RELATIVE INFLUENCE OF COGNITIVE AND MOTIVATIONAL VARIABLES ON GENETIC CONCEPTS IN TRADITIONAL AND LEARNING CYCLE CLASSROOMS

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ABSTRACT

RELATIVE INFLUENCE OF COGNITIVE AND MOTIVATIONAL VARIABLES ON GENETIC CONCEPTS IN TRADITIONAL AND LEARNING CYCLE CLASSROOMS

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The purpose of the study is to explore relationships among elementary school students' gender, relevant prior knowledge, meaningful learning orientation, reasoning ability, self-efficacy, locus of control, attitudes toward science and achievement in genetics in learning cycle and traditional classrooms.

The study was conducted on 213 8^{th} grade students from eight classes of two public elementary schools in Ankara in 2005-2006 Spring-semester. Students in the experimental group (N=104) received learning cycle instruction that helps students acquire conceptual understanding of scientific concepts, and the students in the control group (N=109) received traditional instruction. The students were given Genetics Achievement Test as a pre-test before and as a post-test after the instruction. Students were also given Learning Approach Questionnaire that measures students' learning orientations and Test of Logical Thinking that determines students' reasoning abilities. Students' levels of self-efficacy, locus of control and their attitudes toward science also were measured.

One-way ANOVA analysis revealed that learning cycle instruction improved students' achievement in genetics compared to traditional instruction. Stepwise multiple regression analysis revealed that in learning cycle classrooms, the main predictors of achievement in genetics were students' meaningful learning orientation (49.6%) and their attitudes toward science (11.8%). In traditional classrooms, students' attitudes toward science (44%) and reasoning ability (9.8%) were the main predictors of achievement while remaining 5.7% of the variance explained by relevant prior knowledge, locus of control and meaningful learning orientation. This study revealed that different variables may be important for 8th grade students' genetics achievement in learning cycle and traditional classes.

Keywords: Meaningful learning orientation, reasoning ability, self-efficacy, locus of control, attitude, learning cycle, traditional instruction.

ÖZ

BİLİŞSEL VE GÜDÜSEL DEĞİŞKENLERİN GELENEKSEL VE ÖĞRENME EVRESİ SINIFLARINDAKİ ÖĞRENCİLERİN GENETİK KAVRAMLARINI ANLAMASINA ETKİSİ

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Bu çalışmanın amacı ilköğretim öğrencilerinin cinsiyetleri, ön bilgileri, anlamlı öğrenme yaklaşımları, mantıksal düşünme yetenekleri, güdüsel inançları, denetim odakları ve Fen Bilgisi dersine olan tutumlarının, öğrenme evresi ve geleneksel yaklaşım sınıflarında genetik başarıları ile olan ilişkisini ortaya çıkarmaktır.

Çalışmaya 2005-2006 bahar döneminde Ankara'daki iki devlet okulunda bulunan iki yüz on üç 8. sınıf öğrencisi katılmıştır. Deney grubundaki öğrenciler (N=104) genetik konusunu öğrenme evresi ile, kontrol grubundaki öğrenciler (N=109) ise geleneksel yaklaşım ile işlemişlerdir. Öğrencilere genetik başarı testi ön-test olarak uygulamadan once, son-test olarak ise uygulamadan sonra verilmiştir. Çalışmadan önce öğrencilerin ezbere mi yoksa anlayarak mı öğrendiklerini ölçmek için Öğrenme Yaklaşımı Anketi, somuttan soyuta değişen mantıksal işlem seviyelerini belirlemek üzere Mantıksal Düşünme Testi, güdüsel inançlarını

ölçmek için güdüsel inanç ölçeği uygulanmış, denetim odakları ve Fen Bilgisi dersine karşı tutumları da ölçülmüştür.

Tek yönlü varyans analizi (ANOVA) sonucunda öğrenme evresinin geleneksel yaklaşıma göre, öğrencilerin genetik başarılarını artırıcı etkisi saptanmıştır. Çoklu regrasyon analizi sonunda, öğrenme evresi sınıflarında başarının temel belirleyicileri öğrencilerin anlamlı öğrenme yaklaşımları (%49.6) ve Fen Bilgisi'ne yönelik olan tutumları (%11.8) olarak bulunmuştur. Öte yandan, geleneksel yaklaşım sınıflarında öğrencilerin Fen Bilgisi'ne yönelik tutumları (%44) ve mantıksal düşünme yetenekleri (%9.8) başarının temel belirleyicileri olarak bulunurken, kalan %5.7'lik varyans ise öğrencilerin ön bilgileri, denetim odakları ve anlamlı öğrenme yaklaşımları ile açıklanmıştır. Bu çalışma, öğrenme evresi veya geleneksel yaklaşımın uygulandığı sekizinci sınıf öğrencilerinin genetik başarısında farklı değişkenlerin önemli olabileceğini açığa çıkarmıştır.

Anahtar Kelimeler: Anlamlı öğrenme yaklaşımı, mantıksal düşünme yeteneği, güdüsel inanç, denetim odağı, tutum, öğrenme evresi, geleneksel yaklaşım.

To My Family

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LIST OF SYMBOLS

EG: Experimental Group

CG: Control Group

LCI: Learning Cycle Instruction

MOI: Mode of Instruction

CCT: Conceptual Change Text

LAQ: Learning Approach Questionnaire

LAQ-M: Learning Approach Questionnaire-Meaningful

LAQ-R: Learning Approach Questionnaire-Rote

TOLT: Test of Logical Thinking

GAPRET: Genetics Achievement Pretest

GAPOST: Genetics Achievement Posttest

SES: Self-Efficacy Scale

LOC: Locus of Control Scale

ATS: Attitude towards Science Scale

DEFINITION OF TERMS

Some of the terms used in this dissertation may be unfamiliar for the reader. Therefore the following definitions are provided.

Learning Cycle Instruction

The activity-oriented instructional technique at which students explore new knowledge with minimum guidance (Johnson, 1993). Learning cycle is an inquiry approach with three phases that are exploration at which students explore new concepts; term introduction at which students develop relationships and concept application that helps students apply a new understanding of their observations (Lawson, 1996; Marek & Cavallo, 1997).

Traditional Instruction

Instructional technique that is generally employed in classrooms. In that type of instruction, new terms and concepts are introduced by textbook, lecture or other media that informs the student what he or she is expected to learn.

Learning Orientation

Students' approaches to learning which are consistent with their understanding. (Boujaoude, 1992; Cavallo, 1996). There are two types of learning orientation: rote and meaningful learning orientation. Ausubel (1963, 1968) describes the formulation of the relationships between theoretical concepts in making sense of the word as 'meaningful learning'. In contrast to meaningful learning, in rote learning new knowledge may be attained by verbatim memorization and incorporating into a persons' knowledge structure without connecting it to information or framework previously acquired (Ausubel, 1963; Baird, 1986).

Reasoning Ability

Reasoning ability is the cognitive development level of students.

Concrete Reasoning Ability: Reasoning ability level of students at concrete operational stage. At that stage students can think operationally, represent transformations, and understand concrete problems. They fail to explain the logical relationships between scientific concepts and cannot eliminate alternative conceptions after instruction. Concrete operational stage ends at age eleven or twelve (Piaget, 1950).

Formal Reasoning Ability: Reasoning ability level of students at formal stage. In formal stage children can think logically and abstractly. Formal reasoning patterns are necessary for the elimination of some biological misconceptions and constructing logical relationships between concepts (Lawson and Thompson, 1988). Formal thought begins to develop at age 11 or 12 and reaches an equilibrium state at around 15 or 16 (Piaget, 1950). Chidren at that stage can use logical symbols related to abstract concepts. There are five modes of formal reasoning: controlling variables, proportional reasoning, probabilistic reasoning, correlational reasoning, and combinatorial reasoning.

Self-Efficacy

Self-efficacy is ″people's judgements of their capabilities to organize and execute courses of action required to attain designated types of performances″ (Bandura, 1986, p. 391).

Locus of Control

The perceptions of students of their successes and failures. Students may have external or internal locus of control. When the students think that their performance was not affected even if they spent great amount of effort, they develop external locus of control. When they believe that their academic effort results in better outcomes, students have internal locus of control (Rotter, 1975).

Attitude towards Science

Feelings, beliefs and values of students towards science.

Achievement

To be successful in learning discipline specific facts and concepts, processing necessary concepts, differentiating relevant with irrelevant information.

CHAPTER I

INTRODUCTION

1.1 Background of the Study

In science, specifically in biology, there are several units and concepts many of which are unfamiliar and difficult to remember for students. The concepts in each unit are closely related with each other. Therefore, students face with difficulties to understand the basic concepts of biology when they could not understand the previously instructed concepts. Novak (1970) stated that if students could not make these interrelations, they would show wide range of difficulties to understand the basic concepts of biology. To be able to overcome the difficulties, lessons should be designed in such a way that contributes the students' understanding of some major ideas or concepts, constructing relationships between concepts of biology and also making the students better aware of the nature of biological inquiry. This can be done only when the teacher builds each new lesson by considering the students' level of understanding and performance at earlier lessons. Designing lessons by taking the students' understanding of concepts into account contributes to the transfer of learned concepts for related subjects and future learning.

Genetics has been recognized as one of the most important and difficult topics of the biology/science curriculum. The research carried out by Finley, Steward, and Yarroch (1982) showed that there is a general agreement among biology teachers that Mendelian genetics, the chromosomal theory of inheritance, and the concept of genes, are the difficult subjects for students to learn. They argued that inspide their difficulty, they should be taught at secondary school. The concepts in genetics such as allele, chromosome, gene, DNA, homologous chromosome are closely linked with each other functionally and theoretically. At that point, understanding these concepts is important to be able to provide students' understanding of genetics in addition to cell division and fertilization. Because understanding these concepts require qualified knowledge about the terms in genetics. For example, to be able to understand cell division, students should know the meaning of homologous chromosomes. Similarly, the meaning of gametes should be known for meaningful understanding of fertilization. Understanding Mendelian genetics also require knowledge about these concepts. Most students are able to understand how to use diagrams to figure out the probability of genotypes and phenotypes of offspring but trying to take it a step further and comprehend the genetic crosses is often confused. Students have been taught Mendelian genetics without complete understanding and providing the correct answer does not necessarily mean the problem has been understood (Banet & Ayuso, 2000). Students by using some personal algorithm can correctly answer the problem without understanding the concepts they use (Hackling &

Treagust, 1984). Therefore, most of the time students' ideas do not reveal in learning environments and it is known that understanding major concepts is important to build a strong base of supporting factual information and know how to apply knowledge into new situations.

In genetics, like in any content area, students bring their preconceptions based on their prior experiences to the learning environments. When these preconceptions differ from those commonly accepted, they are considered misconceptions. For effective learning, after identification of the misconceptions, the instruction should be designed to prevent them from occurring and to make necessary conceptual change on students' minds. The conceptual change approach to science instruction is designed to encourage students to alter their alternative conceptions and is based on Piaget's notions of assimilation, accomodation, and disequilibrium (Wang & Andre, 1991). Posner, Strike, Hewson and Gertzog (1982) theorized that students would remain committed to their ideas unless they need neessary modification of their ideas to understand the subject. The student must be dissatisfied with the existing conception, meaning the child's ideas must no longer make sense to the child in explaining the concept. A new idea must be intelligible as well as plausible. Finally, the conception must be fruitful, and make sense in many situations. The design of learning environments to promote conceptual change in science must be based on systematic research on the acquisiton of science concepts that require extensive reorganization of prior knowledge (Vosniadou, Ioannides, Dimitrakopolou & Papademetriou, 2001).

Many researchers have prepared different instructional techniques to promote meaningful learning mainly through conceptual change. Learning cycle is a specific activity-oriented instructional technique designed to promote conceptual change. The learning cycle approach has its origin in an elementary curriculum project sponsored by the National Science Foundation in the 1960s (Karplus & Their, 1967). An activity based elementary science program known as the Science Curriculum Improvement Study (SCIS) firstly used learning cycle as a teaching strategy in 1974. In an evaluation of SCIS, the learning cycle was found to be effective in helping students develop science concepts and process skills. Besides, research has shown that this strategy has widespread applicability to a variety of grade levels, including college (Purser & Renner, 1983; Saunders & Shepardson, 1987; Barman, 1992; Barman, Cohen & Shedd, 1993).

Learning cycle is an inquiry approach with three phases that are exploration, term introduction, and concept application. When students explore new concepts through an exploration, their new experiences cause them to reevaluate their post experiences. This produces disequilibria in the students and he/she needs to accommodate the concepts to reach equilibrium. In the term introduction phase, students develop relationships, which help them apply a new understanding of their observations. In the final stage of concept application, students gain familiarity with the introduced concept and either assimilate or accommodate the new concept into their schemata (Karplus, 1977). More specifically, the learning cycle incorporates the Piagetian approach into a concise methodology of learning: experiencing the phenomena or concept (Exploration), applying terminology to the concept (Term Introduction), and application of the concepts into additional conceptual frameworks (Application) (Odom & Kelly, 2000). In addition to learning cycle model including three phases, there are other learning cycle models, including 5 and 7 phases, namely 5E and 7E learning cycle model. 5E learning cycle model extends the three stages into five: engage, explore, explain, elaborate and evaluate. The stages of 5E model are expanded into seven stages which are elicit, engage, explore, explain, elaborate, evaluate and extend in 7E model.

Apart from learning cycle, conceptual change texts have been used to promote student construction of conceptions more consistent with those accepted by the scientific community. In conceptual change text, students are given posssible misconceptions about the subject and then they are given the scientifically correct concepts and definitions. So that, students are familiarized with misconceptions, they are dissatisfied with existing concepts in their mind. After inducing dissatisfaction, the instructor provides the learner with the correct scientific explanation in a manner that is intelligible, plausible and fruitful.

Besides, there are cognitive and motivational factors that are related with students' meaningful learning of science concepts. Therefore, while developing and implementing teaching strategies, such variables should be taken into consideration. Reasoning ability, one of the cognitive variables, is related with the students understanding of scientific concepts. Lawson and Thompson (1988) claimed that formal reasoning patterns are necessary for the elimination of some biological misconceptions and constructing logical relationships between concepts. Students with formal reasoning ability can evaluate alternative conceptions, discuss about the evidences that support scientific concepts and the ones that contradict with alternative conceptions. On the other hand, concrete operational students fail to explain the logical relationships between scientific concepts and cannot eliminate alternative conceptions after instruction. In addition to reasoning ability, learning approach of students is another cognitive variable that affects meaningful understanding. Researchers stressed the importance of meaningful learning orientation for students' meaningful understanding of science and reported that meaningful learning orientation contributes, together with reasoning abilities to students' attainment of meaningful understanding of genetics (Cavallo & Schafer, 1994; Cavallo, 1996). In addition to students' meaningful learning orientation and reasoning abilities, many studies revealed that prior knowledge was the significant predictor of science achievement (Ausubel, 1963; Pashley, 1994).

Self-efficacy, locus of control and students' attitudes toward science are motivational variables that are found to be related with students' understanding of science concepts. Self-efficacy is defined as "people's judgements of their capabilities to organize and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391). Student self-efficacy beliefs regarding academic performance can have important implications for improving learning environments and, consequently, student outcomes. Therefore, focusing on students' academic self-efficacy increases students' perceptions of the learning environment and their understanding. The perceptions of students about their successes and failures may also affect learning. Students may have external or internal locus of control. When students think that their performance is not affected even if they spent great amount of effort, they develop external locus of control. According to students with external locus of control, success in the academic field mostly is related with chance. When students have internal locus of control, they believe that their academic effort results in better outcomes. The development of self-management skills of students is important to develop internal locus of control. Attitudes and feelings of students are recognized as important for science instruction. Lack of students' enthusiasm, interest or motivation in science contributes to reduced participation in science classes. Furthermore, science attitudes were found to have a positive correlation with science achievement and participation in advanced science courses (Weinburg & Englehar 1994; Lee & Burkam, 1996).

In line with the findings reported in the literatute, in the present study, the relationship among 8th grade school students' cognitive variables; prior knowledge, learning approach, reasoning ability and motivational variables; self-efficacy, locus of control, attitudes toward science in relation with students' achievement in genetics in different types of classrooms; learning cycle and traditional classrooms in two public schools in Ankara was investigated.

1.2 Significance of the Study

The present study was concerned with relative influence of cognitive and motivational variables on genetic concepts in traditional and learning cycle classrooms. While several studies have measured direct relation between these variables and students understanding, some studies have assessed the effectiveness of learning cycle teaching strategy on students' understanding. Many of these studies have focused on mainly the cognitive variables that may contribute science achievement. Relatively few studies have addressed the attributes of students' motivational constructs. However, in addition to cognitive variables, motivational constructs also important in science learning and instruction (Pintrich, Marx & Boyle, 1993). Besides, researchers have attempted to investigate certain variables which may contribute to students' science achievement without considering the influence of different teaching strategies. This study investigates the contributions of cognitive and motivational variables on students' achievement in genetics in learning cycle and traditional classrooms so that it presented which variable are the better predictor of achievement under which teaching strategy.

This study, also presents the influence of learning cycle teaching strategy on students' understanding of genetics by integrating conceptual change text in the term introduction phase of learning cycle. So that, while teacher establishing a discussion environment, students were introduced with related scientific terminology included in genetics unit.

To sum up, review of the literature has provided information concerning the relationships among cognitive variables, motivational variables and students' achievement in mainly inquiry-based science classes. However, comparisons with other course formats have not been well documented. Hence, there is little evidence about types of interaction in relation to type of instruction. In the present study, our aim is to extend the finding of previous studies by comparing the nature and extent of the relationships in two different instructional modes, (traditional vs. learning cycle). Therefore, this study is designed to contribute to students' current understanding of genetics by investigating the possible relationships among cognitive and motivativational variables in learning cycle and traditional classes.

