of the patient given in the case. After that, the students realized that they needed more information like blood test results or X-ray of lungs to make a more accurate decision concerning patients' illness. So, the doctor requested the test results and the teacher gave the related page. Based on the new information, they revised their hypotheses and ideas. During this process, the teacher guided them and asked them to be careful about the values that were above or below the normal range. Students recognized that bilirubin, potassium and iron values were slightly higher and the total iron binding chapacity was lower that the expected values. When they checked the blood cell counts they realized that all the values were lower than normal and reticulocyte value was quite high. Moreover, ferritinin value was high. Some groups aggreed on the idea that they should search for all these terms such as bilirubin, ferritin on the internet net and find out their functions. At the end of the group session, the teacher gave time to students to evaluate their performance. Students generally said that they could get along well with their peers, shared their ideas freely and performed well by now. However, they stated that it was hard for them to find the information by themselves and the last page given included test results which were difficult for them to understand. The teacher said that they can request help from other people outside who can make it easier for them to understand related topics. When the lesson was over, the teacher reminded that each student had to prepare an individual report that explained their group work, individual studies, resources that they used and their findings. Students were supposed to bring their reports to next lesson. Two of the final reports of students about this case are given in Appendix O.

In the next lesson, a student from each group was selected randomly and they explained what they did until this point. Then the teacher gave five minutes to the groups to discuss and share their findings and make a group decision on the hypotheses and ideas. Meantime, the teacher checked their "what we know", "hypothesis/ideas" "what wee need to know" columns on their worksheets. Groups had generated different hypotheses and made different diagnosis such as kidney-failure, anemia, and sickle-cell anemia. The teacher asked them how they concluded on these illnesses. One of the students in a group, who agreed with the idea that the patient was suffering from kidney-failure said that "My mom is a nurse. When I asked her which illness causes a decrease in the number of blood cells and higher bilirubin level, she told me that all these could happen in the case of a kidney-failure. So, as a group we decided on this illness." The groups, which decided on the kidney failure as a possible reason for the patient's symptoms, suggested that as part of treatment the patient should follow a restricted diet and be careful about salt-water balance. The group further suggested that the patient should undergo dialysis if the symptoms worsen. The groups deciding on the iron-deficiency anemia as the illness of the patient, however, thought that the patient was suffering from iron-deficiency so he could take iron pills to get better. On the other hand, the groups who proposed that the patient was suffering from sickle cell anemia supported their decision considering blood test results and the picture of peripheral smear provided on test results page of the case. They also supported their decision by explaining all symptoms of the sickle-cell anemia. They mentioned about the pains on the bones or fingers, having fever, delayed growth, and enlargement of liver and spleen. What is more, some groups explained that they could better understand the disease by finding the meanings of concepts in test results by searching on the internet. They stated that reticulocyte means immature erythrocyte, and based on this information they thought that there was something wrong with erythrocyte production. Moreover, some groups gave details about relative marriage, and the characteristics of the illness. The students searched information from internet, library and books. Furthermore, they went to the hospitals, policlinics and sought advice from doctor or nurse neighbors or relatives. When all of the presentations and discussions were finished, the teacher gave the last page which included information about diagnosis and treatment: The patient was suffering from sickle cell anemia and the reason for the abdominal swelling was the enlargement of liver and spleen. As part of the treatment iron binding drugs were given. He was advised to consume limited amount of iron containing food. He was also informed that he has to come to hospital frequently for blood transfusion if symptoms worsen. Then the teachers started a discussion about the reasons of the symptoms and students expressed their ideas about these. For example, the teachers asked why liver and spleen enlargement might have occurred. One of the ideas generated was lack of oxygen in the organs due to anomaly on erythrocytes. Another student did not agree with this idea and generated a different idea. According to him, lack of oxygen might have caused only speedy breathing not swelling. He further stated that enlargement of spleen and liver must be related with the production and destruction of erythrocytes, because blood cells are made in liver, spleen and bones, and also destructed in spleen. At the end of the discussion they all agreed that when the amount of the erythrocytes is low, liver, spleen and bones works more to produce enough blood cells to body. Skull deformation is a result of increasing in amount of bone narrow to meet the over activity of the bone marrow. Sickle cells clumps and interference with blood circulation, and this gives rise to local failures in body supply like lung damage or muscle and joint damage. Moreover, collection of the sickle cells in the spleen causes enlargement of spleen. Deficiency of erythrocytes causes an increase in iron level in the blood and a decrease in iron binding capacity. Paleness and yellow skin arises from high bilirubin level caused by hemolyisis of erythrocytes. Then, the teacher asked why the relative marriage is not recommended. Then some of the students gave examples from their families and they answered the question as the possibility of having same recessive characters on parents and passing them to child is high. So the recessive illnesses like sickle-cell anemia may not be shown on parents but affects their child. They agreed that relatives may have similar genes, and these genes may cause recessive illnesses. All of the students assigned to make crossing with using letter for genotypes of people in this case individually, and achieved this assignment with given feedback by the teacher.

The groups who did not hypnotize sickle-cell anemia thought that they were unsuccessful. The teacher explained that the important point is not to find the right answer but to generate ideas and hypotheses, search for information to support their hypotheses and share them with their peers, and to communicate well and to put the required effort in the mean time. They learned the important points such as why relative marriage is not advised, what a recessive illness is and how it works. Moreover, the teacher added that they were really successful at gathering the necessary information from sources like the library, the web, experts and then using their data to support their hypotheses. They were doing well in to revising their ideas with the information from the sources and through discussions with other groups and peers. At the end of the lesson the teacher gave some homework to students to search other recessive illnesses and they were reminded that the following session, they had to bring their group report including their ideas generated during the class hour, discussions about group process, how they reached their conclusion, and the summary of what they learnt from that case.

The following session started with a discussion about the previous session's homework. The students mentioned about albinism and polydactyly. Some of them tried to give examples like color blindness, hemophilia and the teacher stated that these illnesses are different from others and that they will learn about them later. Then the third case of a patient with red-green colorblindness which is associated with the sex-linked inheritance was given to students in the fourth week (see Appendix P). The case was covered in two sessions and one session was spent for presentations and discussions. It was observed that students were more comfortable in sharing the ideas, and they approached the problem from various aspects in this case. They studied with the same group members and shared the roles voluntarily. The roles included parents, a 5-year-old boy, a medical doctor, a writer and a reader. The first page, which includes information about the patient and his problems, was given to the parents and they explained that information to the doctor and other members of the group. The patient's kinder garden teacher realized that he was unwilling to colour the pictures and cut the shapes on colored cartons was roughly handled by him. The teacher thought that there might be a problem with his eyes and the parents thereupon brought him to the doctor. Then the doctor and other members started to think about the questions to ask to the patient for further information. They generated ideas like subnormality, delayed growth, squinting and poor eye-sight. Moreover, ideas related to the child's environment and emotions were produced. For example, one group thought that the light of the class might be not enough for the kid and others thought that he might find these activities boring. However, they agreed to ask more questions and then make some examination. They decided to ask if there was a person in their family with a sight problem. Following that, the teacher gave them the second page, providing more information of the patient and his family: the kid can not achieve to learn the colors correctly, his father is nearsighted and uses glasses while reading, there are other members using glasses in the family, and the kid's maternal grandmother, which lives in a village, can not distinguish the colors. At this point some groups added color blindness to their hypotheses. Afterwards, the doctors said that they gathered enough information and they requested the physical examination results to see if there was squinting. When the teacher gave the page to the students, they eliminated squinting and learned that there is no problem on his pupil. Some groups wanted to do a colorblindness test, but the teacher tried to guide them to eliminate some other hypotheses. After that, they took the results of the eye-examination report. Following of the examination of the report, the doctor explained that the patient has no sight problem and does not need to use glasses. The writer eliminated this hypothesis and they started to think about colorblindness more intensively. At this point, the teacher asked each group what reason made them think colorblindness existed. One student said: "We eliminated all other ideas and realized they were not valid. Then we wanted to try this hypothesis." Another student explained; "He [the patient] does not have any sight problems. We know he has never been able to learn the colors exactly. So he has a problem with colors. " Another idea generated by other students was: "We know the colorblindness is a genetic disease and his grandmother finds it hard to differentiate between colors, so she also could be colorblind, and then the likelihood of colorblindness is high in the patient." The teacher thereupon said; "But the mother has no problem with colors." Students answered "This must be a recessive disease, it did not show itself on his parents but the child has it". Afterwards, the teacher asked another question: "Don't you think the father has to have these genes in order for you to claim it is a recessive disease? It is mentioned in the case that there is no person in his family with such a disease.". Upon their teacher's startling the question, students requested to more time to search answers to this question after testing their colorblindness hypothesis and so the teacher allowed them. When the students wanted the colorblindness test result from the teacher, she told them there was no result report, and that they should do the test themselves. The doctors asked to come to the teacher and she explained to them how to test the colorblindness, showing the shapes on the given page. They were supposed to ask to the child what he sees in the shapes and he is expected to find the way from X to X in the rounded shapes. Then the doctors went back to their desks. Thereafter, she called the students who pretended to be the child and gave a paper which wrote the answers that they were supposed to give when the doctor asked them the question. They, too, went back to their groups. The doctor showed the first picture and asked the patient what he saw. The answer was “A sailboat”. However, in following pictures, there were shapes the patient could not see and he was not able to find the way in the rounded shapes. The researcher observed the students were really excited when they realized the child could not see some shapes and they had fun while playing the roles. Subsequently, they agreed that the child was colorblind when two sessions was about to be over. Since there was no time left, students were reminded that they needed to search the teacher’s question and to prepare their group and individual reports for next lesson.

First session of the fifth week started with a discussion on students’ findings regarding the teacher’s question. The teacher walked around and gave feedback to each group as they were sharing their ideas and findings with their peers. In the course of their research, they found out that some diseases are carried on the sex chromosomes. The teacher asked for examples and they said, “red-green color blindness, hemophilia and muscular dystrophy”. Also, they gave examples like hairy ear syndrome and scaly skin. At this point the teacher asked the difference between these two diseases with the previous examples. Students answered former carried on X chromosome while the latter Y chromosomes. Next, the teacher asked which diseases can be seen only in males. The answer was given as: “X chromosome exists in both male and females, on the contrary Y chromosome is present in only males, so hairy ear syndrome and scaly skin are peculiar to males.”. After the discussion, each group presented their results and summarized their process. Not only did they explain all their ideas and evidences that helped them to eliminate hypotheses other than “red-green color blindness” but also presented their data about the disease and information of not existence of a cute. All of the groups reached the same conclusion. Then the teacher gave the last page of the case with a sheet to make students think about sex-linked inheritance more and deal with composing a pedigree. The sheet asked the students why red-green color blindness appears in males more than females. Students thought about this situation, made discussions with peers, searched the textbook and supplementary books. When all the groups had ideas, the teacher let them share and discuss their ideas between groups. After the discussion, they concluded that the reason is females have 2 X chromosomes while males have only one. Thus, females may have heterozygote genotype while the males have no chance to have it. As a result, when an X chromosome carries the gene of the disease, there is more possibility of being sick in males than females. Thereafter, the teacher asked them to go to the next question which requested the pedigree of the family in the case. One of the students complained that they had never seen a pedigree and they had no idea about how to make it. The teacher encouraged her as they were also uninformed about the previous cases, subjects and concepts. However, they could overcome them and now if they do a research in the books, they may find examples. They formed the pedigrees by the help of books individually and the teacher gave feedback to each of the students respectively. Before the session was over, students gave their reports and they were assigned to make a pedigree of their own family in their notebooks. Sample of students’ final report prepared for this case is given in Appendix R.

Second lesson of the fifth week started with the checking of homework given the previous lesson. Then the teacher gave students the second worksheet which included all the possibilities of crossing the sex-linked inheritance (see Appendix S). Like the prior crossing worksheet, students solved the problems individually, compared with group mates and took feedback from the teacher. They also wrote questions for all crossing problems by using the X-linked diseases and concepts like homozygote, heterozygote, dominant etc. A student from each group came to the blackboard and wrote one question, and another student solved it.

During the implementation of the cases, all of the students were expected to generate ideas, attend the group discussions, do research both in and out of class, share the information frequently and listen the group members' ideas and findings respectfully. The teacher accentuated being active in the groups and also doing individual research out of the class. Students were responsible for their own learning, expected to evaluate their process themselves and encouraged to think critically. On the other hand, the teacher always guided them by asking open-ended, general questions and gave feedback when they needed. Students played their roles individually in the group; however, questions, that were asked to get further information, and ideas were generated altogether. For example, while the patient or the parents of the patient explained the complaints to the doctor that interviewed them by the help of the questions that were written by other group peers. Meantime, the reader read the given pages aloud after the role was played, and the writer wrote down the information, facts, ideas, hypotheses, learning subjects that were decided to seek out, and sources that were used. All of the students were expected to prepare an individual report that summarized their ideas, findings and the data reached at the end of individual work. Moreover, at the end of each case, students prepared a group report that included their entire ideas, hypothesis and summary of their process.

After the treatment, in the sixth week, the GAT was administered to control and experimental groups as a post-test to measure the academic achievement and performance skills in the unit of Genetics throughout one session.

4.7. Analysis of Data

As descriptive statistics, means and standard deviations were used to investigate the general characteristics of the sample.

MANCOVA was used to investigate the effect of problem based learning and traditionally designed science instruction on students' academic achievement and performance skills in the unit of Genetics when students' prior knowledge, prior performance skills, reasoning abilities, and learning approaches were controlled.

4.8. Assumptions and Limitations

Following assumptions and limitations were encountered for this study:

4.8.1. Assumptions

1. The teachers who applied the study were not biased during the treatment.

2. The administration of the questionnaires and test was under standard conditions.

3. Students responded the questions seriously.

4. There was no interaction between the control and the experimental group students.

4.8.2. Limitations

1. The study was limited to 192 eighth grade students at a public school in Ankara.

2. The research findings are limited to Genetics unit in science.

3. Independency of observations assumptions of MANCOVA might be violated since experimental group students worked in group.

CHAPTER 5

RESULTS AND CONCLUSION

In this chapter, descriptive statistics of data, inferential statistics by which the null hypotheses are tested, students' opinion about the problem based learning and conclusions will be presented.

5.1. Descriptive Statistics

Table 5.1 shows the descriptive information related to academic achievement, performance skill, reasoning ability and learning approach for both the experimental and the control groups.

As seen from the Table 5.1, in terms of prior knowledge the control group students appeared to have higher mean scores than the experimental group students. When the pre-performance skills are considered, mean of the pre-performance skill scores of the experimental group was found to be slightly higher than the control group. In addition, students' reasoning ability in the experimental group appeared to be slightly higher than the control group while mean scores for learning approach was very close for both groups.

Independent sample t-test were conducted to determine whether the observed mean difference between two groups with respect to prior knowledge, prior performance skills, reasoning ability and learning approach statistically significant. Analyses of results showed that there was no significant mean difference between the control and the experimental groups with respect to prior performance skills ($\underline{t}(190)=1.933$, $\underline{p}=.05$), reasoning ability ($\underline{t}(190)=-1.692$, $\underline{p}=.09$) and learning approach ($\underline{t}(190)=-.367$, $\underline{p}=.07$) and there is a significant mean difference with respect to prior knowledge ($\underline{t}(190)=-4.604$, $\underline{p}=.00$). However, magnitude of the difference was not large (eta squared=.10). These variables were used as covariates in the study in order to equalize two groups with respect to prior knowledge, prior performance skills, reasoning ability and learning approach, and to reduce error variance arising from them. Indeed, when preexisting differences are small the use of MANCOVA is appropriate (Hinkle, Wiersma & Jurs, 2003).

5.2. Inferential Statistics

Multivariate analysis of covariance was performed to investigate the relative effect of problem-based learning and traditionally designed science instruction (TDSI) on students' academic achievement and performance skills after controlling for prior knowledge, prior performance skills, reasoning abilities and learning approaches were controlled. Before conducting MANCOVA, the assumptions were checked.

5.2.1. Assumptions of Multivariate Analysis of Covariance

5.2.1.1. Sample Size

Sample size of the study was enough to proceed MANCOVA analysis since the cases in each cell were greater than the number of dependent variables (Pallant, 2001).

Table 5.1: Descriptive Statistics for Academic Achievement, Performance Skill, Reasoning Ability and Learning Approach for both the Experimental and the Control groups

	Experimental Group								Control Group							
Variables	N	Mean	S.D.	Range	Min.	Max.	Skewness	Kurtosis	N	Mean	S.D.	Range	Min.	Max.	Skewness	Kurtosis
Prior Knowledge	101	5.4	2.90	15	0	15	.730	.461	91	7.5	3.45	15	1	16	.286	-.506
Academic Achievement	101	11.8	3.35	15	4	19	-.280	-.339	91	10.9	3.32	15	3	18	-.098	-.217
Prior Performance Skill	101	1.4	1.42	5	0	5	.673	-.689	91	1.0	1.10	4	0	4	.795	-.268
Post-Performance Skill	101	2.6	1.36	5	0	5	.112	-.966	91	2.2	1.45	5	0	5	.028	-.931
Reasoing Ability	101	1.8	1.91	8	0	8	1.362	1.215	91	2.3	2.21	9	0	9	1.171	.597
Learning Approach	101	2.7	.29	1.23	2.09	3.32	-.041	-.664	91	2.8	.28	1.32	2.09	3.41	.020	-.113

5.2.1.2. Normality and Outliers

Univariate normality is tested by checking skewness and kurtosis values of dependent variables which are shown in the Table 5.1. Table shows that the values are vary between-1 and +1, which is in acceptable range (Pallant, 2001), for the experimental and the control groups. Moreover, normality of the distribution of the scores is checked by the histograms for each group and that is observed the scores distributed normally.

To check multivariate outliers Mahalanobis value was calculated and compared with critical value for two dependent variables given in the Chi-square table (Pallant, 2001). Critical value in table was found to be 13.82. Since the maximum Mahalanobis distance of the sample (11.082) was lower than the critical value, there was no need to remove any value from the data.

5.2.1.3. Linearity

The linearity assumption is assessed by generating scatterplots between each pair of the dependent variables and each of the covariates. Although, the scatterplots do not provide an indication of a perfect linearity, it can be assumed that there is no serious violation of this assumption.

5.2.1.4. Multicollinearity and Singularity

In order to check multicollinearity and singularity assumption, zero-order correlations were computed between two dependent variables and four independent variables. Zero-order correlations were presented in Table 5.2. As shown in the table, there is not a strong relationship between the variables of concern (<.8) (Pallant, 2001).

Table 5.2: Zero-order Correlations

	Prior knowledge	Prior performance skills	Academic Achievement	Post performance skills	Reasoning ability	Learning approach
Prior Knowledge	1.000					
Prior Performance Skills	-.223(**)	1.000				
Academic Achievement	.342(**)	.052	1.000			
Post Performance Skills	.070	.297(**)	.385(**)	1.000		
Reasoning Ability	.320(**)	.014	.424(**)	.154(*)	1.000	
Learning Approach	.048	-0.008	.134	.251(**)	.052	1.000

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

5.2.1.5. Homogeneity of Variance-Covariance Matrices

Homogeneity of variance-covariance matrices assumption was assessed by using Box's Test of Equality of Covariance Matrices. Results showed that there was no violation of homogeneity of variance-covariance matrices assumption with a Box's M significance value of 0.327.

Table 5.3: Box's Test of Equality of Covariance Matrices

Box's Test of Equality of Covariance Matrices	
Box's M	3.49
F	1.15
df1	3
df2	9978392
Sig.	.327

Moreover, homogeneity of variance checked by examining the result of Levene's Test of Equality of Error Variances. As Table 5.4. shows, there was no violation of homogeneity of variance assumption for both academic performance skills (p=0.448) and academic achievement (0.971).

Table 5.4: Levene's Test of Equality of Error Variances

	F	df1	df2	Sig.
Post-performance skills	.57	1	190	.448
Academic Achievement	.00	1	190	.971

5.2.1.6. Homogeneity of Regression Slopes

This assumption was assessed through syntax using the MANOVA program. In general, the test of the pooled covariates by the treatment (the experimental and the control group) showed that there was no interaction between the covariates and the treatment because, Sig of related F were found to be grater than .05.

In summary, preliminary analyses conducted to check the assumptions of MANCOVA, showed that there was no serious violation of the assumptions.

5.2.2. Multivariate Analysis of Covariance (MANCOVA)

Hypothesis: There is no statistically significant mean difference between students who taught by PBL and traditionally designed science instruction (TDSI) with respect to academic achievement and performance skills in the unit of genetics after controlling for their prior knowledge, prior performance skills, reasoning abilities and learning approaches.

A multivariate analysis of covariance was performed to investigate the effect of PBL and TDSI on students' academic achievement in Genetics and performance skills. The two dependent variables were academic achievement and performance skills measured after the treatment. The independent variable was the type of treatment: problem-based learning for the experimental group versus traditionally designed science instruction for the control group. Students' prior knowledge, prior performance skills, reasoning ability and learning approach were used as covariates in this analysis.

Table 5.5: Results of MANCOVA

Effect	Wilks' Lambda Value	F	Hypothesis df	Error df	Sig.	Partial Eta Squared
Reasoning Ability	.868	14.091	2.000	185.000	.000	.132
Learning Approach	.927	7.236	2.000	185.000	.001	.073
Prior Knowledge	.887	11.758	2.000	185.000	.000	.113
Prior Performance Skill	.901	10.210	2.000	185.000	.000	.099
Treatment	.904	9.812	2.000	185.000	.000	.096

Table 5.5 shows the results of the MANCOVA. As seen from the table, there was a statistically significant mean differences between the groups instructed by problem-based learning instruction and traditional instruction with respect to academic achievement and performance skills: Wilks' λ=,.904 $F(2,185)= 9.812$, p=.00, eta squared=.096. The multivariate eta-squared with the value of .096 signifies that about 10% of multivariate variance of dependent variables was related with the treatment. In addition, the results showed that reasoning ability (Wilks'λ= .868, $F(2,185)= 14.091$,

p=.00, eta squared=.132), learning approach (Wilks'λ= .927, F(2,185)= 7.236, p=.01, eta squared=.073), prior knowledge (Wilks'λ= .887, F(2,185)= 11.758, p=.00, eta squared=.113), and prior performance skill (Wilks'λ= .901, F(2,185)= 10.210, p=.00, eta squared=.099) significantly contributed to collective dependent variables.

Following univariate analyses were conducted in order to analyze the effectiveness of treatment on each dependent variable separately. Table 5.6 presents the findings of these analyses.

Table 5.6: Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	F	Sig.	Partial Eta Squared	Observed Power(a)
Reasoning Ability	Post Performance skill	4,225	1	2,589	,109	,014	,360
	Academic Achievement	224,880	1	28,330	,000	,132	1,000
Learning Approach	Post Performance skill	22,929	1	14,050	,000	,070	,962
	Academic Achievement	24,825	1	3,127	,079	,017	,421
Prior Knowledge	Post Performance skill	6,562	1	4,021	,046	,021	,514
	Academic Achievement	184,553	1	23,250	,000	,111	,998
Prior Performance Skill	Post Performance skill	33,504	1	20,529	,000	,099	,995
	Academic Achievement	14,373	1	1,811	,180	,010	,268
Treatment	Post Performance skill	11,030	1	6,759	,010	,035	,734
	Academic Achievement	140,217	1	17,664	,000	,087	,987
Error	Post Performance skill	303,549	186				
	Academic Achievement	1476,448	186				

According to the results shown in Table 5.6. there was a statistically significant difference between the experimental and the control groups with respect to academic achievement: F(1,186)=17.664, p=.00, eta squared=.09. In addition, a significant relationship was found between academic achievement and students' prior knowledge (F=23.250, p=.000), and reasoning ability (F=28.330, p=.000).

As it can be inferred form Table 5.6., there was a statistically significant difference between the experimental and the control groups on their performance skill: F(1,186)=6.76, p=.01, eta squared=.04. Moreover, a significant relationship were found between score of post-performance skill and prior knowledge (F=23.250, p=.000), prior performance skill (F=20.529, p=.000) and learning approach (F=14.050, p=.000).

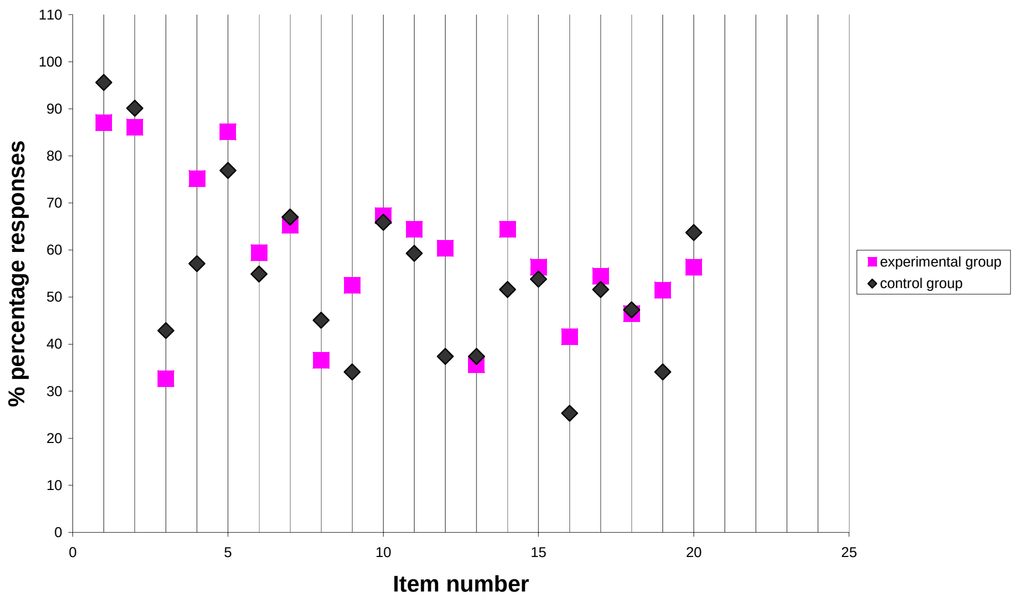


Figure 5.1: Comparison between post-Genetic Achievement Test scores of the experimental and the control groups

Descriptive statistics showed that the experimental group students (M=11.80, SD=3.348) had higher mean scores than the control group students (M=10.91, SD=3.318). At this point, it is important to note that , some of the items in the Genetic achievement test were in the knowledge level while others were comprehension and above in the Bloom's taxonomy. For this reason, students needed to realize interrelationships among the concepts and apply their knowledge about genetics to be able to respond to latter items correctly. Figure 5.1 shows the proportions of correct responses to each item in post Genetic Achievement Test for the control and the experimental groups. Analyzing the item responses indicated that, students in the control group appeared to be more successful in knowledge based items while the students in the experimental group in items which needs comprehension and higher order thinking skills. Moreover, the differences between the percentiles of students' responses in questions, which the experimental groups succeeded more, are higher than questions that the control groups succeeded.