CHAPTER 2

REVIEW OF RELATED LITERATURE

This chapter includes six parts. First part is about the studies conducted in the field of students' understanding of genetics concepts, second part includes the studies about the conceptual change, namely learning cycle and conceptual change text, third part comprises the studies about students' reasoning abilities, fourth part is about the studies in the area of students' learning orientations and fifth part includes the studies about students' affective variables that are self-efficacy, locus of control and attitudes toward science.

2.1 Research on Students' Understanding of Genetic Concepts

There is a great deal of research done on teaching and learning of genetics and inheritance. Research has shown that students do not fully understand major concepts in genetics such as chromosomes, genes, or alleles (Longden, 1982; Alabaladejo & Lucas, 1988; Collins & Steward, 1989; Pashley, 1994; Lewis, Leach & Wood-Robinson, 2000; Lewis, 2004); cannot effectively interpret some concepts such as homozygous or heterozygous, dominance and recessiveness (Slack & Steward, 1990; Heim, 1991); have alternative views for some processes such as meiosis (Hackling & Treagust, 1984; Brown, 1990; Steward, 1982; Kinfield, 1994b; Steward, Hafner & Dale, 1990); and do not understand the meaning of probability for genotypic and phenotypic frequencies (Browning & Lehman, 1988). Heim (1991) stated that students incorrectly think that the dominant form of a gene is stronger than the recessive form and when they are together with heterozygote, the dominant allele suppresses the action of the recessive one. He discussed the dominant and recessive relationships that may be different at different levels of analyses between phenotype and genotype, possible causes of dominance.

In a study carried out by Longden (1982), sources of misconceptions and learning difficulties were identified by interviewing academically sound A-level students who were having difficulties with genetics. The study indicated that misconceptions were related to nature of concepts used in genetics and to instructional strategies. Smith and Good (1984), studied about organization of problem solving in genetics, and they stated the importance of understanding the organization of knowledge is necessary to understand the expert problem solving in genetics.

In 1988, Lawson and Thompson explored the relationships between seventh grade students' misconceptions of genetics and natural selection and four cognitive variables: reasoning ability; mental capacity; verbal intelligence; and cognitive style. One hundred and thirty one seventh grade American students in the sections of a life-science course at a public high school were included in their study. Following instruction, students were administered a test about principles of genetics and natural selection. Responses of the students were compared whether reasoning ability, mental capacity, verbal intelligence and cognitive style was related with number of misconceptions. The results of the study indicated that only reasoning ability was related with students' number of misconceptions. Concrete operational students hold greater number of misconceptions compare to formal operational students. Formal students seemed to understand that a newborn child's characteristics are determined by a combination of parental genes carried in the sex cells and that environmentally induced changes in parents will not affect the offspring. On the other hand, concrete operational students have failed to achieve this understanding. They suggest that formal reasoning patterns are necessary for the elimination of some biological misconceptions.

Slack and Stewart (1990) studied on 30 students in 9 to12 grade levels from five high schools to be able to add to the understanding of students' problem solving strategies and to develop a model of student performance. Students had completed three to four weeks of genetic instruction in introductory level biology courses and solved 119 problems generated by the computer program Genetics Construction Kit (GCK). While solving GCK problems students planned experiments, generated and interpreted data, and reasoned from effects to causes.

It was found that students lacked three important genetics-specific ways of thinking about problem solving: genotypic thinking, generational thinking, and ability to distinguish between an inheritance pattern and modifier. At the end of the study, the three trends in general problem solving procedures were identified: (1) unplanned approach; (2) working backward; (3) emphasis on a quantitative level of counting numbers of individuals and using ratios in independent crosses. Slack and Steward recommended that instruction in genetics like other field of science should reinforce problem-solving strategies, teach not only conceptual knowledge, but the relationship of conceptual knowledge to problem solving.

Pashley (1994) studied on students' understanding of genetics, their misconceptions and how they might be resolved. She worked on 96 American secondary school students from four different educational establishments. The students were studying syllabuses, which were virtually identical with respect to genetics components. In the study, the chromosome model was used to resolve the students' misconceptions. The chromosome model was a 'tool' that allowed the students to recognize where their problems lie and to see that their concepts do not fit the accepted scientific concepts. Students asked to explain the relationship between the 21 different pairs of genetic terms included in a test booklet. She observed that the misconceptions centered on the terms 'gene' and 'allele' and identified three general types of misconceptions: a) Genes contain alleles; b) Alleles contain genes; c) Genes and alleles are the same. These misconceptions led to confusion of other terms like homozygous, heterozygous, dominance or recessiveness. Use of the chromosome model was defined as an effective tool for resolving misconceptions and promoting conceptual change. It was also found that once students had resolved any difficulty with the relationship between gene and allele and the teachers were aware of their students' misconceptions, students' performance in genetics showed a significant improvement.

In a separate study, Lewis, Leach, and Wood-Robinson (2000) investigated the school students' understanding of the processes of cell division and fertilization towards the end of the compulsory science education by pointing out to the importance of students' awareness of the physical relationship between chromosomes, genes, and the genetic information. 478 students aged 14-16 took part in the study. Students wrote their responses to written questions about understanding of the processes, purposes and products of cell division and the fertilization. The difficulties, which students have in understanding the purposes and products of these processes, were discussed and the origins of some of these difficulties were identified. For example, some of the students could not make a distinction between meisosis and mitosis or some confused the terms used to describe cell division. At the end of the study, it was found that students although understood some aspects of the cell division, fertilization, and reproduction, they had no coherent conceptual framework which could explain the whole set of processes. The researchers attributed to the source of all these problems to the lack of understanding of chromosomes, genes, genetic information, the role and nature of chromosomes. Also, students could not construct a conceptual framework and were confused by the words used to describe the processes of cell division. Findings of that study, not only confirm that school students have major difficulties with cell division and the fertilization, but also identified the sources of those difficulties.

In another study, Lewis, Leach, and Wood-Robinson (2000) investigated the students' ability to distinguish between genes and genetic information and the extent to which they are aware of the continuity of genetic information between cells within one individual. A sample of 482 young people aged 14-16, drawn from across the ability range took part in the study. Written data were collected using the series of written questions. Students in the study had a very poor understanding of the purposes, processes and products of cell division and made little distinction between meiosis and mitosis. Many students hold the misconception that cells of different types will contain different genetic information because they have different functions and will therefore require different information. In that study, few students understood the distinction between a gene and the genetic information encoded within that gene. They also stated that without the understanding of the basic concepts it would be difficult for the students to develop a coherent explanation as a whole.

The misconceptions of students about the concepts of genetics were also investigated by Banet and Ayuso (2000). They studied on 267 secondary school students' previous knowledge concerning some basic aspects related to the location of inheritance information by interviews and questionnaires. They stated that the cell structure, living organisms, sexual reproduction and the concepts of genes, alleles and chromosomes should be taught before starting genetics. In the same study, another sample consisting of 109 advanced secondary students were enrolled to diagnose students' knowledge of genetics after traditional instruction. The results of these two studies were used to plan, implement and subsequently modify a teaching program, based on constructivism, on 177 secondary school students. They demonstrated that many students at the secondary school level have significant misconceptions regarding inheritance information location. The study also has pointed out some deficiencies in traditional genetics teaching methods. They presented the characteristics of a teaching program that includes objectives, activities that will be followed during different phases of instruction on inheritance information. The role of teacher and students during that teaching program also presented. Results obtained indicated that many students involved in this specific teaching program on inheritance information restructured their initial misunderstanding of the location of inheritance information and acquired a scientific knowledge.

As understood from the results of the above-mentioned studies, students have considerable amount of difficulties while connecting basic concepts and processes about genetic. Marbach-Ad and Stavy (2000) linked these difficulties to different levels of organization of genetics concepts: macroscopic, microscopic and submicroscopic levels of organization. They conducted a study on three populations of students: 9^{th} graders, 12^{th} graders (N = 305) and preservice biology teachers (N = 26) to probe Israeli students' understanding at different levels of organization of genetics concepts on their ability to connect ideas and concepts across different levels. For these purposes, three different types of questions were asked. One question was about molecular level. Two of the questions measured students' ability to make bridge between levels. It was observed that students had difficulties in interrelating the major concepts because they are simultaneously exposed to a variety of concepts and processes at different levels of organization, which they cannot deal with simultaneously.

Sampson (2002) redesigned a genetics unit including the concepts of genes and chromosome, human inheritance patterns and applied genetics. Sixty-six students (39 female, 27 male) in a public high school in three General Biology classes consist of sophomores and juniors were enrolled in the study. (86 percent of students were Caucasian, 12 percent were African-American and 2 percent were other minority groups). The units began with pretests that serve to determine the prior knowledge of each student before entering the class and reveal the areas that need to be covered in more detail. Also, classroom discussions were designed according to students' level of prior knowledge revealed by pretests. While implementing genetic unit, the researcher replaced paper and pencil worksheets with laboratory activities, used online activities and problem solving activities. Power point lecture notes with current and relevant information and eye-catching graphics were used during the presentation of new information. Students were given outline that they used as a tool to record pertinent information. Students also involved in laboratory activities. Students' performance on posttest, activities and students' weekly reflections were assessed for the evaluation of the effectiveness of these techniques. The pretest for each section consisted of open-ended questions. During the course, at each section, quizzes were given to provide students evaluate students' comprehension of the subject matter. The posttest given at the end of each unit contained open ended questions found in the pretest in addition to multiple choice and true/false questions. Sampson observed that changes in teaching style and increase in the number of group and laboratory activities results in increase in students' learning and understanding of genetics.

More recently, Knippel, Waarlo and Boersma (2005), to be able to find whether findings of other researchers can be applied to secondary genetics education in Netherlands, concentrated on two problem categories: the abstract and complex nature of genetics. The separation of inheritance, reproduction and meiosis in the curriculum accounts for the abstract nature of genetic, while the different levels of biological organisation e.g. molecule, cell and organism contribute to its complex nature. They carried out a case study by observing and audio typing 13 lessons of traditional general upper-secondary genetic course. In observed lessons students were asked to solve multiple genetics problems and to calculate the probabilities of specific traits in the next generation. Twenty-two students (aged 16-17) kept personal notebook about their learning outcomes, perceived difficulties and questions. Then, they interviewed with six, four girls, two boys, of these students. The results from the review study and the focus group interviews indicated that it is important to adequately sequence the subject matter according to the levels of biological organization and to pay attention to the relationship between inheritance, sexual reproduction and meiosis. The case study suggested focus should not be on solving genetic cross problems, but on interconnecting sexual reproduction, meiosis and genetic traits. They also examined two chapters about meiosis and Mendelian genetics of three Dutch upper-secondary biology textbooks and no explicit conceptual relationships between the observed chapters were found.

Rotbain, Marbach-Ad and Stavy (2006) explored the contribution of using models in molecular genetics instruction in high school students' understanding of concepts and processes in genetics. In their study, with a total of 258 students, three groups of 11th and 12th graders participated: The control group was taught in the traditional lecture format, while the others received instructions which integrated a bead model, or an illustration model. In both groups the instructions and questions asked to the students were similar. The bead model is a physical three-dimensional model, consisting of plastic color-coded beads that represent the major components of the genetic material (DNA and RNA) and the proteins encoded by them. The illustrations model consists mainly of chemical formulas of the DNA, RNA, and protein molecules. Three instruments were used in their study: a multiple-choice, an open-ended written questionnaire and personal interviews. Five of the multiple-choice questions were also given to students as pretest. Their study revealed that students who used one of the two types of models improved their knowledge in molecular genetics compared to the control group while, the open-ended questions revealed that bead model activity was significantly more effective than illustration activity. They stated that using three-dimensional models and also students participation in class activities may improve their achievement when compared to traditional instruction.

Changes in students' knowledge structure viewed from different perspectives: epistemological, ontological and social/affectice (Tyson, Venville, Harrison & Treagust, 1997). For example, Venville and Treagust (1998) investigated students' conceptions of genes from epistemological, ontological and social/affective perspectives. In their study, from the ontological perspective, different mental models which was employed by the students were identified. They stated that students assume a gene as a passive particle passed from parent to offspring. From a social/affective perspective, they observed that students were not intereseted in the microscopic explanatory mechanism of genetics, although they seem to enjoy the genetic course and participated in classroom activities. Also, students' ontological conceptions of gene was classified as being intelligible, plausible and fruitful from an epistemological perspective. Results revealed that learning about the concept of gene is an evolutionary process. Tsui and Treagust (2004) also examined students' conceptual learning of genetics from an ontological perspective. They stated that gene conceptions of most students were not sophisticated and there was litlle or no conceptual change across ontological categories in the students' conceptions. Young children's understandings of genetic concepts from ontological and epistemological perspectives were investigated by Venville, Gribble and Donovan (2005). They observed that while most students were familiar with terms such as gene or DNA they did not have a conceptual understanding of what genes or DNA do. They pointed out to the potential ontological and epistemological barriers to further learning about genetics.

To sum up, these research studies documented students' difficulties in understanding of various genetic concepts, such as genes, alleles, chromosomes, phenotype, genotype, dominance and recessiveness. To provide meaningful learning, ways must be found to eliminate or prevent misconceptions. Various instructional methods can be used for this purpose. One such method involves the use of a conceptual change approach.

2.2 Research on Conceptual Change Approach

It is known that students' existing knowledge affects their understanding of natural phenomena. According to Piaget (1950), new experiences were understood by applying the preexisting mental structures to them. This process is called as assimilation. A state of disequilibria occurs when existing structures cannot create an understanding of the new experience. At the end of disequilibria, learner develops new mental structure in order to understand new experiences, called accommodation. In order to create accommodation in individuals' understanding Posner, Strike, Hewson, and Gertzog (1982) suggest following four conditions:

- Dissatisfaction: Students must be dissatisfied with existing conceptions. Therefore, major changes on their current concepts become necessary to solve the problems.

- Intelligibility: A new conception must be easily understood. The individual must be able to grasp how experience can be structured by a new concept sufficiently to explore the possibilities inherent in it.

- Plausibility: A new concept must be consistent with the other knowledge and have the capacity to solve the problems generated by its predecessors.

- Fruitfullness: A new concept should have the capacity to be extended to open up new areas of inquiry, to serve to resolve new problems, to suggest new approaches.

These conditions give us a criterion to judge students' readiness to learn new ideas. The model of learning as conceptual change suggests these conditions, which a new conception has to satisfy before it can be integrated with existing knowledge. An instruction with conceptual change should provide the learner with an explanation that is understandable, believable, and be seen to apply to situations that produced the dissatisfaction (Posner, Strike, Hewson & Gertzog, 1982). According to Hewson and Hewson (1983), the implications of the conceptual change model for teaching are clear. The teacher has to assure that the students find new content to be intelligible, plausible, and fruitful, and this can only be done by taking account of prior knowledge. Students perceive ideas differently and the teacher must take into consideration of the ideas of the students.

Students perceive new knowledge differently that may require different teaching strategies. Possible teaching strategies stated by Hewson and Hewson (1983) are as follows:

Integration: Teacher integrates the new conceptions with existing conceptions, or different existing conceptions with each other.

Differentiation: Teacher differentiates existing conceptions into more clearly defined, separated, but closely related conceptions.

Exchange: Teacher exchange an existing conception for a new one, because they contradict with one another and cannot, therefore is plausible.

Conceptual Bridging: Teacher establishes an appropriate context in which important abstract concepts can be linked with meaningful common experiences.

Science educators have published many studies on students' understanding of scientific concepts. Based on these works that are mentioned some of them above, Mintzes, Wondersee and Novak (1998; p.76) offered a set of 12 knowledge claims about understanding of conceptual change in science:

1. Learners are not ‘empty vessels’ or ‘blank slates’; they bring with them to their formal study of science concepts; a finite but diverse set of ideas about natural object and events; often these ideas are incompatible with those offered by science teachers and textbooks.

2. Many alternative conceptions are robust with respect to age, ability, gender and cultural boundaries; they are characteristic of all formal science disciplines including biology, chemistry, physics, and the earth and space sciences; they typically serve a useful function in the everyday lives of individuals.

3. The ideas that learners bring with them to formal science instruction are often tenacious and resistant to change by conventional teaching strategies.

4. As learners construct meanings, the knowledge they bring interacts with knowledge presented in formal instruction; the result is a diverse set of unintended learning outcomes; because of limitations in formal assessment strategies, these unintended outcomes may remain hidden from teachers and students themselves.

5. The explanations that learners cling to often resemble those of previous generations of scientists and natural philosophers.

6. Alternative conceptions are products of a diverse set of personal experiences, including direct observation of natural objects and events, peer culture, everyday language, and the mass media as well as formal instructional intervention.

7. Classroom teachers often subscribe to the same alternative conceptions as their students.

8. Successful science learners possess a strongly hierarchical, cohesive framework of related concepts and they represent those concepts at a deeper, more principal level.

9. Understanding and conceptual change are epistemological outcomes of the conscious attempt by learners to make meanings; successful science learners make meanings by restructuring their existing knowledge frameworks through an orderly set of cognitive events (i.e., subsumption, superordination, integration, and differentiation).

10. The differential ability to solve problems in novel, real-world settings is attributable primarily to the advantages conferred on individuals possessing a highly integrated, well-differentiated framework of domain-specific knowledge which is activated through concentrated attention to and sustained reflection on related objects and events.

11. Learners who excel in the natural sciences habitually employ a set of metacognitive strategies enabling them to plan, regulate, and control their own learning.

12. Instructional strategies that focus on understanding and conceptual change may be effective classroom tools.

In their study, Hewson and Hewson (1983) applied different instructional methods; traditional versus conceptual change strategies, to effect the learning of scientific conceptions concerning mass, volume, and density. Ninety 9th grade students participated in the study. For the identification of misconceptions about the scientific conceptions of mass, volume, and density, prior to instruction students were interweaved. During the instruction, the teacher addressed these misconceptions in the experimental group. The students in experimental group realized that their existing conception was not plausible and they were dissatisfied with their existing knowledge. The existing knowledge of students integrated with new concepts during instruction assuming that the existing ones are not contradictory to the thoughts of teacher. During instruction in the control group, the new concepts were linked with existing ones without pointing out to the misconceptions. After instruction, students were evaluated by paper and pencil posttest. The study took about two weeks and the total teaching time amounted to five hours for the control group and six hours for the experimental group. At the end of the study it was found that, the experimental group achieved significantly greater negative change scores than the control group on the subtest for alternative conceptions of mass and volume as a result of instruction (X^2 (1) = 8.7, $p<0.005$). Authors indicated that the experimental group showed the better understanding of the concepts of density, mass, and volume than control group by gaining more scientific conceptions and lost more alternative conceptions than the control group.

In addition, Beeth (1998) studied on 12 fifth grade class students while they were studying physical science concepts about force and motion by applying a conceptual change instruction. During the instructions with conceptual change model, students could monitor and improve their learning; they mentioned their conceptions in terms of plausibility and intelligibility. Students instead of passively receiving information, they could actively examined their own conceptions. The reflection of students of their conceptions also helped the teacher to progress in learning these science concepts and plan instruction according to these learning outcomes. Teacher could monitor the progress of students' development, because to assess the status of concepts of students during instruction was possible.

Smith, Blakeslee, and Anderson (1993) examined 13 seventh grade life science teachers to see the effect of the use of teaching strategies associated with conceptual change model. The teachers taught units on photosynthesis, cellular respiration, and matter recycling in ecosystems in their regular classes. The teachers were divided into three groups. In the first group, teachers with researchers discussed a conceptual change orientation to teaching and specific teaching strategies. Second group attended no workshop but used curriculum materials written by the research project staff for the photosynthesis and cellular respiration units. Third group attended workshops and used the materials about only photosynthesis. At the end of study the authors claimed that, appropriately designed teaching materials can help teachers increase both their use of conceptual change teaching strategies and their students' success in learning.

One of the teaching procedures that promote conceptual change is learning cycle.

2.2.1 Research on Learning Cycle

Learning cycle is an inquiry based teaching strategy that provides conceptual change. In learning cycle, students present their arguments, predict, and test their hypothesis, result in the construction of knowledge. The learning cycle, that incorporates the Piagetian approach into a succinct methodology of learning, has three distinct phases: (a) Exploration at which teacher presents student with a problem or task, so that students experience the phenomena or concept (b) Term introduction at which teacher introduces the main concept of the lesson and any new vocabulary pertinent to the concept. In that phase the teacher assumes a more traditional role. (c) Concept application that provide opportunity to the students to study the additional examples of the concept (Lawson, 1996; Marek & Cavallo, 1997; Odom & Kelly, 2000).

The learning cycle is a great strategy for middle school and high school science teaching because it works, is flexible, and places realistic demands on teachers and students (Colburn & Clough, 1997). There are many studies conducted to measure the effectiveness of learning cycle (Wright, 1995; Lawson, 1996; Colburn & Clough, 1997; Blank, 1999; Lee, 2003; Lauer, 2003). For example, Schneider and Renner (1980) compared the intellectual development of students experiencing inquiry teaching and those of students experiencing exposition. The inquiry group was instructed by learning cycle. The researchers studied on 48 students drawn from a sample of approximately 150 ninth grade students from a rural junior high school in central Oklahoma. The learning cycle teaching method with three phases was used in the inquiry group that consisted of 23 students and 25 students were assigned to the exposition group. During the study four physical science units (static electricity, current electricity, light and optics and sound) were presented for 12 weeks. The results of the study indicated that the learning cycle group exhibited greater gains in intellectual development than the group during the instructional period.

In another study, Barman, Barman and Miller (1996) compared the learning cycle teaching approach with a textbook demonstration method of instruction to determine whether one method was more effective in facilitating conceptual change concerning sound. Thirty-four fifth grade students were randomly selected and assigned to the two treatment groups. To assess the students' understanding of specific sound concepts, an interview protocol was administered to both groups before and immediately after instruction. Students were given a numerical rating corresponding to their levels of understanding. To be able to define whether there was an agreement among scores; students' numerical values were compared with the ratings that were established independently by two individuals. In the study, one class received instruction using textbook/demonstration method which was teacher centered and students in that class read information from a textbook. Discussions and demonstrations were used in addition to textbook. Other class received learning cycle instruction, which was student centered and consisted of three phases of learning cycle. In that class, students had a chance to decide about how they will learn, questions aroused as a result of classroom interactions. At the end of two weeks instructional period, students who were taught using the learning cycle had a significantly better understanding. The findings and the data from the given study indicated that the learning cycle is an effective teaching model in helping students refines their ideas about science concepts at a variety of grade levels.

The effectiveness of the learning cycle, concept mapping, expository instruction, and a combination of concept mapping/learning cycle in promoting conceptual understanding of diffusion and osmosis were studied by Odom and Kelly (2000). The results indicated the concept mapping/learning cycle and concept mapping treatment groups significantly outperformed the expository treatment in conceptual understanding of diffusion and osmosis. However, they could not find any significant difference among the learning cycle and other treatment groups.

Cavallo (2003) examined 60 ninth grade physical science students' understanding of chemical reactions during learning cycle. In their study, students and teachers were familiar with learning cycle by previous lessons. The learning cycle used in the investigation focused on the concept of chemical change and the relationship between atoms and compounds. Two forms of open-ended essay questions were used for evaluation of students. One of the form included key terms by which students could write essays and the other did not. The essays were administered at three points: pre-learning cycle, post concept application, and after additional concept application activities. The result of the study indicated that students who were not given key terms prior to learning cycle, seemed to have better understanding than the ones who were given key terms. The researcher stated that using key terms in open-ended evaluation to elicit understanding and misunderstanding should be used after the students constructed concept understanding. Students' explanations also indicated that students' understanding increased over the learning cycle.

In their study, Colburn and Clough (1997) proposed several tips to help teachers while designing the learning cycle approach. These are; doing the laboratory first, before introducing concept discussing the laboratory, requiring students to record and present laboratory findings, providing tests that require students to use what they did in the laboratory, providing students' to clarify some aspects of their thinking, helping students to invent the laboratory procedures, changing teachers' role during laboratory activity, providing students to apply what they learned. They stated that learning cycle is an effective teaching technique for students to explore new science concepts. In addition to studies measuring effectiveness of learning cycle, many researchers, while pointing out its effectiveness, presented examples of useful learning cycles in different subjects of science. For instance, Wright (1995) in his article, while recommending the use of the learning cycle as an instructional strategy, especially since it promotes logical reasoning and applications of appropriate psychomotor skills, also presented three examples of learning cycle instruction about plant growth, freezing point and static electricity. Similarly, Lawson (1996) pointed that, learning cycle is better than traditional instructional approaches because in the learning cycle the development of thinking skills is an important goal. Many students have shown that a large proportion of the secondary and college population have poorly developed thinking skills (Lawson, p.39). Lawson presented an example of learning cycle that can be used to teach Mendelian genetics. In his learning cycle method, there were two sections. The first section includes an introduction, a materials list, a procedure to guide to student inquiry, and a set of application questions to extend the lesson. The second section includes content related background and teaching tips for each phase of learning cycle.

Another example of learning cycle was presented by Blank (1999). He used a revised learning cycle model called as metacognitive learning cycle that emphasizes formal opportunities for teachers and students to talk about their science ideas about ecology unit. Two science classrooms studied identical ecology content using different pedagogical orientations. One class used metacognitive learning cycle (MLC) and the other used Science Curriculum Improvement Study (SCIS) learning cycle. In SCIS learning cycle students made predictions before exploring concepts and they also generated hypotheses to explain new phenomena. In SCIS learning cycle formal opportunities for students to reflect on their science ideas were not provided. In MLC, students were asked to reveal and reflect upon conditions under which a learner constructs knowledge: dissatisfaction, intelligibility, plausibility and fruitfulness of their science ideas through the instruction. Only in the metacognitive classroom were students asked to reveal their science ideas and to discuss the status of their conceptions throughout the instruction. Results showed that students in the metacognitive classroom did not gain a greater content knowledge of ecology, but they did experience more permanent restructuring of their ecology understandings. Students' generation of causal questions helped them to develop scientific reasoning skills and awareness of the nature of science that are important for students.

Lawson (2000) to be able to improve students' thinking skills, to provoke the generation of causal questions and to help students construct meaningful concepts developed an osmosis learning cycle. The researcher presented student material that includes introduction, list of materials, a procedure to guide, students' inquiry, a set of application questions to extend the lesson and the teacher material that includes tips for teachers. Exploration phase of that learning cycle includes observation of what happens when red onion, elodea and red blood cells placed in distilled and salt water. After details about the molecular nature of the water and salt solution are discussed, students generate alternative hypothesis that explain their observations. Then, they test their hypothesis using nonliving model cells made of dialysis tubing. In the concept application phase, the process of diffusion and osmosis are introduced and the students' explanations are discussed. The questions for application phase were also presented in the students' material of the learning cycle.

Cavallo (2001) developed two learning cycles for upper elementary and middle school students to provide better understand air and water movement. The researcher presented steps that should be followed at each phase of learning cycle and materials used in each learning cycle. The first learning cycle was about the effects of temperature on air movement. In the exploration phase, students performed laboratory activities. After the laboratory activities in the exploration phase of first learning cycle, students understood that warm air rises and cool air sinks. After students read statements about the laboratory activities, they made comparisons between their own and the teacher-introduced terms. In the concept application phase, another laboratory setup was described. In the second learning cycle, students were observed warm water rises and cool water sinks by carrying out another laboratory activity. Again, teacher facilitated the discussion about the students' statements and the students constructed one statement that summarizes and explains the observation. The researcher also presented additional science experiment for the concept application phase. It was stated that students worked on collaborative groups and engaged in active inquiry in these learning cycles. Similarly, Lee (2003) presented a learning cycle for elementary majors with science majors about plant nutrition that includes collaborative work at the pair and small group level. In that learning cycle the exploration phase started with a question about nutrients that were required for plant growth. Then, students designed an experiment using different nutrients as variables and collected data. Students synthesized data into table and graphs for presentation to the class. In the concept application phase data were discussed by the students and following the reading assignments main concepts about plant nutrition were introduced. For the application phase several procedures were presented by the researcher: chemical testing of different soils to see their nutrient components, examining fertilizer containers for nutrient present, relating fertilizer use instructions to the nutrient. He stated that the exploration and application phases provide opportunities for either cooperative or collaborative learning, which are ideal teaching strategy for learning cycles. With cooperative learning, students' roles can be structured during active laboratory time and by collaborative learning, teachers can encourage interdependence in classroom.

The teacher perceptions of the learning cycle are also important for providing students' meaningful understanding of the scientific literacy. Since appropriate usage of learning cycle instruction affects students' understanding. In science, constructing a learning cycle lesson requires instructors who are qualified, and informed about the phases of learning cycle. Reap (2000) carried out a study to describe and explore the teachers' use of learning cycle and general understanding of the teaching paradigm. The researcher also examined teacher characteristics and practices of a master and a novice learning cycle science teacher and identify possible patterns in their understanding and implementation of paradigm in the classroom. Seventy experienced teachers in grade 6 and 12 were enrolled in the study. These teachers all worked in districts that support the application of learning cycle science and the use of learning cycle curricula. Also a master and novice learning cycle teacher was chosen from the pool of 70 participants. The learning cycle survey was sent to participants of the study. The survey consisted of the two parts. The first part included 17 items, which obtained the demographic and descriptive information about the learning cycle teachers. Second part consisted of 13 items that investigated teachers' understanding of learning cycle. Analysis of the surveys showed no significant difference in master and novice teacher understandings of learning cycle. One master and novice learning cycle teacher were interviewed; lessons of these teachers were observed and videotaped. However, the differences in the implementation of the learning cycle were observed. The master learning cycle teacher showed a more developed teaching philosophy and had more engaged extensive interactions with students. The novice learning cycle teacher held a more naive teaching philosophy and had fewer, less developed interactions with students. While master teacher was using diverse questioning techniques, the novice teacher used more rote response questions.

Barman (1992) described the evaluation of a technique that introduced elementary science methods students to the learning cycle and provided them with a mechanism for using this strategy with current elementary science textbooks. In that technique, students experienced several learning cycle lessons and they were asked to analyze a chapter of a current elementary science textbook to determine whether its chapters follow the learning cycle format. Students discussed their analyses and they were asked to select a chapter from their science textbook, organize its lessons to follow the learning cycle. For the evaluation of the technique, another sample consisted of forty-eight preservice teachers in two different sections of an elementary science method class at a large Midwestern University were used. The study showed that the preservice teachers need several opportunities to work through elementary science lessons, that follow this approach and that they need practice in developing, using, and evaluating learning cycle lessons.

As summarized in the related literature, learning cycle, which is a specific activity-oriented instructional technique, promotes conceptual change while providing better understanding of scientific concepts.

2.2.2 Research on Conceptual Change Texts

Another conceptual change approache that facilitate conceptual change is conceptual change text. Conceptual change texts have been used to promote student construction of conceptions more consistent with the accepted by scientists to help students acquire a more complete conceptual understanding of scientific concepts. In the conceptual change texts, students are asked explicitly to predict what would happen in a situation before being presented with information that demonstrates the inconsistency between common misconceptions and the scientific conception (Chambers & Andre, 1997). Conceptual change text is designed to change students' misconceptions, focuses on strategies to promote conceptual change by challenging students' misconception, producing dissatisfaction, followed by a correct explanation, which is both understandable and plausible to the students.

There are many studies conducted to measure the effectiveness of conceptual change texts. For example, the effects of conceptual change text manipulations with gender, interest and experience in electricity on learning fundamental direct current concepts examined by Chambers and Andre (1997). The study showed that the conceptual change text did lead to better conceptual understanding of electricity concepts. When interest level, experience and prior knowledge were included in the analysis, conceptual change text led to better understanding of electricity concepts than did the traditional text, and the effect of gender was eliminated. The researchers stated that conceptual change text manipulations are likely to be effective for both man and woman.

Another study that examines the effect of text design on conceptual change concerning photosynthesis was carried out by Mikkila (2001). Two hundreds and nine 5th grade students studied either a traditional text version about photosynthesis or a conceptual change text version. Students were evaluated by pretest and posttest scores. As a result students who studied the conceptual change text design performed statistically better than the traditional text group on post-tests.

As a result of the previous studies, it can be concluded that conceptual change texts are the valuable tools for providing conceptual change in addition to learning cycle.

2.3 Research on Students' Reasoning Abilities

Teaching methods and materials should be consistent with students' level of conceptual development. Because childrens' cognitive status changes over time and they will not learn if they do not have the required cognitive skills. According to Piaget (1950) children in the concrete operational stage are able to take another's point of view and take into account more than one perspective simultaneously. They can think operationally, represent transformations, and understand concrete problems. Piaget thought that the concrete operational stage ended at age eleven or twelve. On the other hand, only children in formal stage can think logically and abstractly. According to Piagetian model, formal thought begins to develop at age 11 or 12 and reaches an equilibrium state at around 15 or 16. Chidren at that stage can use logical symbols related to abstract concepts. Piaget considered formal operational stages as ultimate stage of development and stated that although the children still have to revise their knowledge base, their way of thinking is powerful, as it would get.

Students' level of cognitive development is related with their meaningful understanding of science because science processes requires intellectual skills used in collecting and analyzing data to solve problems. Processes such as observing, classifying and recording data act as prerequisites for integrated processes such as hypothesizing, controlling variables and defining operationally. The variables that influence process skill learning are learner attributes such as formal reasoning ability and locus of control; and rates and types of academic engagement (Tobin & Capie, 1982).

There are many studies investigated students' reasoning abilities and its relationship with students' understanding (Lawson & Renner, 1975; Ehindero, 1979; Johnson & Lawson, 1998; Musheno & Lawson, 1998; Tobin & Capie, 1982; Valanides, 1996; BouJaoude & Giuliano, 1994). For example, in 1975, Lawson and Renner conducted a study to assess understanding of concrete- and formal operational concepts by concrete and formal operational students in secondary school biology, chemistry and physics classes**.** One hundred thirty four subjects were selected from a single high school in a single town over 2000 students. They identified the distribution of concrete and formal operational students in selected biology, chemistry and physics classes: in biology sample one subject was categorized as transitional formal, and no subjects were determined to be fully formal operational; the chemistry sample showed a majority of subjects somewhere in the transition between concrete operational and formal operational; in physics sample majority of the subjects were between concrete operational and formal operational with higher number of fully formal operational subjects than chemistry sample by four Piagetian-styled tasks. Then they concluded that majority of the subjects were below the levels of intellectual development as outlined by Piaget. The major concepts taught during the year in each science class were classified as concrete and formal operational and written tests involving those concepts were constructed and administered. The result of that study showed that secondary school science curricula may not be suitable for the intellectual level of students and it should be appropriate for students' level of understanding. Therefore, students' intellectual level should be major consideration for curriculum developers.

Ehindero (1979) investigated the relationship between performance of very bright biology students and intellectual precocity, and compared these performances with their low biology counterparts. He used 110 students at nine and ten grade levels from six high schools in Nigeria. Students were classified as high and low achievers by teachers. At the end of the study, it was found that brightness, defined by students' performance on the biology tests, is significantly related to cognitive developmental precocity, especially at the formal operational level.

As Lawson and Thompson (1988) stated, reasoning abilities of the students are one of the factors that can contribute to students' failure to understand scientific conceptions. They conducted a study on 131 seventh grade students to measure whether formal operational students hold significantly fewer misconceptions than concrete operational students. Students enrolled in a life science course in a junior high school in Arizona. Prior to the study, students' reasoning ability, mental capacity, verbal intelligence and cognitive style were measured. Instruction lasted for about one month covered the evolution and genetic units. During instruction a standard lecture-textbook reading, which includes discussions, textbook readings and study questions, was used. Students posttested by an essay test about genetics and natural selection. In the study, it was stated that for the elimination of some misconceptions, students' formal reasoning patterns were necessary. Concrete operational students held greater number of misconceptions. No significant role of mental capacity, verbal intelligence and cognitive style in the amount of misconceptions were found.