More specifically, the first three items were at knowledge level and prepared to determine students' knowledge about genetic concepts like genotype, carrier, gene and chromosome. As seen from the figure, students in the control group likely to be more successful in these questions. Moreover, percentage of correct responses of the control group was higher for item 8 which assess students' knowledge on Mendel's laws.

On the contrary, percentage of correct responses for item 9, 12 and 14, which needs higher order thinking skills, was higher in the experimental groups. Question 9 was related to an experiment of a scientist in crossing of peas. Students were asked to predict the result of the experiment. They were expected to find out which treatments are dominant and recessive from the results of the experiment. Likewise, there was a striking difference between the experimental and the control groups concerning the percentiage of correct responses to item 12 which required students make an inference for parents genotypes from offspring In addition, it was necessary for students to apply their knowledge on the genetic concepts to select the correct answer. The reason of the highest percentage of correct responses for the experimental group may be that, they were asked to write problems to a given crossing situations in the worksheets by using the concepts that appeared in of this question (see Appendix M and Appendix S). Similarly, in item 14 concerning recessive diseases, students needed to infer the genotype of the family from their phenotype. This question required the ability to interpret a given pedigree. Students in PBL classes learned how to make inference concerning genotypes and phenotypes of a family or how to interpret pedigrees while dealing with ill-structured problems posed to them as cases form daily life. Therefore, they actively involved in the learning process and constructed knowledge by themselves. On the contrary, in the control group classes, the teacher explained the recessive diseases in humans, solved related problems, drown a pedigree on the blackboard and gave homework about pedigree of students' family.

Similarly, results in Table 5.6. showed that there was a statistically significant difference between the experimental and the control groups with respect to performance skills: $\underline{F}(1,186)=6.759$, $\underline{p}=.01$, eta squared=.04. In addition, a significant relationship was found between performance skill and students' prior knowledge (F=4.021, p=.05), prior performance skill (F=20.529, p=.000) and learning approach (F=14.050, p=.000). The experimental group students (M=2.63, SD=1.36) are found to have higher mean scores than the control group students (M=2.20 SD=1.45). Maximum possible score on the essay type item measuring performance skill was five.

While there were no students in the control group receiving five, there were students in the experimental group recording the maximum possible score. To be able to get this score students had to be able to select, organize and interpret the important information given in the case and use them by incorporating it with information from outside resources. Moreover, they had to articulate the uncertainties and minimize them, organize concepts and information, and reinterpret data when new information was obtained were attached importance. In addition, students had to approach the problem as a guide to build their learning not as a question that needs an answer. Results showed that PBL students appeared to be better in terms of these skills.

In summary, the findings indicates that there was a statistically significant mean difference between the control group, exposed to traditionally designed science instruction, and the experimental group, exposed to problem based learning, with respect to students' academic achievement and performance skills in the unit of genetics when students' prior knowledge, prior performance skills, reasoning abilities and learning approaches are controlled. Analysis of the effects of treatment showed that students exposed to PBL were more successful than students exposed to traditionally designed science instruction.

5.3. Students' Opinion about the Problem Based Learning

A survey instrument, prepared by Sungur (2004), was administered to students in the experimental group in order to get their opinions about the problem-based learning (see Appendix F). The representative responses of the students to survey questions are given below.

Q1. How do you describe PBL? In your opinion, what characteristics best describe PBL?

Student 11: PBL is a model that encourages students to do research and ask questions. The information is not given directly in PBL. Some clues are given in cases to help us reach the relevant information.

Student 26: it is a good method based on group working and research. In this method students learn by themselves. The teacher did not teach the subject directly. She helped us understand and construct knowledge by giving us some scenarios.

Student 202: a student centered method. Group working was done. In this way, different ideas were produced and therefore we could exchange our ideas. Students were encouraged to search, ask questions, exchange their ideas to learn and understand. It is an active learning method that makes us curious and feel responsible.

Student 267: in PBL model we formed groups and studied on scenarios. We talked about our ideas. We tried to find solutions through discussions. The session was very enjoyable. I feel that I understand more easily and better through this approach.

The purpose of this question was to specify students' perceptions about PBL (Sungur, 2004). Their responses revealed that students perceive PBL as a student centered method which helps them construct knowledge. They stated group work, presence of cases, and discussions as key elements of PBL.

Q2. Which of these characteristics contributed most to your learning?

Student 11: clues were the most contributed characteristic for me. Thus I could generate new ideas. I could think about the problem by intensifying on clues.

Student 27: for one thing, it made me inclined to search about something. It happened for the first time in 8 years! We learned to head for something together.

Student 217: the scenarios were the most contributed among all characteristics. Productivity to session was increased. Study and research took over. Because of this, nobody is passive anymore and so everybody has a chance to talk. Furthermore, we became more successful and we made an effort to learn.

Student 267 Firstly, because of the sessions became more enjoyable, the subjects were like easier. Sharing our ideas, and discussing them provided most contribution.

According to students, searching information individually then sharing them with their peers, generating ideas and discussing them through group work contributed to the learning. Moreover, they pointed out the importance of scenarios and clues in the promoting the learning by searching from different sources.

Q3. What aspects of PBL would you definitely change?

Student 8: I would not like to change anything because it is a very nice method.

Student 38: I would definitely exclude report writing.

Student 274: I would not change anything because everything works perfectly in this method.

Student 275: I would like to have2 or at most 3 people the most in each group instead of 6.

The students were generally pleased with the method. However, some students thought that it was hard to prepare reports and presentations. Some complained that the groups were crowded. However, as students' answers to the previous question revealed majority of students are aware of that group working is a beneficial characteristic of PBL.

Q4. What aspects of PBL would you definitely keep?

Student 221: scenarios based on real life.

Student 248: playing roles like in a theatre, and group working.

Student 260: small group work, cases and student involvement in accessing information should definitely be kept.

Student 25: in PBL, cases promote learning. We repeated subjects many times by preparing reports, and filling out what we know/ what we need to know table. We proposed solutions to given problems by generating *ideas and hypotheses. Because of all these, such activities in PBL must be implemented.*

Student 36: scenarios must be kept. Such cases based on real life can help students' understand subject matter easier. Even students with lower levels of motivation to learn can benefit from the cases. Because they are enjoyable.

The students pointed out the group work, scenarios and being responsible for their own learning as aspects of PBL that should definitely be kept in PBL. They also stated that they were enjoyed while playing roles, and subjects were understood well while searching information individually and using what we know/what we need to know table. Students' responses revealed that they were aware of the advantages of student-centered learning environments for themselves.

Q5. What problems were faced with during PBL?

Student 22: I did not have any difficulty at all. On the contrary, mentally, I learned to think and ponder. I thought more and I developed my logical thinking skills.

Student 271: I had difficulties in group working. At first, we sometimes argued about the roles but later we learned how to communicate with each other. Actually, these were nice memories. I learned to be respectful to others' opinions.

Student 36: I found it a little hard to prepare a report at the end of each case. Except that, there was no other problem.

Student 276: sometimes, we could not reach the information that we were searching for from the resources. However, even though our research took much time, we were able to find what we needed to know. We did not have any other difficulty. It was pretty clear and lucid.

The analysis of the students' answers showed that preparing report and research from different resources were difficult for them. Moreover, some students revealed that they had difficulty in adapting to group work.

Q6. How would you describe the ideal facilitator? (Science background, knowledge of group process, level of participation/guidance, etc.)

Student 29: she/he must be a good educator in every aspect and teach us to find the right solution by guiding us. In addition, he/she must have the ability of explaining subject well enough.

Student 27: she/he must not give the information directly and must encourage us to make an effort. One more thing, she/he must help us right on time when we need.

Student 202: firstly, the facilitator must be competent in the field and know about the purpose of this implementation as why it is applied and what it is supposed to teach us. His/her emphasis, mimics, and tonality must be appropriate and he/she must deal with all groups at all times. He/she must also inform us about the sources that we needed to search.

Student 205: I think, when students ask a question when they are stuck, the facilitator must not give the answer directly. The facilitator could explain that the students can find it themselves.

Students' answers showed that they are aware of the role of the teacher in PBL. They stated that an ideal facilitator should guide and promote them to do researches, and learn by themselves and should not give the answers or subjects directly.

Q7. What qualities do you think make for a good PBL student?

Student 21: he/she must express his/her ideas related to the subject and search about the theme. He/she must contribute to group work and be supported by other group members.

Student 263: he/she must research before coming to class, take responsibility of his/her duties and bring materials about the lesson to the class.

Student 275: a good PBL student is sensitive to subject, and is active, sociable, not a person who sits in the corner alone.

Student 36: students must be hard workers, they have to know how to research, how to learn well, how to listen to others. But the most important thing is being able to research and read a lot.

Students' answers showed that the most important quality to become a good PBL student is the ability to do research efficiently. In addition, they attached importance on sharing opinions and listening to others' ideas. Taking responsibility in group work was necessary, too.

Q8. How well written are the cases?

Student 15: they were quite well. Especially the cases related to diseases interested me. I understood Mendelian genetics and crossings better, thanks to these cases.

Student 22: they were nice. They made me curious. I wondered what was going to come in the following step after each event. New ideas raised in my mind after receiving each page. Thus I comprehended the subject better owing to the cases.

Student 265: they were pretty nice. I was pleased very much. We became closer to the real world by the help of the cases.

Student 7: I was informed about diseases that we examined in cases. I felt like a doctor myself and that made it easier for me to focus on the session.

Students were pleased with the cases and they thought that it was nice to have the cases based on real life.

Q9. Do you think that any of the skills that you acquired in PBL have made a difference in your other academic or social situations? If so, please explain?

Student 209: it widened my perspective in learning and this enabled me to perceive various ideas to a case in different ways.

Student 25: PBL increases solidarity in class, mutually respect and cooperation. Because it is based on research, it increases the acquiring knowledge. Besides, group working increases the densities of idea, suggestion, and thought.

Student 38: there is no change in my social life. If we talk about academic life, I learned information that I will never forget in my whole life.

Student 26: I can talk about my ideas more easily. It affected me positively in doing research. We sometimes discuss the cases respectfully with my friends out of class. Thus, we learn how to discuss in a considerate environment.

Students' answers revealed that they learned how to work in groups as a result of PBL. According to them, their social skills such as, communicating, sharing ideas, discussing subjects in a respectful manner and considering others' opinions were improved. They added that they reached life-long learning and their research skills were enhanced.

To sum up, students in general were pleased with the PBL implementation. They realized the important characteristics of PBL such as, cases, group work, research and taking responsibility of their own learning. They thought cases were important for PBL and these cases were conductive to learning, well prepared, amusing and provided a link between the subject and the real world. They mentioned that understanding the science lesson was easier with the cases. Furthermore, students were aware of the expected roles of the teacher and students; their answers indicated that a good facilitator should encourage them, give feedback when they needed it, and offer guidance. The facilitator is not supposed to provide the answers for the questions of students but to give them clues to help. Meanwhile, the role of the students is to learn subjects by doing research and small group discussions. According to students, an ideal PBL student must be active in the class, share ideas without hesitating, do research out of class and take the responsibilities, give importance to others' ideas and be able to discuss in a suitable manner in the group. They specified in the answer of 4^{th} question that they appreciated the importance of group working. Some students stated that they started to be more active in the class while some others have learned to respect others' ideas through group work and cases. On the other hand, PBL students explained that one of the problems they faced was regarding resources. However, they believe that they could get over the difficulties. In addition, most of the students stated in 3^{rd} question that they had difficulty in preparing reports although they were aware of importance of it in their learning. Finally, students' responses to the last question revealed that cases, searching for information and discussing with peers, helped them acquire knowledge that they will remember over a long time, while group working redounded their social interaction, self confidence to tell and defend their ideas, and communication..

5.4. Conclusions:

In conclusion, the result of the current study revealed that, students in PBL classes were more successful than the students taught by traditional teaching method, as revealed by mean academic achievement and performance skills determined after the treatment. Therefore, it appeared that, PBL students were more successful to use relevant information in addressing the problem, articulate uncertainties, organize concepts, and interpret information.

The results also underlined a significant contribution of students' reasoning ability, learning approach, prior knowledge and prior performance skills on their academic achievement and performance skills in Genetics.

CHAPTER 6

DISCUSSION

This chapter includes the discussion, internal and external validity threats, implications of the study, and recommendations for further research.

6.1. Discussion:

The present study aimed at investigating relative effectiveness of problem based learning and traditional designed instruction on students' academic achievement in Genetics and performance skills after controlling for their prior knowledge, learning approach and reasoning ability.

Before the treatment, Genetics Achievement Test, Learning Approach Questionnaire and Test of Logical Thinking were administered to determine students' prior knowledge and prior performance skills, learning approach and reasoning ability, respectively. Pre-test results were used to examine the equality of the control and the experimental groups with respect to collective variables. The analyses showed the similarity between groups with respect to reasoning ability and learning approach. However, a significant difference was found with respect to prior knowledge. To be able to equalize the groups, these variables were attained as the covariates. During the treatment, the Genetics concepts were taught to the experimental group students through PBL method while those concepts were taught to the control group students through traditional instruction method based on teacher explanations and textbooks. After the treatment, Genetics Achievement Test was implemented to measure the difference in scores between the experimental and the control groups. The items in the achievement test were at knowledge, comprehension and above levels in the Bloom's taxonomy. The experimental group students were more successful than the control group students, especially in the items that require higher order thinking or reasoning. For example, item 9 was a question that asks students the aim and the result of a crossing experiment. Students had to have the deep understanding of crossing and Mendel laws. Moreover, students needed to understand the experiment and identify the information, infer the genotypes of parents and possible offspring from their phenotypes by hypothesizing and testing in order to be able to generate a conclusion to answer. On the other hand, concerning the items at knowledge level, performance of the experimental group students and the control group students were comparable. Indeed, a meta-analysis, conducted by Dochy, Segers, Van den Bossche and Gijbels (2003) showed that PBL improves students' skills to apply knowledge, their general learning and thinking skills. In general, the findings of the present study is compatible with the assertions in the study by Gordon, Rogers, Comfort, Gavula and McGee (2001) claiming that PBL promoted students' critical thinking and Chin and Chia (2005) who state that PBL may develop students' scientific thinking. According to Krynock and Robb (1999), PBL students use crucial critical-thinking skills and think at a higher level.

Actually similar to the findings of the current study, McBroom and McBroom (2001) showed that students in PBL group scored significantly higher than students received traditional lecture in the Molecular genetics subjects at high school. Moreover, Gordon et al. (2001) stated that PBL improved middle school students' science grades.

Moreover, analysis of the essay type item in the post achievement tests showed that experimental group students surpassed the control group students with respect to performance skills. This means, the PBL students were more successful than the traditional students in their ability to use information to solve the problem, articulate uncertainties, organize and interpret the information and concepts, utilize the alternatives objectively, and approach the problem scientifically. In fact, in the literature, it is suggested that ill-structured problems encourage the creation of several hypotheses, solutions (Levin, 2001; Sage, 1996) and require considering alternatives by using personal opinions, organizing the content and the knowledge and the reasoning thinking (Hmelo-Silver & Barrows, 2006; Jonassen, 2000; Hung, 2006). Moreover, students learn how to collect and interpret the information through PBL since the problems are guides for students and teachers are facilitators (Chin & Chia, 2005; Hmelo-Silver, 2004; Song, Grabowski, Koszalka, & Harkness, 2006). Similar to the result of current study, Vernon and Blake (1993) found out in their meta-analysis that the PBL students' performances are better than students in traditional lectures. Additionally, Cerezo (2004) showed that PBL affected students' performance positively.

What is more, students' opinions about PBL were positive just like in the studies of Gordon et al. (2001) and Sage (1996). The students thought that cases, individual learning and group work, doing research and sharing ideas contributed to their learning during the PBL implementation. The students also explained that group work increased their social skills such as communicating, sharing ideas, discussing subjects in a respectful manner and considering others' opinions. This result is in line with the contention of Rivarola and Garcia (2000) who reported that team work is an effective way to encourage student participation and interaction, discussion, corporation and conceptual communication. Furthermore, Xiuping (2002) proposed that PBL produces team building skills. Moreover, McBroom and McBroom (2001) showed that PBL increases the interaction between students and their self-efficacy by providing them with problem-solving situations. Although the present study did not investigate the effect of PBL on self-efficacy, it is expected that PBL students develop higher sense of self-efficacy as they deal with problems and realize the link between their effort and progress.

When the covariates of the present study were taken into consideration, it was found that prior knowledge, prior performance skills, learning approach and reasoning ability contributed to academic achievement and performance skills. The relationship between achievement, and prior knowledge and reasoning ability reached an agreement with the findings in the literature. Majority of the studies showed that, prior knowledge and reasoning ability are the predictors of the achievement. Johnson and Lawson (1998) showed that while prior knowledge was the best predictor, reasoning ability was the second predictor of biology achievement. Similarly, Williams and Marek (1999) reasoning ability was the second predictor, followed the prior knowledge in the Physic concepts. In fact, Raine and Collett (2003) claimed that prior knowledge is a valid contribution to the group effort in PBL. Moreover, since the achievement test included items that require the higher order thinking skills and abstract level of thinking, it is reasonable to expect the effect of reasoning ability on academic achievement. Additionally, Johnson and Lawson (1998) stated that reasoning ability was an important factor to success in inquiry based instructions, like PBL. More specifically, Smith and Sims (1992) showed that reasoning ability had an important effect on the achievement in Genetics concepts. Same result were found in the studies of Cavallo (1996) and Smith and Sims (1992) who reported that reasoning ability is a contributory factor in the success of Genetics and problem solving. Furthermore, Lawson and Thomson (1988) revealed that reasoning ability is effective to overcome misconceptions in Genetics. In addition, Cavallo (1996) showed that learning approach was an important variable in students' genetics understanding, as meaningful learners performed better than rote learners. BouJaoude (1992) also found that meaningful learning positively influenced students' performance in chemistry. Furthermore, Cavallo, Rozman, Blickenstaff and Walker (2003) proposed that inquiry based courses requires meaningful learning rather than rote learning to be successful since this approach supports learning actively and meaningfully. According to Damnjanovic (1999), students are responsible to construct their own knowledge base and understanding in the inquiry classes. Additionally, Dipasquale, Mason and Kolkhorst (2003) stated that students learn and construct the new knowledge by questioning and seeking information, and in inquiry classes, critical thinking and integrating the new knowledge with previous experiences is required rather than rote memorization of concepts and facts. Therefore, learning approach is expected to be an important predictor of students' achievement in inquiry-based classes.

In sum, the results of the present study revealed that PBL approach has a positive effect on students' academic achievement and performance skills. Additionally, students' prior knowledge, prior performance skills, learning approach and reasoning ability are the contributors of the academic achievement and performance skills. Therefore, PBL method is suggested to use in elementary schools to improve students' academic achievement and performance skills in science lessons by providing them the opportunity to learn by themselves.

6.2. Validity Threats of the Study

6.2.1. Internal Validity of the Study

The school involved in the study was selected by convenience sampling. Moreover, intact classes were used during the treatment. This situation prevented random assignment of individuals, since the groups were already formed. On the other hand the control and the experimental groups were assigned randomly to the classes.

Some of the subject characteristics, such as gender, intelligence, attitude, prior knowledge, learning approach, reasoning ability, are possible threats for this study. In an attempt to equalize the experimental and the control groups with respect to prior knowledge, learning approach and reasoning ability, these variables were used as covariates. Other student characteristics can be considered in further research.

Location was not considered as a potential threat for this study since the implementations were made in similar conditions.

The effect of instrumentation threat was controlled by the administration of the tests by single person, the researcher. The researcher treated both groups equally during the implementation. Moreover, the essay type item was evaluated by two different people to avoid the data collector bias.

The researcher tried to prevent the implementation threat by training the teachers. Each teacher had both the experimental and the control groups during the treatment.

Confidentiality could not be a threat since the names of the participants known only by the researcher and names were not used in anywhere.

6.2.2. External Validity of the Study

Subjects of the study were selected in a convenience manner from the accessible population. In the present study, 192 8th grade students from just one school were involved. This can considered as a potential threat for external validity. The findings can be generalized to the schools that have the same conditions as library, computer laboratory and internet connection.

6.3. Implications of the Study

One of the main goal of science education is to grow up people who aware of the nature of the world and use of scientific processes. In order to achieve this end, new Turkish science curriculum was designed around inquiry based activities and student centered instructional methods. Present study revealed that PBL instructional method which is consistent with this approach. Indeed, PBL was found to help students recognize relevant information while dealing with a problem, generate and test the hypotheses, and construct new knowledge, learn in a meaningful manner rather than memorization.. Therefore, it is suggested that PBL should be integrated into science lessons taking the three main components –ill-structured problems, group work, and teacher as a facilitator– into consideration which are necessary for a successful PBL implementation. Accordingly, since the problems are the center of the PBL, the experts who have enough experience about science, education and PBL should prepare ill-structured problems linked with the real-world. In addition, the teachers should be trained about the implementation of the PBL because of their vital role as a facilitator in student learning. Lastly, the students should be encouraged to learn by themselves and work on open-ended tasks cooperatively, and explore the knowledge by hypothesizing and testing just like a scientist. Furthermore, students should be supplied with variety of resources which will allow them to make research through multimedia materials, computers, internet, and written materials.

Moreover, to be able to realize the true benefits of problem based learning, evaluation should be in accordance with this student-centered approach and not only students' knowledge but also their performance skills should be evaluated.

6.4. Recommendations for Further Research

1. The effect of PBL on achievement and performance skills in science topics other than Genetics can be investigated.
2. The effect of PBL on different grade levels can be investigated.
3. The effect of PBL on students from different schools can be investigated and compared.
4. The effect of PBL on retention can be investigated.
5. Some other instructional methods can be implemented in the unit of Genetics and compared with the effectiveness of PBL.
6. The effect of PBL on gifted or failed students' achievement and performance skills can be studied.

7. The effect of PBL on other different variables from achievement and performance skill, like motivation, reasoning ability, learning approach can be examined.
8. The items in the Genetics Achievement Test can be revised and new items can be added in order to increase internal consistency.
9. Sub-dimensions of Genetics Achievement Test can be investigated in order to determine effect of PBL on students' knowledge and higher order thinking skills separately.

REFERENCES

Arambula-Greenfield, T. (1996). Implementing Problem-based learning in a college science class. *Journal of College Science Teaching 26*(1), 26-30.

Archilles, C. M., & Hoover, S. P. (1996, November). *Exploring problem-based learning (PBL) in Grades 6-12*. Paper presented at the Annual Meeting of the Mid-South Educational Research Association, Tuscaloosa.

Askar, P. & Akkoyunlu, B. (1993). Kolb ögrenme stili envanteri. *Egitim ve Bilim, 17*(7), 37-48.

Ausubel, D. (1963). *The Psychology of Meaningful Verbal Learning*. New York: Grune & Stratton.

Ausubel, D. P. (1968). *Educational Psychology. A Cognitive View* New York: Holt, Rinehart and Winston.

Bahar, M., Johnstone, A. H., & Hansell, M. H. (1999). Revisiting learning difficulties in Biology. *Journal of Biological Education, 33*(2), 84-86.

Baker, W. P., & Lawson, A. E. (2001). Complex instructional analogies and theoretical concept acquisition in college genetics. *Science Education, 85*(6), 665-683.

Bitner, B. L. (1991). Formal operational reasoning modes: predictors of critical thinking abilities and grades assigned by teachers in science and mathematics for students in grades nine through twelve. *Journal of Research in Science Teaching, 28,* 265-274.

Blight, J. (2000). Problem-based learning the story continues to unfold. *Medical Education, 34*, 688-689.

BouJaoude, S. B. (1992). The relationship between students' learning strategies and the change in their misunderstandings during a high school chemistry course. *Journal of Research in Science Teaching, 29* (7), 687-699.

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

BouJaoude, S., & Barakat, H. (2003). Students' problem solving strategies in stoichiometry and their relationships to conceptual understanding and learning approaches. *Electronic Journal of Science Education, 7(3), March 2003*.

BouJaoude, S., Salloum, S., & Abd-El-Lhalick, F. (2004). Relationship between selective cognitive variables and students' ability to solve chemistry problems. *International Journal of Science Education, 23*(1), 63-84.

BouJoude, S. (1992). The relationship between students' strategies and the change in their misunderstandings during a high school chemistry course. *Journal of Research in Science Teaching, 29*(7), 687-699.

Burgess, K. L. (2004). Is your case a problem? *Journal of STEM Education, 5*, 1-2.

Cavallo, A. L. (1992). *The retention of meaningful understanding of meiosis and genetics.* Paper presented at a poster session at the Annual Conference of the National Association for Research in Science Teaching, Boston, MA.

Cavallo, A. M. L. (1994). Do females learn biological topics by rote more than males?. *The American Biology Teacher, 56*, 348-352.

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

Cavallo, A. M. L., & Rozman, M. (2004). Gender differences in learning constructs, shifts in learning constructs, and their relationship to course achievement in a structured inquiry, yearlong college physics course for life science majors. *School Science and Mathematics, 104*, 288-300.

Cavallo, A. M. L., Rozman, M., & Potter, W. H. (2004). Gender differences in learning constructs, shifts in learning constructs, and their relationship to course achievement in a structured inquiry, yearlong college physics course for life science majors. *School Science and Mathematics, 104*(6), 288-300.

Cavallo, A. M. L., Rozman, M., Blickenstaff, J., & Walker, N. (2003). Learning, reasoning, motivation and epistemological beliefs: differing approaches in college science courses. *Journal of College Science Teaching, 33*, 18-23.

Cavallo, A. M. L., & Schafer, L. E. (1994). Relationships between students' meaningful learning orientation and their understanding of genetics topics. *Journal of Research in Science Teaching, 31* (4), 393-418.

Cerezo, N. (2004). Problem-based learning in the middle school: A research case study of the perceptions of at-risk females. *Research in Middle Level Education Online, 27*(1), 20-23.

Chiappetta, E. L., & Russell, J. M. (1982). The relationship among logical thinking, problem solving instruction, and knowledge and application of earth science subject matter. *Science Education, 66*(1), 85-92.

Chin, C., & Chia, L. (2005). Problem-based learning: Using ill-structured problems in biology project work. *Sicence Education, 90*(1), 44-67.

Chin, C., & Chia, L. (2005). Problem-based learning: Using students' questions to drive knowledge construction. *Science Education, 88*(5), 707-727.