In their study, Johnson and Lawson (1998) measured the relative effects of reasoning ability and prior knowledge on biology achievement in expository and inquiry classes. They examined 366 students (Mean age=23.11) enrolled in one-semester nonmajors' biology course. Written items involving proportional reasoning and controlling variables were chosen to assess reasoning ability. Students were pretested during laboratory sessions at the start of the semester to determine their reasoning abilities and prior knowledge. Learning cycle is used in inquiry instruction classes. To measure students' achievement, a total semester examinations and quiz percentages, final examination scores were used. They found that reasoning ability limits achievement more than prior knowledge among biology students, whether they were enrolled in inquiry or expository classes. In inquiry classes, significant improvements in reasoning abilities of students are also observed. The variance explained by reasoning ability in expository classes (18.8%) was more than the one in inquiry classes (7.2%).

Musheno and Lawson (1998) conducted a study on 123 high school students from two suburban schools in the southwestern United States to measure the effects of learning cycle and traditional text on comprehension of science concepts by students at different reasoning levels. The reasoning levels of the students were assessed using Lawson's Classroom Test of Scientific Reasoning and students were classified as empirical-inductive, transitional, or hypothetical-deductive reasoners. Then, the students were randomly assigned to read either a learning cycle or traditional text passages. After reading text passages students were given posttest covering the concepts presented for reading comprehension. One week later, students completed the delayed posttest, which consisted of the same concept comprehension questions and the subjective question. Results indicated that, students who read the learning cycle passage earned higher scores on concepts comprehension questions than students who read the traditional passages, at all reasoning levels. Therefore, it was also stated that learning cycle passages effective on students' concept comprehension at all reasoning levels.

Tobin and Capie (1982) also studied on twelve pupils from each of the thirteen middle school science classes measuring each pupil on nine engagement modes by using Test of Logical Thinking (TOLT). They found that formal reasoning ability measured by TOLT as the strongest predictor of process skill achievement and retention on science achievement. Formal reasoning ability and the locus of control that is related to an individual's tendency to accept responsibility for academic success or failure were each correlated with specific engagement modes. Formal reasoning ability was positively related with rates of generalizing and comprehending.

Valanides (1996), in his study used performance of 195 seventh-, eight-, and ninth- grade students on the Test of Logical Thinking to identify differences related to five reasoning modes. Five forms of formal logical thought which are; control of variables, proportional, probabilistic, correlational and combinatorial reasoning were measured among the three grade levels and between male and female students. Result revealed that only 13.9% of the students reached formal operational stage. He found no significant difference between female and male students on any of the five reasoning modes. In his study, students showed low performance on combinatorial reasoning problems. In another study, Valanides (1997) investigated the differences related to formal reasoning abilities among twelfth grade students attending different sections (science, economics, unified) of four schools in Cyprus. He randomly selected 227 boys and 242 girls. Students' performance on TOLT was used as a measure of their cognitive abilities. At the end of the study it was found that gender, section of study, achievement in mathematics, and grade point average, but not achievement in science and Greek language, contributed to predicting performance on TOLT. Students also showed differences among performances between items related to the same or different reasoning mode.

In the study of Oliva (2003), existing relationship between the degree of structural coherence of students' preconceptions in mechanics and the viability of conceptual change is looked into. 155 tenth grade students completed a Spanish version of TOLT and they also were given two tests on conceptions of mechanics both before and after instruction. It was found that students with the highest level of formal reasoning change their alternative conceptions more easily when these display a higher level of initial structuralization. Students showing concrete reasoning changed alternative conceptions more easily when their conceptions are less structured.

In the light of these studies we can say that to provide better understanding of the scientific conceptions, teachers not only consider the prior knowledge but also reasoning abilities of the students and design instruction accordingly.

2.4 Research on Students' Learning Orientation

In addition to reasoning abilities of students, their learning orientation is another cognitive variable that affects students understanding. Learning orientation refers to the students' approaches to learning which are consistent with their understandings (Boujaoude, 1992; Cavallo, 1996). There are two types of learning orientation: rote and meaningful learning orientation. Meaningful learning is a constructive process in which the learner strives to build an understanding of the information and observations, which make up the 'body of knowledge' of science. Ausubel (1963, 1968) describes the formulation of relationships between theoretical concepts in making sense of the word as ‘meaningful learning’. In contrast to meaningful learning, rote learning in which new knowledge may be attained by verbatim memorization and incorporating into a persons’ knowledge structure without connecting it to information or framework previously acquired (Ausubel, 1963; Baird, 1986). Relationships between learning orientation, reasoning ability and students’ meaningful understanding were investigated by researchers because as stated in many studies it was observed that these variables affect students’ understanding and achievement in science.

Reap and Cavallo (1992) in their study, determined possible relationships of students’ meaningful learning orientations with their attainment of meaningful understanding of meiosis, the Punnett square method, and the procedural and conceptual relations between meiosis and the Punnett square method. 163 tenth grade students from a suburban high school enrolled in their study. Scores of learning approach questionnaire and teacher ratings of their students’ learning approach were used to identify students’ meaningful learning orientations. Then, students were given instruction on meiosis by their classroom teachers. Type-written audio tutorial instructional packets that reviewed meiosis, introduced Punnett square method and detailed relation between these subjects, were administered to students. In their study, no significant differences between males and females in terms of meaningful learning orientation were reported and meaningful understanding of any of the genetic topics was observed.

Cavallo and Schafer (1994) investigated the relationship between students' meaningful learning orientation, relevant prior knowledge, instructional treatment and all interactions of these variables on 163 tenth grade students' meaningful understanding of meiosis, genetics and relationship between these topics. In one treatment (reception treatment) the highlighted questions and problems addressed the relationship between meiosis and the Punnett square method and answers to the questions were provided. In another treatment (generative treatment), same highlighted questions and same problems in reception treatment were included but in generative treatment, students generated the answers to questions by themselves. The results of the correlations and multiple regressions indicated that meaningful learning orientation contributed to the students' attainment of meaningful understanding independent of aptitude and achievement motivation. They also found little effect of type of instruction (reception versus generative) on students' meaningful learning.

Cavallo (1996) explored the relationship between meaningful learning orientation, reasoning ability and students' understanding and problem solving of topics in genetics. 189 tenth grade students in college entrance biology course enrolled in the study. During instruction a laboratory based learning cycle teaching procedure, which was also used throughout the district, was employed. Students' general level of cognitive operation and learning approaches were measured by pencil and paper edition of the Classroom Test of Scientific

Reasoning (CTSR) (Lawson, 1987) and Learning Approach Questionnaire (LAQ) (Cavallo, 1996). Genetics knowledge of students was measured by the test of genetics meaning, test of genetics problems, mental model test, developed by Cavallo and Schafer (1994). Regression analysis showed that meaningful learning orientation best predicted (13%) students' understanding of genetics interrelationships and reasoning ability best predicted (9%) students' achievement in solving genetics problems.

Saunders, Cavallo and Abraham (1999) investigated the relationship between epistemological beliefs, gender, approaches to learning and implementation of instruction in chemistry laboratory. 232 college students from an introductory chemistry laboratory course at a large Midwestern university enrolled in their study. Laboratory experiences were characterized as "more inquiry" or "less inquiry". In their study, type of instruction was not correlated with learning approach. Meningful learning approach was not related to students' epistemological beliefs but rote learning approach and epistemological beliefs were correlated. However, they observed that students' perceptions of classroom tasks influence their choice of meaningful or rote learning strategies. Moreover, they stated that meaningful and rote approaches to learning are not opposite constructs.

BouJaoude and Giuliano (1994) investigated the relationships between students' approaches to studying, prior knowledge, logical thinking ability, and gender and their performance in a nonmajors' college freshman chemistry course. 220 students enrolled in the second semester of a freshman chemistry course for nonmajors at a private university in New York State were selected for the study. TOLT and seven subscales of the Approaches to Studying Inventory were used to measure logical thinking ability and students' approaches to studying respectively. The results showed that prior knowledge, TOLT scores, and meaning orientation accounted for the 32 % of the variance on the final examination scores. Female students' meaningful orientation scores were higher than male students while male students' TOLT scores were significantly higher than the scores of female students.

BouJaoude et al. (2004) compared students' performance on conceptual and algorithmic chemistry problems; investigated the relationship between learning orientation, formal reasoning, and mental capacity and students' performance on conceptual and algorithmic problems; and investigated interactions among these three cognitive variables. 68 eleventh grade students enrolled in science sections of three Lebanase schools. Learning orientation, formal reasoning and mental capacities were measured using LAQ, TOLT, and the Figural Intersection Test. Study showed that meaningful learners were better than the rote learners on a test of conceptual problems while there were no difference between both levels in algorithmic problems. As a result of multiple regression and stepwise multiple regression analyses, three cognitive variables were found to be the predictors for 26% of the variance in performance on conceptual chemistry problems. Both learning orientation and formal operational reasoning had significant contributions at 0.05 levels. It was also stated that meaningful learners outperformed rote learners on the test of conceptual problems. No significant differences were observed for both levels of algorithmic problems.

In the light of related literature, we can say that besides reasoning ability and prior knowledge, students' meaningful learning orientation is an important predictor of students' understanding of science.

2.5 Research on Students' Affective Variables

Teachers generally want their students' cognitive engagement in the lessons. They want their students to think critically and creatively about the content to be learned, to realise what they know and do not know, to use different strategies for learning that increase their understanding of the material (Linnenbrink & Pintrich, 2003). Teachers also want students to be engaged in the content or tasks in terms of their interest, value, and affect. Because, in addition to the cognitive variables, affective variables also have impact on students' understanding (Strike & Posner, 1992; Cavallo, Rozman & Potter, 2004; Kang, Scharmann, Noh &

Koh, 2005). Teachers are always concerned with increasing student engagement and learning. Therefore, they should also consider students' affective variables to increase the level of understanding. In the same classroom some students are involved, engaged, and motivated for schoolwork while others are disengaged and reluctant. That situation is not only related with students' cognitive development but also their motivations to learn. The students are motivated to learn when they are excited, the subjects are interesting or when they think that the concepts are important and worth learning. Motivation research has shown that these feelings and beliefs about interest and value lead to more student engagement and learning (Pintrich & Schunk, 1996). Self-efficacy, locus of control and attitudes toward science are three of these affective variables that may affect students' understanding.

Self-efficacy is part of social cognitive theory, which postulates that human achievement depends on interactions between one's behaviors, personal factors (e.g., thoughts and beliefs), and environmental conditions (Bandura, 1986, 1997). Self-efficacy beliefs are defined as ‘‘people's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances’’ (Bandura, 1986, p. 391). With respect to the link between personal factors and behaviors, much research shows that students' self-efficacy beliefs influence such achievement behaviors as choice of tasks, effort, persistence, and achievement (Schunk, 1995; Bandura, 1997). Also, efficacy beliefs of students can be affected by students' behaviors. When students note their goal progress and accomplishment while working on a task they think that they are capable of performing well, which enhances self-efficacy for continued learning (Schunk, 2003). The more a student is engaged, and especially the more they learn and the better they perform, the higher their self-efficacy (Linnenbrink & Pintrich, 2003). Students with high self-efficacy by engaging actively in lesson may create a productive classroom environment. The influence of environment on thought is evident when teachers give students feedback, which raises self-efficacy and sustains motivation for learning. Students with high self-efficacy also tend to work harder when they faced with difficulties (Linnenbring & Pintrich, 2003). On the other hand, students with low self-efficacy avoid accomplish a task (Linnenbring & Pintrich, 2003). Success increases students' self-efficacy while failure decreases it. In their revised model of conceptual change, Strike and Posner (1992) suggested that a student possessing a high self-efficacy should show more conceptual change. Previous research reported that students' self-efficacy judgements are related to their use of cognitive and metacognitive strategies as well as their actual performance (Pintrich & De Groot, 1990). Students who believe they can do the task are much more likely to recruit more adaptive cognitive and metacognitive strategies (Linnenbrink & Pintrich, 2003). Researchers have also found that students who reported high self-efficacy tended to persist toward achieving their goals (Pintrich & De Groot, 1990; Schunk, 1990). Therefore, a student with a higher self-efficacy may be more likely to engage in challenging tasks inherent in activities like discrepant events (Kang et al., 2005). So that, using cognitive and metacognitive strategies regardless of previous achievement or ability, work harder, taking role in challenging task help to increase students' conceptual change. In inquiry based, student-centered courses, students can better assess their strengths and weaknesses in the subject and assume control of their own learning (Shavelson & Bolus, 1982). As stated, self-efficacy of students for self regulated learning contributes both to students' motivational beliefs and to the academic success they experience (Zimmerman, 1989; Zimmerman & Martinez-Pons, 1990; Zimmerman & Bandura, 1994).

Cavallo, Rozman & Potter (2004) studied on the relationship and influence of self-efficacy, learning approaches, motivational goals, beliefs about science and reasoning ability on conceptual understanding of physics and course achievement among male and female students. The subjects were 290 college students (103 male, 187 female) attending in a structured inquiry physics course at a large university. For providing all students to construct understanding, discussion/laboratory in which students working collaboratevily in a group was used. Students attended 80-minute lecture that emphasizes connections among content with the other parts of the course and with the other courses. Students, to be able to provide the development of their specific skills or abilities, were given questions/problems and exercises. In lectures students were also given weekly quizes. At the end of study, students were administered a final exam. Moreover, the tests and questionnaires measuring students' learning approaches, motivational goals, self-efficacy, epistemological beliefs, scientific reasoning abilities, and understanding of central physics concepts, were administered to participants at the beginning and at the end of the study. In the study, self-efficacy was found to be positively correlated with meaningful leaming ($r = .381$) and learning goals ($r = .345$) for both males and females and negatively correlated ($r = -.366$, $p = .01$) with rote learning among females only. Female students' concepts understanding were best predicted (33%) by higher self-efficacy and reasoning ability. For male students, learning goals and rote learning negatively predicted physics concept imderstanding and self-efficacy positively predicted students' physics understanding, while together explaining 38% of the variance. Results of the stepwise multiple regression analyses revealed that course achievement was best predicted (35%) by reasoning ability and higher self-efficacy. For males, learning goals and rote learning strategies negatively predicted (45%) course achievement while it was positively predicted by self-efficacy. The findings reveal that different variables of learning and motivation may be important for females' success in inquiry physics compared to males.

Generalizing findings about the motivational constructs is important. Otherwise findings can be domain specific and confined to one experimental situation. To be able to define whether self-efficacy beliefs in addition to other motivational constructs: task value, ability and effort attributions, mastery performance approach and performance avoidance achievement goal orientations do generalize across multiple subject matter area, Bong (2004) conducted a study. 389 freshmen (all female) at a public high school in Korea enrolled in her study. Motivational beliefs in three specific subject matters: Korean, English, mathematics were assessed by the motivation surveys administered several times throughout the year. The study showed that students form motivational beliefs that are subject matter specific and that some beliefs generalize more than others across multiple academic domains. On average, attributional beliefs appeared least "generalizable," followed by task value and mastery achievement-goal orientations. Academic self-efficacy beliefs were correlated moderately, whereas performance-approach and performance-avoidance achievement-goal orientations demonstrated strong correlation across different contexts.

Shim and Ryan (2005) studied on the relationship between achievement goals and changes in students' self-efficacy, challenge avoidance, and intrinsic value in response to grades in a short-term longitudinal study. 361 college students coming from eight different classes and representing different disciplines, enrolled in the study. Surveys were used to measure achievement goals. Students' self-efficacy was measured by three items including students' judgments of their capability to complete their course work successfully. Data were collected at the beginning of the semester and immediately after students received their grades on their first major exam or paper. At the end of the study, it was observed that when students received high grades, a performance-approach goal was unrelated to changes in self-efficacy; desire to avoid challenge, or intrinsic value. On the other hand, when students received low grades, a performance-approach goal was related to decreased intrinsic value and increased desire to avoid challenge. Reserachers stated the importance of focusing on the mastery goals that support self-efficacy and intrinsic value and decreasing the performance goals in the classroom.

Kang, Scharmann, Noh and Koh (2005) examined the relationship between students' cognitive/motivational variables, cognitive conflict and conceptual change. 159 seventh grade students selected from two city middle schools in Korea enrolled in their study. The cognitive variables were logical thinking ability, field dependence/independence and learning approach and the motivational variables were failure tolerance, goal orientation and self-efficacy. Students were given six pretests prior to the study. Then the preconception test that asks a specific question and the Test of Responses to a Discrepant Events (TRDE) that includes initial explanation, discrepant event and students' rating were administered. Both of these tests were given to examine the degree of students' cognitive conflict induced by a discrepant event. About the concept of density, students were exposed to about 15 minutes of conceptual change intervention, which was computer-assisted instruction. As postest a conception test that was designed to measure students' understanding of basic density concept was administered. In their study, only field dependence/ independence was significantly correlated with cognitive conflict ($p<0.01$). All cognitive variables and failure tolerance and self-efficacy from motivational variables were significantly correlated with conceptual change. The results of stepwise multiple regression analysis showed that logical thinking ability (28%), field dependence /independence (4%) and failure tolerance (3%) were statistically significant predictors of conception test scores. They concluded that the nonsignificant relationship between meaningful learning approach and conception test scores was linked to the characteristics of the learning topics or context of learning used.