Curry, J. J. (2002). *Problem-based learning pathway student handbook*. The Ohio State University, College of Medicine and Public Health.

Dahlgren, M. A. (2000). Portraits of PBL: Course objectives and students' study strategies in computer engineering, psychology and physiotherapy. *Instructional Science, 28*, 309-329.

Damnjanovic, A. (1999). Attitudes toward inquiry-based teaching: Differences between preservice and in-service teachers. *School Science and Mathematics, 99*(2), 71-76.

De Grave, W. S., Schmidt, H. G., & Boshuizen, H. P. A. (2001). Effects of problem-based discussion on studying a subsequent text: A randomized trial among first year medical students. *Instructional Science, 29*, 33-44.

DeBacker, T. K. & Nelson, R. M. (2000). Motivation to learn science: Differences related to gender, class type, and ability level. *The Journal of Educational Research, 93*(4), 245 - 254.

DiPasquale, D. M., Mason, C. L., & Kolkhorst, F. W. (2003). Exercise in inquiry: Critical thinking in an inquiry-based exercise physiology laboratory course. *Journal of College Science Teaching, 23*(6), 388-393.

Dochy, F., Segers, M., Van den Bossche, P., & Gijbels, D. (2003). Effects of problem-based learning: A meta-analysis. *Learning & Instruction, 13*(5), 533-568.

Doig, K., & Werner, E. (2000). The marriage of traditional lecture-based curriculum and problem-based learning: Are the offspring vigorous? *Medical Teacher, 22*(2), 173-178.

Driessen, E., & Van Der Vleuten, C. (2000). Matching student assessment to problem-based learning: Lessons from experience in law faulty. *Studies in Continuing Education, 22*(2), 235-48.

Eck, J. C., & Mathews, D. G. (2000). A sample of assessment findings related to Samford University's problem-based learning initiative. *PBL Insight, 3*(3), 12-13.

Ehindero, O. J. (1979). Formal operational precocity and achievement in biology among some Nigerian high school students. *Science Education, 63*(2), 231-236.

Entwistle, N., & Ramsden, P. (1983). *Understanding Student Learning*. London and Canberra: Croom Helm.

Esiobu, G. O., & Soyibo, K. (1995). Effects of concept and vee mappings under tree learning modes on students' cognitive achievement in ecology and genetics. *Journal of Research in Science Teaching, 32*(9), 971-995.

Fink, F. K. (2002). Problem-based learning in engineering education: A catalyst for regional industrial development. *World Transactions on Engineering and Technology Education, 1*(1), 29-32.

Fosnot, C. T. (1989). *Enquiring Teachers Enquiring Learners: A constructivist approach for teaching*. New York : Teachers College Press.

Fraenkel, R., & Wallen, E. (1996). *How to Design and Evaluate Research in Education* (3rd ed.). New York: McGraw-Hill.

Fuller, R. G. (2001). *Physics curriculum reform: How can we do it?* Paper presented at the First International Girep Seminar, Udine.

Fyrenius, A., Bergdahl, B., & Silén, C. (2005). Lectures in problem-based learning – Why, when and how? An example of interactive lecturing that stimulates meaningful learning. *Medical Teacher, 27*(1), 61-65.

Galand, B., Bentein, B., Bourgeois, K., & Frenay, E. M. (2003, August). *The effect of PBL curriculum on students' motivation and self-regulation.* Paper presented at the Biennial conference of the European Association for Research on Learning and Instruction, Padova, Italy.

Gallagher, S. A., Stepien, W. J., Sher, B. T., & Workman, D. (1995). Implementing problem-based learning in science classrooms. *School Science and Mathematics. 95*(3), 136-146.

Geban, Ö., Aşkar, P., & Özkan, İ. (1992). Effects of computer simulated experiments and problem-solving approaches on high school students. *Journal of Educational Research, 86*, 5-10.

Gerber, B. L., Marek, E. A., & Cavallo, A. M. L. (1997). *Relationships among informal learning environments, teaching procedures and scientific reasoning ability*. Paper presented at the 1997 annual meeting of the National association for Research in Science Teaching, Oak Brook, IL, March 21-24, 1997.

Gilbert, J. K., Osborne, R. J., & Fensham, P. J. (1982). Children's science and its consequences for teaching. *Science Education, 66*(4), 623-633.

Gordon, P. R., Rogers A. M., Comfort, M., Gavula, N., & McGee, B. P. (2001). A taste of problem-based learning increases achievement of urban minority middle-school students. *Educational Horizons, 79*(4), 171-175.

Greenwald, N. (2000). Learning from problems. *The science teacher, 67*(4), 28-32.

Hansen, J. D. (2006). Using problem-based learning in accounting. *Journal of Education for Business, 81*(4), 221-224.

Harwood, W. S., & McMahon, M. M. (1997). Effects of integrated video media on student achievement and attitudes in high school chemistry. *Journal of Research in Science Teaching, 34*(6), 617-631.

Heim, W. G. (1991). What is a recessive Allele? *The American Biology Teacher, 53*(2), 94-97.

Hinkle, D. E., Wiersma, W., & Jurs, S. G. (2003). *Applied Statistics for the Behavioral Sciences* (5th ed.). New York: Houghton Mifflin Company.

Hmelo-Silver, C. E. (2004). Problem-based learning: what and how do students learn? *Educational Psychology Review, 16*(3), 235-266.

Hmelo-Silver, C. E., & Barrows, H. S. (2006). Goals and strategies of a problem-based learning facilitator. *Interdisciplinary Journal of Problem-based Learning, 1*(1), 21-39.

Hung, W. (2006). The 3C3R model: A conceptual framework for designing problems in PBL. *Interdisciplinary Journal of Problem-based Learning, 1*(1), 55-77.

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

Jonassen, D. H. (2000). Toward a design theory of problem solving. *Educational tehcnology research & Development*, 48(4), 63-85.

Karabulut, U. S. (2002). *Curricular elements of problem-based learning that cause developments of self-directed learning behaviors among students and its implications on elementary education.* Unpublished doctoral dissertation, The University of Tennessee, Knoxville.

Keleş, Ö., Uşak, M., & Aydoğdu, M. (2006). Elementary school 8th degree science lessons “genetics” chapter effect of comprehension of DNA Watson-Crick model with in-class applications to student success. *International Journal Of Environmental and Science Education, 1*(1),53-64.

Kindfield, A. C. H. (1991). Confusing chromosome number and structure: a common student error. *Journal of Biological Education, 25*(3), 193-200.

Knippels, M. P. J., Waarlo, A. J., & Th Boersma, K. (2005). Design criteria for learning and teaching genetics. Journal of Biological Education, 39(3), 108-112.

Kolb, D. A. (1985). *Learning style Inventory. Self -scoring Inventory and Interpretation Booklet*. McBer and Co., Boston MA.

Krynock, K., & Robb, L. (1999). Problem solved: How to coach cognition. *Association for Supervision and Curriculum Development, 57*(3), 29-32.

Law, N., & Lee, Y. (2004). Using an iconic modelling tool to support the learning of genetics concepts. *Journal of Biological Education, 38*(3), 118-141.

Lawson, A. E. (1982), Formal reasoning, achievement, and intelligence: An issue of importance. *Science Education, 66,* 77-83.

Lawson, A. E., Banks, D. L., & Logvin, M. (2007). Self-efficacy, reasoning ability, and achievement in college biology. *Journal of Research in Science Teaching, 44*(5), 706-724.

Lawson, A.E., & Thomson, L.D. (1988). Formal reasoning ability and misconceptions concerning genetics and natural selection. *Journal of Research in Science Teaching, 25*, 733-746.

Levin, B. (2001). *Energizing Teacher Education and Professional development with Problem-Based Learning*. Alexandria, VA: Association for Supervision & Curriculum Development.

Lewis, J. and Kattman, U. (2004). Traits, genes, particles and information – Revisiting students' understandings of genetics. *International Journal of Science Education. 26*(2), 195-206.

Lewis, J., & Leach, J. (2004). Traits, genes, particles and information: Re-visiting students' understandings of genetics. *International Journal of Science Education, 26*(2), 165-206.

Lewis, J., & Wood-Robinson, C. (2000). Genes, chromosomes, cell division and inheritance – Do students see any relationship? *International Journal of Science Education, 22*(2), 177-195.

Lewis, J., Leach, J., & Wood-Robinson, C. (2000a). All in the genes? – Young people's understanding of the nature of genes. *Journal of Biological Education, 34*(2), 74-79.

Lewis, J., Leach, J., & Wood-Robinson, C. (2000b). What's in a cell? - Young people's understanding of the genetic relationship between cells, within an individual. *Journal of Biological Education, 34*(3), 129-132.

Lewis, J., Leach, J., & Wood-Robinson, C. (2000c). Chromosomes: The missing link – Young people's understanding of mitosis, meiosis, and fertilization. *Journal of Biological Education, 34*(4), 189-199.

Lord, T. R. (1994). Using constructivism to enhance student learning in college biology. *Journal of College Science Teaching, 23*(6), 346-48.

Lynch, C.L. & Wolcott. S.K. (June 25, 2003). Steps for Better Thinking Rubric. Retrieved February, 11, 2006, from http://www.WolcottLynch.com.

Mackinnon, J. (2006). Problem based learning and New Zealand legal education. *Web Journal of Current Legal Issues*, [2006](3).

McBroom, D. G., & McBroom, W. H. (2001). Teaching molecular genetics to secondary students: An illustration and evaluation using problem-based learning. *Problem Log, 6*, 2-4.

McKeachie, W. J. (2002). *Teaching Tips: Strategies, Research, and Theory for College and University Teachers* (8th ed.). USA: Houghton Mifflin Company.

Mierson, S. (1998). A problem-based learning course in physiology for undergraduate and graduate basic science students. *Advances in Physiology Education, 20*(1), 16-28.

Mwamwenda, T. S. (1993). Formal operations and academic achievement. *Journal of Psychology Interdisciplinary and Applied, 127*, 99-102.

Ngeow, K., & Kong, Y. (2001). *Learning to learn: Preparing teachers and students for problem-based learning.* ERIC Clearinghouse on Reading English and Communication Bloomington IN. (ERIC Document Reproduction Service No. ED 457524)

Norman, G. R., & Schmidt, H. G. (2000). Effectiveness of problem-based learning curricula: Theory, practice and paper darts. *Medical Education, 34*, 721-728.

Okebukola, P. A. (1990). Attaining meaningful learning of concepts in genetics and ecology: an examination of the potency of the concept-mapping technique. *Journal of Research in Science Teaching, 27*(5), 493-504.

Oliva, J. M. (2003). The structural coherence of students' conceptions in mechanics and conceptual change. *International Journal of Science Education, 25*, 539-561.

Orcajo, T. I., & Aznar, M. M. (2005). Solving problems in Genetics II: Conceptual restructuring. *International Journal of Science Education, 27*(12), 1495-1519.

Pallant, J. (2001). *SPSS survival manual : A step by step guide to data analysis using SPSS for Windows*. Buckingham : Open University Press.

Paris, S.C., & Paris, A. H. (2001). Classroom applications of research on self-regulated learning. *Educational Psychologist, 36*, 89-101.

Plucker, J. N., & Nowak, J. (1999). How to Use Problem-Based Learning in the Classroom. *Roeper Review, 22*(1), 69.

Raine, D., & Colett, J. (2003). Problem-based learning in astrophysics. *European Journal of Physics, 24*, 41-46.

Rivarola, V. A., & Garcia, M. B. (2000). Problem-based learning in veterinary medicine: protein metabolism. *Biochemical Education, 28*, 30-31.

Robins, J. (2005). Beyond the bird unit. *Teacher Librarian, 33*(2), 8-19.

Rotbain, Y., Marbach-Ad, G., & Satvy, R. (2006). Effect of bead and illustrations models on high school students' acheivement in molecular genetics. *Journal of Research in Science Teaching, 43*(5), 500-529.

Sage, S. M. (1996, April). *A qualitative examination of problem-based learning at the K-8 Level: Preliminary findings*. Paper presented at the Annual Meeting of the Mid-South Educational Research Association. New York.

Saka, A., Cerrah, L., Akdeniz, A. R., & Ayas, A. (2006). A cross-age study of the understanding of three genetic concepts: How do they image the gene, DNA and chromosome? *Journal of Science Education and Technology, 15*(2), 192-202.

Salvatori, P. (2000). Implementing a problem-based learning curriculum in occupational therapy: A conceptual model. *Australian Occupational Therapy Journal, 47*, 119-133.

Savery, J. R. (2006). Overview of problem-based learning: Definitions and distinctions. *Interdisciplinary Journal of Problem-based Learning, 1*(1), 9-20.

Savery, J. R., & Duffy, T. M. (1995). Problem Based Learning: An instructional model and its constructivist framework. *Educational Technology, 35*, 31-38.

Savoie, J. M., & Hughes, A. S. (1994). Problem-based learning as classroom solution. *Educational leadership, 52*(3), 54-57.

Silberman, M. (1996). *Active Learning: 101 Strategies to teach any subject*. United States of America: Allyn and Bacon.

Slack, S. J, & Stewart, J. (1990). High school students' problem-solving performance on realistic genetic problems. *Journal of Research in Science Teaching, 27*(1), 55-67.

Smith, M. U., & Sims, O. S. (1992). Cognitive development, genetics problem solving, and genetics instruction: A critical review. *Journal of Research in Science Teaching, 29*(7), 701-713.

Song, H., Grabowski, B. L., Koszalka, T. A., & Harkness, W. L. (2006). Patterns of instructional-design factors prompting reflective thinking in middle-school and college level problem-based learning environments. *Instructional Science, 34*(1), 63-87.

Spronken-Smith, R. (2005). Implementing a problem-based learning approach for teaching research methods in geography. *Journal of Geography in Higher Education, 29*(2), 203-221.

Sungur, S. (2004). *An implementation of problem based learning in high school biology courses*. A Thesis Submitted to the Graduate School of Natural and Applied Sciences of the Middle East Technical University, Ankara, in Partial Fulfillment of the Department of the Requirements for the Degree of Doctor of Philosophy in the Department of Secondary Science and Mathematics Education.

Sungur, S., & Tekkaya, C. (2003). Students' achievement in human circulatory system unit: the effect of reasoning ability and gender. *Journal of Science Education and Technology*, *12*, 59-64.

Sungur, S., Tekkaya, C., & Geban Ö. (2006). Improving achievement through problem-based learning. *Journal of Educational Research, 40*(4), 155-160.

Sungur, S., Tekkaya, C., & Geban, Ö. (2001). The contribution of conceptual change texts accompanied by concept mapping to students' understanding of the human circulatory system. *School Science and Mathematics, 101*, 91-101.

Şahin, F., & Parim, G. (2002). *Problem tabanlı öğretim yaklaşımı ile DNA, gen ve kromozom kavramlarının öğretilmesi*. In *V. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi Bildiriler Kitabı* (pp. 28-33). Odtü, Ankara.

Şenocak, E., & Taşkesengil, Y. (2005). Probleme dayalı öğrenme ve fen eğitiminde uygulanabilirliği. *Kastamonu Eğitim Dergisi, 13*(2), 359-366.

Taber, K. S. (2004). Understanding, assessment and 'elliptical' thinking. *Physics Education, 39*(4). 318-319.

Tatar, N., & Cansüngü-Koray, Ö. (2005). İlköğretim sekizinci sınıf öğrencilerinin 'genetik' ünitesi hakkındaki kavram yanılgılarının belirlenmesi. *Kastamonu Eğitim Dergisi, 13*(2), 415-426.

Thomson, N., & Stewart, J. (2003). Genetics inquiry: strategies and knowledge geneticists use in solving transmission genetics problems. *Science Education, 87*(2), 161-80.

Tobin, K. G., & Capie, W. (1982). Relationships between formal reasoning ability, locus of control, academic engagement and integrated process skill achievement. *Journal of Research in Science Education, 19*, 113-121.

Tobin, K. G., & Capie, W. (1981). The development and validation of a group test of logical thinking. *Educationa and Psychologica Measurement, 41*, 413 - 423.

Torp, L., & Sage, S. (2002). *Problems as possibilities: problem-based learning for K-16 education* (2nd ed.). Alexandria, VA: Association for Supervision and Curriculum Development.

Tsui, C., & Treagust, D. (2003). Learning genetics with computer dragons. *Journal of Biological Education, 27*(2), 96-98.

Tsui, C., & Treagust, D. (2004). Conceptual change in learning genetics: an ontological perspective. *Research in Science and Technology Education, 22*(2), 185-202.

Uyeda, S., Madden, J., Brihjam, L. A., Luft, J. A., & Washburne, J. (2002). Solving authentic science problems: Problem-based learning connects science to the world beyond school. *The science teacher, 69*(1), 24-29.

Valanides, N. C. (1996). Formal reasoning and science teaching. *School Science and Mathematics, 96*, 99-107.

Vass, E., Schiller, D., & Nappi, A. J. (2000). The effects of instructional intervention on improving proportional, probabilistic, and correlational reasoning skills among undergraduate education majors. *Journal of Research in Science Teaching, 37,* 981-995.

Vernon, D. T., & Blake, R. L. (1993). Does problem-based learning work? A meta-analysis of evaluative research. *Academic Medicine, 68*(7), 550-563.

West, S. A. (1992). Problem-based learning-A viable addition for secondary school science. *School Science Review, 73*, 47-55.

Williams, K. A., & Marek, E. A. (2000). *Ausubel and Piaget: A contemporary investigation*. DC (ERIC Document Reproduction Service No. ED441687)

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

Wood-Robinson, C., Lewis, J., & Leach, J. (2000). Young people's understanding of the nature of genetic information in the cells of an organism. *Journal of Biological Education, 35*(1), 29-36.

Xiuping, Z. (2002). The combination of traditional teaching method and problem based learning. *The China Papers*, *1*, 30-36.

Yenilmez, A. (2006). *Exploring relationships among students' prior knowledge, meaningful learning orientation, reasoning ability, mode of instruction and understanding of photosynthesis and respiration in plants*. A Thesis Submitted to the Graduate School of Social Sciences of Middle East technical University, Ankara, in Partial Fulfillment of the Requirements for the Degree of Master of Science in Elementary Science and Mathematics Education.

APPENDICES

APPENDIX A

ÖĞRENME STİLLERİ ENVANTERİ

Aşağıda her birinde dörder cümle bulunan on iki tane durum verilmektedir. Her durum için size en uygun cümleyi 4, ikinci uygun olanı 3, üçüncü uygun olanı 2, en az uygun olanı ise 1 olarak ilgili cümlenin başında bırakılan boşluğa yazınız. Teşekkür ederim.

Örnek:	Hatırlamanız için:
Öğrenirken __4__ mutluyum.	4 – en uygun olan
__1__ hızlıyım.	3 – ikinci uygun olan
__2__ mantıklıyım.	2 – üçüncü uygun olan
__3__ dikkatliyim.	1 – en az uygun olan

1. Öğrenirken --- duygularımı göz önüne almaktan hoşlanırım --- izlemekten ve dinlemekten hoşlanırım. --- fikirler üzerine düşünmekten hoşlanırım. --- birşeyler yapmaktan hoşlanırım.	7. En iyi --- kişisel ilişkilerden öğrenirim --- gözlemlerden öğrenirim. --- akılcı kuramlardan öğrenirim. --- uygulama ve denemelerden öğrenirim.
2. En iyi --- duygularıma ve önsezilerime güvendiğimde öğrenirim --- dikkatlice dinlediğim ve izlediğimde öğrenirim. --- mantıksal düşünmeyi temel aldığımda öğrenirim. --- birşeyler elde etmek için çok çalıştığımda öğrenirim.	8. Öğrenirken --- kişisel olarak o işin bir parçası olurum. --- işleri yapmak için acele etmem. --- kuram ve fikirlerden hoşlanırım. --- çalışmamdaki sonuçları görmekten hoşlanırım.

3. Öğrenirken --- güçlü duygu ve tepkilerle dolu olurum. --- sessiz ve çekingen olurum. --- sonuçları bulmaya yönelirim. --- yapılanlardan sorumlu olurum.	9. En iyi --- duygularıma dayandığım zaman öğrenirim. --- gözlemlerime dayandığım zaman öğrenirim. --- fikirlerime dayandığım zaman öğrenirim. --- öğrendiklerimi uyguladığım zaman öğrenirim.
4. Öğrenirken --- duygularımla öğrenirim. --- izleyerek öğrenirim. --- düşünerek öğrenirim. --- yaparak öğrenirim.	10. Öğrenirken --- kabul eden biriyim. --- çekingen biriyim. --- akılcı biriyim. --- sorumlu biriyim.
5. Öğrenirken --- yeni deneyimlere açık olurum. --- konunun her yönüne bakarım. --- analiz etmekten ve onları parçalara ayırmaktan hoşlanırım. --- denemekten hoşlanırım.	11. Öğrenirken --- katılırım. --- gözlemekten hoşlanırım. --- değerlendiririm. --- aktif olmaktan hoşlanırım.
6. Öğrenirken --- sezgisel biriyim. --- gözleyen biriyim. --- mantıklı biriyim. --- hareketli biriyim	12. En iyi --- akılcı ve açık fikirli olduğum zaman öğrenirim. --- dikkatli olduğum zaman öğrenirim. --- fikirleri analiz ettiğim zaman öğrenirim. --- pratik olduğum zaman öğrenirim.

APPENDIX B

GENETİK BAŞARI TESTİ

Ad Soyad:
Sınıf:

Bölüm 1.

Bu bölümde 20 adet çoktan seçmeli soru bulunmaktadır. Her soruda size göre en doğru olan cevabı işaretleyiniz.

1) Aşağıdakilerden hangisi bir organizmanın genetik yapısına verilen addır?

a) Fenotip
b) Genotip
c) Dominant (Baskın)
d) Resesif (Çekinik)

2) Herhangi bir hastalık genini bulunduran fakat kendisi sağlıklı olan bireye ne ad verilir?

a) Resesif (Çekinik)
b) Taşıyıcı
c) Arı döl
d) Homozigot

3)

I- Gen
II- Organizma
III- DNA
IV- Çekirdek
V- Kromozom

Yukarıdaki kavramların büyükten küçüğe doğru sıralanışı aşağıdakilerden hangisidir?

a) II – IV – I – V– III **b)** II – IV – V – III – I
c) IV – II – V – I – III **d)** IV – II – I – V – III

4) Genotipleri; I.SS II.Ss III. ss
olan bireylerden fenotipleri aynı olanlar, aşağıdakilerden hangisinde verilmiştir?

a) I ve II **b)** II ve III
c) I ve III **d)** I, II ve III

5) Bir kadında aşağıda verilen hücre çeşitlerinden hangisi monoploit (haploit) kromozom içermektedir (n kromozoma sahiptir)?

a) Sinir **b)** Deri **c)** Yumurta **d)** Kas

6) Görme bozukluğuna sebep olan geni taşıyan bir kadının çocuklarını bu hastalıktan korumak için hatalı genin onarılması gereken yer aşağıdakilerden hangisidir?

a) Göz hücreleri **b)** Kan hücreleri
c) Sinir hücreleri **d)** Üreme hücreleri

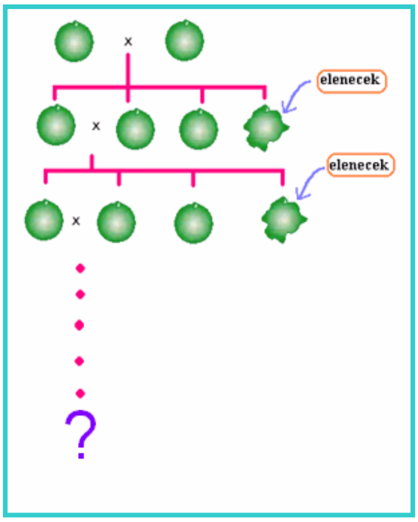
7) Herhangi bir özellik açısından heterozigot bir gene sahip birey aşağıdakilerden hangisine sahiptir?

a) Gene ait 2 özdeş alele
b) Gene ait 2den fazla kopyaya
c) Gene ait 2 farklı alele
d) Gene ait 2 özdeş kopyaya

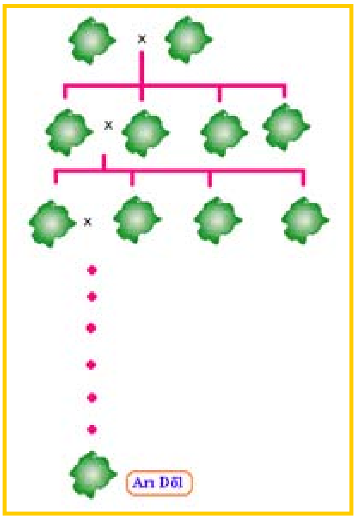
8) Aşağıdakilerden hangisi Mendel'in deneylerinden çıkan sonuçlardan biri değildir?

a) Karakterlerin kalıtımını belirleyen genler vardır
b) Aleller değişmeden eşit olasılıkla gametlere dağılır
c) Her karakter için bir canlıda birbirine benzeyen (AA, aa) veya farklı (Aa) iki gen vardır.
d) Bazı karakterlerin dişilerde ve erkeklerde görülme oranı farklıdır.

9)



Şekil 1



Şekil 2

Bir bilim insanı bezelye tohumlarının buruşuk veya düz olduğunu farketmiştir.

Düz olan bezelye tohumlarını birbirleri ile çaprazladığında düz ve buruşuk bezelyeler elde etmiştir. Fakat düz bezelyelerin buruşuk bezelyelere göre daha yüksek oranda çıktığını farketmiştir. (Şekil 1)

Buruşuk bezelyeleri birbiriyle çaprazladığında ise Şekil 2'deki gibi sadece buruşuk bezelyeler ortaya çıktığını görmüştür. Bilim insanı daha sonraki deneylerinde düz bezelyeleri defalarca çaprazlamış ve meydana gelen tüm buruşuk bezelye döllerini eleyerek sonraki çaprazlamalara katmamıştır.

Bu deney sonucunda bilim insanı aşağıdaki döllerden hangisine ulaşır?

a) Homozigot dominant (BB) **b)** Heterozigot (Bb)
c) Homozigot resesif (bb) **d)** Kesin birşey söylenemez

10) Bezelyelerde, bezelye tanelerinin rengini belirleyen genlerden sarı gen (A) yeşil gene(a) baskındır. Buna göre baskın genin çekinik gen üzerine olan etkisini her dölde incelemek isteyen bir bilim insanı nasıl genotiplere ve fenotiplere sahip bezelyeleri çaprazlamalıdır?

a) Sarı (AA) ve Sarı (AA)
b) Yeşil (aa) ve Yeşil (aa)
c) Sarı (Aa) ve Yeşil (aa)
d) Sarı (AA) ve Yeşil (aa)

11) İki bezelye çaprazlandığında 750 uzun, 250 kısa gövdeli bezelye elde edildiğine göre, çaprazlanan bezelyelerin gen durumları hangisidir? (U= uzun, u= kısa)

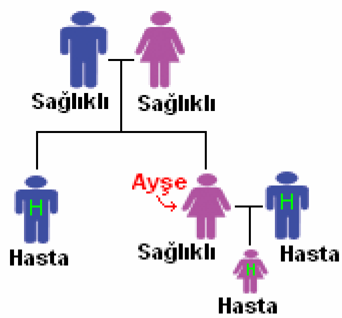
a) uu x uu **b)** Uu x uu
c) Uu x Uu **d)** UU x uu

12) Dominant uzun boylu ve resesif kısa boylu bezelyelerin çaprazlanması ile elde edilen döllerin ½ si uzun boylu olduğuna göre, çaprazlanan bezelyelerin karakteri hangisidir?

a) Melez dominant – Arı döl resesif
b) Arı döl resesif - Arı döl dominant
c) Arı döl dominant – Melez dominant
d) Melez dominant – Melez dominat

13) Farklı karakterlerde iki arı döl çaprazlandığında, resesif karakter hangi dölde, hangi oranda görülür?
a) F_1; 1/1 **b)** F_2; 3/4
c) F_2; 1/4 **d)** F_2: ½

14) Yandaki şema Ayşe ve ailesini temsil etmektedir.



Annesi, babası ve kendisi sağlıklı olan Ayşe'nin erkek kardeşi genetik bir hastalığa sahiptir. Ayşe aynı hastalığa sahip bir kişiyle evlendiğinde hasta bir kızı olmuştur.

Ayşe'nin genotipi hakkında ne söyleyebilirsiniz?

a) AA **b)** Aa **c)** aa **d)** Kesin Birşey Söylenemez

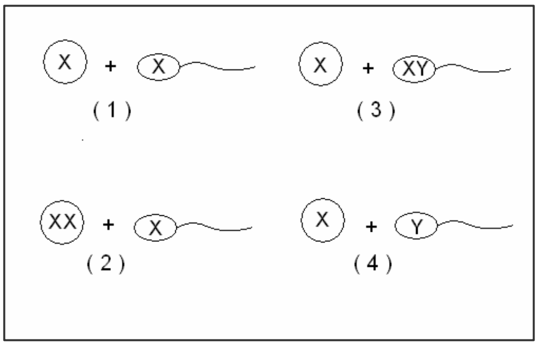
15) Sağ elini kullanma dominant (baskın / B) bir genden, solaklık ise resesif (çekinik / b) genden kaynaklanır. Buna göre sağ elini kullanan anne ve babanın çocuğu solak ise anne ve babanın genotipleri nasıldır?

a) BB x BB
b) bb x bb
c) BB x bb
d) Bb x Bb

16) Aslı ve Hakan evlenmeyi düşünüyorlar. Her ikisi de orak hücreli anemi hastası birer kardeşe sahipler. Kendileri ve anne babaları sağlıklı olmasına rağmen kardeşlerinde görülen bu hastalığın ileride çocuklarında da görülmesinden korkuyorlar. Bir genetik uzmanı olsaydınız bu durumda çifte aşağıdakilerden hangisini söylerdiniz?

- **a)** Çocuklarınızın hiçbirisi hasta olamaz
- **b)** Çocuklarınızın 1/4 oranında hasta olma ihtimali vardır
- **c)** Tüm çocuklarınız hasta olacaktır
- **d)** Çocukların hepsi sağlıklı olabilir fakat emin olmak için hepsine kan testi yapılmalıdır.

17. ve **18.** soruları aşağıdaki şekile göre cevaplayınız.



17) Yandaki şekle göre hangi durum normal bir erkek meydana getirir?

a) 1 **b)** 2 **c)** 3 **d)** 4

18) Yandaki şekle göre hangi durum normal bir kadın meydana getirir?

a) 1 **b)** 2 **c)** 3 **d)** 4

19) Hemofili eşey kromozomlarıyla taşınan bir hastalıktır. Bu hastalığın erkeklerde kadınlara oranla daha sık görülmesinin sebebi aşağıdakilerden hangisidir?

- **a)** Hemofili geni Y kromozomuyla taşınır
- **b)** Eşey kromozomuyla taşınan bir gen anneden kızına asla geçmez
- **c)** X kromozomuyla taşınan hastalıkların kadınlarda görülmesi için aynı alelden 2 adet olmalıdır.
- **d)** Eşeye bağlı hastalıklar kadınlarda asla görülmez.

20) Renkkörlüğü hastalığına X kromozomu üzerindeki çekinik bir gen neden olmaktadır. Buna göre renkkörü bir kadın ile normal bir erkek evlenirse, çocukları için aşağıda verilen durumlardan hangisi söylenebilir?

- **a)** Tüm çocuklar renk körü olur.
- **b)** Tüm çocuklar normal olur.
- **c)** Tüm kızlar renk körü, tüm erkekler normal olur.
- **d)** Tüm kızlar taşıyıcı, tüm erkekler renk körü olur.

Bölüm 2.

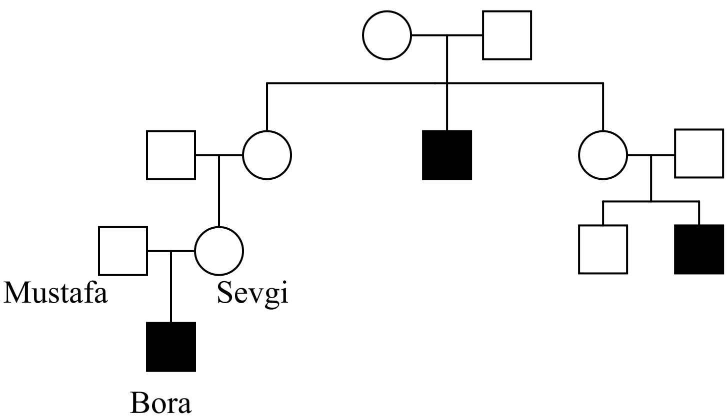
Bu bölümde bir örnek olay ve örnek olaya dayalı sorular bulunmaktadır. Örnek olayı okuyunuz ve bilgiler doğrultusunda soruları cevaplayınız.

Örnek olay:

Hacettepe hastanesinde çocuk doktoru olduğunuzu varsayın, Mustafa ve Sevgi çifti 8 aylık Bora isimli bebeklerini ağız içindeki kanamadan dolayı size getirdi. Bora ağzına darbe almamış, hiçbir yere çarpmamıştır. Aile kanamanın görünür bir sebebi olmadığını kanama başladığında diş çıkarmadan kaynaklanabileceğini düşündüklerini ama kanama durmayınca hastaneye getirdiklerini belirtmişlerdir.

Aile ile yapılan görüşmeler sonucunda akrabalarda kanama ile ilgili problemler yaşayan ve hayatını kaybeden bireyler olduğu tesbit edilmiştir. Sevgi, teyzesinin 2 oğlundan yalnızca birisinin oyun esnasında yaralandığında yaralarının çok kanadığını veya hafif darbeler aldığında dahi vücudunda morarmalar olduğunu belirtmiştir. Ayrıca Sevgi, dayısının yıllar önce köyde bir kaza geçirdiğini, kazadaki diğer insanlar gibi hafif yaralanmasına rağmen aşırı kan kaybından öldüğünü hatırlamıştır. Bunun haricinde Sevgi'nin ailesinde benzer şikayetlere sahip kimse bulunmamaktadır. Mustafa'nın ailesinde ise benzer rahatsızlıklar görülmemiştir.

Bu bilgilere dayanarak şu şekilde bir soy ağacı çizdiniz;



Sorular:

a) Örnek olayda önemli gördüğünüz bilgileri kendi cümlelerinizle sıralayın.

b) Örnek olayda bebekte görülen rahatsızlığın nedeni ne olabilir? Düşüncelerinizi örnek olayda verilen bilgiler doğrultusunda açıklayın.

c) Bebekte görülen rahatsızlık hangi vücut sistemini etkilemiş olabilir?Nicin?

APPENDIX C

RUBRIC

Performans Becerileri			
A	**B**	**C**	**D**
* Problemin çözümü için gerekli bilgilerin seçilebilmesi ve kullanımı *Belirsizliklerin ifadesi	* Bilginin organize edilmesi *Bilginin yorumlanması	*Farklı alternatiflerin objektif olarak değerlendirilmesi için prensiplerin, rehber niteliği taşıyacak bilgilerin kullanımı	* Probleme genel yaklaşım

1 Puan	2 Puan	3 Puan	4 Puan	5 Puan
(A, B, C, D performans becerilerinin hepsi zayif ise)	**(A performans becerisi yeterli fakat B, C, D performans becerileri zayif ise)**	**(A, B performans becerileri yeterli fakat C, D performans becerileri zayif ise)**	**(A, B, C performans becerileri yeterli fakat D performans becerisi zayif ise)**	**(A, B, C, D performans becerilerinin hepsi yeterli ise)**
Daha çok gerçekler ve üzere çok az bilgi kullanilmis Eger bir takim belirsizilikler ifade edilmis ise, bu daha çok sahip olunan bilginin eksikligine baglanmis ya da konunun uzmanlari tarafindan aydinlatilacak geçici belirsizlikler olarak ortaya atilmistir	Daha çok genel olarak varilan sonucu destekleyen bilgiler ve edinilen veriler olmak üzere az bilgi kullanilmis Eger bir takim belirsizilikler ifade edilmis ise, bu belirsizlik için en az bir neden gösterilmis	Dikkatlice degerlendirilerek gözden geçirilmis, probleme ilgili çesitli bilgiler kullanilmis Belirsizliklere iliksin nedenler ve bu belirsizliklerden kaynaklanan güçlükler ifade edilmis	Farkli çözüm yollarinin degerlendirilmesine olanak saglayan kriterleri de içine alan dikkatlice degerlendirilerek gözden geçirilmis, problemle ilgili çesitli bilgiler kullanilmis Farkli belirsizlikler ve bu belirsizliklerin kaynaklarinin göreceli önemi ortaya konmus	Farkli çözüm yollarinin degerlendirilmesine olanak saglayan kriterleri de içine alan dikkatlice degerlendirilerek gözden geçirilmis, probleme ilgili çesitli bilgiler kullanilmis ve çözüm yollarinin limitasyonlarini ortaya koyan bilgileri meydana çikaracak uygulanabilir stratejiler gelistirilmis Devam eden arastirma sirasinda ortaya çikan belirsizlikleri minimum düzeye indirmek için gerekli çaba ortaya konmuş

* Bilgi dogru, yanlis, ya da belirsiz olarak kategorilere ayrilmis * bilgi verilmis ama yorumu yapilmamis	* Probleme, problemi parçalara ayirmaksizin yaklasilmis ve daha genis bir kontekste, daha farkli bakis açilari göz önüne alinmamis * Bilgi farkli görüsleri destekiyor ya da desteklemiyor diyerek yorumlanmis	* Bilgi organize edilmis ve kavramlar problemin farkli yönlerini incelemeye olanak saglayacak tarzda bir iskelet olusturmus * Bilgi çesitli bakisli açilarindan nitel olarak degerlendirilmis, birtakim varsayimlar, eldeki verilerin niteligi tartisilmis,	* Bilgi ve kavramlar organize edilmis, farkli bakis açilari için geçerli, ve farkli çözüm yolarinin nitel degerlendirilmesine olanak saglayan genel kriterler kullanilmis * Farkli bakis açilarinin degerlendirilmesine olanak saglayacak genel prensipler kullanilarak bilgi nitel olarak degerelendirilmis	* Bilgi ve kavramlar organize edilmis, farkli bakis açilari için geçerli, ve farkli çözüm yolarinin nitel degerlendirilmesine olanak saglayan genel kriterler kullanilmis ve daha iyi çözüm yollari üretebilmek için kriterler, izlenebilecek yollar nasil gelistirilebilir ifade edilmis * Zaman içersinde yeni bilgiler ortaya çiktikça, eldeki veriler tekrar tekrar yorumlanmis
* Eldeki veri ve bilgilere dayanarak mantikli çikarimlarda bulunulmamis, daha çok test edilmemis, dogrulugu gösterilmemis fikirler üzerinden gerekçeler gösterilmis	* Farkli yaklasimlara çok az yer verilmis, sonuçlara kismen sorgulayarak varilmis, düsünceler, probleme yaklasim yüzeysel olarak anlasilmis bilgi ve verilerle desteklenmis	* Eldeki veriler belli bir perspektif içersinde mantiksal olarak degerlendirilmis (fakat uygulanan kriter farkli çözüm opsiyonlari için daima geçerli olmak zorunda degil)	* Farkli çözüm yollarinin arasindan objektif olarak seçmeye ve objektif olarak karsilastirmaya olanak saglayan saglam temellere dayanan, kapsamli bilgiler, prensipler kullanilmis	* Kendi bakis açisini desteklemek için ikna edici çok yönlü tartisma yapilms. Görüslerinin güçlü ve zayif yönleri belirtilmis. Ortaya atilan çözüme sistematik bir yaklasim, arastirma, düsünme tarziyla nasil ulasildigi ifade edilmis
* Probleme tek bir çözüm yolu ve tek bir dogru cevabi olan kapali uçlu bir problem gibi yaklasilmis	* Varolan birtakim belirsizliklere ragmen amaç varilan sonucu desteklemek için bilgi ve verileri siralamakmis gibi probleme yaklasilmis	* Amaç, farkli bakis açilarinin dengeli ve önyargidan uzak bir tarzda verilmesiymis gibi probleme yaklasilmis	* Amaç, farkli bakis açilarin in objektif olarak egerlendirilmesi sonucu ortaya çikmis saglam temellere dayanan sonuçlar ortaya koymakmis gibi probleme yaklasilmis	* Amaç bilgiyi kendisinin insa etmesi, kendisinden emin olarak saglam temellere dayanan sonuçlar ortaya koymasiymis gibi probleme yaklasilmis

APPENDIX D

ÖĞRENME YAKLAŞIMI ÖLÇME TESTİ

	Kesinlikle Katılmıyorum	Katılmıyorum	Katılıyorum	Kesinlikle Katılıyorum
1. Genellikle ilk bakışta zor gibi görünen konuları anlamak için çok çaba sarfederim.	1❑	2❑	3❑	4❑
2. Bir konuya çalışırken, öğrendiğim yeni bilgileri eskileriyle ilişkilendirmeye çalışırım.	1❑	2❑	3❑	4❑
3. Ders çalışırken, öğrendiğim konuları günlük hayatta nasıl kullanabileceğimi düşünürüm.	1❑	2❑	3❑	4❑
4. Konuları en iyi, öğretmenin anlattığı sırayı düşündüğümde hatırlarım.	1❑	2❑	3❑	4❑
5. Öğrenmek zorunda olduğum konuları ezberlerim.	1❑	2❑	3❑	4❑
6. Önemli konuları tam olarak anlayana kadar tekrar ederim.	1❑	2❑	3❑	4❑
7. Öğretmenler, öğrencilerden, sınavda sorulmayacak konular üzerinde çok fazla zaman harcamalarını **beklememelidirler.**	1❑	2❑	3❑	4❑
8. Birkez çalışmaya başladığımda, her konunun ilgi çekici olacağına inanırım.	1❑	2❑	3❑	4❑
9. Derslerde duyduğum ya da kitaplarda okuduğum bazı bilgiler hakkında sık sık düşünürüm.	1❑	2❑	3❑	4❑
10. Konuların birbirleri ile nasıl ilişkilendiğini anlayarak, yeni bir konu hakkında genel bir bakış açısı edinmenin benim için faydalı olduğunu düşünürüm.	1❑	2❑	3❑	4❑
11. Anladığımdan iyice emin olana kadar dersten ya da laboratuvardan sonra notlarımı tekrar tekrar okurum.	1❑	2❑	3❑	4❑
12. Bir konu hakkında çok fazla araştırma yapmanın zaman kaybı olduğunu düşündüğümden, sadece	1❑	2❑	3❑	4❑

sınıfta ya da ders notlarında anlatılanları ciddi bir şekilde çalışırım.				
13. Okumam için verilen materyalleri, anlamını tam olarak anlayıncaya kadar okurum.	1❑	2❑	3❑	4❑
14. Gerçek olaylara dayanan konuları, varsayıma dayanan konulardan daha çok severim.	1❑	2❑	3❑	4❑
15. Bir konuda öğrendiğim bilgiyi başka bir konuda öğrendiğimle ilişkilendirmeye çalışırım.	1❑	2❑	3❑	4❑
16. Benim için teknik terimlerin ne anlama geldiğini anlamanın en iyi yolu ders kitabındaki tanımı hatırlamaktır.	1❑	2❑	3❑	4❑
17. Bulmaca ve problemler çözerek mantıksal sonuçlara ulaşmak beni heyecanlandırır.	1❑	2❑	3❑	4❑
18. Genelde okumam için verilen materyalin bana sağlayacağı faydayı **düşünmem.**	1❑	2❑	3❑	4❑
19. Konuları ezberleyerek öğrenirim, yani öğrendiğime inanana kadar ezberlerim.	1❑	2❑	3❑	4❑
20. Çoğunlukla, konuları gerçekten anlamadan okurum.	1❑	2❑	3❑	4❑
21. Bir konuyla ilgili verilen fazladan okumalar kafa karıştırıcı olabileceğinden sadece derste öğrendiklerimize parallel olarak tavsiye edilen birkaç kitaba bakarım.	1❑	2❑	3❑	4❑
22. Ekstra birşeyler yapmanın gereksiz olduğunu düşündüğüm için, çalışmamı genellikle derste verilen bilgiyle sınırlarım.	1❑	2❑	3❑	4❑

APPENDIX E

MANTIKSAL DÜŞÜNME YETENEK TESTİ

AÇIKLAMA: Bu test, çeşitli alanlarda, özellikle Fen ve Matematik dallarında karşılaşabileceğiniz problemlerde neden-sonuç ilişkisini görüp, problem çözme stratejilerini ne derece kullanabileceğinizi göstermesi açısından çok faydalıdır. Bu test içindeki sorular mantıksal ve bilimsel olarak düşünmeyi gösterecek cevapları içermektedir.

NOT: Soru Kitapçığı üzerinde herhangi bir işlem yapmayınız ve cevaplarınızı yalnızca cevap kağıdına yazınız. CEVAP KAĞIDINI doldururken dikkat edilecek hususlardan birisi, 1 den 8 e kadar olan sorularda her soru için cevap kağıdında iki kutu bulunmaktadır. Soldaki ilk kutuya sizce sorunun uygun cevap şıkkını yazınız, ikinci kutucuğa yani AÇIKLAMASI yazılı kutucuğa ise o soruyla ilgili soru kitapçığındaki Açıklaması kısmındaki şıkları okuyarak sizce en uygun olanını seçiniz. Örneğin 12'nci sorunun cevabı sizce b ise ve Açıklaması kısmındaki en uygun açıklama ikinci şık ise cevap kağıdını aşağıdaki gibi doldurun:

12. [b] AÇIKLAMASI [2]

9. ve 10. soruları ise soru kitapçığında bu sorularla ilgili kısımları okurken nasıl cevaplayacağınızı daha iyi anlayacaksınız.

SORU 1: Bir boyacı, aynı büyüklükteki altı odayı boyamak için dört kutu boya kullandığına göre sekiz kutu boya ile yine aynı büyüklükte kaç oda boyayabilir?

a. 7 oda
b. 8 oda
c. 9 oda
d. 10 oda
e. Hiçbiri

Açıklaması:

1. Oda sayısının boya kutusuna oranı daima $\frac{3}{2}$ olacaktır.
2. Daha fazla boya kutusu ile fark azalabilir.
3. Oda sayısı ile boya kutusu arasındaki fark her zaman iki olacaktır.
4. Dört kutu boya ile fark iki olduğuna göre, altı kutu boya ile fark yine iki olacaktır.
5. Ne kadar çok boyaya ihtiyaç olduğunu tahmin etmek mümkün değildir.

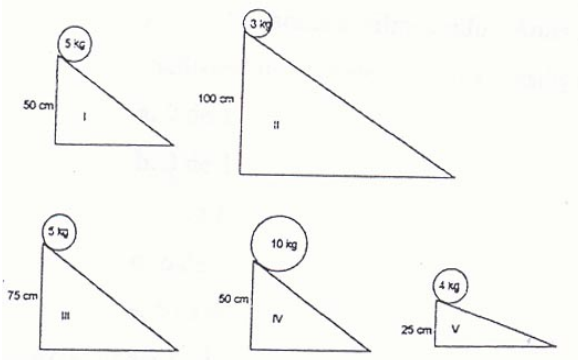
SORU 2: On bir odayı boyamak için kaç kutu boya gerekir? (Birinci soruya bakınız)

a. 5 kutu
b. 7 kutu
c. 8 kutu
d. 9 kutu
e. Hiçbiri

Açıklaması:

1. Boya kutusu sayısının oda sayısına oranı daima $\frac{2}{3}$ dür.
2. Eğer beş oda daha olsaydı, üç kutu boya daha gerekecekti.
3. Oda sayısı ile boya kutusu arasındaki fark her zaman ikidir.
4. Boya kutusu sayısı oda sayısının yarısı olacaktır.
5. Boya miktarını tahmin etmek mümkün değildir.

SORU 3: Topun eğik bir düzlemden (rampa) aşağı yuvarlandıktan sonra kat ettiği mesafe ile eğik düzlemin yüksekliği arasındaki ilişkiyi bulmak için deney yapmak isterseniz, aşağıda gösterilen hangi eğik düzlem setlerini kullanırdınız?

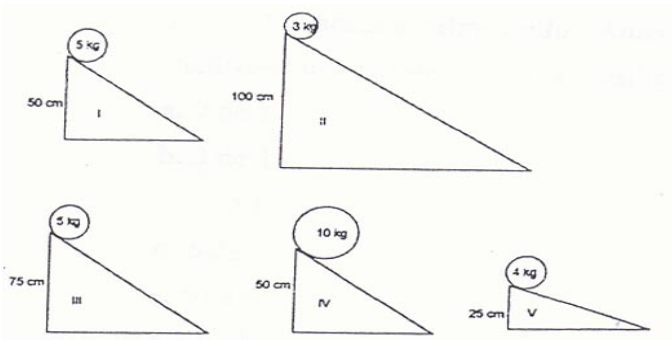


a. I ve IV
b. II ve IV
c. I ve III
d. II ve V
e. Hepsi

Açıklaması:

1. En yüksek eğik düzlemle (rampa) karşı en alçak olan karşılaştırılmalıdır.
2. Tüm eğik düzlem setleri birbiriyle karşılaştırılmalıdır.
3. Yükseklik arttıkça topun ağırlığı azalmalıdır.
4. Yükseklikler aynı fakat top ağırlıkları farklı olmalıdır.
5. Yükseklikler farklı fakat top ağırlıkları aynı olmalıdır.

SORU 4: Tepeden yuvarlanan bir topun eğik düzlemden (rampa) aşağı yuvarlandıktan sonra kat ettiği mesafenin topun ağırlığıyla olan ilişkisini bulmak için bir deney yapmak isterseniz, aşağıda verilen hangi eğik düzlem setlerini kullanırdınız?



a. I ve IV
b. II ve IV
c. I ve III
d. II ve V
e. Hepsi

Açıklaması:

a. En ağır olan top en hafif olanla kıyaslanmalıdır.
b. Tüm eğik düzlem setleri birbiriyle karşılaştırılmalıdır.

c. Topun ağırlığı arttıkça, yükseklik azaltılmalıdır.

d. Ağırlıklar farklı fakat yükseklikler aynı olmalıdır.

e. Ağırlıklar aynı fakat yükseklikler farklı olmalıdır.

SORU 5: Bir Amerikalı turist Şark Expresi'nde altı kişinin bulunduğu bir kompartımana girer. Bu kişilerden üçü yalnızca İngilizce ve diğer üçü ise yalnızca Fransızca bilmektedir. Amerikalının kompartımana ilk girdiğinde İngilizce bilen biriyle konuşma olasılığı nedir?

a. 2 de 1

b. 3 de 1

c. 4 de 1

d. 6 da 1

e. 6 da 4

Açıklaması:

1. Ardarda üç Fransızca bilen kişi çıkabildiği için dört seçim yapmak gerekir.
2. Mevcut altı kişi arasından İngilizce bilen bir kişi seçilmelidir.
3. Toplam üç İngilizce bilen kişiden sadece birinin seçilmesi yeterlidir.
4. Kompartımandakilerin yarısı İngilizce konuşur.
5. Altı kişi arasından, bir İngilizce bilen kişinin yanısıra, üç tanede Fransızca bilen kişi seçilebilir.

SORU 6: Üç altın, dört gümüş ve beş bakır para bir torbaya konulduktan sonra, dört altın, iki gümüş ve üç bakır yüzük de aynı torbaya konur. İlk denemede torbadan altın bir nesne çekme olasılığı nedir?

a. 2 de 1

b. 3 de 1

c. 7 de 1

d. 21 de 1

e. Yukarıdakilerden hiçbiri

Açıklaması:

1. Altın, gümüş ve bakırdan yapılan nesneler arasından bir altın nesne seçilmelidir.
2. Paraların $\frac{1}{4}$ ü ve yüzüklerin $\frac{4}{9}$ u altından yapılmıştır.

3. Torbadan çekilen nesnenin para ve yüzük olması önemli olmadığı için toplam 7 altın nesneden bir tanesinin seçilmesi yeterlidir.
4. Toplam yirmi bir nesneden bir altın nesne seçilmelidir.
5. Torbadaki 21 nesnenin 7 si altından yapılmıştır.