Locus of control is another affective construct in addition to self-efficacy. The concept of locus of control was first introduced by Rotter (1966) in explanation of the differences between individuals in how they make attributions about their success or failure and how this affects learning. Locus of control attempts to bridge the gap between operant and cognitive psychology. Locus of control is the general belief that one's behavior can have an impact on the environment and that one is capable of controlling outcomes through one's own behavior (Martinez, 2003). Students may have internal or external locus of control. Students who take an internal responsibility for their academic performance have higher levels of overall achievement than students who take an external responsibility for their academic performance. Internal locus of control refers to the belief that events or outcomes are contingent upon one's own behavior or on relatively permanent personal characteristics, such as ability (Rotter, 1975). Students with external locus of control do not have any control of what happens to them has been correlated with lower academic achievement. Control orientations have been extensively studied and they have been found to be critical in relation to academic achievement and motivation (Kalechstein & Nowicki, 1997). The research literature has shown consistently that generalised locus of control is predictive of academic achievement and related behaviours (Kalechstein & Nowicki, 1997). For instance, Duke and Nowicki (1974) have concluded that there is evidence of a positive relationship between an internal locus of control and academic success. Finn and Rock (1997), pointed to external locus of control as an explanation for academic failure. Although locus of control sounds similar to self-efficacy, it is generalized outcome expectancy because it is concerned with the extent to which one believes one's behavior controls outcomes, not confidence in one's ability to perform certain behaviors (Bandura, 1986).

There are many studies that investigate the affects of self-efficacy and locus of control on students understanding and achievement (Duke & Nowicki, 1974; Wishart, 1997; Susskind, 2005; Anderson, Hattie & Hamilton, 2005). For example, Susskind (2005) examined the effects of non-interactive computer assisted instruction on students' performance, self-efficacy, motivation, and attitudes. Students were general psychology students attending a small, liberal arts college. Half the lectures presented to two Introduction to Psychology college classes were taught in a traditional lecture format and half were accompanied by PowerPoint multimedia. The first section was composed of 33 students (14 males and 19 females) and the second section was composed of 18 students (10 males and eight females). Each student received both traditional and PowerPoint lectures by the same instructor by switching lecture format for providing to examine whether students prefer PowerPoint or traditional lecture formats. Students were asked to answer eight questions examining their self-efficacy and behavior in the course. At the end of study it was observed that students had more positive attitudes about the course and greater self-efficacy with use of PowerPoint. However, lecture style did not affect academic performance. They believed that it was easier to understand the lecture and to take notes when PowerPoint accompanied lecture.

The development of the control expectanices was connected to perceived reinforcement as contingent on the individuals' behavior (Rotter, 1966). Once expectancy is established: ''Reinforcement acts to strengthen an expectancy that a particular behavior or event will be followed by that reinforcement in the future'' (1966, p. 2). Carton, Nowicki, and Balser (1996) investigated the amount of the contingent support provided by mothers of both students with internal control expectancies and the students with external control expectancies. In their study 51 second grade children (25 female and 26 male) and their mothers were videotaped while attempting puzzle-solving tasks. The children's locus of control of reinforcement was measured by the Children's Nowicki-Strickland Internal-External Locus of Control Scale prior to the videotaped puzzle solving session. In the study, children from five elementary schools were given puzzles while their mothers were staying with them and answering a questionnaire. After giving first easy puzzle, in the second stage, a more difficult jigsaw puzzle was given to student. Following that stage a third easy puzzle was given to child. All video-taped sessions were transcribed for both verbal and nonverbal behaviour. In the study no significant result was obtained for the easy level task. In the difficult task mothers of boys with internal control expectancies provided more contingent support when their sons faced with difficulties and were less likely to respond to their son's difficulties by performing the task for their sons. Mothers of girls with internal control expectancies were more ignored their daughters' accomplishments and difficulties than mothers of girls with external control expectancies. Thus, the results provided partial support for predictions derived from Rotter's social learning theory that mothers of children with internal control expectancies would provide more contingent reinforcement, support, and encouragement than mothers of children with external control expectancies.

Tobin and Capie (1982) in their study with twelve pupils in middle school science classes measured each pupil on nine engagement modes. They found that formal reasoning ability and the locus of control that is related to an individual's tendency to accept responsibility for academic success or failure were each correlated with specific engagement modes. They also revealed that, students' total engagement and rates of attendance was significantly related with students' locus of control.

The attitudes of students toward the subject being taught also related with students' control. Wishart (1997) studied with 153 postgraduate students in teacher training to examine whether students internal locus of control were correlated thier attitudes toward using computers and involvement in the use of computers. Postgraduate teacher training students were tested with a questionnaire survey of attitudes towards computers and internal locus of control. The questionnaire asked the students to describe their attitudes towards computers and how much experience they had of using computers as well as asking them to complete the Internal Locus of Control Index (Duttweiler, 1984). The internal dimension of locus of control in females and attitude towards computers were correlated in the study. Those who are more likely to locate control of their actions internally also hold more positive attitudes to using computers. A significant correlation between being internally controlled and being more prepared to use a computer was observed in the study indicating that students with more internal locus of control are more likely to have a positive attitude to using computers and become more involved in the use of computers.

Beside, students' locus of control and self-efficacy, researchers in science education have given great attention to attitudes because of assumed relationship between attitude and a variety of variables such as achievement, grade levels, socioeconomic status, and gender (Bloom, 1976; Schibeci, 1984; Simpson & Oliver, 1985; Talton and Simpson, 1986; Germann, 1988; Koballa, 1988; Shemesh, 1990; Freedman, 1997; Parker, 2000). For example, Friedler and Tamir (1990) analyzed 40 studies, in the six universities of the country to compare the achievement in science and the Israeli male and female students' attitudes towards science and science learning. The researchers stated that in the elementary school boys and girls are very similar in their attitudes towards science, in achievement in biology, in inquiry skills, in application, and in practical work. Yet, even in these early years boys' knowledge and understanding of physics and chemistry are somewhat better than that of girls. They also stated that observed sex differences which exist in all areas are very large at the end of junior high-school. In another study, Friedler and Tamir (1990) investigated 13-14 yer old students' degree of enjoyment in their science classes; their perceptions of the importance of science; attitudes toward practical and non-practical activities in science lessons; views on how difficult science is to learn in eigth schools. The research involved the analysis of a 34 item questionnaire with Likert-type five point attitude scale completed by 1038 students. This was followed by conducting structured interviews with a representative sample (N=72) of the students. It was shown that overall both boys and girls have positive attitudes towards science and boys have a greater preference for science. For the development of positive attitudes the involvement of practical work in lessons was seen as the most significant factor. The majority of students were aware of the importance of science. Relatively few students saw it as an area of study that they would wish to pursue beyond the age of compulsory schooling.

Johnson (1993) stated that students' attitudes predict their achievement. In her study, 383 college students enrolled in the course about biology concepts. Students' attitudes toward biology were obtained prior to the study and after the instruction. There were two groups, which are learning cycle, and expository group in the study. Students' achievement was measured by biology achievement examinations. In the study, it was found that for both types of instruction higher attitude results in higher scores on the final examination and students' positive post attitude.

Francis and Greer (1999) worked on 24 grammar schools in Northern Ireland with 2129 secondary school students to measure students attitudes toward science. Each students was given a questionnaire including questions concerning sex, age and science subjects taken at General Certificate and Secondary Education and science related items. Statistical analysis demonstrated that males had more positive attitude toward science than females and younger pupils record a more positive attitude toward science than other pupils.

In their study, Thompson and Soyibo (2002) investigated students' attitudes to chemistry and understanding of electrolysis in both experimental group and control group. Instruction in experimental group included the use of the combination of lecture, teacher demonstrations, class discussion and student practical work in small groups, while control group was not exposed to practical work. One hundred and thirty eight 138 Jamaican 10th graders (66 in the experimental group and 72 in the control group) in two high schools enrolled in their study. Attitudes to Chemistry Questionnaire which was adapted from Soyibo and Pinnock's (1998) attitudes to science questionnaire was adapted and used to measure the subjects' attitudes to chemistry. Understanding of Electrolysis Test to measure the subjects' understanding of electrolysis were used for data collection. Two weeks before the treatment started, the two instruments were administered to the main study subjects as pre-tests. Nine lessons were taught during the treatment and the treatment lasted 4 weeks and the subjects were post-tested with the instruments 2 weeks after the treatment. The study revealed, altough two groups' attitudes to chemistry before the treatment were similar, the statistically significant differences between the students' post-test attitudes to chemistry in favor of the experimental group. It was also found that the experimental groups' post-test mean scores on the Understanding of Electrolysis Test were statistically significantly better than those of the control groups. The use of the combination of lecture, teacher demonstrations, class discussion and practical work in small groups statistically signi. cantly improved selected Jamaican 10th graders' attitudes to chemistry and understanding of electrolysis more than the students' attitudes in control group who were not exposed to student practical work.

Osborne, Simon and Collins (2003) in their study which includes the review of the major literature about attitudes to science and its implications over the past 20 years stated the importance of kind of classroom environment and activities to raise pupils' interest in studying school science. They also, stated the importance of gender which may influence students' attitudes toward science.

The relationship between students' attitudes toward science and achievement may be different for different teaching environments and different countries. For example, in their study, Papanastasiou and Zembylas (2004) investigated the relationship between attitudes towards science and science achievement for senior high school students in Australia, Cyprus and the USA. The data for this study were obtained from the Third International Mathematics and Science Study (1995) database which included students in their final year of secondary school who were taking advanced mathematics and science classes at the time of the study. Researchers used the structural equation modeling to examine the predictors of the attitudes. The results of the statistical analysis revealed that in Australia, high achievement influenced the students' positive attitudes towards science. However, science attitudes were not able to statistically predict the students' science achievement. On the other hand, in Cyprus positive science attitudes influenced the students' high achievement, although achievement was not able to significantly predict their attitudes in science. In USA, results were quite different from Australia and Cyprus. First, like in Cyprus, positive attitudes significantly influenced high science achievement. However, the interesting finding was that high science achievement influenced negative science attitudes. The results of this study demonstrated the differential effects that science achievement and science attitudes can have on each other and these effects depends on the characteristics of the educational systems in each country.

Over the years, gender was taken great attention by the researchers in science education because it was assumed that there was a relationship between gender and a variety of variables such as achievement and attitude (Adamson, Foster, & Reed, 1998; Dimitrov, 1999; Erickson & Erickson, 1984; Jones, Howe & Rua, 2000; Okeke & Ochuba, 1986; Soyibo, 1999; Weinburg & Englaher, 1994; Young & Fraser, 1994). While some of the researchers reported significant gender differeneces (Soyibo, 1999; Young & Fraser; 1994; Okeke & Ochuba, 1986), some others indicated no significant difference between boys and girls in the achievement of life sciences (Dimitrov, 1999). The study carried out by Okeke and Ochuba (1986) reported no significant difference between boys and girls with respect to achievement in biology tests. Moreover, Dimitrov (1999) revealed that there was no significant difference between girls and boys with respect to achievement in life sciences. On the other hand, Soyibo (1999) showed that girls significantly performed better on a test of errors in biological labelling. Another study conducted by Young and Fraser (1994), revealed significant gender differences in biology achievement of 14 and 17 year old Australian students in favor of the boys. Furthermore, Erickson and Erickson (1984) indicated boys better in understanding of biology. However, generally, in many of such studies, the significance values for the differences are not markedly large. The situation is almost the same when the effect of gender on students' attitude toward science is considered. Students' attitude toward science is dependent on whether the life science or physical science is under consideration (Chiapetta, Koballa & Collette, 1998). The study carried out Weinburg and Englaher (1994) supported the idea that suggesting that students' attitudes differ among science disciplines. They found that although the effect was small, girls appeared to have more positive attitude toward biology than boys. Moreover, Jones et al., (2000) reported that while more grade boys wanted to learn about planes, cars, computers, light, electricity, new sources of energy, more girls wanted to learn about rainbows, healthy eating, animal communication. In addition, the study conducted by Adamson et al., (1998) revealed that boys are more likely to work on the projects in life sciences. These findings, in general, suggested that boys show more positive attitude toward physical sciences whereas girls show a more positive attitude toward life sciences.

2.6 Summary

Studies that investigate the relationship between cognitive and motivational variables and students' achievement in the different subjects of science can be summarized as follows:

1. Students have considerable amount of misconceptions that are related with genes, alleles, chromosomes, genotype, phenotype, dominance and recessiveness location of inheritance information (Longden, 1982; Smith & Good, 1984; Lawson & Thompson, 1988; Heim, 1991; Marbach-Ad & Stavy, 2000; Banet & Ayuso, 2000). Misconceptions of students about the major concepts in genetics affect students' understanding of reproduction, meiosis and fertilization (Lewis, Leach & Wood-Robinson, 2000). Teachers' awareness about students' prior knowledge in genetics is important for providing meaningful and effective learning (Pashley, 1994). Researchers also suggested effective teaching strategies or lessons for genetic instruction (Slack & Steward, 1990; Sampson, 2002, Knippels, Waarlo & Boersma, 2005). The reasoning abilities of students are related with students' understanding of the concepts in genetics (Lawson & Thompson, 1988; Slack & Stewart, 1990; Marbach-Ad & Stavy, 2000).

2. Students perceive ideas differently and the teacher must take into consideration of the ideas of the students. Therefore, teachers develop instruction

accordingly. Conceptual change strategies provide better understanding of scientific conceptions (Posner, Strike, Hewson & Gertzog, 1982; Hewson & Hewson, 1983; Smith, Blakeslee & Anderson, 1993; Beeth, 1998; Mintzes, Wandersee & Novak, 1998).

3. Learning cycle is a specific activity-oriented instructional technique promotes conceptual change and provides better understanding of scientific conceptions (Schneider & Renner, 1980; Barman, 1992; Barman, Barman & Miller, 1996; Odom & Kelly, 2000; Cavallo, 2003; Colburn & Clough, 1997; Wright, 1995; Lawson, 1996; Blank, 1999; Lawson, 2000, Lee, 2003).

4. Conceptual change texts are the valuable tools for providing conceptual change and for the elimination of misconceptions (Chambers & Andre, 1997; Hynd, McWhorter, Phares & Suttles, 1994; Mikkila, 2001).

5. Reasoning abilities of the students are one of the factors that can contribute to students' understanding scientific conceptions. Cognitive levels of students should be taken into consideration while developing instruction (Tobin & Capie, 1982; Lawson & Thompson, 1988; Lawson & Renner, 1975; Ehindero, 1979; Johnson & Lawson, 1998; Musheno & Lawson, 1998; Valanides, 1996; BouJaoude & Giuliano, 1994; Oliva, 2003).

6. Meaningful learning approach among students is important for their meaningful understandings of science concepts (Reap & Cavallo, 1992; Cavallo & Schafer, 1994; BouJaoude, 2004).

7. Students motivational construct affects their understanding. Self-efficacy may facilitate students' engagement, performance in the classroom and can provide conceptual change (Bandura, 1986, 1997; Zimmerman, 1989; Zimmerman & Martinez-Pons, 1990; Strike & Posner, 1992; Pintrich & De Groot, 1990; Zimmerman & Bandura, 1994; Schunk, 1990; Pajare, 2002; Cavallo, Rozman & Potter, 2004; Shim & Ryan, 2005; Kong, Scharmann, Noh & Koh, 2005). Locus of control is another factor explaning academic achievement in science (Rotter, 1966; Duke & Nowicki, 1974; Finn & Rock, 1997; Carton, Nowicki & Balser, 1996; Wishart, 1997; Susskind, 2005). In addition to self-efficacy and locus of control, students' attitudes may be related with a variety of variables such as achievement, grade levels, socioeconomic status, and gender (Bloom, 1976; Schibeci, 1984; Erickson & Erickson, 1984; Simpson & Oliver, 1985; Okeke & Ochuba, 1986; Talton & Simpson, 1986; Germann, 1988; Koballa, 1988; Shemesh, 1990; Friedler & Tamir, 1990; Weinburg & Englaher, 1994; Young & Fraser, 1994; Freedman, 1997; Adamson et al., 1998; Dimitrov, 1999; Soyibo, 1999; Jones et al., 2000; Parker, 2000; Thompson & Soyibo, 2002; Papanastasiou & Zembylas, 2004).

This summary proposes that students' cognitive and motivational constructs and also type of instruction have important impacts on students' achievement.

In the present study, we investigated the relationship among 8^{th} grade school students' cognitive variables (prior knowledge, learning approaches, reasoning abilities) and motivational variables (self-efficacy, locus of control and attitudes toward science) in relation to students' achievement in genetics in different types of classrooms; learning cycle and traditional classrooms.

CHAPTER 3

In this chapter; the problems, sub-problems and hypoheses of the study are presented.

PROBLEMS AND HYPOTHESIS

3.1 Problems

3.1.1 Main Problem 1

What are the relevant prior knowledge, learning approaches, reasoning abilities, attitudes toward science, self-efficacy and locus of control of 8^{th} grade students in two public schools in Ankara?

3.1.1.1 Sub-problems

1. What is the relevant prior knowledge of 8^{th} grade students in genetics?

2. What are the 8th grade students' learning approaches?

3. What are the reasoning abilities of 8th grade students?

4. What is the self-efficacy of 8th grade students?

5. What is the locus of control of 8th grade students?

6. What are the attitudes of 8th grade students toward science?

3.1.2 Main Problem 2

What is the effect of learning cycle instruction on 8th grade students' understanding of genetics?

H_0(i): There is no significant effect of learning cycle instruction on 8th grade students' understanding of genetics.

3.1.3 Main Problem 3

What is the relationship among 8th grade students' relevant prior knowledge, learning approach, reasoning ability, self-efficacy, locus of control, attitudes toward science and achievement in genetics in learning cycle and traditional classrooms in two public schools in Ankara?

H_0(i): There is no significant relationship among 8th grade students' relevant prior knowledge, learning approach, reasoning ability, self-efficacy, locus of control, attitudes toward science and achievement in genetics in learning cycle and traditional classrooms.

3.1.3.1 Sub-problems

1. What is the possible relationship among 8th grade students' relevant prior knowledge, learning approach, reasoning ability, self-efficacy, locus of control and attitudes toward science and students' achievement in genetics in learning cycle classrooms?