SORU 7: Altı yaşındaki Ahmet'in şeker almak için 50 lirası vardır. Bakkaldaki kapalı iki şeker kutusundan birinde 30 adet kırmızı ve 50 adet sarı renkte şeker bulunmaktadır. İkinci bir kutuda ise 20 adet kırmızı ve 30 adet sarı şeker vardır. Ahmet kırmızı şekerleri sevmektedir. Ahmet'in ikinci kutudan kırmızı şeker çekme olasılığı birinci kutuya göre daha fazla mıdır?

a. Evet
b. Hayır

Açıklaması:

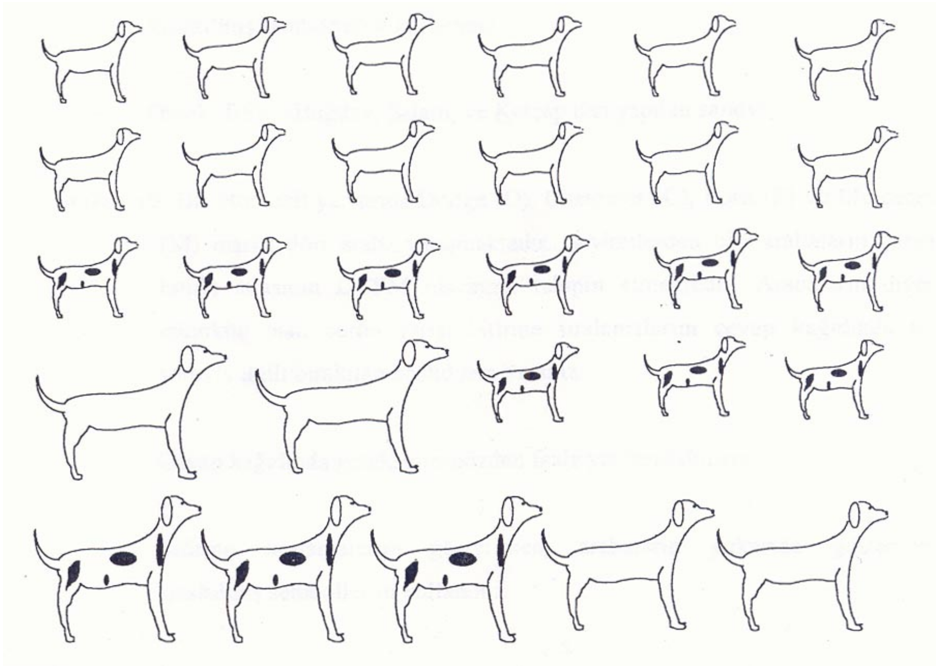
1. Birinci kutuda 30, ikincisinde ise yalnızca 20 kırmızı şeker vardır.
2. Birinci kutuda 20 tane daha fazla sarı şeker, ikincisinde ise yalnızca 10 tane daha fazla sarı şeker vardır.
3. Birinci kutuda 50, ikincisinde ise yalnızca 30 sarı şeker vardır.
4. İkinci kutudaki kırmızı şekerlerin oranı daha fazladır.
5. Birinci kutuda daha fazla sayıda şeker vardır.

SORU 8: 7 büyük ve 21 tane küçük köpek şekli aşağıda verilmiştir. Bazı köpekler benekli bazıları ise beneksizdir. Büyük köpeklerin benekli olma olasılıkları küçük köpeklerden daha fazla mıdır?

a. Evet
b. Hayır

Açıklaması:

1. Bazı küçük köpeklerin ve bazı büyük köpeklerin benekleri vardır.
2. Dokuz tane küçük köpeğin ve yalnızca üç tane büyük köpeğin benekleri vardır.
3. 28 köpekten 12 tanesi benekli ve geriye kalan 16 tanesi beneksizdir.
4. Büyük köpeklerin $\frac{3}{7}$ si ve küçük köpeklerin $\frac{9}{21}$ i beneklidir.
5. Küçük köpeklerden 12 sinin, fakat büyük köpeklerden ise sadece 4ünün beneği yoktur.



SORU 9: Bir pastanede üç çeşit ekmek, üç çeşit et ve üç çeşit sos kullanılarak sandviçler yapılmaktadır.

Ekmek Çeşitleri	Et Çeşitleri	Sos Çeşitleri
Buğday (B)	Salam (S)	Ketçap (K)
Çavdar (Ç)	Piliç (P)	Mayonez (M)
Yulaf (Y)	Hindi (H)	Tereyağı (T)

Her bir sandviç ekmek, et ve sos içermektedir. Yalnızca bir ekmek çeşidi, bir et çeşidi kullanılarak kaç çeşit sandviç hazırlanabilir?

Cevap kağıdı üzerinde bu soruyla ilgili bırakılan boşluklara bütün olası sandviç çeşitlerinin listesini çıkarın.

Cevap kağıdında gereksiniminizden fazla yer bırakılmıştır.

Listeyi hazırlarken ekmek, et ve sos çeşitlerinin yukarıda gösterilen kısaltılmış sembollerini kullanınız.

Örnek: BSK= Buğday, Salam ve Ketçap dan yapılan sandviç

SORU 10: Bir otomobil yarışında Dodge (D), Chevrolet (C), Ford (F) ve Mercedes (M) marka dört araba yarışmaktadır. Seyircilerden biri arabaların yarışı bitiriş sırasının DCFM olacağını tahmin etmektedir. Arabaların diğer mümkün olan bütün yarışı bitirme sıralamalarını cevap kağıdında bu soruyla ilgili bırakılan boşlukalara yazınız.

Cevap kağıdında gereksiniminizden fazla yer bırakılmıştır.

Bitirme sıralamalarını gösterirken, arabaların yukarıda gösterilen kısaltılmış sembollerini kulanınız.

Örnek: DCFM yarışı sırasıyla önce Dodge'nin, sonra Chevrolet'in, sonra Ford'un ve en sonra Mercedes'in bitirdiğini gösterir.

APPENDIX F

PROBLEME DAYALI ÖĞRENME MODELİ'NE İLİŞKİN GERİBİLDİRİM FORMU

Ad Soyad:
Sınıf:

Aşağıda verilen sorular Probleme Dayalı Öğrenme Modeline ilişkin görüşlerinizi belirlemek için hazırlanmıştır. Görüşleriniz, bu model doğrultusunda yeni ders planlari hazırlanırken gözönüne alinacaktir. Bu nedenle verdiğiniz cevaplar probleme dayalı öğrenme modelinin ileride etkili bir şekilde uygulanabilmesi için büyük önem taşımaktadır. Lütfen her soruyu dikkatlice okuyarak, görüşlerinizi içtenlikle belirtiniz. Teşekkürler.

1. Probleme Dayalı Öğrenme Modelini nasıl tanımlarsınız? Sizce Probleme Dayalı Öğrenme Modelinin karakteristik özellikleri nelerdir?

2. Yukarıda belirttiğiniz karakteristik özelliklerden hangisinin öğrenmenize en çok katkısı oldu?

3. Probleme Dayalı Öğrenme Modelindeki hangi özellikleri kesinlikle değistirmek isterdiniz?

4. Probleme Dayalı Öğrenme Modelindeki hangi özellikler kesinlikle uygulanmaya devam edilmelidir?

5. Probleme Dayalı Öğrenme Modelinin uygulanması sırasında ne tür zorluklarla karşılaştınız?

6. Sizce Probleme Dayalı Öğrenme Modelinde ideal bir öğretmen ne tür özellikler taşımalıdır? (Alan bilgisi, grup çalişmasina katki vb. Açılardan)

7. Probleme Dayalı Öğrenme Modelinin uygulandığı sınıflarda iyi bir öğrencinin özellikleri ne olmalidir?

8. Ders sırasında işlenen örnek olaylar hakkindaki görüsleriniz nelerdir?

9. Probleme Dayalı Öğrenme Modelinin size akademik ve sosyal açıdan neler kazandırdığını düşünüyorsunuz?

APPENDIX G

HANDBOOKS

Probleme-Dayalı Öğrenme Modeli

ÖĞRENCİ EL KİTAPÇIĞI

Hazırlayan: Semra SUNGUR
Eylül 2003

A. Probleme Dayalı Öğrenme Modelinde Öğrencilerin Rolü

Probleme dayalı öğrenme modelinin uygulandığı sınıflarda her biri yaklaşık 7 kişiden oluşan gruplar oluşturulur. Bu modelde öğrenciler bir takım karmaşık roller üstlenirler. Mesela grubun aktif bir üyesi olarak öğrenciden yapıcı eleştiriler yapabilmesi ve kendisi için yapılan eleştirileri hoşgörüyle karşılayabilmesi, eksikliklerini fark edebilmesi ve bireysel olarak da çalışabilmesi beklenir. Ayni zamanda öğrenciler yaptıkları çalışmaları hem bireysel olarak hem de grup düzeyinde dürüstçe değerlendirebilmelidir. Bunların yanı sıra öğrencilerden sınıfta oynamaları beklenen bir takım roller vardır. Örneğin, birtakım şikayetlerle acil servise gelen bir hastanın yer aldığı bir örnek olayda öğrencilerden birisi gönüllü olarak hasta diğeri doktor rolünü üstlenir. Yine gönüllü olarak gruptaki bir öğrenci öğretmen tarafından dağıtılan ve örnek olayı içeren sayfaları okuma rolünü üstlenir. Başka bir öğrenci örnek olayda verilenleri, örnek olaya ilişkin grubun düşüncelerini, örnek olayda verilen problemle basa çıkabilmek için cevap verilmesi gereken soruları ve nelerin öğrenilmesi gerektiğini tahtaya not eder. Tahtaya yazılanlar konusunda tüm grup üyelerinin fikir birliği içersinde olması gerekmektedir. Öğrencilerin verilen örnek olaydaki probleme çözüm üretebilmeleri yaklaşık 4-6 ders saati almaktadır. Öğrencilerden bir diğeri ders basında bir önceki ders saatinde probleme ilişkin yapılanları özetler. Bu sırada öğrenci örnek olayda verilen bilgilerden, grup harici bireysel çalışma sırasında bulduklarından, ve bulduklarıyla ilgili yorumlarından bahseder. Genel olarak etkin bir grup çalışması için beklenen özellikler su şekilde özetlenebilir:

Risk : Öğrenciler test edildikten sonra yanlış olduğu anlaşılabilecek hipotezlerini ifade edebilmeli ve bu riski göze alabilmelidir. Düşüncelerini rahatça dile getirebilmelidirler.

Açıklık: Grup üyeleri birbirlerine karsı açık olmalıdır. Birbirleriyle düşüncelerini, bilgilerini, deneyimlerini paylaşmalı gerektiğinde birbirlerini eleştirebilmelidir.

Katilim: İyi bir grup çalışmasının temelini katilim oluşturmaktadır. Grubun her bir üyesinin katilimi teşvik edilmelidir.

Deneyim: Her bir öğrenci örnek olayda verilen problemle uğraşmalı ve problemi çözebilmek için gerekli olan sorgulama sürecinden geçmelidir. Dolayısıyla burada bahsedilen öğrencilerin önceden sahip oldukları deneyimler değil, grup çalışması sırasında probleme çözüm yolu ararken kazanılan deneyimlerdir.

Duyarlık : Grup içersinde her bir öğrenci diğerinin farklı ortamlardan farklı deneyimlerle gelmiş olabileceğini göz önüne almalı ve öğrenciler birbirlerinin ihtiyaçlarına ve duygularına karşı duyarlı olmalıdır.

B. Probleme Dayalı Öğrenme Modelinde Öğretmenin Rolü

Öğrenci merkezli olan ve bilgiyi birbirinden izole gerçekler olarak öğretmekten çok bilgiye ulaşmak için gerekli tutum ve yeteneklerin kazanılmasını hedefleyen probleme dayalı öğrenme modelinde, öğrencilerden beklenen davranışların geliştirilebilmesi için öğretmene de büyük görevler düşmektedir. Öğretmen konuyu öğreten değil grup içersinde öğrenciler arasında tartışma ortamı sağlayan, teşvik eden ve öğrenciler için gerekli öğrenme ortamını, materyalleri sağlayan olmalıdır. Probleme dayalı öğrenme modelinin uygulandığı sınıflarda öğretmenin rolü söyle özetlenebilir:

- Her bir ders saatinde öğrencilerin gönüllü olarak birtakım rolleri üstlenmesinin sağlanması: her ders saatinde örnek olaya ilişkin bilgilerin yer aldığı sayfaları okuyacak ve bu bilgileri, ortaya çıkan fikirleri, vb. tahtaya yazacak, ve örnek olayda geçen rolleri oynayacak gönüllü öğrenciler belirlenir.

- Örnek olaya ilişkin materyallerin uygun zamanda dağıtılması Her bir ders saatinin öz değerlendirme ile bitmesinin sağlanması: öğrencilerin her ders saati sonunda kendilerini, arkadaşlarını, ve de öğretmeni değerlendirmesi beklenmektedir. Ayni zamanda öğretmen de kendisini grubun bir parçası olarak görüp görüşlerini dile getirir ve kendisine yapılan eleştirileri dinler.

- Grubun belirlenen hedef doğrultusunda hareket etmesinin sağlanması: probleme dayalı öğrenme modelinde ana hedef örnek olayda verilen problemin anlaşılması, çözüm üretebilmek için gerekli olan konuların belirlenmesi ve öğrenilmesidir. Öğretmen eğer öğrencilerin bu hedeften uzaklaştığını fazla düşünüp sorgulamaksızın sadece probleme bir çözüm bulma eğiliminde olduğunu fark ederse, uygulanan bu modelde ana hedefin ne olduğunu öğrencilerin hatırlamasını, gerekirse ellerindeki kitapçıktan okumalarını ister

- Grup çalışmasının gözlemlenmesi ve notların alınması: öğretmen öğrencilerin karar vermiş olduğu öğrenilmesi gereken konular listesini not eder. Eğer bu listede öğrenilmesi önemli olan bir konu yer almıyorsa, öğretmen öğrencilerin bunun farkına varabilmesi için yardımcı olur. Ancak öğretmen böyle bir durumda mümkün olduğunca öğrencileri yönlendirmekten kaçınmalıdır. Açık uçlu sorularla grubun uyarılıp idare edilmesi: bu öğretmenin en zor görevlerinden birisidir. Çünkü öğretmenin grubu yönlendirmemesi ve grubun kontrolünü almaması gerekmektedir. Fakat ayni zamanda yeri geldiğinde bir takım açık uçlu sorularla grupta tartışma ortamı yaratması gerekmektedir. Burada dikkat edilmesi gereken nokta öğrencilerin basitçe direk olarak cevap verebileceği soruların sorulmamasıdır.

- Öğrencilerin değerlendirilmesi: öğrenciler değerlendirilirken uygulanan yazılı sınavın sonucunun yanı sıra öğretmen ve grup üyelerinin doldurduğu değerlendirme formları da göz önüne alınır. Bu formlarda öğrenciler grup içersindeki katılımları, katkıları, birbirleriyle olan ilişkileri, ne ölçüde hazırlıklı geldikleri gibi kriterlere göre değerlendirilirler

C. Probleme Dayalı Öğrenme Modelinde Ders İslenişi

Probleme dayalı öğrenme modelinin temelini grup halinde çalışan öğrenciler ve öğretmen oluşturmaktadır. Grubun her bir üyesi grubun diğer üyelerini yapıcı olarak eleştirebilmeli, sorgulayabilmeli ve eleştirilmekten, sorgulanmaktan çekinmemelidir. Bu tür davranışlar grup üyelerinde rahatsızlık oluşturabileceğinden, ilk baslarda bunu gerçekleştirmek zor olabilir. Fakat zaman geçtikse, öğrenciler modele alıştıkça bu, öğrencilerin bilgilerini arttırmaları gerektiği konulara yoğunlaşmasını sağlayan eğlenceli bir egzersiz haline gelecektir.

Biyoloji derslerinde kullanılabilecek bir örnek olayın probleme dayalı öğrenme modeli ile islenişi aşağıda belirtildiği gibi olmaktadır:

Ders başlamadan önce örnek olaya ilişkin bilgileri kimin okuyacağı, kimin tahtaya yazacağı belirlenir. Ayrıca kimin hasta, kimin doktor rolünü oynayacağı da belirlenir. Bu rol dağılımı gönüllü öğrenciler arasında yapılır. Eğer örnek olay daha önceki ders saatlerinde başladıysa kura ile belirlenen bir öğrenci daha önceki ders saatlerinde örnek olaya ilişkin yapılanları özetler bu arada grup harici bireysel çalışma sırasında bulduklarından ve kendi düşüncelerinden kısaca bahseder.

Roller belirlendikten sonra örnek olayın ilk sayfası öğrencilere dağıtılır. Örnek olay bir hastayı anlatır. Hastaya ilişkin bilgiler 5 yada daha fazla sayfada verilir. Genel olarak birinci sayfada hastanın adi, cinsiyeti, yaşı ve şikayeti belirtilir. İkinci sayfada hastanın şikayetleri, geçmişteki rahatsızlıkları, kullandığı ilaçlar, ailesinde görülen rahatsızlıklar ve yasam tarzı ile ilgili daha detaylı bilgiler verilir. İkinci sayfa hasta rolünü üstlenecek öğrenciye birinci sayfayla birlikte verilir. Öğrenciler birinci sayfa üzerine tartışırken hasta rolünü oynayan öğrenci bir taraftan da ikinci sayfayı içinden okur. Üçüncü sayfada muayene sonucu elde edilen veriler yer alır. Dördüncü ve onu takip eden sayfalarda yapılan test, çekilen röntgen, EKG sonuçları ve diğer ilgili sonuçlar bulunur. Son sayfada ise teşhis yer alır.

İlk sayfa dağıtıldıktan sonra örnek olayda verilenleri okumaktan sorumlu olan öğrenci ilk sayfada verilen bilgileri yüksek sesle okur diğer öğrenci tahtaya bilgileri not eder. Bu arada öğrenciler verilen bilgiler hakkında tartışmaya başlarlar. Hastanın şikayetleri hangi organ sistemiyle ilgili olabilir, daha çok bilgi edinebilmek için hastaya ne tür sorular sorulmalıdır gibi konular üzerine odaklaşırlar. Öğrenciler düşüncelerini belirtirken niçin öyle düşündüklerini de açıklarlar ve ortaya atılan düşünceleri, söylenen bilgileri doğrulukları konusunda sorgularlar. Tartışma sırasında probleme çözüm üretebilmek için hangi konularda bilgi edinmeleri gerekiyor buna karar verirler. Tüm bu tartışmalar yapılırken tahtaya yazmaktan sorumlu olan kişi hastanın probleminin hangi sistemle ilgili olduğu, ne gibi sorulara cevap bulunması ve hangi konuların öğrenilmesi gerektiğine dair grubun vermiş olduğu kararları tahtaya yazar. Daha sonra doktor rolünü oynayacak olan öğrenci belirlenen soruları hasta rolünü oynayan öğrenciye sorar. Bu arada diğer öğrenciler akıllarına başka sorular gelirse hastaya sorabilirler. Hastanın verdiği cevaplar tahtaya not edilir ve bu yeni bilgiler doğrultusunda daha önceki düşüncelerini gözden geçirirler. Bu arada öğrenilmesi gereken konular üzerinde tartışırlar. Gerekli bilgileri sordukları sorularla edindiklerini düşündüklerinde örnek olaya ilişkin ikinci sayfayı öğretmenden isterler ve öğretmen ikinci sayfayı dağıtır. Örnek olayı okumaktan sorumlu olan öğrenci yüksek sesle ikinci sayfayı okur. Daha sonra öğrenciler spesifik olarak hangi fiziksel muayene sonucuna ihtiyaç duyulduğuna karar verir ve öğretmenden fiziksel muayene sonuçlarını içeren üçüncü sayfayı ister. Öğrenciler ilk üç sayfada verilen bilgileri kullanarak hastadan ne tür tetkiklerin istenmesi gerektiğine karar verirler. Mesela, hastanın kan değerlerine, akciğer röntgenin sonucuna ihtiyaç duyabilirler. Öğrenciler hangi testlerin sonucuna ihtiyaç duyulduğuna karar verince öğretmen dördüncü sayfayı dağıtır. Öğrenciler örnek olaya ilişkin bilgilerin yer aldığı sayfaları edindikçe daha önce ortaya atmış oldukları düşünceleri, hipotezleri gözden geçirirler ve teşhis koymaya çalışırlar ve aralarında tartıştıktan sonra öğretmen teşhisi içeren besinci sayfayı dağıtır. Bu arada öğrenciler esas amacın bu örnek olay sayesinde bir takım biyolojik kavramların konuların öğrenilmesi olduğu, teşhis koymak olmadığının bilincinde olmalıdır.

Probleme dayalı öğrenme modelinin uygulanışına ilişkin olarak vurgulanması gereken önemli noktalardan birisi sudur: Bir örnek olay yaklaşık 4-6 saatte tamamlanır. Bu da öğrencilerin 2 yada 3 kere grup çalışması yapmasına denk gelmektedir. Öğrenciler her bir grup çalışmasının sonunda öğrenilmesi gereken konular ve bu konular hakkında nerelerden bilgi edinebileceklerine dair karar verirler ve bir sonraki grup çalışmasına kadar bu konular üzerinde bireysel çalışma yaparlar. Bireysel çalışma sırasında öğrenciler kitaplardan, internetten faydalanabilir yada konusunda uzman bir kişiye danışabilirler. Öğrenciler isterlerse grup halinde de çalışabilirler. Her bir öğrenci konu hakkında bilgi edindikten sonra, bu bilgiler doğrultusunda görüşlerini belirtecek tarzda hazırlanarak bir sonraki ders saatine katılır. Her öğrencinin ders saatlerine hazırlıklı gelmesi gerekmektedir. Çünkü bir sonraki dersin basında kurayla bir öğrenci belirlenir ve bu öğrenci örnek olayda hastaya ilişkin verilen bilgileri ve bireysel çalışma sonucu elde ettiği bilgiler doğrultusunda probleme ilişkin görüşlerini anlatır. Daha sonra diğer öğrenciler görüşlerini belirtir ve bir önceki ders saatinde kalındığı yerden örnek olay üzerinde tartışılmaya devam edilir, yeri geldikçe ilgili sayfalar istenir.

Öğrenciler kendi aralarında tartışırken öğretmen onları gözlemler. Herhangi bir şekilde öğrencileri yönlendirmez. Fakat raporun 'probleme dayalı öğrenme modelinde öğretmenin rolü' kısmında belirtildiği gibi gerektiğinde birtakım stratejiler izleyerek dersin model doğrultusunda öğrenci merkezli olarak islenmesini sağlar.

Genel olarak özetlemek gerekirse probleme dayalı öğrenme modelinin uygulandığı sınıflarda:

- öğrenciler öğrenme sürecinde aktif olarak yer alır
- öğrencilerde bilgiye ulaşabilmek için gerekli olan tutum ve davranışlar geliştirilir.
- öğrenciler ortak bir problemi analitik olarak grup içersinde çözebilme ortamı bulur.

Probleme-Dayalı Öğrenme Modeli

ÖĞRENCİ EL KİTAPÇIĞI

Hazırlayan: Semra SUNGUR
Eylül 2003

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Açıklık: Grup üyeleri birbirlerine karsı açık olmalıdır. Birbirleriyle düşüncelerini, bilgilerini, deneyimlerini paylaşmalı gerektiğinde birbirlerini eleştirebilmelidir.

Katilim: İyi bir grup çalışmasının temelini katilim oluşturmaktadır. Grubun her bir üyesinin katilimi teşvik edilmelidir.

Deneyim: Her bir öğrenci örnek olayda verilen problemle uğraşmalı ve problemi çözebilmek için gerekli olan sorgulama sürecinden geçmelidir. Dolayısıyla burada bahsedilen öğrencilerin önceden sahip oldukları deneyimler değil, grup çalışması sırasında probleme çözüm yolu ararken kazanılan deneyimlerdir.

Duyarlık : Grup içersinde her bir öğrenci diğerinin farklı ortamlardan farklı deneyimlerle gelmiş olabileceğini göz önüne almalı ve öğrenciler birbirlerinin ihtiyaçlarına ve duygularına karsı duyarlı olmalıdır.

B. Probleme Dayalı Öğrenme Modelinde Öğretmenin Rolü

Öğrenci merkezli olan ve bilgiyi birbirinden izole gerçekler olarak öğretmekten çok bilgiye ulaşmak için gerekli tutum ve yeteneklerin kazanılmasını hedefleyen probleme dayalı öğrenme modelinde, öğrencilerden beklenen davranışların geliştirilebilmesi için öğretmene de büyük görevler düşmektedir. Öğretmen konuyu öğreten değil grup içersinde öğrenciler arasında tartışma ortamı sağlayan, teşvik eden ve öğrenciler için gerekli öğrenme ortamını, materyalleri sağlayan olmalıdır. Probleme dayalı öğrenme modelinin uygulandığı sınıflarda öğretmenin rolü söyle özetlenebilir:

- Her bir ders saatinde öğrencilerin gönüllü olarak birtakım rolleri üstlenmesinin sağlanması: her ders saatinde örnek olaya ilişkin bilgilerin yer aldığı sayfaları okuyacak ve bu bilgileri, ortaya çıkan fikirleri, vb. tahtaya yazacak, ve örnek olayda geçen rolleri oynayacak gönüllü öğrenciler belirlenir.

- Örnek olaya ilişkin materyallerin uygun zamanda dağıtılması
Herbir ders saatinin öz degerlendirme ile bitmesinin saglanmasi:

ögrencilerin her ders saati sonunda kendilerini, arkadaşlarını, ve de öğretmeni değerlendirmesi beklenmektedir. Ayni zamanda öğretmen de kendisini grubun bir parçası olarak görüp görüşlerini dile getirir ve kendisine yapılan eleştirileri dinler.

- Grubun belirlenen hedef doğrultusunda hareket etmesinin sağlanması: probleme dayalı öğrenme modelinde ana hedef örnek olayda verilen problemin anlaşılması, çözüm üretebilmek için gerekli olan konuların belirlenmesi ve öğrenilmesidir. Öğretmen eğer öğrencilerin bu hedeften uzaklaştığını fazla düşünüp sorgulamaksızın sadece probleme bir çözüm bulma eğiliminde olduğunu fark ederse, uygulanan bu modelde ana hedefin ne olduğunu öğrencilerin hatırlamasını, gerekirse ellerindeki kitapçıktan okumalarını ister

- Grup çalışmasının gözlemlenmesi ve notların alınması: öğretmen öğrencilerin karar vermiş olduğu öğrenilmesi gereken konular listesini not eder. Eğer bu listede öğrenilmesi önemli olan bir konu yer almıyorsa, öğretmen öğrencilerin bunun farkına varabilmesi için yardımcı olur. Ancak öğretmen böyle bir durumda mümkün olduğunca öğrencileri yönlendirmekten kaçınmalıdır.

- Açık uçlu sorularla grubun uyarılıp idare edilmesi: bu öğretmenin en zor görevlerinden birisidir. Çünkü öğretmenin grubu yönlendirmemesi ve grubun kontrolünü almaması gerekmektedir. Fakat ayni zamanda yeri geldiğinde bir takım açık uçlu sorularla grupta tartışma ortamı yaratması gerekmektedir. Burada dikkat edilmesi gereken nokta öğrencilerin basitçe direk olarak cevap verebileceği soruların sorulmamasıdır. Öğrencilerin değerlendirilmesi: öğrenciler değerlendirilirken uygulanan yazılı sınavın sonucunun yanı sıra öğretmen ve grup üyelerinin doldurduğu değerlendirme formları da göz önüne alınır. Bu formlarda öğrenciler grup içersindeki katılımları, katkıları, birbirleriyle olan ilişkileri, ne ölçüde hazırlıklı geldikleri gibi kriterlere göre değerlendirilirler.

Probleme dayalı öğrenme modeli uygulanırken çok farklı gruplarla, öğrencilerle karşılaşılabilir. Kimi gruplarda öğrenciler birbirlerine karsı olumsuz, saldırgan davranışlar sergilerken, kimi gruplarda öğrenciler ortaya atılan fikirleri hiç sorgulamadan kabul etme eğiliminde olabilirler. Öğretmenin bunun farkında olup her koşulda öğrencilerin merkezde olduğu ve modelin gerektirdiği tarzda davrandığı bir ortam oluşturması gerekmektedir. Mesela, öğrenciler ne yapmaları, nasıl davranmaları gerektiği konusunda belirsizliğe düşerse öğretmen hemen müdahale etmemeli, beklemelidir. Eğer öğrenciler tamamen bir belirsizlik içersinde ise öğretmen 'problemi anlayabilmek için ne tür ek bilgilere ihtiyacınız var?', 'tüm bunlardan ne çıkarabilirsiniz' gibi genel, direkt cevabi olmayan sorular sorabilir. Benzer bir şekilde, eğer öğrenciler birtakım bilgileri, fikirleri sorgulamadan kabul ediyorsa 'bunu nerden öğrendin?', 'bu söylemiş olduğun bir gerçek mi yoksa senin düşüncen mi?', 'bu konuda emin misin?', 'herkes bu konuda hemfikir mi?' gibi sorular yöneltebilir. Dolayısıyla karsılaştığı grubun özellikleri ne olursa olsun öğretmenin sınıfın kontrolünü almadan rolünü yerine getirebilmesi için:

- tartışma ortamının kontrolünün ve devamlılığının öğrencilerde olmasını sağlamalıdır. Eğer öğrenciler soru sorarsa kontrolün tekrar onlara geçmesini sağlayacak tarzda davranmalıdır. Grup çalışması öğretmen ve her bir öğrenci arasındaki soru cevap oturumlarına dönüşmemelidir.
- öğrencilerin konuya yönlenmelerini, konu üzerine daha derinlemesine düşünmesini sağlamalıdır. Bunu yapabilmek için ise açık uçlu, çok genel sorular sormalıdır
- sabırlı olmalıdır. Özellikle probleme dayalı öğrenme modelinin ilk uygulanmaya başladığı sıralarda öğrenciler beklendiği gibi davranamayabilir. Öğretmen öğrencilerine zaman tanımalıdır

- öğrencilerin sorgulama yeteneklerini geliştirmelidir. Öğrenciler buldukları bilgileri hemen kabul etmeyip üzerinde düşünmelidirler.

Öğretmenin sınıfta yapmaması gerekenler söyle sıralanabilir:

- sessizlik olduğunda hemen kontrolü almamalıdır
- sorulan sorulara direkt olarak cevap vermemelidir
- öğrencilere doğru yada yanlış yolda olduklarını söylememelidir
- direkt olarak öğrencileri öğrenmeleri gereken konular konusunda yönlendirmemelidir

C. Probleme Dayalı Öğrenme Modelinde Ders İslenişi

Probleme dayalı öğrenme modelinin temelini grup halinde çalışan öğrenciler ve öğretmen oluşturmaktadır. Grubun her bir üyesi grubun diğer üyelerini yapıcı olarak eleştirebilmeli, sorgulayabilmeli ve eleştirilmekten, sorgulanmaktan çekinmemelidir. Bu tür davranışlar grup üyelerinde rahatsızlık oluşturabileceğinden, ilk baslarda bunu gerçekleştirmek zor olabilir. Fakat zaman geçtikse, öğrenciler modele alıştıkça bu, öğrencilerin bilgilerini arttırmaları gerektiği konulara yoğunlaşmasını sağlayan eğlenceli bir egzersiz haline gelecektir.

Biyoloji derslerinde kullanılabilecek bir örnek olayın probleme dayalı öğrenme modeli ile islenişi aşağıda belirtildiği gibi olmaktadır:

Ders başlamadan önce örnek olaya ilişkin bilgileri kimin okuyacağı, kimin tahtaya yazacağı belirlenir. Ayrıca kimin hasta, kimin doktor rolünü oynayacağı da belirlenir. Bu rol dağılımı gönüllü öğrenciler arasında yapılır. Eğer örnek olay daha önceki ders saatlerinde başladıysa kura ile belirlenen bir öğrenci daha önceki ders saatlerinde örnek olaya ilişkin yapılanları özetler bu arada grup harici bireysel çalışma sırasında bulduklarından ve kendi düşüncelerinden kısaca bahseder.

Roller belirlendikten sonra örnek olayın ilk sayfası öğrencilere dağıtılır. Örnek olay bir hastayı anlatır. Hastaya ilişkin bilgiler 5 yada daha fazla sayfada verilir.

Genel olarak birinci sayfada hastanın adi, cinsiyeti, yası ve şikayeti belirtilir. İkinci sayfada hastanın şikayetleri, geçmişteki rahatsızlıkları, kullandığı ilaçlar, ailesinde görülen rahatsızlıklar ve yasam tarzı ile ilgili daha detaylı bilgiler verilir. İkinci sayfa hasta rolünü üstlenecek öğrenciye birinci sayfayla birlikte verilir. Öğrenciler birinci sayfa üzerine tartışırken hasta rolünü oynayan öğrenci bir taraftan da ikinci sayfayı içinden okur. Üçüncü sayfada muayene sonucu elde edilen veriler yer alır. Dördüncü ve onu takip eden sayfalarda yapılan test, çekilen röntgen, EKG sonuçları ve diğer ilgili sonuçlar bulunur. Son sayfada ise teşhis yer alır.

İlk sayfa dağıtıldıktan sonra örnek olayda verilenleri okumaktan sorumlu olan öğrenci ilk sayfada verilen bilgileri yüksek sesle okur diğer öğrenci tahtaya bilgileri not eder. Bu arada öğrenciler verilen bilgiler hakkında tartışmaya başlarlar. Hastanın şikayetleri hangi organ sistemiyle ilgili olabilir, daha çok bilgi edinebilmek için hastaya ne tür sorular sorulmalıdır gibi konular üzerine odaklaşırlar. Öğrenciler düşüncelerini belirtirken niçin öyle düşündüklerini de açıklarlar ve ortaya atılan düşünceleri, söylenen bilgileri doğrulukları konusunda sorgularlar. Tartışma sırasında probleme çözüm üretebilmek için hangi konularda bilgi edinmeleri gerekiyor buna karar verirler. Tüm bu tartışmalar yapılırken tahtaya yazmaktan sorumlu olan kişi, hastanın probleminin hangi sistemle ilgili olduğu, ne gibi sorulara cevap bulunması ve hangi konuların öğrenilmesi gerektiğine dair grubun vermiş olduğu kararları tahtaya yazar. Daha sonra doktor rolünü oynayacak olan öğrenci belirlenen soruları hasta rolünü oynayan öğrenciye sorar. Bu arada diğer öğrenciler akıllarına başka sorular gelirse hastaya sorabilirler. Hastanın verdiği cevaplar tahtaya not edilir ve bu yeni bilgiler doğrultusunda daha önceki düşüncelerini gözden geçirirler. Bu arada öğrenilmesi gereken konular üzerinde tartışırlar. Gerekli bilgileri sordukları sorularla edindiklerini düşündüklerinde örnek olaya ilişkin ikinci sayfayı öğretmenden isterler ve öğretmen ikinci sayfayı dağıtır. Örnek olayı okumaktan sorumlu olan öğrenci yüksek sesle ikinci sayfayı okur. Daha sonra öğrenciler spesifik olarak hangi fiziksel muayene sonucuna ihtiyaç duyulduğuna karar verir ve öğretmenden fiziksel muayene sonuçlarını içeren üçüncü sayfayı ister. Öğrenciler ilk üç sayfada verilen bilgileri kullanarak hastadan ne tür tetkiklerin istenmesi gerektiğine karar verirler. Mesela, hastanın kan değerlerine, akciğer röntgenin sonucuna ihtiyaç duyabilirler. Öğrenciler hangi testlerin sonucuna ihtiyaç duyulduğuna karar verince öğretmen dördüncü sayfayı dağıtır. Öğrenciler örnek olaya ilişkin bilgilerin yer aldığı sayfaları edindikçe daha önce ortaya atmış oldukları düşünceleri, hipotezleri gözden geçirirler ve teşhis koymaya çalışırlar ve aralarında tartıştıktan sonra öğretmen teşhisi içeren besinci sayfayı dağıtır. Bu arada öğrenciler esas amacın bu örnek olay sayesinde bir takım biyolojik kavramların konuların öğrenilmesi olduğu, teşhis koymak olmadığının bilincinde olmalıdır.

Probleme dayalı öğrenme modelinin uygulanışına ilişkin olarak vurgulanması gereken önemli noktalardan birisi sudur: Bir örnek olay yaklaşık 4-6 saatte tamamlanır. Bu da öğrencilerin 2 yada 3 kere grup çalışması yapmasına denk gelmektedir. Öğrenciler her bir grup çalışmasının sonunda öğrenilmesi gereken konular ve bu konular hakkında nerelerden bilgi edinebileceklerine dair karar verirler ve bir sonraki grup çalışmasına kadar bu konular üzerinde bireysel çalışma yaparlar. Bireysel çalışma sırasında öğrenciler kitaplardan, internetten faydalanabilir yada konusunda uzman bir kişiye danışabilirler. Öğrenciler isterlerse grup halinde de çalışabilirler. Her bir öğrenci konu hakkında bilgi edindikten sonra, bu bilgiler doğrultusunda görüşlerini belirtecek tarzda hazırlanarak bir sonraki ders saatine katılır. Her öğrencinin ders saatlerine hazırlıklı gelmesi gerekmektedir. Çünkü bir sonraki dersin basında kurayla bir öğrenci belirlenir ve bu öğrenci örnek olayda hastaya ilişkin verilen bilgileri ve bireysel çalışma sonucu elde ettiği bilgiler doğrultusunda probleme ilişkin görüşlerini anlatır. Daha sonra diğer öğrenciler görüşlerini belirtir ve bir önceki ders saatinde kalındığı yerden örnek olay üzerinde tartışılmaya devam edilir, yeri geldikçe ilgili sayfalar istenir.

Öğrenciler kendi aralarında tartışırken öğretmen onları gözlemler. Herhangi bir şekilde öğrencileri yönlendirmez. Fakat raporun 'probleme dayalı öğrenme modelinde öğretmenin rolü' kısmında belirtildiği gibi gerektiğinde birtakım stratejiler izleyerek dersin model doğrultusunda öğrenci merkezli olarak islenmesini sağlar.

Genel olarak özetlemek gerekirse probleme dayalı öğrenme modelinin uygulandığı sınıflarda:

- öğrenciler öğrenme sürecinde aktif olarak yer alır
- öğrencilerde bilgiye ulaşabilmek için gerekli olan tutum ve davranışlar geliştirilir.
- öğrenciler ortak bir problemi analitik olarak grup içersinde çözebilme ortamı bulur.

APPENDIX H

POSTERS

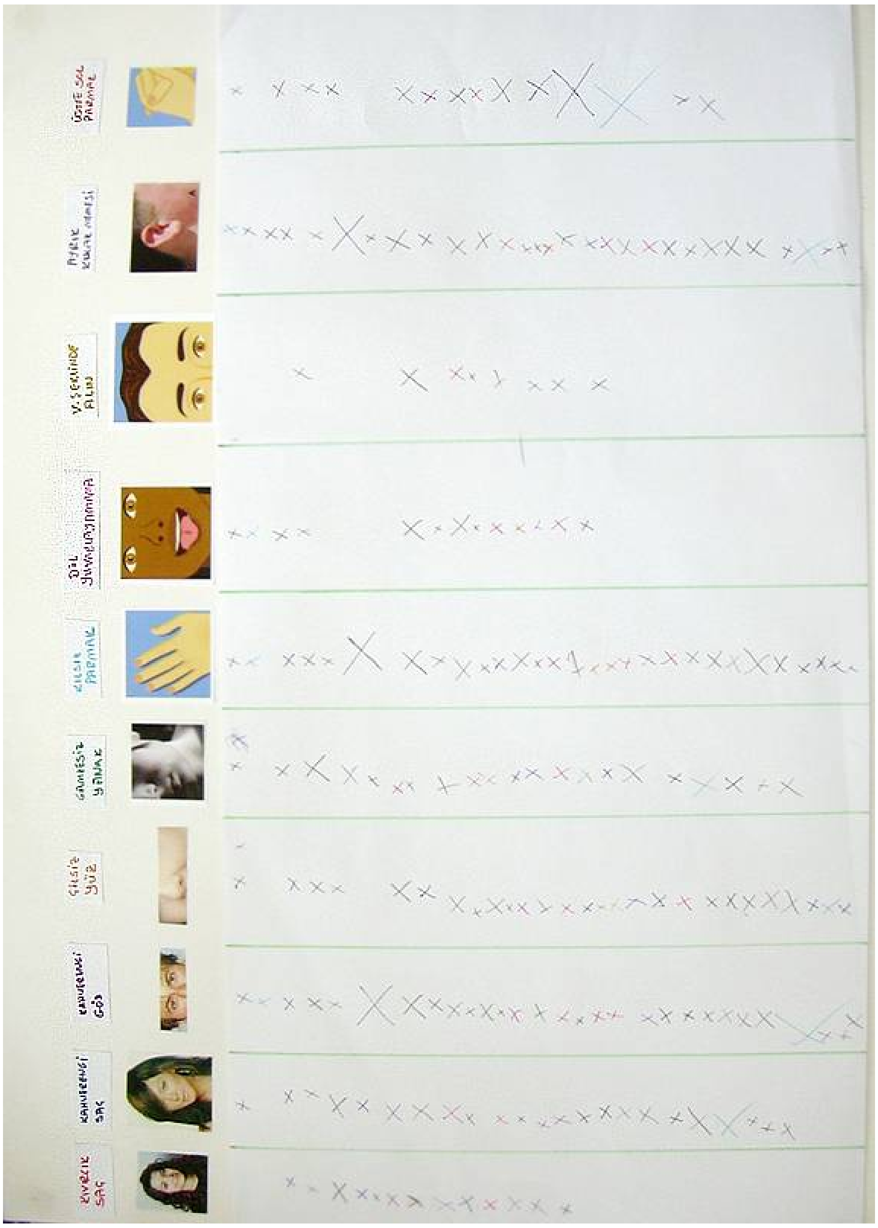


Figure H.1: Poster A: Dominant Characters

Figure H.2: Poster B: Recessive Characters

APPENDIX I

PREPERATION ACTIVITY

ODTÜ de Moleküler Biyoloji ve Genetik bölümünde çalışan bir öğretim görevlisi olarak sizden ilköğretim seviyesindeki öğrencilere genetik konusunu 3 haftalık bir sürede toplam 12 ders saatinde öğretecek bir öğrenim planı hazırlamanız istendi. Bu konuyu 5 kategoride planlamaya karar verdiniz:

DNA: DNA Molekülünün yapısı, görevleri, ve DNA molekülünün kendini eşlemesi.

DNA-GEN-KROMOZOM: Kavramların tanımları ve aralarındaki farklar.

KALITIM VE KALITSAL ÖZELLİKLER: Bireylerin birbirinden farklılıklarının sebepleri, kalıtımın dış görünüşümüze etkileri(saç-göz rengi, saç yapısı, gamze, dil yuvarlama, kulak memesi şekli).

ÇAPRAZLAMALAR: Genetik, Kalıtım, Genotip, Fenotip, Alel gen, Melez döl, Arı döl, Çekinik (Resesif) gen, Baskın (Dominant) gen, Homozigot, Heterezigot, Homolog Kromozom kavramlarının tanımları ve örnekleri. Mendel'in bezelye bitkisi üzerinde yaptığı çalışmalar ve Mendel Yasaları.

KALITIMSAL HASTALIKLAR VE AKRABA EVLİLİĞİ: Eşey kromozomları ve cinsiyet, Gamet, Taşıyıcılık, Renk körlüğü, Orak hücreli anemi, Hemofili.

Göreviniz sadece bilgileri elde etmek değil, bu bilgileri öğretirken kullanılabilecek **çalışma yaprakları** hazırlamak ve **güncel bilgiler, resimler bulmaktır**.

☺ Planı tablo halinde yapabilirsiniz.
☺ Güncel bilgiler dergi ve makalelerden genetikle ilgili haberler olabilir.
☺ Resimler internetten, gazete ve dergilerden, kitaplardan edinilebilir.
☺ Çalışma sayfalarında kavramların tanımları, boşluk doldurmalı veya eşleştirmeli sorular olabilir.

Not:	Grup olarak değil bireysel çalışacaksınız. Süreniz 1 hafta.

APPENDIX J

CASE 1

Örnek Olay
-1-
Bezelye

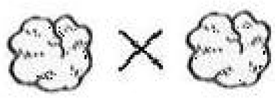
Mehmet Bey Bursa'nın bir köyünde çiftçilik yapmaktadır. Mehmet Bey tarlasında bezelye yetiştirmekte ve yetiştirdiği bezelyeleri pazara giderek satmaktadır. Pazara getirdiği bezeleyelerin büyük bir kısmının tohumları yuvarlak daha az bir kısmının ise buruşuktur. Pazarda buruşuk tohumlu bezelyelerin çok satılmadığını farkeden Mehmet Bey bezelyenin niçin farklı özellikler gösterdiğini merak etmekte ve bunun nedenini bulabilirse daha çok yuvarlak tohumlu bezelye yetiştirebileceğini düşünmektedir.

Örnek Olay
-1-
Bezelye

Mehmet Bey bütün bezelyeleri aynı şartlarda yetişmektedir : Bezelyeler aynı özellikteki toprağa sahip tarlaya, aynı gün ekilmiştir ve eşit miktarda güneş ışığına maruz kalmıştır, tüm tarla aynı su ile sulanmıştır. Mehmet Bey, pazara bezelye getiren diğer çiftçi arkadaşlarının tarlalarında da hem yuvarlak tohumlu hem de buruşuk tohumlu bezelyeler yetiştiğini gözlemlemiştir.

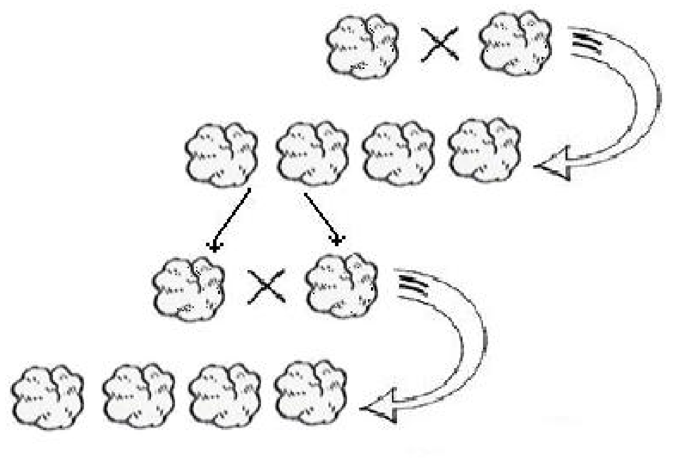
Örnek Olay
-1-
Bezelye

Mehmet Bey, buruşuk tohumlu bezelyeleri birbiriyle çaprazlamaya karar vermiştir. (birinin çiçek tozunu, diğerinin dişi organlarının tepecikleri üzerine serpmiştir)



Örnek Olay
-1-
Bezelye

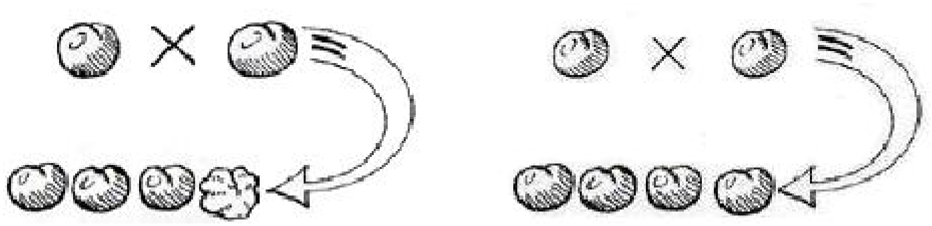
Mehmet Bey buruşuk tohumlu bezelyeleri çaprazladığında elde ettiği bezelyelerin tümü her defasında buruşuk tohumlu olmuştur. Elde ettiği buruşuk bezelyeleri tekrar çaprazladığında ise gene buruşuk bezelyeler elde etmiştir.



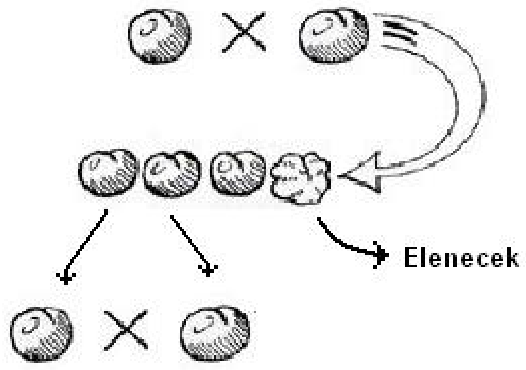
Bunun üzerine Mehmet bey yuvarlak tohumlu bezelyeleri kendi aralarında çaprazlarsa yuvarlak tohumlu bezelyeler elde edip edemeyeceğini merak etmiştir. Böylece yuvarlak tohumlu olan bezelyelerle diğer yuvarlak tohumlu bezelyeleri çaprazlamıştır.

Örnek Olay
-1-
Bezelye

Mehmet Bey, sonraki nesillerde bütün bezelyelerin yuvarlak tohumlu olmadığını görmüştür. İçlerinde buruşuk bezelye tohumları da çıkmıştır. Bu durum karşısında çok şaşırmıştır. Neden tamamı yuvarlak tohumlu olmamıştı da buruşuk tohumlu bezelyeler de çıkmıştı?

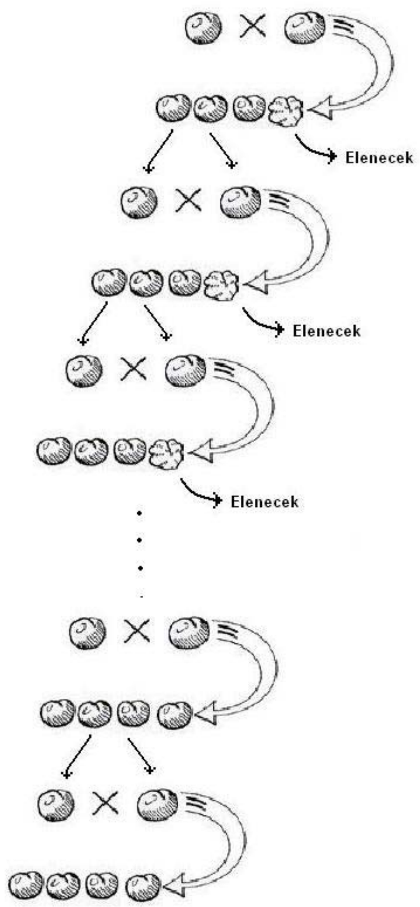


Bunun üzerine Mehmet Bey, sonraki nesillerde çıkan buruşuk bezelye tohumlarını her seferinde eledi ve yalnızca yuvarlak tohumlu bezelyeleri birbirleriyle çaprazladı.



Örnek Olay
-1-
Bezelye

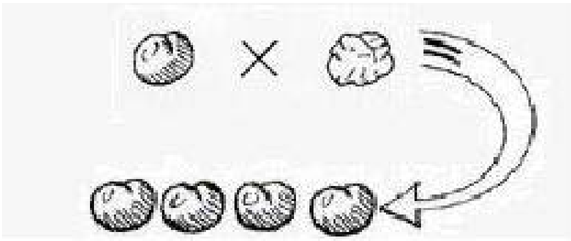
Mehmet Bey, her seferinde buruşuk tohumlu bezelyeleri eleyerek çaprazlamalarına devam etti ve artık hiç buruşuk bezelye elde etmemeye başladı. Artık yaptığı her çaprazlama sonucunda yuvarlak tohumlu bezelye elde ediyordu.



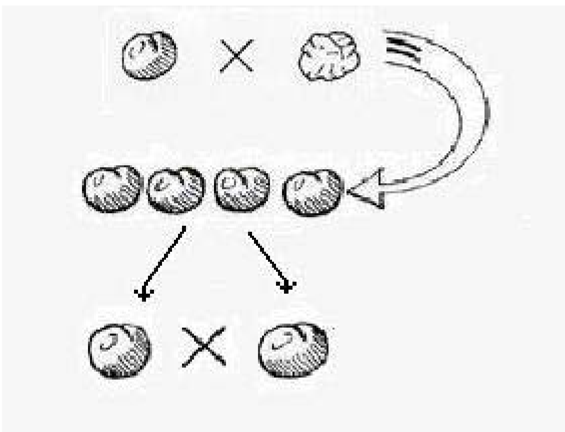
Mehmet Bey, sonunda sadece yuvarlak bezelyeler elde edebiliyordu. Ama merak ettiği birşey vardı. Acaba yuvarlak tohumlularla buruşuk tohumluları çaprazlarsa ne olacaktı? Bunun üzerine sürekli elde ettiği yuvarlak tohumlu bezelyelerle buruşuk tohumlu bezelyeleri çaprazladı.

Örnek Olay
-1-
Bezelye

Yuvarlak ve Buruşuk tohumlu bezelyeleri çaprazladığında elde ettiği bezelyelerin tamamı yuvarlak tohumluydu.

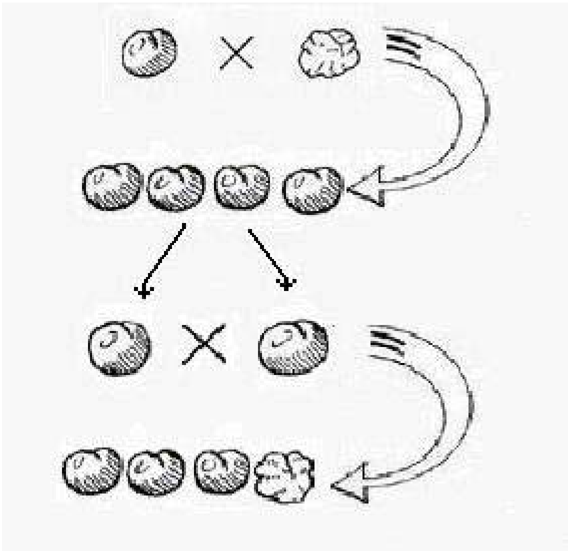


Yeni elde ettiği bu yuvarlak tohumlu bezelyeler arasında neden buruşuk tohumlu yok diye düşündü. Acaba bu bezelyelerin içinde buruşuk bezelyelerle ilgili bir bilgi var mıydı? Bunu test etmek için bu yuvarlak tohumlu bezelyeleri kendi aralarında çaprazlamaya karar verdi.