H_0(i): There is no significant relationship among 8th grade students' relevant prior knowledge, learning approach, reasoning ability, self-efficacy, locus of control, attitudes toward science and students' achievement in genetics in learning cycle classrooms.

2. What is the possible relationship among 8th grade students' relevant prior knowledge, learning approach, reasoning ability, self-efficacy, locus of control

and attitudes toward science and students' achievement in genetics in traditional classrooms?

H_0(i): There is no significant relationship among 8^{th} grade students' relevant prior knowledge, learning approach, reasoning ability, self-efficacy, locus of control, attitudes toward science and students' achievement in genetics in traditional classrooms.

3.1.4 Main Problem 4

What are the contributions of 8^{th} grade school students' relevant prior knowledge, learning approach, reasoning ability, self-efficacy, locus of control and attitudes toward science and gender on their achievement in genetics in learning cycle and traditional classrooms?

H_0(i): There is no contribution of 8^{th} grade students' relevant prior knowledge, learning approach, reasoning ability, self-efficacy, locus of control and attitudes toward science on students' achievement in genetics in learning cycle and traditional classrooms.

3.1.4.1 Sub-problems

1. Whether relevant prior knowledge, learning approach, reasoning ability, self-efficacy, locus of control, attitudes toward science and gender of 8^{th} grade students contribute students' achievement in genetics in traditional classrooms?

H_0(i): Relevant prior knowledge, learning approach, reasoning ability, self-efficacy, locus of control, attitudes toward science and gender of 8^{th} grade students do not contribute to students' achievement in genetics in traditional classrooms.

2. Whether relevant prior knowledge, learning approach, reasoning ability, self-efficacy, locus of control, attitudes toward science and gender of 8^{th} grade students contribute students' achievement in genetics in learning cycle classrooms?

H_0(i):Relevant prior knowledge, learning approach, reasoning ability, self-efficacy, locus of control, attitudes toward science and gender of 8^{th} grade students do not contribute to students' achievement in genetics in learning cycle classrooms.

3.1.5 Main Problem 5

Which variable best-predicted students' achievement in traditional and learning cycle classrooms?

3.1.6 Main Problem 6

Which variable best-predicted female and male students' achievement in traditional and learning cycle classrooms?

CHAPTER 4

DESIGN OF THE STUDY

The literature review, problems and hypotheses of the study were presented in the previous three chapters. In this chapter, major characteristics of the population and sample, selection and the description of the instruments, procedures, methods used to analyze data are defined.

4.1 The Experimental Design

In this study, the Non-Equivalent Control Group Design as a type of Quasi-Experimental Design was used. The random assignment of already formed classes to experimental and control groups was employed. Intact classes were used because it is too disruptive to the curriculum and too time consuming to take students out of their classes for treatment. Moreover, due to administrative rules the classes were chosen randomly not students. Design of the study is presented in Table 4.1.

Table 4.1 Research Design of the Study

Groups	*Pretest*	*Mode of instruction*	*Posttest*
EG	GAPRET, LAQ, TOLT, SES, LOC, ATS	LCI	GAPOST
CG	GAPRET, LAQ, TOLT, SES, LOC, ATS	TI	GAPOST

In the above table, EG represents the Experimental Group instructed by learning cycle instruction. CG represents the Control Group instructed traditionally. GATPRE is Genetics Achievement Pretest, GATPOST is Genetics Achievement Posttest, LAQ is Learning Approach Questionnaire, TOLT is Test of Logical Thinking, SES is Self-Efficacy Scale, LOC is locus of Control Scale and ATS is Attitude towards Science Scale. LCI refers to Learning Cycle Instruction and TI refers to Traditional Instruction.

4.2 Population and Sample

All eight-grade elementary school students in the public schools of Yenimahalle were identified as the target population of the study. There are 89 public elementary schools in Yenimahalle. However, since it is not feasible to get in touch with this target population, the accessible population was determined as all eight-grade elementary school students in all public elementary schools in Çayyolu area. There are 12 public elementary schools in Çayyolu area and two of these elementary schools were randomly selected as representative sample. The study sample chosen from the accessible population was a sample of convenience.

Convenience sampling was chosen because the schools were close to the researcher by providing easy access. Four experimental and four control groups enrolled in the study. While the experimental groups instructed by learning cycle, the control groups instructed by the traditional method. 234 students (age 13-14) assumed with similar socio-economic status, the educational level and income of the parents enrolled in the study. Because the scores of some of the students' were absent the scores of 213 (92 female, 121 male) students were used in the study. The number of students that involved in one of the school was 108. Teacher had two randomly assigned experimental group classes and two control group classes. In the other school the number of students that involved in one of the school was 126. Two teachers each had one randomly assigned experimental group classes and one-control group classes instructed the students.

The content of the genetic course is same for all eight-grade students in Turkey because of the regulations of Turkish Ministry of Education. All of the students are familiar with the prerequisite subjects that are cell structure and function, organic compunds and nucleic acids from their previous classes.

4.3 Variables

There are nine variables involved in the study. The variables are categorized as dependent variables (DV) and independent variables (IV).

4.3.1 Dependent Variable

The DV of the study is students' Genetics Achievement Posttest scores (GAPOST). It is continuous variable and measured on interval scale.

4.3.2 Independent Variables

Students' gender, Genetics Achievement Pretest scores (GAPRET), students' Learning Approach Questionnaire scores (LAQ), students' Test of Logical Thinking scores (TOLT), Mode of Instruction (MOI) (learning cycle and traditional method), Self-Efficacy scores (SES), Locus of Control scores (LOC), Attitudes towards Science scores (ATS) are the IVs of the study. The students' gender, LAQ, TOLT, MOI, SES, LOC, and ATS are determined as discrete variables and measured on nominal scale. Students' GAPRET is considered continuous variable and measured on interval scale.

4.4 Instruments

Seven instruments were used in this study; Genetics Achievement test, Genetic Knowledge Inventory, Learning Approach Questionnaire, Test of Logical Thinking, Locus of Control Scale, Self-Efficacy Scale, Attitude towards Science Scale.

4.4.1 Genetics Knowledge Inventory (GKI)

Before the study, students' ideas about basic concepts in genetics were investigated using Genetics Knowledge Inventory (See Appendix A). Most of the items in the GKI were selected and adapted into Turkish from Lewis and Wood-Robinson (2000). The purpose of the GKI is to obtain students' ideas about concepts in genetics and to detect their misconceptions, so that conceptual change texts could be developed. The GKI contains four questions about the major concepts in genetics. In the first question, after pointing out the concepts about genetics (cell, organism, gene, alele, chromosome, DNA and nucleus) that are familiar to them, students are asked to write them in correct order from the one that is biggest in size to the one that is smallest in size. The second question contains seven sub questions each measures whether students have any idea about the concepts that are presented in question one, then require explanations for the open ended questions about each concept. The last two questions are open-ended questions that measure the students' ideas about gametes, dominant and recessive characters.

4.4.2 Genetics Achievement Test (GAT)

The Genetic Achievement Test was developed by researcher to evaluate students' genetics achievement (Appendix B). It consists of 20 questions: 18 multiple-choice questions and 2 open ended questions. The objectives that were used while developing the tests were ability to understand the relationships between concepts of genetics, to evaluate some crosses in genetics, to explain Mendelian genetics and to recognize main rules that base the genetic crosses. Genetic Achievement Test was given as pretest to measure students' relevant prior knowledge and as posttest to measure their understanding of genetics. The reliability coefficient calculated as 0.76.

4.4.3 Learning Approach Questionnaire (LAQ)

The Learning Approach Questionnaire is a four-point Likert-type instrument (absolutely disagree, disagree, agree, absolutely agree) designed to measure students' orientations to learning ranging from meaningful to rote (Cavallo & Schafer, 1994; Cavallo, 1996). This instrument consisted of 22 items and used a four–point Likert-type scale ranging from "Always True" to "Never True" or

“Strongly Disagree” to “Strongly Agree” to overcome the tendency of respondents to select the neutral option. The test was translated and adapted to Turkish by Yenilmez (2006) (See Appendix C). For this study Croncbach alpha was found as 0.85.

4.4.4 Test of Logical Thinking (TOLT)

Test of Logical Thinking which is used to measure five modes of formal reasoning: controlling variables, proportional reasoning, probabilistic reasoning, correlational reasoning, combinatorial reasoning of the students was originally developed by Tobin and Capie (1981). The test consists of 10 items: items 1 and 2 measures controlling variables, items 3 and 4 measures proportional, items 5 and 6 measures probabilistic, items 7 and 8 measures correlational, and items 9 and 10 combinational reasoning. Students select a response from among five possibilities and then they are provided with five justifications among which they choose from. The correct answer is the correct choice plus the correct justification. Students’ performance on ten-item test was used to determine students’ formal reasoning abilities and as a means to categorize them in the stages of cognitive development based on Piagetian criteria. Test scores from 0-3, 4-7, and 8-10 were used as a basis for classifying the subjects as low level, medium level and high level of formal thought (Oliva, 2003). Test of Logical Thinking was translated and adapted into Turkish by Geban, Aşkar, and Özkan

(1992) (See Appendix D) and reliability was found as 0.81. For this study, reliability was found to be 0.73.

4.4.5 Self-Efficacy Scale (SES)

Students' self-efficacy was assessed by the Motivational Strategies for Learning Questionnaire. It is a self-report questionnaire, which was originally developed by Pintrich and Garcia (1991). It consists of two sections, a motivational orientations and use of various learning strategies. The motivation subscales tap into three broad areas: Value components, Expectancy components, and Affect component. In this study, only items belonging to self-efficacy were used to measure students' self-efficacy. These items were translated and adapted into Turkish by Özkan (2003). The self-efficacy subscale consisted of nine items regarding perceived competence and confidence in performance of class work. Students scoring high on this subscale were sure they could learn and understand the material being taught in the class and perform well in the class. For this study, the reliability coefficient for SE was found to be 0.86. (See Appendix E)

4.4.6 Locus of Control Scale (LOC)

Students' locus of control was assessed by Locus of Control Scale (See Appendix F). This scale aims to give an idea about students' level of internal control which is the level they believe their actions determine the events outside them. The LOC scale in the present study consisted of 9 pairs of statements. Respondents were asked to select one statement from each pair which best reflected their opinion. The items in the scale were selected from the Locus of Control Scale developed originally by Rotter (1966). The original scale had 29 forced choice items, which deal with ways in which an individual views his/her capacity to control his own reinforcement. Later Kağıtçıbaşı (1972) adapted and translated a short version of this scale into Turkish. The reliability coefficient of the 9-item LOC scale was found to be 0.87 for this study.

4.4.7 The Attitude towards Science Scale (ATS)

It is a 15-item, 5 point Likert type scale developed by the (Geban, Ertepınar, Yılmaz, Altın and Şahbaz, 1994) to determine students' attitudes toward science as a school subject. The choices of each item was strongly agree, agree undecided, disagree, and strongly disagree. The reliability coefficient computed by Cronbach alpha estimates of internal consistency of this scale was found to be 0.91. For this study, the reliability coefficient for ATS was found to be 0.89 (See Appendix G)

4.5 Validity of Measuring Tools

One associated professor and two assistant professors from the faculty of Education at METU, one high school biology teacher and two science teachers controlled the Genetics Knowledge Inventory and Geneteics Achievement Test according to format and content of the instruments to provide content and face validity. The appropriateness of the instruments for the grade level was also evaluated by science teacher. Also, the Genetics Knowledge Inventory and Genetics achievement test was pilot tested and necessary amendments were made.

4.6 Treatment

Students in the experimental group were instructed by learning cycle. In this study, three learning cycle lessons were designed to promote conceptual understanding concerning genetics concepts. At the beginning, the objectives of the course were determined by the researcher and lesson plans were developed accordingly. Since, hands on experiences and appropriate classroom discussions are important part of learning cycle, different activities were developed for each distinct phases of the learning cycle. Activities were prepared to present the student with a problem or task. Then, to be able to introduce the main concepts of the lesson in the term introduction phases of learning cycles, conceptual change text (CCT) was used (See Appendix H). The conceptual change text, used in learning cycle, included two parts: major concepts in genetics and Mendelian genetics. The first part covered the explanations of concepts included in genetics: chromosomes, nucleus, allele, gene, homozygote, heterozygote, phenotype, genotype, dominant and recessive alleles and homologous chromosomes and the relationship between these concepts. Second part of the conceptual change text, included Mendels' contributions to genetics, Mendels' laws, and simple genetic crosses. At the last phase of learning cycle, by additional activities students studied the additional examples of the concept.

Three learning cycle lesson plans were developed each containing two separate activities. First lesson plan was developed about the relationship between gene, allele, chromosome, DNA, organism and nucleus. In that learning cycle, students observed the picture of a family. Then working in groups they reported their observations about some characteristics such as eye color, hairstyle, skin color etc. Teacher directed the discussion of students results in which patterns are discovered. Teacher asked students to list questions that are raised by these observations and get students to participate in hypothesis generations. In the introduction phase of learning cycle, conceptual change text about concepts in genetics was given to students. Students became familiarized with terms, interpreted their hypothesis. In the concept application phase of learning cycle, students were given the pictures that symbolize the terms introduced in the first phase of learning cycle. They arranged these terms so that they deepen their understanding of newly constructed concepts.

The second learning cycle lesson plan was developed about concepts in genetics; dominant and recessive allele, homologous chromosome, homozygote, heterozygote, phenotype and genotype. The activities in the learning cycle lesson plans were adapted and translated into Turkish by the researcher from Martin, Sexton and Franklin (2002). In that learning cycle, students again worked in groups and given pipettes that symbolize the chromosomes of parents, and alleles were pointed out on the pipettes with different colors. Students were asked to identify possible offspring that can be obtained with these different colored pipettes. They generated questions, discussed and teachers asked them to report their hypothesis on the board. In the term introduction phase, students used again the same conceptual change text about terms in genetics. The terms homologous chromosome, allele, dominance, recessive, phenotype, genotype, homozygous and heterozygous were described by the teacher after students read the conceptual change text. In the concept application phase, students extend their idea about these concepts by working with groups on definition of the possible phenotypes and genotypes of puppies. So that, they used the terms they learned in the term introduction phase and applied probability rules.

The third learning cycle lesson plan also included two activities about genetic crosses. In the exploration phase again students worked in groups and performed a simple experiment. In that experiment beans symbolized the alleles of mother and father. Teacher asked students to discuss their observations. Each group wrote their results on the board. Students proposed hypothesis about their results. Teachers stated that in the experiment heterozygote mother is crossed by heterozygote father. Also, teacher stated independent assortment rule of Mendelian genetics was explored in that experiment. In the term introduction phase, students used second part of conceptual change text that is about Mendelian genetics. This part of the learning cycle was teacher centered at which teachers monitored the students to read conceptual change text and the monohybrid cross and Punnett square were identified. In the concept application phase of last learning cycle, students applied the terms that they learned to a problem by discussing patterns of inheritance, deepen their understanding.

Students in the control group, on the other hand, were taught by traditional instruction. For the students in control groups, expository text about the basic terms in genetics and Mendelian Genetics was developed. During instruction, students read the expository text while instruction was teacher centered. The content and the concepts that are included in the instruction were the same as in the learning cycle instruction. Expository text is given in Appendix I.

The time that was required for the application was four weeks with three science lessons in each week. After the treatment, all groups were administered Genetics Achievement Test. One class hour also was given to experimental and control groups to complete the test.

Before the beginning of the study, the teachers were informed about the learning cycle teaching method and conceptual change texts and their application in class. Before the study, for one-month period, the researcher worked with the teachers and explained each part of the lesson plans. Teachers were trained by the researcher by conducting examples of each activity, by explaining the possible student outcomes for each part of the learning cycle. The teachers were explained that while conducting the study the procedures should be standardized for experimental and control groups that means all the conditions except the type of instruction in learning cycle and traditional classrooms were same. The tests were administered to all groups under same conditions; teachers' attitudes were same for all classess.

It is important to define whether the method of teaching; learning cycle was used as defined in the experimental groups and whether the treatments were different from one another for the verification of the treatment. Therefore, lesson plans firstly were prepared according to criteria required for learning cycle instruction and a schedule that explains each detail of the instruction with objectives was developed according to these lesson plans. To increase treatment fidelity, each teacher was trained for the appropriate application of the treatment. The schedule contained both the ones that should be done and the others that should not be done. Systematic controls of the lessons according the criteria developed by the researcher were done for controlling the independent variable. So that, at the end of the study valid interpretations of the effects were obtained, replication studies can be carried out and the research findings may be enhanced by empirical confirmation of the independent variables.

The students were informed about the purposes of the instruments; GKI, GAPRET, GAPOST, LAQ, TOLT, SES, LOC Scale, ATS Scale. Before application of the GAPRET and GAPOST, to be able to ensuring confidentiality of research data, students were explained that the results of the study will not be used as grades and the results of the LAQ, TOLT, SES, LOC Scale, ATS Scale will not be given to anyone else, they will be used only by the researcher. Also, the data obtained in the study was used only by the researcher. In the study, it was provided that the treatment did not effect the regular program of the teachers and the curriculum, did not affect any of the students negatively to be able to protect participants from harm.

To be able to evaluate whether the learning cycles and conceptual change texts were implied as intended, a checklist was developed by researcher and was given to teachers. So that, the researcher can ensure that the treatment was different for experimental and control groups as predetermined by providing treatment verification.

4.7 Procedure

At the start of the study, a detailed literature review was conducted. The keywords; 'Conceptual change approach and science education', 'conceptual change texts and science education', 'learning cycle and science education', 'misconceptions and genetics', 'learning cycle and genetics', 'reasoning ability and students' achievement', 'learning approach and education', 'learning approach and science achievement', 'self-efficacy and students' achievement', 'self-efficacy and science education', 'locus of control and students' achievement', 'locus of control and science achievement', 'students' attitudes and science achievement' were determined.

After defining the keyword list, International Dissertation Abstracts, Educational Resources Information Center (ERIC), Social Science Citation Index (SSCI), Science Direct and Internet (google) were searched. The documents were obtained from TUBİTAK Ulakbim, Bilkent library. The obtained studies were read and critically analyzed. Results of the various studies were compared and contrasted. Then, four books were read carefully to be able to develop LC and

CCT. The books were; The Study of Life (Schraer & Stoltze, 1995), Biology: The Unity and Diversity of Life (Starr & Taggart, 1996), Concepts of Genetics (Klug & Cummings, 1994).

The characteristics of the subjects in the study may account for observed relationships. In this study, not the individuals but the groups were randomly selected; therefore many subject characteristics (previous knowledge, age, attitude and gender) might affect results of the study. To be able to overcome with this threat, students' gender and attitudes were included in the study. Therefore, an attitude scale was given to students in both control and experimental group prior to the study. Moreover, instrumentation, that is instruments and procedures used in collecting data; and location, that is the possibility that results are due to characteristics of the setting or location in which the study is conducted, cannot be a threat to the study since the tests will be administered to all groups in similar conditions and the teachers were trained similarly. Also, implementation can be another possible threat to internal validity since there are different teachers who may have different ability and attitude toward the method. To able to cope with this threat each method was used with several teachers in that each teacher had both experimental and control group and treatment. Mortality, that may be caused by lose of subjects that are different from those who remain, can be a threat to internal validity but making a missing data analysis prevented it. Subject attitudes also can be possible threat to internal validity. To be able to eliminate that threat, subjects in both experimental and control groups had texts about genetics and the activities that were used during learning cycle also were done with control groups just after the completion of the traditional instruction. Testing threat also can be another threat to internal validity. To be able to overcome testing threat the necessary time interval was given between pre and posttest.

This study is an experimental study. The experimental and control groups were assumed as similar because of random assignment of classes into two groups.

Before the treatment, instruments (LAQ, TOLT, SES, LOC scale and ATS) were given to the teachers participating in the study to conduct the instruments to the subjects. Teachers in the study gave one class hour to students to complete the TOLT and appropriate time also given to complete LAQ, SES, LOC Scale and ATS Scale. Teachers were explained that the tests; LAQ, TOLT, SES, LOC Scale, ATS Scale should be given to each class at about same time and between the applications of each test there should be time interval. One class hour also was given to experimental and control groups to complete the GAPRET. The students were told that the results of the test do not affect their grades.

After completion of GKI, GAPRET, LAQ, TOLT, SES, LOC Scale and ATS Scale by the students, the teachers and the researcher collected the instruments from the students. To be able to prevent missing of any data, each instrument was held separately for each class.

4.8 Assumptions

1. The teachers who applied this study was not biased during the treatment
2. Tests were administered under standard conditions.
3. Students answered Genetics Achievement Pre-test (GAPRET), Genetics Achievement Post-test (GAPOST), Learning Approach Questionnaire (LAQ), Test of Logical Thinking (TOLT), Self-Efficacy Scale (SES), Locus of Control Scale (LOC) and Attitude Toward Science Scale (ATS) seriously.

4.9 Limitations

1. The research findings were limited to the concepts in genetics and Mendelian genetics.
2. The subjects of this study were limited to 213 eight grade students.
3. The study was limited to public schools.

CHAPTER 5

RESULTS

In this chapter, the results of the analyses which were conducted to describe data and to answer research questions were presented.

5.1 Descriptive Statistics

In this part, Main Problem 1 and related sub-problems (1-6) are answered.

Main Problem 1.

What are the relevant prior knowledge, learning approaches, reasoning abilities, attitudes toward science, self-efficacy and locus of control of 8^{th} grade students in two public schools in Ankara?

The mean, median, mode, standard deviation, skewness, kurtosis and the histograms were presented for both control and experimental groups with respect to gender. Skewness and kurtosis values were used to check normality assumption. The skewness and kurtosis values of all variables lies within the range ±1, that is excellent. However the kurtosis value for self-efficacy is between ±2 that is also acceptable.

Table 5.1 Descriptive Statistics for the Variables of the Study

Instrument	Possible range	Actual range	Mean	SD	Skewness	Kurtosis
GAPRET						
Girls		0-14	5.78	2.79		
Boys		0-12	4.85	2.46		
Total	0-20	0-20	5.38	2.69	.49	.11
GAPOST						
Girls		3-18	11.51	4.12		
Boys		3-20	11.41	3.83		
Total	0-20	3-20	11.47	3.99	-.14	-.93
LAQ						
Girls		34-84	62.79	8.80		
Boys		42-79	61.55	8.47		
Total	22-88	34-84	62.09	8.61	-.25	.12
LAQ-M						
Girls		11-44	31.78	6.56		
Boys		11-43	30.74	6.81		
Total	11-44	11-44	31.19	6.70	-.68	.46
LAQ-R						
Girls		13-36	25.04	4.31		
Boys		11-35	25.13	4.60		
Total	11-44	11-36	25.09	4.47	-.32	.43

Table 5.1 Continued

TOLT						
Girls		0-10	5.49	2.74		
Boys		1-10	6.15	2.51		
Total	0-10	0-10	5.86	2.62	.33	.17
SES						
Girls		20-45	33.88	5.31		
Boys		9-45	33.19	6.21		
Total	9-45	9-45	33.49	5.83	-.55	1.36
LOC						
Girls		0-1	0.62	0.23		
Boys		0-1	0.61	0.20		
Total	0-1	0-1	0.61	0.21	-.17	-.13
ATS						
Girls		30-75	56.29	10.87		
Boys		22-75	56.75	10.26		
Total	15-75	15-75	56.55	10.50	-.74	.42

The data presented in Table 5.1 are interpreted under each sub-problem.

Sub-problem 1 *What is the relevant prior knowledge of 8th grade* students *about genetics?*

The Genetics Achievement Test (GAT) is used as pretest (GAPRET) to measure students' relevant prior knowledge prior to the treatment. Of a possible 20 correct answers, a relatively low mean score of M=5.38 indicating low level of relevant prior knowledge is obtained. The right-skewed diagram also shows that most of the students have low scores on GAPRET (Figure 5.1.).

Regarding gender difference, Table 5.1 suggests that girls (M=5.78) have higher scores than boys (M=4.85) in pretest.

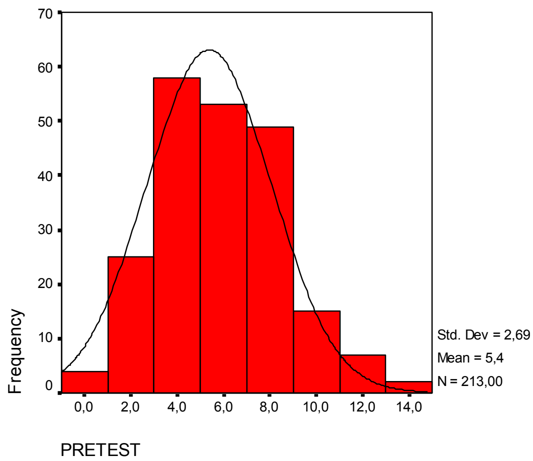

Figure 5.1 Range of pretest scores

The same instrument is used as a posttest (GAPOST) to determine students' level of understanding about genetics at the end of the topic. The slightly above half score (M=11.47) is obtained. The left-skewed diagram shows that most of the students have higher scores on GAPOST (Figure 5.2.).

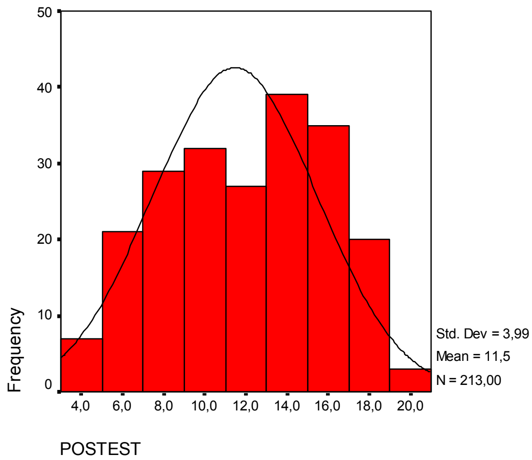

Figure 5.2 Range of posttest scores

Regarding gender difference, Table 5.1 suggests that boys (M=11.41) have slightly lower scores than girls (M=11.51) in GAPOST.

Sub-problem 2 *What are the 8th grade students' learning approaches?*

The Learning Approach Questionnaire (LAQ) is used to measure students' approaches to learning as meaningful or rote. The mean, median, mode, standard deviation, skewness and kurtosis values are summarized in Table 5.1. The skewness and kurtosis values all lie between ±1.0 that is considered excellent for most psychometric purposes. The possible ranges of both LAQ-M and LAQ-R scales are 11-44. The actual ranges were 11-44 for LAQ-M and 11-36 for LAQ-R. While students' LAQ-M scores vary between low to high meaningful approaches to learning, LAQ-R scores vary between low to moderate rote approaches to learning. The mean of meaningful learning scores (M=31.19) is higher than rote learning (M=25.09) that means that students generally use meaningful learning approaches than rote learning approaches.

The mean score of the total learning approaches of students is 62.1. The left-skewed diagram also shows that most of the students have higher scores on LAQ (Figure 5.3.).

Regarding gender difference, Table 5.1 suggests that total learning approaches of girls (M=62.79) higher than that of boys (M=61.55).

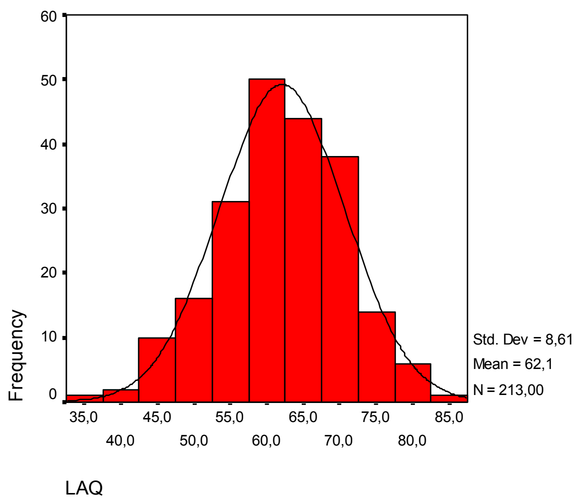

Figure 5.3 Range of LAQ scores

Sub-problem 3 *What are the reasoning abilities of 8th grade students?*

The Test of Logical Thinking (TOLT) was used to determine formal reasoning abilities of students. The distribution of the students' scores is shown in Table 5.2. It suggests a non-normal distribution of scores with a mean of 5.86. The left-skewed diagram also shows that most of the students have higher scores on TOLT (Figure 5.4).

Five reasoning modes that are controlling variables, proportional, probabilistic, correlational and combinatorial reasoning of the students are measured by TOLT. The frequencies of students who give the correct answers to the items on the test according to the reasoning modes are summarized in Table 5.3. As shown, students performed best on 3 & 4th items (71.4%) which measure controlling variables. Students were also good at proportional (58.7%), combinatorial (56.35%) and probabilistic reasoning (54%). They did least on correlational reasoning (51.9%).

Table 5.2 Number and frequencies of students according to the scores on TOLT.

TOLT Score	N	Frequency (%)
0	3	1.4
1	9	4.2
2	16	7.5
3	22	10.3
4	19	8.9
5	20	9.4
6	21	9.9
7	34	16
8	29	13.6
9	30	14.1
10	10	4.7

Table 5.3 Frequencies and percentages of students with respect to five reasoning modes

Item	Reasoning mode		N	Frequency (%)
1 2	Proportional Proportional		142 108	66.7 50.7
		Total	250	58.7
3 4	Controlling variables Controlling variables		165 139	77.5 65.3
		Total	304	71.4
5 6	Probabilistic Probabilistic		116 114	54.5 53.5
		Total	230	54
7 8	Correlational Correlational		103 118	48.4 55.4
		Total	221	51.9
9 10	Combinatorial Combinatorial		134 106	62.9 49.8
		Total	240	56.35

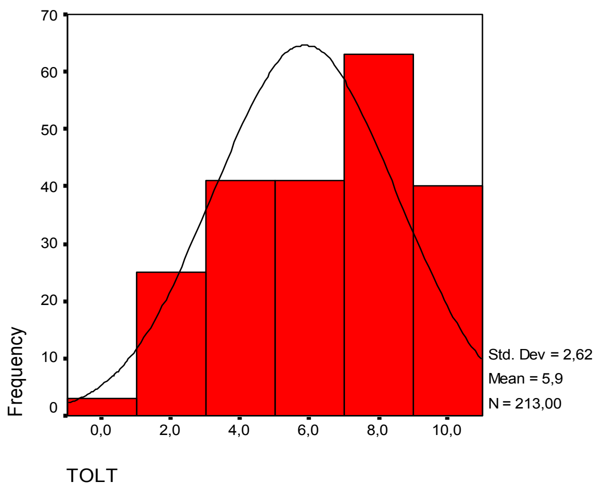

Figure 5.4 Range of TOLT scores

TOLT is also used to classify the subjects as low level (scores from 0-3), medium level (scores from 4-6), and high level (scores from 7-10) of formal thought. In the present study, 51 (24%) of the students were in low level of formal thought, 60 (28%) of the students were in medium level of formal thought, and 102 (48%) of the students were in high level of formal thought (Table 5.4).

Table 5.4 Distribution of students with respect to level of formal thought

	Formal Reasoning Level (N)			
	Low	Medium	High	Total
Boys	25	37	62	124
Girls	26	23	40	89
Total	51	60	102	213

As far as gender difference is considered majority of girls and boys in the sample were at high level of formal thought. The number of boys at high formal reasoning level and at medium formal reasoning level is higher than that of girls. When the total score is considered, majority of the students are at high formal thought.

Sub-problem 4 *What is the self-efficacy of 8th grade students?*

Self-Efficacy Scale is used to measure students' judgements about their capabilities to organize and execute courses of action required to arrive selected types of performances (Bandura, 1986). The possible range of SES is 9-45 and the actual range is 9-45. The distribution of the students' scores suggests a non-normal distribution of scores with a mean of 33.49. The left- skewed diagram also shows that moderate number of the students have higher scores on self-efficacy scale (Figure 5.5). This means that there is moderate number of students with high sense of efficacy to perform given actions.

Regarding gender difference, Table 5.1 suggest that girls (M=33.19) and boys (M=33.88) have about same levels of self-efficacy.

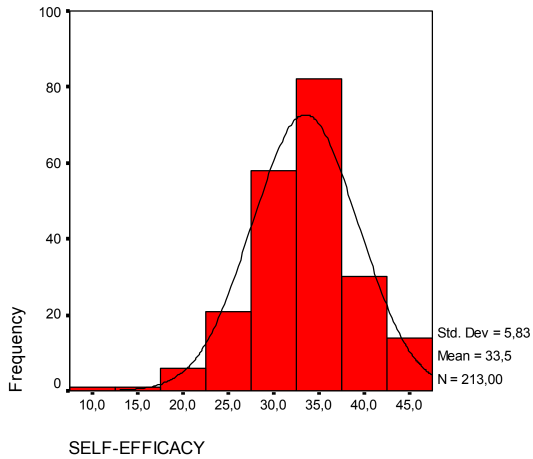

Figure 5.5 Range of SES scores

Sub-problem 5 *What is the locus of control of 8th grade students?*

Locus of Control Scale is used to measure the perceptions of students about their successes and failures. The possible range of LOC scale is 0-1 that is same with the actual range. The distribution of the students' scores suggests a non-normal distribution of scores with a mean of 0.61. The left- skewed diagram also shows that moderate number of students have slightly higher scores on locus of control scale (Figure 5.6). This means they are more likely to believe that they are in control of events.

Regarding gender difference, Table 5.1 suggests that girls (M=0.62) and boys (M=0.61) have about same locus of control orientations.

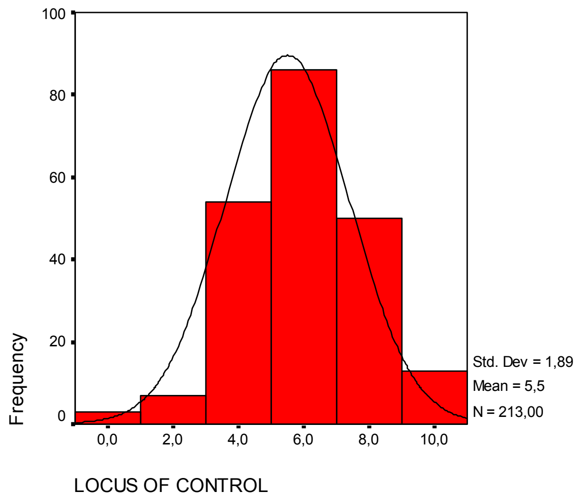

Figure 5.6 Range of LOC scores

Sub-problem 6 *What are the attitudes of 8th grade students toward science?*

The possible range of ATS scale is 15-75 and the actual range is 22-75. The distribution of the students' scores suggests a non-normal distribution of scores with a mean of 56.55. The left-skewed diagram also shows that moderate number of the students has higher scores on attitude scale (Figure 5.7). This means that these students have positive attitudes toward science related activities while preffering actively enrolled in these activities.

Regarding gender difference, Table 5.1 suggests that girls' attitudes toward science scores (M=56.75) are close to the boys' scores (M=56.29).