Örnek Olay
-1-
Bezelye

Elde ettiği bezelyelerde hem yuvarlak tohumlu hem de buruşuk tohumlu bezelyeler vardı. Fakat yuvarlak tohumlu bezelyeler buruşuklardan daha fazlaydı. Mehmet bey bezelye tanelerini saymış ve yaklaşık olarak %75’inin yuvarlak tohumlu % 25’inin ise buruşuk tohumlu olduğunu farketmiştir.



Örnek Olay
-1-
Bezelye

Mehmet Bey yaptığı çaprazlamaların sonuçlarını köylerinde ziraat mühendisi arkadaşı Salih Bey ile paylaştı. Salih Bey ona bu konuyla ilgili şunları söyledi;

- Her canlıda olduğu gibi, bezelye bitkisinde de karakterleri (örneğin tohumların yuvarlak veya buruşuk olmasını) belirleyen bazı birimler (genler) vardır.

- Bezelye bitkisinde her karakter için birbirinin aynı veya farklı 2 birim (gen) bulunur.

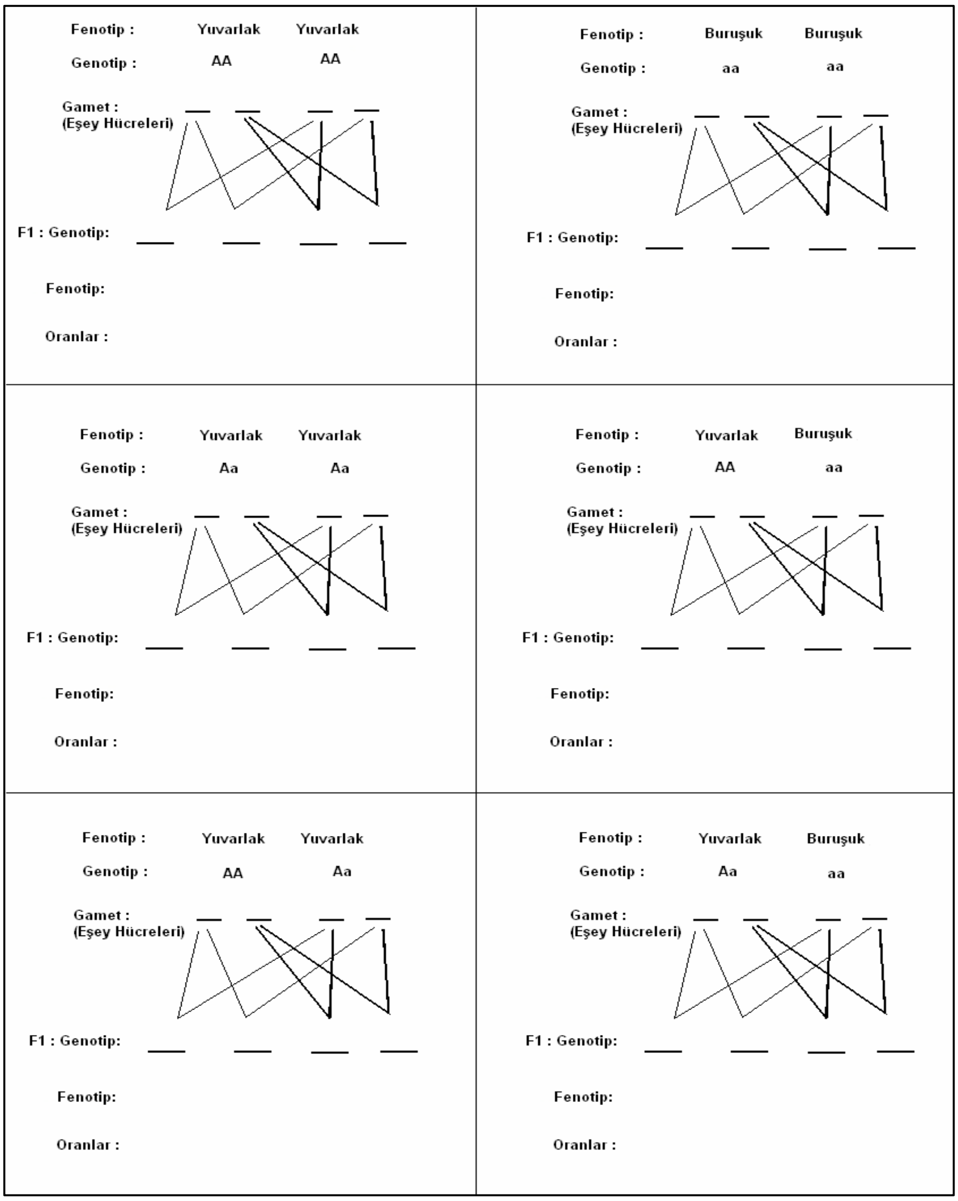
- Birim(gen) çiftleri birbirinden farklı ise baskın olan birimin özelliği görülür. Senin yuvarlak ve buruşuk tohumlu bezelyeleri çaprazladığında yuvarlak tohumlu bezelyeleri daha yüksek oranda elde ediyor olman işte bu yüzdendir.

- Yuvarlak tohumlu bezelyeleri kendi aralarında çaprazladığında buruşuk tohumlu bezelye elde edebilirsin çünkü yuvarlak bezelyeler içlerinde buruşuk tohumlu olma özelliğinden sorumlu birimi saklıyor olabilirler. Buruşuk tohumluları kendi aralarında çaprazladığında hepsi buruşuk oldu çünkü içlerinde yuvarlak bezelye tohumu birimi yok; eğer olsaydı onlar da yuvarlak görünürdü.

- Birtakım biyolojik terimler kullanarak konuyu biraz daha açabilirim: Mayoz bölünme sırasında birim (gen) çiftleri birbirinde ayrılır ve mayoz bölünme sonucunda oluşan her bir gamet gen çiftlerinden yalnızca birisini barındırır. İkisini birden barındırmaz. Döllenme sırasında ise gametler rastgele birleştiklerinden, bir sonraki nesilde farklı gen çifti kombinasyonları ortaya çıkabilir.

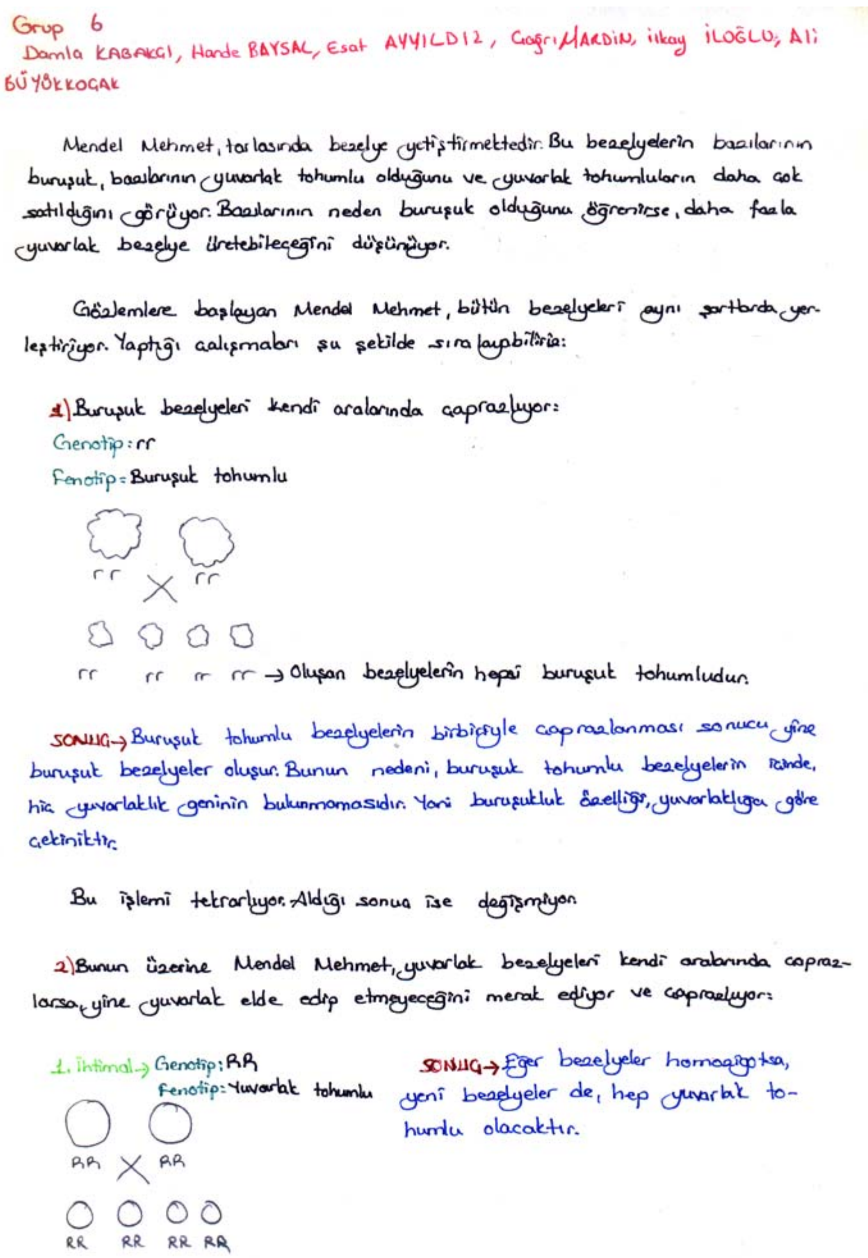
APPENDIX K

WORKSHEET 1



APPENDIX L

SAMPLE OF STUDENTS’ FINAL REPORT FOR CASE 1



Grup 6
Damla KABAKCI, Hande BAYSAL, Esat AYYILDIZ, Çağrı MARDİN, İlkay İLOĞLU, Ali BÜYÜKKOCAK

Mendel Mehmet, tarlasında bezelye yetiştirmektedir. Bu bezelyelerin bazılarının buruşuk, bazılarının yuvarlak tohumlu olduğunu ve yuvarlak tohumluların daha çok satıldığını görüyor. Bazılarının neden buruşuk olduğunu öğrenirse, daha fazla yuvarlak bezelye üretebileceğini düşünüyor.

Gözlemlere başlayan Mendel Mehmet, bütün bezelyeleri aynı şartlarda yerleştiriyor. Yaptığı çalışmaları şu şekilde sıralayabiliriz:

1) Buruşuk bezelyeleri kendi aralarında çaprazlıyor:
Genotip: rr
Fenotip: Buruşuk tohumlu

rr X rr

rr rr rr rr → Oluşan bezelyelerin hepsi buruşuk tohumludur.

SONUÇ → Buruşuk tohumlu bezelyelerin birbiriyle çaprazlanması sonucu yine buruşuk bezelyeler oluşur. Bunun nedeni, buruşuk tohumlu bezelyelerin içinde, hiç yuvarlaklık geninin bulunmamasıdır. Yani buruşukluk özelliği, yuvarlaklığa göre çekiniktir.

Bu işlemi tekrarlıyor. Aldığı sonuç ise değişmiyor.

2) Bunun üzerine Mendel Mehmet, yuvarlak bezelyeleri kendi aralarında çaprazlarsa, yine yuvarlak elde edip etmeyeceğini merak ediyor ve çaprazlıyor:

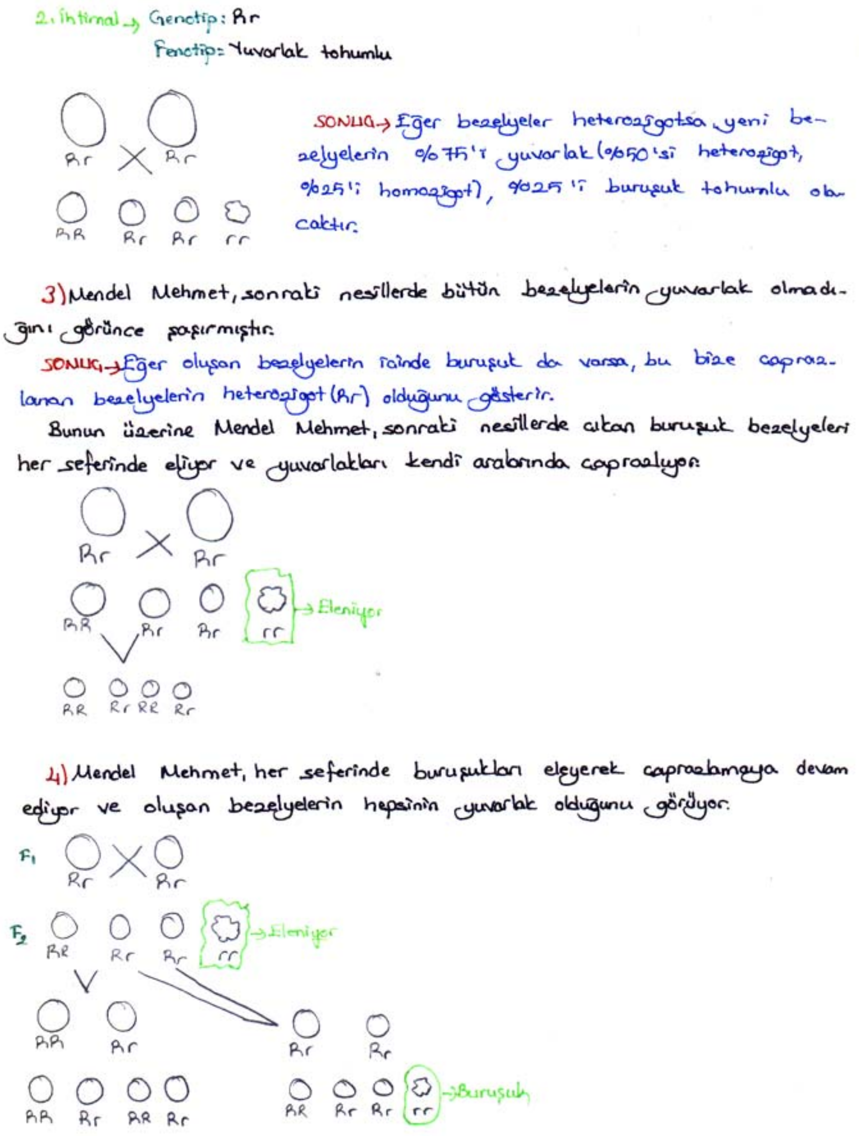
1. İhtimal → Genotip: RR
Fenotip: Yuvarlak tohumlu

RR X RR

RR RR RR RR

SONUÇ → Eğer bezelyeler homozigotsa, yeni bezelyeler de, hep yuvarlak tohumlu olacaktır.

Figure L.1: Sample of Students’ Final Report for Case 1 Page 1



2. İhtimal → Genotip: Rr
Fenotip: Yuvarlak tohumlu

Rr × Rr
RR Rr Rr rr

SONUÇ → Eğer bezelyeler heterozigotsa yeni bezelyelerin %75'i yuvarlak (%50'si heterozigot, %25'i homozigot), %25'i buruşuk tohumlu olacaktır.

3) Mendel Mehmet, sonraki nesillerde bütün bezelyelerin yuvarlak olmadığını görünce şaşırmıştır.

SONUÇ → Eğer oluşan bezelyelerin içinde buruşuk da varsa, bu bize çaprazlanan bezelyelerin heterozigot (Rr) olduğunu gösterir.

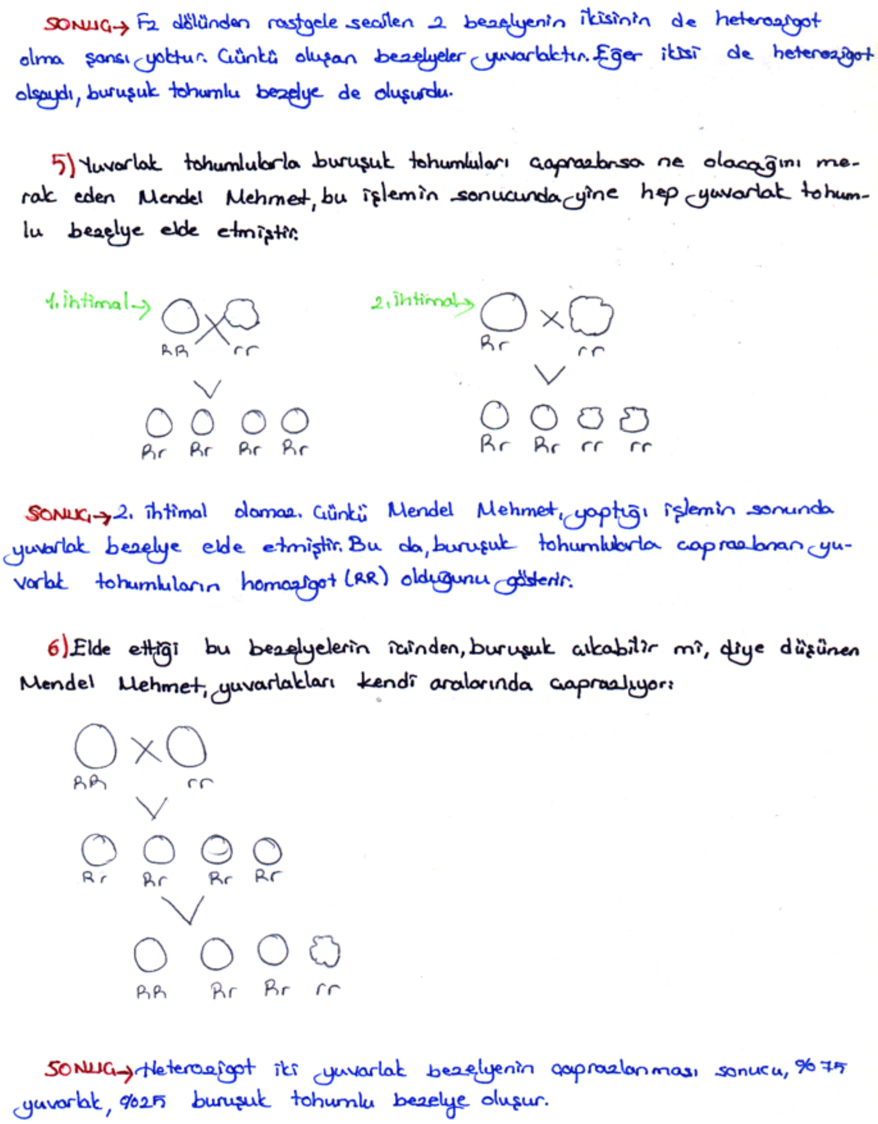
Bunun üzerine Mendel Mehmet, sonraki nesillerde çıkan buruşuk bezelyeleri her seferinde eliyor ve yuvarlakları kendi aralarında çaprazlıyor.

Rr × Rr
RR Rr Rr rr → Eleniyor
RR Rr RR Rr

4) Mendel Mehmet, her seferinde buruşukları eleyerek çaprazlamaya devam ediyor ve oluşan bezelyelerin hepsinin yuvarlak olduğunu görüyor.

F1 Rr × Rr
F2 RR Rr Rr rr → Eleniyor
RR Rr Rr Rr
RR Rr RR Rr RR Rr Rr rr → Buruşuk

Figure L.2: Sample of Students' Final Report for Case 1 Page 2



SONUÇ→ F2 dölünden rastgele seçilen 2 bezelyenin ikisinin de heterozigot olma şansı yoktur. Çünkü oluşan bezelyeler yuvarlaktır. Eğer ikisi de heterozigot olsaydı, buruşuk tohumlu bezelye de oluşurdu.

5) Yuvarlak tohumlularla buruşuk tohumluları çaprazlarsa ne olacağını merak eden Mendel Mehmet, bu işlemin sonucunda yine hep yuvarlak tohumlu bezelye elde etmiştir.

SONUÇ→ 2. ihtimal olamaz. Çünkü Mendel Mehmet, yaptığı işlemin sonunda yuvarlak bezelye elde etmiştir. Bu da, buruşuk tohumlularla çaprazlanan yuvarlak tohumluların homozigot (RR) olduğunu gösterir.

6) Elde ettiği bu bezelyelerin içinden, buruşuk çıkabilir mi, diye düşünen Mendel Mehmet, yuvarlakları kendi aralarında çaprazlıyor:

SONUÇ→ Heterozigot iki yuvarlak bezelyenin çaprazlanması sonucu, %75 yuvarlak, %25 buruşuk tohumlu bezelye oluşur.

Figure L.3: Sample of Students’ Final Report for Case 1 Page 3

APPENDIX M

CASE 2

Örnek Olay
-2-
Emre'nin Hastalığı

Hatay'lı bir aile 4 yaşındaki Emre adlı oğullarını yorgunluk, halsizlik ve sık sık ateşlenme şikayetleriyle doktora getirmişlerdir. Emre'de yaşıtlarına göre gelişim geriliği olduğundan şüphelendiklerini belirtmişlerdir. Ayrıca Emre'nin kalbinde zaman zaman çarpıntı olduğunu da söylemişlerdir.

Örnek Olay
-2-
Emre’nin Hastalığı

Emre’in anne ve babası Emre’in doğumundan beri çok hareketli bir çocuk olmadığını açıklamışlardır. Emre solgun ve bitkin gözükmektedir. Karın bölgesinde şişlik olduğu farkedilmiştir. Emre’nin parmaklarında ağrılar vardır.

Emre’nin anne ve babası amca çocukları olduklarını ve bazı akrabalarında da Emre’ninkine benzer şikayetlerin olduğunu söylemişlerdir.

Örnek Olay
-2-
Emre'nin Hastalığı

Yapılan muayene, tetkikler ve sonuçları 1

Fiziksel Muayene Sonuçları:

Karın bölgesinde şişlik
Deride ve gözlerde solgunluk ve bronz renk
Hızlı nefes alıp verme ve nefes alma güçlüğü
Yaşa göre gelişme geriliği
Kemiklerde yapısal bozukluklar
Yüz kemiklerinde ve elmacık kemiklerinde çıkıklık

Yapılan muayene, tetkikler ve sonuçları 2

LABORATUVAR TEST SONUÇLARI

Hasta Bilgileri : Emre KESKİN
TC, Kimlik No :
Müracat Tarihi : 03/05/2006 10:50

Göndr.Servis Çocuk HEMATOLOJİ
Cinsiyet/Yaş ■Erkek 4 ayakta
Rapor Tarihi 04/05/2006 13:33

UYGULANAN TESTLER	SONUÇ	BIRIM	NORMAL DEGERLER
MERKEZ LABORATUVARI			
(BY01) AÇLIK KAN SEKERl	80	mg/dl	70 - 110
(BY03) AST(SGOT)........................	20	U/L	0 - 40
(BY04) ALT(SGPT)........................		U/L	0 - 40
(BY05) ALKALEN FOSFAT	58	U/L	42 - 128
(BY06) GGT..............................	9	U/L	0 - 50
(BY07) LDH..............................	159	U/L	125 - 243
(BY15) BUN	12	mg/dl	5 - 25
'(BY16) ÜRIK ASIT	3,5	mg/dl	2,6 - 7,2
(BY17) KREATiNIN	0,6	mg/dl	0,5 - 1,4
(BY18) T.PROTEIN	7,1	g/dl	6,4 - 8,5
(BY19) ALBUMIN	4,9	g/dl	3,5 - 5
(BY20) KALSIYUM	8,9	mg/dl	8,2 - 10,6
(BY21) FOSFOR...........................	3,2	mg/dl	2,5 - 4,5
(BY22) KOLESTEROL......................	145	mg/dl	110 - 200
(BY23) HDL-KOLESTEROL..................	55	mg/dl	30 - 80
(BY24) LDL-KOLESTEROL..................	79	mg/dl	60 - 130
(BY25) VLDL-KOLESTEROL	10	mg/dl	10 - 40
(BY26) TRİGLiSERiT.....................	52	mg/dl	50 - 200
(BY27) T.BILIRUBIN....................	0,47	mg/dl	0,2 - 1,3
(BY28) D. BILIRUBIN	*0,7	mg/dl	0 - 0,5
(BY30) KLOR	105	mmol/L	96 - 108
(BY32) SODYUM..........................	138	mmol/L	135 - 146
(BY33) POTASYUM	*6	mmol/L	3,5 - 5,3
(BY93) , . . DEMİR.....................	*250	ug/dl	25 - 156
(BY94) .. DEMIR BAGLAMA KAPASlTESi ...	*150	ug/dl	250 - 450
(BY95) SERUM DEMIRI VE DEMİR BAGLAMA KA			

HEMATOLOJI MERKEZ L

(CBC102) .. RBC (Eritrosit-alyuvar)	*5,27	x10..e6/uL	4 - 5,2
(CBC103) .. HGB (Hemoglobin)	*8,02	g/dL	11 - 16
(CBC104).. HCT (Hematokrit)	*27,9	%	36 - 46
(CBC105) .. MCV (Ortalama Eritrosit Hacm	*52,9	fL	80 - 92
(CBC106).........MCH (Ortalama Hücre Hemoglob	*15,2	pg	27 - 31
(CBC107) .. ..MCHC (Ortalama Hücre Hemog,.K	*28,8	g/dL	32 - 36
(CBC109) ...PLT (Trombosit-kan pulcukları)	205	x10.. 3/uL	130 - 400

Yapılan muayene, tetkikler ve sonuçları 2

LABORATUVAR TEST SONUÇLARI

Hasta Bilgileri: Emre KESKİN
Kimlik No :

Müracat Tarihi : 03/05/2006 10:50

Gondr.. Servis | Çocuk HEMATOLOJİ
Cinsiyet/Yaş | ■Erkek 4 ayakta
Rapor Tarihi | 04/05/2006 13:33

UYGULANAN TESTLER	SONUÇ	BIRIM	NORMAL DEGERLER
(CBC136) ...RTC % (Retikulosit Yüzdesi)	0,801	%	0,5 - 2,5
(CBC142) RETÜKÜLOSİT SAYIMI:...........		/uL	22 - 139
(CBC143) .. RTC # (RETIKULOSIT SAYISI.	*203		
(CBC14 6) .. IRE	9	mm/st	0 - 20
(CBC74) SEDIMANTASYON			
(CBC78) PERIFERIK YAYMA			

MERKEZ LABORATUVARI

(GYTIOO)DISKIDA HRB (MONOKLONAL)			NEGA

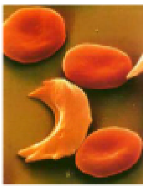
HORMON LABORATUVARI

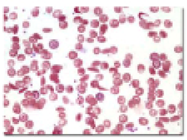
(HM033) FERRITIN ..	*300	ng/ml	4 -204
(HM034) VITAMIN 3-12	322,2	pg/mL	160 -894

MERKEZ LABORATUVARI

(IDR113)STRIP KULLANARAK IDRAR TETKIKl			
(IDR106) .. ..DANSITE............. '..	1020		1015-1025
(IDR110) .. .LOKOSIT..................	neg		NEGA
(1DR112) ...NİTRIT	neg		NEGA
(1DR79) ...IDRARDA pH OLCUMU.........	5		5-7
(tDR111) ...ERITROSIT.................	neg		NEGA
(JDR105) ...PROTEIN...................	neg		NEGA
(tDR80) ...GLUKO TEST	Neg		NEGA
[IDRI07)....KETON(Aseton) ..	neg	mmol/L	0,5
IDR109) ...ÜROBİLİNOJEN.. ..	norm	umol/L	16
IDR108) ...BİLİRUBİN . ..	*15		NEGA

Periferik Yayma ile Mikroskop Görüntüleri:





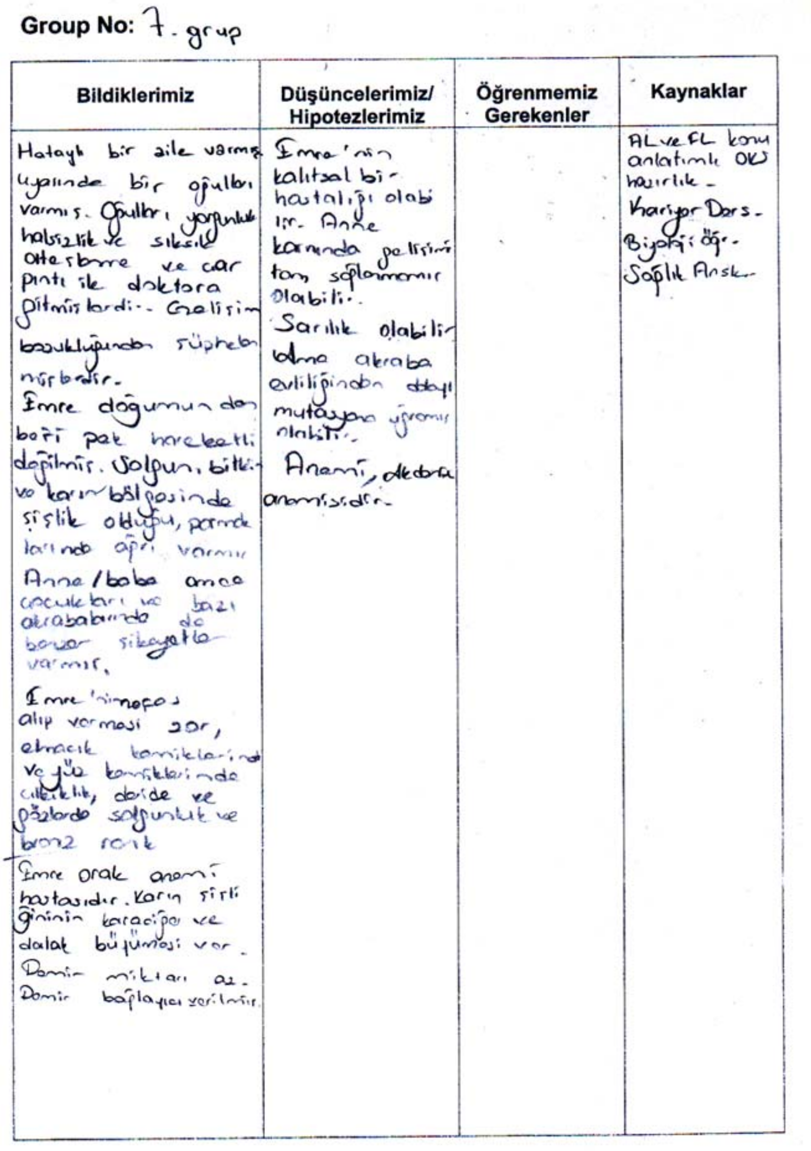
Örnek Olay
-2-
Emre'nin Hastalığı

Yapılan tetkikler ve analizler sonucu Emre'nin orak hücreli anemi hastası olduğu ve karın bölgesindeki şişliğin karaciğer ve dalak büyümesinden kaynaklandığı ortaya çıkmıştır.

Gerekli tedaviye başlanarak Emre'ye demir bağlayıcı ilaçlar verilmiştir. Emre'nin demir miktarı az besinlerle beslenmesi önerilmiş ve hastalığın ilerlemesi halinde kan transfüzyonu için sık sık hasteneye gelinmesi gerektiği belirtilmiştir.

APPENDIX N

SAMPLE GROUP SHEET



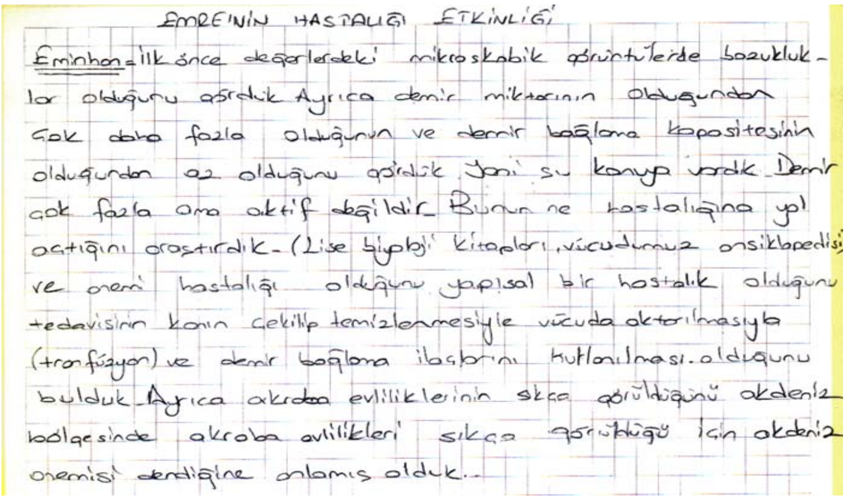
Group No: 7. grup

Bildiklerimiz	Düşüncelerimiz/ Hipotezlerimiz	Öğrenmemiz Gerekenler	Kaynaklar
Hataylı bir aile varmış. Uyşlında bir oğulları varmış. Oğulları yorgunluk halsizlik ve sıksık öttesbme ve çarpıntı ile doktora gitmişlerdi... Gelişim bozukluğundan şüpheleniyorlardır. Emre doğumundan beri pek hareketli değilmiş. Solgun, bitkin ve karın bölgesinde şişlik olduğu, parmaklarında ağrı varmış. Anne/baba amca çocukları ve bazı akrabalarında da benzer şikayetler varmış. Emre'nin neşesi alıp vermesi zor, elmacık kemiklerinde ve yüz kemiklerinde çıkıklık, deride ve gözlerde solgunluk ve bronz renk. Emre orak anemi hastasıdır. Karın şişliğinin karaciğer ve dalak büyümesi var. Demir miktarı az. Demir bağlayıcı verilmiş.	Emre'nin kalıtsal bir hastalığı olabilir. Anne karnında gelişimini tam sağlamamış olabilir. Sarılık olabilir. Anne akraba evliliğinden dolayı mutasyona uğramış olabilir. Anemi, akdeniz anemisidir.		AL ve FL konu anlatımlı OKS hazırlık. Kariyer Ders. Biyoloji öğr. Sağlık Ansk.

Figure N.1: A Sample of Group Sheet

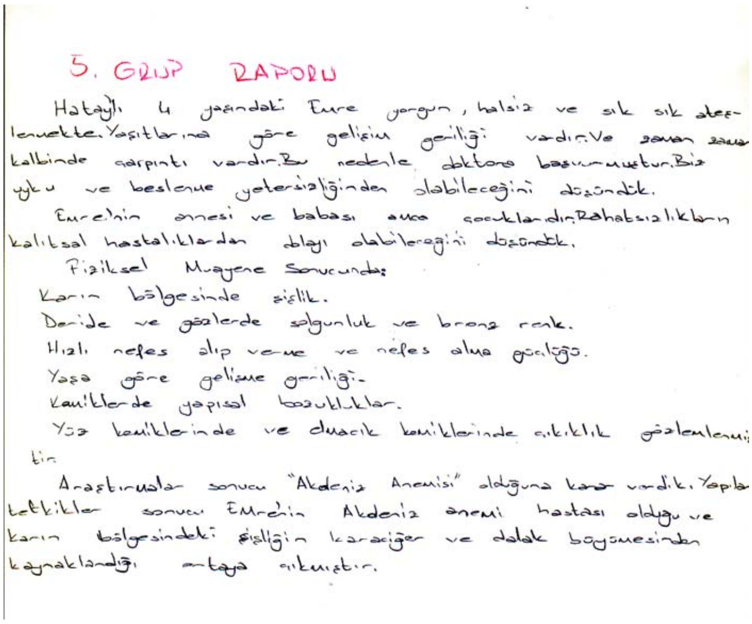
APPENDIX O

SAMPLES OF STUDENTS' FINAL REPORT FOR CASE 2


EMRE'NİN HASTALIĞI ETKİNLİĞİ

Eminhan: İlk önce değerlerdeki mikroskobik görüntülerde bozukluklar olduğunu gördük. Ayrıca demir miktarının olduğundan çok daha fazla olduğunun ve demir bağlama kapasitesinin olduğundan az olduğunu gördük. Yani şu konuya vardık. Demir çok fazla ama aktif değildir. Bunun ne hastalığına yol açtığını araştırdık. (Lise biyoloji kitapları, vücudumuz ansiklopedisi) ve önemli hastalığı olduğunu yapısal bir hastalık olduğunu tedavisinin kanın çekilip temizlenmesiyle vücuda aktarılmasıyla (tranfüzyon) ve demir bağlama ilaçlarını kullanılması olduğunu bulduk. Ayrıca akraba evliliklerinin sıkça görüldüğünü akdeniz bölgesinde akraba evlilikleri sıkça görüldüğü için akdeniz anemisi dendiğine anlamış olduk..

Figure O.1: Students' Final Report for Case 2 Sample 1


5. GRUP RAPORU

Hataylı 4 yaşındaki Emre yorgun, halsiz ve sık sık ateşlenmekte. Yaşıtlarına göre gelişim geriliği vardır. Ve zaman zaman kalbinde çarpıntı vardır. Bu nedenle doktora başvurmuştur. Biz uyku ve beslenme yetersizliğinden olabileceğini düşündük.

Emre'nin annesi ve babası amca çocuklarıdır. Rahatsızlıkların kalıtsal hastalıklardan dolayı olabileceğini düşündük.

Fiziksel Muayene Sonucunda:

Karın bölgesinde şişlik.

Deride ve gözlerde solgunluk ve bronz renk.

Hızlı nefes alıp verme ve nefes alma güçlüğü.

Yaşa göre gelişme geriliği.

Kemiklerde yapısal bozukluklar.

Yüz kemiklerinde ve dudak kemiklerinde çıkıklık gözlenlenmiştir.

Araştırmalar sonucu "Akdeniz Anemisi" olduğuna karar verdik. Yapılan tetkikler sonucu Emre'nin Akdeniz anemi hastası olduğu ve karın bölgesindeki şişliğin karaciğer ve dalak büyümesinden kaynaklandığı ortaya çıkmıştır.

Figure O.2: Students' Final Report for Case 2 Sample 2

APPENDIX P

CASE 3

Örnek Olay
-3-
Ali

Murat Bey ve Elif Hanım 5 yaşındaki oğulları Ali'yi kreşe göndermektedirler. Kreşteki öğretmeni Nesrin Hanım, Ali'nin renkli kartonları kesmek ve boya kalemleriyle resim yapmak gibi etkinliklere katılımda isteksiz davrandığını farketmiştir. Ayrıca Ali, renkli kartonlar üzerinde yer alan başka renkteki şekilleri keserken zorlanmakta, şekillerin sınırlarını belirleyememektedir. Bu sebeplerden dolayı öğretmeni Nesrin Hanım Ali'de bir göz problemi olabileceğini düşünmektedir. Nesrin Hanım, Ali'nin ailesiyle görüşerek, Ali'yi bir göz doktoruna götürmelerini önermiştir. Ailesi de Ali'yi gözünde bir problem olup olmadığını öğrenmek için doktora getirmiştir.

Örnek Olay
-3-
Ali

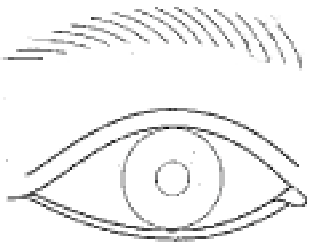
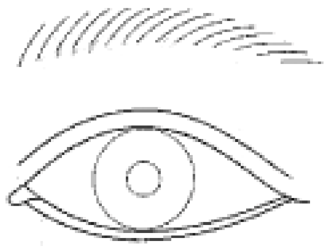
Ailesi doktora Ali'nin renkleri tam olarak öğrenemediğini, fakat bunun haricinde çocuklarında hiçbir öğrenme veya gelişim geriliği gözlemlemediklerini belirtmişlerdir.

Ali'nin annesi Elif Hanım gözlük kullanmazken, 45 yaşında olan babası Murat Bey yakını çok iyi seçemediği için gazete okurken gözlük kullanmaktadır.Murat Bey ile Elif Hanım'ın ailelerinde de gözlük kullanan bireyler vardır. Elif Hanım, köyde yaşayan annesinin de renkleri seçmekte zorlandığını belirtmiştir. Murat Bey ve Elif Hanım, diğer akrabalarında gözle ilgili bir problemin olmadığını söylemiştir.

Örnek Olay
-3-
Ali

<u>Fiziksel muayene:</u>

Ali'nin gözlerinde fiziksel açıdan bir bozukluk bulunmamaktadır.
Şaşılık gözlenmemiştir.
Göz bebeklerinin ışığa karşı duyarlılığı normaldir.

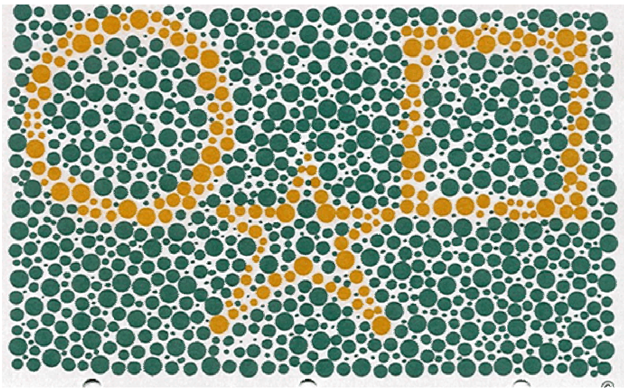
Dr. Adı Soyadı:	Soyadı Adı: **Ali Çetin**
	Yaşı: **5**
Tanı:	
Sağ  Fundus	Sol  Fundus
T.O.	

	– GÖRME –		
	Camsız: **Tam**	Camsız: **Tam**	
	Camlı:	Camlı:	

Refraksiyon ve Akomadosyon Tashihi	Tıbbi Tedavi:
• Uzak - Daimi Gözlük: od:	
os:	
• Yakın Gözlüğü: od:	
os:	

Renk Körlüğü Testi

(1)



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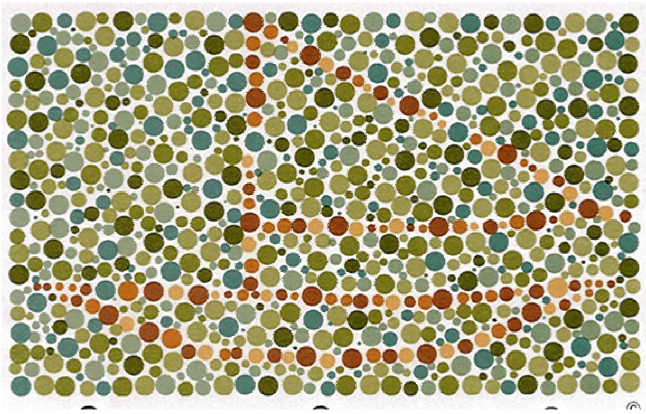
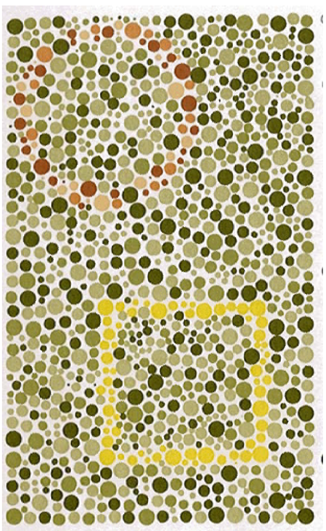
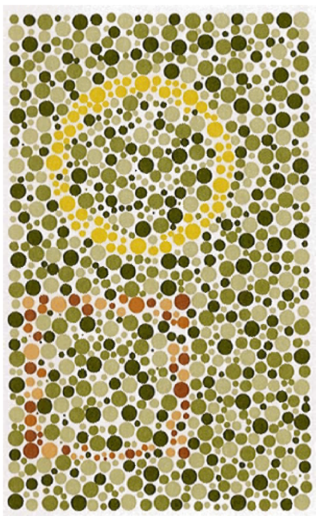


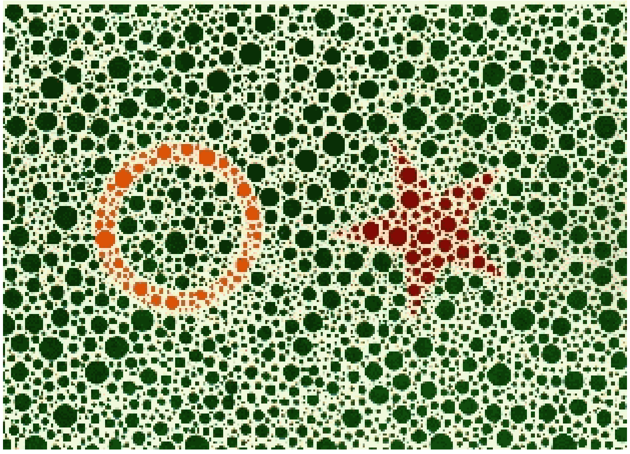
(3)



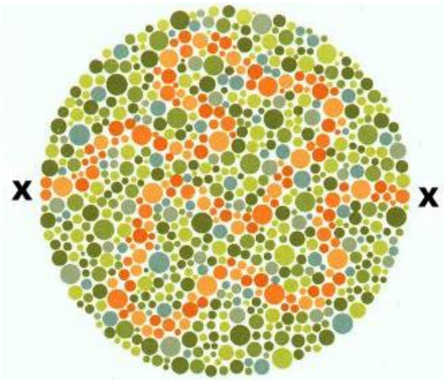
(4)



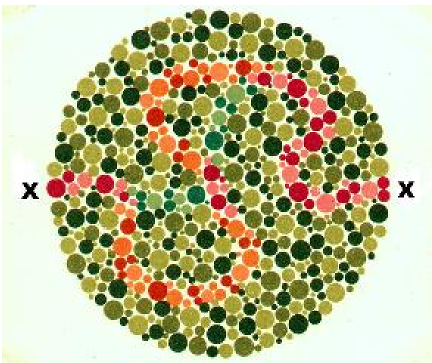
(5)



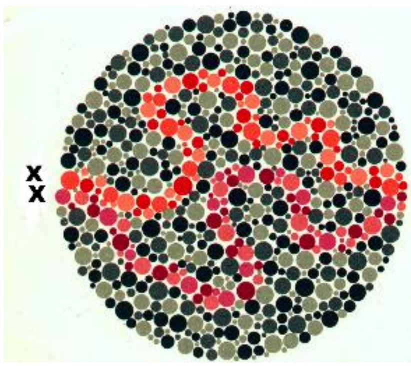
(6)



(7)



(8)



Ali'nin Cevapları:

1. Şekil : Kare – Yıldız ve Yuvarlak görüyorum.
2. Şekil : Hiçbirşey yok.
3. Şekil : Bir Kare var.
4. Şekil : Bir Yuvarlak var.
5. Şekil : Bir Yuvarlak var.

6. , 7. ve 8. Şekiller : Yolu bulamıyorum.

Örnek Olay
-3-
Ali

Yapılan testler sonucu Ali'nin kırmızı-yeşil renkkörü olduğu tespit edilmiştir. Aileye bu hastalığın kalıtsal bir hastalık olduğu ve herhangi bir tedavisi olmadığı açıklanmıştır. Ali'ye bu konuda yardımcı ve destek olmaları, ileride seçeceği mesleğe yönelik uygun yönlendirmeler yapmaları gerektiği belirtilmiştir.

Araştırın:

- Renkkörlüğü erkeklerde kadınlara oranla daha sık görülen bir hastalıktır. Neden?

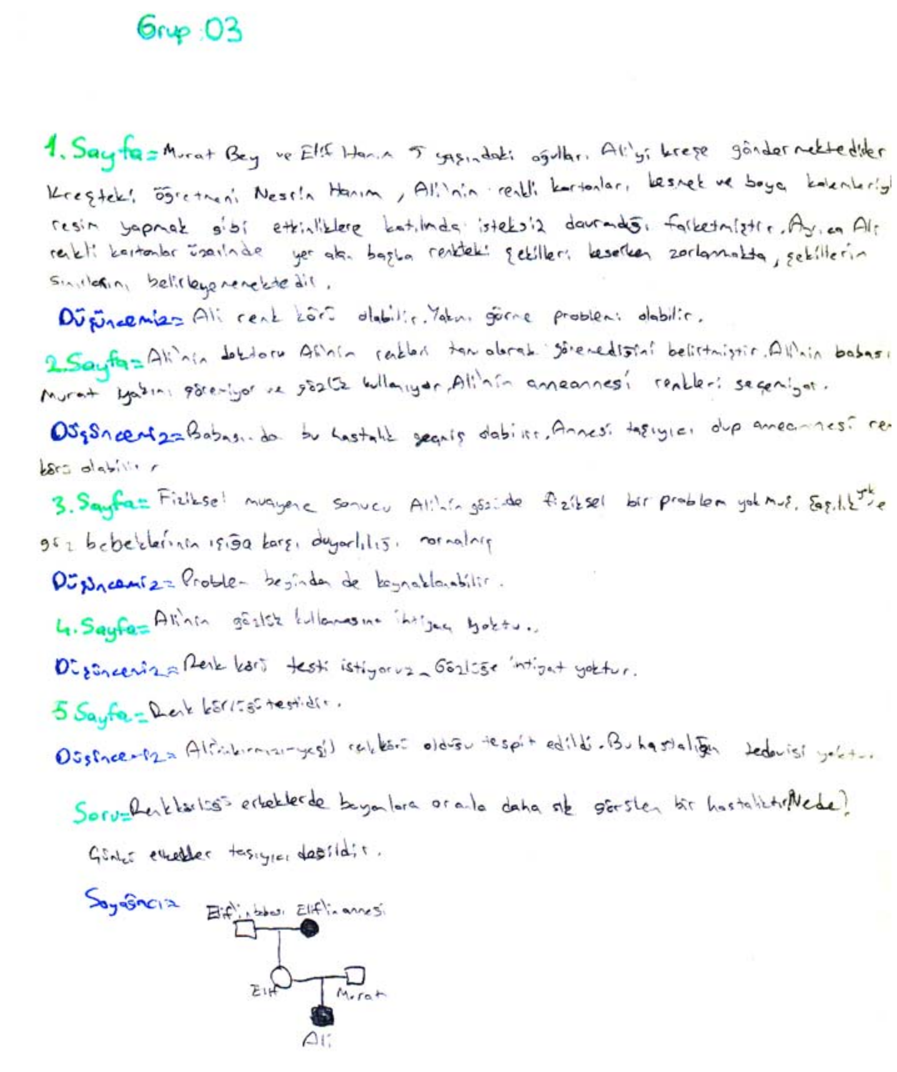
- Senaryoda verilen bilgilere göre Elif'in annesini ve babasını, Elif'i, Murat'ı ve Ali'yi içeren bir soyağacı çiziniz.

Bireyler için aşağıdaki şekilleri kullanın:

Sağlıklı erkek: □	Sağlıklı kadın: ○
Hasta erkek: ■	Hasta kadın: ●

APPENDIX R

SAMPLE OF STUDENTS' FINAL REPORT FOR CASE 3



Grup :03

1. Sayfa= Murat Bey ve Elif Hanım 5 yaşındaki oğulları Ali'yi kreşe göndermektedirler. Kreşteki öğretmeni Nesrin Hanım, Ali'nin renkli kartonları kesmek ve boya kalemleriyle resim yapmak gibi etkinliklere katılmada isteksiz davrandığı farketmiştir. Ayrıca Ali renkli kartonlar üzerinde yer alan başka renkteki şekilleri keserken zorlanmakta, şekillerin sınırlarını belirleyememektedir.

Düşüncemiz= Ali renk körü olabilir. Yakını görme problemi olabilir.

2.Sayfa= Ali'nin doktoru Ali'nin renkleri tam olarak göremediğini belirtmiştir. Ali'nin babası Murat yakını göremiyor ve gözlük kullanıyor. Ali'nin anneannesi renkleri seçemiyor.

Düşüncemiz= Babasından da bu hastalık geçmiş olabilir. Annesi taşıyıcı olup anneannesi renk körü olabilir.

3. Sayfa= Fiziksel muayene sonucu Ali'nin gözünde fiziksel bir problem yokmuş. Şaşılığı yok ve göz bebeklerinin ışığa karşı duyarlılığı normalmiş.

Düşüncemiz= Problem beyinden de kaynaklanabilir.

4. Sayfa= Ali'nin gözlük kullanmasına ihtiyacı yoktur.

Düşüncemiz= Renk körü testi istiyoruz. Gözlüğe ihtiyacı yoktur.

5 Sayfa= Renk körlüğü testidir.

Düşüncemiz= Ali'nin kırmızı-yeşil renk körü olduğu tespit edildi. Bu hastalığın tedavisi yoktur.

Soru= Renk körlüğü erkeklerde bayanlara oranla daha sık görülen bir hastalıktır. Neden?

Çünkü erkekler taşıyıcı değildir.

Soyağacı:

Figure R.1. Students' Final Report for Case 3

APPENDIX S

WORKSHEET 2