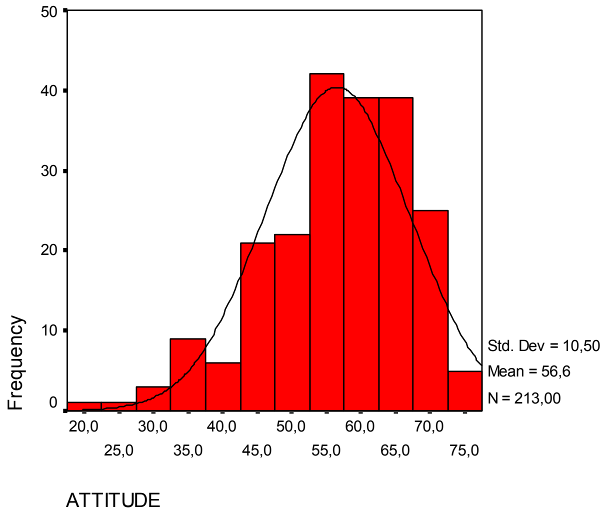

Figure 5.7 Range of ATS scores

Main Problem 2.

What is the effect of learning cycle instruction on 8th grade students' understanding of genetics?

To answer the hypothesis of main problem 2 stating that there is no significant effect of learning cycle instruction on students' understanding of genetics one-way ANOVA was conducted. The result indicated that there is a significant mean difference between experimental and control group in favor of the experimental group *(F (1, 211) = 56.182, p=.000).*

5.2 The Relationships among Variables of the Study

The main problem 2 that investigates the relationships among variables of the study is analyzed in this part. The analyses are conducted for the experimental group and the control group separately in terms of the variables.

Main Problem 3.

What is the relationship among 8th grade students' prior knowledge, learning approach, reasoning ability, self-efficacy, locus of control and attitudes toward science and achievement in genetics in learning cycle and traditional classrooms in two public schools in Ankara?

Pearson correlation analysis was conducted for each group to detect the relationships that might exist among students' prior knowledge, learning approach, formal reasoning ability, self-efficacy, locus of control, attitudes toward science and genetics achievement in two different types of instruction (Table 5.5).

Table 5.5 Correlation coefficients among variables of the study for each group

Group		GAPRET	GAPOST	LAQ	TOLT	SE	LOC	ATS
Learning cycle classrooms	GAPRET	-	.319**	.342**	.291**	.217*	.269**	.336**
	GAPOST	-	-	.708**	.538**	.214*	.153	.694**
	LAQ	-	-	-	.462**	.292*	.248*	.581**
	TOLT	-	-	-	-	.253**	.250*	.577**
	SES	-	-	-	-	-	.282**	.214*
	LOC	-	-	-	-	-	-	.299**
Traditional classrooms	GAPRET	-	-.049	.112	.092	-.051	.073	.181
	GAPOST	-	-	.075	.637**	.253**	.506**	.667**
	LAQ	-	-	-	.209*	.441**	.247**	.277**
	TOLT	-	-	-	-	.211**	.445**	.559**
	SES	-	-	-	-	-	.278**	.295**
	LOC	-	-	-	-	-	-	.482**

*Correlation is significant at the 0.05 level
** Correlation is significant at the 0.01 level

For the learning cycle classroom, students' post-test scores were significantly and positively correlated with their pre-test scores (r=.32, p=.001), meaningful learning orientation (r=.71, p=000), formal reasoning ability (r=.54, p=.000), self-efficacy (r=.21, p=.030) and attitudes toward science scores (r=.69, p=.000). Students' pre-test scores also significantly correlated with their meaningful learning orientation (r=.34, p=.000), formal reasoning ability (r=.29, p=.003), attitudes toward science (r=.34, p=.000), self-efficacy (r=.22, p=.006) and locus of control (r=.27, p=.027). Students' meaningful learning orientation was also significantly correlated with their formal reasoning ability (r=.46, p=.000), self-efficacy (r=.29, p=.000), locus of control (r=.25, p=.011) and attitudes toward science (r=.58, p=.000). Moreover, students' formal reasoning abilities were significantly correlated with their attitudes toward science (r=.58, p=.000), self-efficacy (r=.25, p=.010) and locus of control (r=.25, p=.010). Students' attitudes toward science also were significantly correlated with their self-efficacy (r=.21, p=.029) and locus of control scores (r=.30, p=.002). Besides, students' self-efficacy was found to be related with their locus of control scores (r=.28, p=.004). However, no statistically significant correlation between post-test scores and locus of control was determined (p>.05). This was the only nonsignificant correlation between the variables in learning cycle classrooms.

For the traditional classroom, students' post-test scores were found to be significantly correlated with their formal reasoning ability (r=.64, p=.000), self-efficacy (r=.25, p=.008), locus of control (r=.51, p=.000) and attitudes toward science (r=.67, p=.000). Students' meaningful learning orientation was significantly correlated with their formal reasoning ability (r=.21, p=.029), self-efficacy (r=.44, p=000), locus of control (r=.25, p=.010) and attitudes toward science (r=.28, p=.004). Students' pre-test scores also significantly correlated with their attitude toward science (r=.18, p=.059). Moreover, students' formal reasoning ability was also significantly correlated with their attitudes toward science (r=.56, p=.000), self-efficacy (r=.21, p=.027), locus of control (r=.45, p=.000). Students' attitudes toward science also were significantly correlated with their self-efficacy (r=.30, p=.002) and locus of control (r=.48, p=.000). Students' self-efficacy also was found to be related with their locus of control (r=.28, p=.003). However, no statistically significant correlation between post-test scores and pre-test scores and meaningful learning approaches; pre-test scores and formal reasoning ability, locus of control, meaningful learning approaches and self-efficacy were determined (p>.05).

These results suggest that in learning cycle classrooms, students' understanding of genetics was related with their relevant prior knowledge, meaningful learning orientation, formal reasoning ability, self-efficacy and attitudes toward science. This means that students having higher prior knowledge scores, more meaningful learning orientations, high formal reasoning abilities, high self-efficacy and have more positive attitudes toward science had better understanding of genetics in learning cycle classrooms. In traditional classrooms, same as learning cycle classrooms, students' understanding of genetics was related with their formal reasoning abilities, self-efficacy and attitudes toward science. Students' post-test scores also significantly correlated with their locus of control. This means that, in traditional classrooms, students having higher formal reasoning abilities, self-efficacy beliefs, and locus of control orientations and having more positive attitudes toward science had better understanding of genetics. However, meaningful learning orientation and relevant prior knowledge had no significant effect on students' understanding of the genetics in traditional classrooms. Therefore, higher meaningful learning orientation and higher level of relevant prior knowledge do not result in higher scores achievement in traditional classrooms.

Main Problem 4.

What are the contributions of 8^{th} grade school students' relevant prior knowledge, learning approach, reasoning ability, self-efficacy, locus of control, attitudes toward science and gender on students' achievement in genetics in learning cycle and traditional classrooms?

Multiple Regression Analysis (MRC) was conducted to determine the contributions of these variables and gender on students' understanding for the learning cycle and traditional classrooms (Table 5.6). Post-test scores were the dependent variable while the pre-test scores, meaningful learning orientation, formal reasoning ability, self-efficacy, locus of control, attitude toward science and gender served as independent variables.

Before conducting the multiple regression analyses, the assumptions were checked:

1. Sample Size: According to formula given by Tabachnik and Fidell (1996) the required sample size calculated as N=98 which is smaller than the one that was used in the present study (N=213).

2. Multicollinearity: Multicollinearity exists when the independent variables are highly correlated (r=.9 and above) (Stevens, 1996). In the present study, the correlations between the independent variables are less than that value as given on Table 5.5.

3. Outliers, Normality, Linearity, Homoscedasticity and Independence of Residuals: To check these assumptions residual scatterplots and the Normal Probability Plot of the regression standardized residuals were obtained.

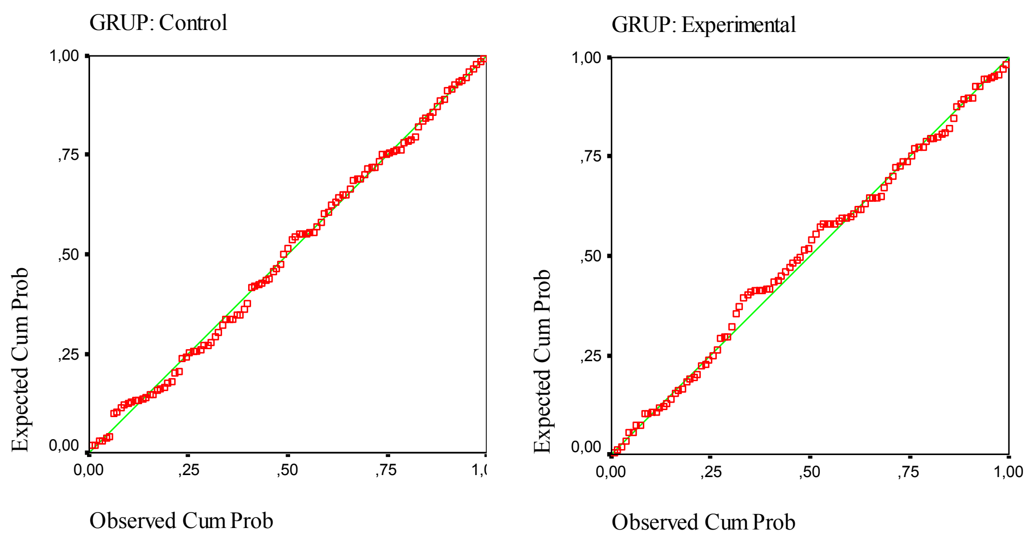

Figure 5.8 Normal probability plot for control group and experimental group

In the Normal Probability Plot all points lie in a straight diagonal line means that there are no major deviations from normality for control group and experimental group.

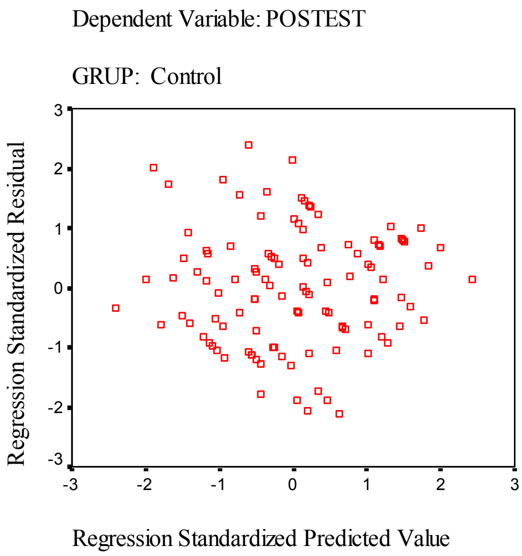

Figure 5.9 Scatterplot of the standardized residuals for the control group

As shown in Figure 5.9, most of the scores concentrated in the centre for the control group.

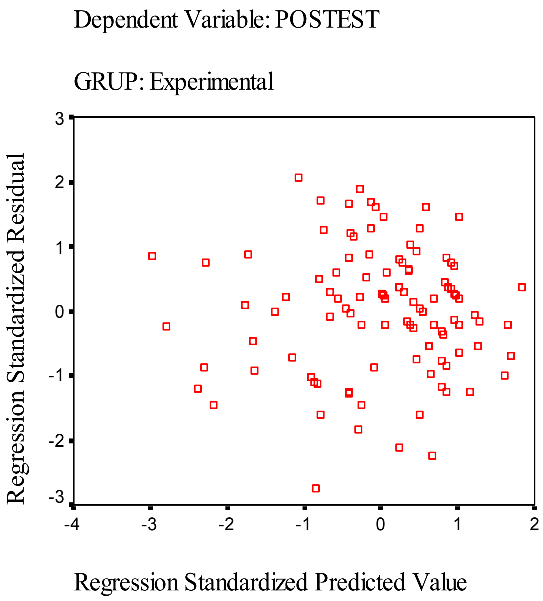

Figure 5.10 Scatterplot of the standardized residuals for the experimental group

As shown in Figure 5.10 there is no systematic patterns to the residuals indicating that there are no outliers violating the assumptions.

Table 5.6. Independent contributions of Gender, GAPRET, LAQ, TOLT, SES, LOC and ATS to understanding of genetics.

	Mode of Instruction							
Variables	Traditional Instruction				Learning Cycle Instruction			
	B	β	t	p	B	β	t	p
GENDER	.323	.051	.803	.424	.065	.008	.130	.897
GAPRET	-.203	-.141	-2.205	.030*	.042	.033	.479	.633
LAQ	-.068	-.183	-2.602	.011*	.199	.441	5.551	.000*
TOLT	.441	.355	4.617	.000*	.197	.133	1.705	.091
SES	.035	.068	-.949	.345	-.005	-.007	-.106	.916
LOC	.267	.170	2.314	.023*	-.247	-.112	-1.674	.097
ATS	.127	.441	5.474	.000*	.150	.385	4.568	.000*

*Significant at the 0.05 level

For the learning cycle classrooms, the multiple correlation *(R)* was .80 with R^2=.64. This result means that the model significantly accounted for the 64% variation in students' understanding in learning cycle classrooms *(F=24.628,* *p=.000).* Students' meaningful learning orientation and attitudes toward science significantly contributed to their understanding of genetics.

For the traditional classrooms, the multiple correlation *(R)* was .787 with R^2=.62. This means that the model significantly accounted for the 62% variation in students' understanding in traditional classrooms *(F=23.521, p=.000).* Students' meaningful learning orientation, reasoning ability, locus of control and their attitudes toward science significantly contributed to their understanding of genetics. On the other hand, students' relevant prior knowledge and meaningful learning orientation, significantly contributed to their understanding of genetics in negative direction.

In short, students' attitudes toward science and meaningful learning orientations significantly contributed to the understanding of genetics in learning cycle classrooms. However, attitudes toward science, formal reasoning ability and locus of control significantly contributed to students' understanding of genetics in traditional classrooms while relevant prior knowledge and meaningful learning orientation contributed negatively.

Main Problem 5.

Which variable best-predicted students' achievement in traditional and learning cycle classrooms?

To be able to determine which variable best predicted students' understanding in traditional and learning cycle classrooms stepwise multiple regression analysis was performed (Table 5.7).

Table 5.7 Stepwise multiple regression results for the traditional and learning cycle classrooms

		β	Adjusted R^2	F	p
GAPOST					
Traditional classrooms	ATS	.456	.595	23.521	.000
	TOLT	.348			
	GAPRET	-.159			
	LOC	.181			
	LAQ	-.151			
Learning cycle classrooms	LAQ	.426	.614	24.628	.000
	ATS	.460			

For the learning cycle classrooms, results revealed that, students meaningful learning orientation was the main predictor of performance on post-test scores, explaining 49.6% variance, while students' attitudes toward science explaining remaining 11.8% variance on the post-test scores. For the traditional classrooms, however, attitudes of the students toward science was the main predictor of performance on the post-test scores, explaining 44% of the variance, while formal reasoning ability accounted for 9.8%. Remaining 5.7% of the variance explained by pre-test scores, locus of control, and meaningful learning orientations on the post-test scores in traditional classrooms.

The results of the stepwise multiple regression analysis suggest that while students' attitudes toward science was the main predictor of performance on post-test in traditional classrooms, students' meaningful learning orientation was the main predictor of performance in learning cycle classrooms.

Main Problem 6.

Which variable best-predicted female and male students' achievement in traditional and learning cycle classrooms?

To be able to determine which variable best predicted students' understanding in traditional and learning cycle classrooms in relation to gender stepwise multiple regression analysis was performed (Table 5.8).

Table 5.8 Stepwise multiple regression results for the traditional and learning cycle classrooms with respect to gender

		β	Adjusted R^2	F	p
GAPOST					
Traditional classrooms					
Boys	ATS	.511	.502	51.885	.000
	TOLT	.279			
Girls	TOLT	.538	.648	45.164	.000
	ATS	.485			
	GAPRET	-.281			
Learning cycle classrooms					
Boys	ATS	.446	.609	55.229	.000
	LAQ	.450			
	LOC	-.184			
Girls	LAQ	.406	.649	50.216	.000
	ATS	.520			

In traditional classrooms, results of the stepwise multiple regression analysis revealed that for boys, attitudes toward science was the main predictor of performance on the post-test scores, explaining 46.3% of the variance, while formal reasoning ability accounted for 3.9% on the post-test scores. On the other hand, for girls, formal reasoning ability accounted for 47.9% while attitudes toward science explained 11.3% variance on the post-test scores. The pre-test scores predicted 5.6% of the variance on post-test scores, in negative direction.

For the learning cycle classrooms, attitude toward science was the main predictor of performance of boys on pos-test scores explaining 47.5%, while meaningful learning orientation explaining 10.7% variance on the post-test scores. Remaining 2.7% of the variance was explained by locus of control in post-test scores, in negative direction. For girls, post-test scores were explained by meaningful learning orientation, 54% of the variance, while attitudes toward science explained 10.9% of the variance in post-test scores.

The results of the stepwise multiple regression analysis showed that, for boys, attitudes toward science best predicted achievement on post-test in both learning cycle and traditional classrooms. For girls, meaningful learning orientation positively and significantly predicted achievement on post-test in learning cycle classrooms, while reasoning ability was significantly predicted post-test scores in traditional classrooms.

5.3 Power Analysis

For the analyses the probability of rejecting true null hypothesis (probability of making Type I-error) was set to .05 and significance level was set to .05, because of being widely used in educational research (Cohen, 1977). Power of this study was set to .80. Therefore, the probability of failing to reject the false null hypothesis (probability of making Type II-error) was found as .20 (i.e., 1- .80). Moreover, effect size was considered as medium effect size. After that, sample size was calculated as 158 for medium effect size (f^2 = 0.09) by taking the number of variables used in the study into consideration. The study was conducted on 213 eight-grade elementary school students and six variables were used. That means the statistical power of the study is larger when the sample size of the study is considered.

5.4 Conclusions

In conclusion, the main predictor of achievement in learning cycle classrooms was students' meaningful learning orientation. This means that, students' meaningful learning approach was the most important determinant of students' understanding of genetics. Students' relevant prior knowledge, formal reasoning ability, self-efficacy and locus of control, on the other hand, failed to account for variance of the post-test scores, while attitudes toward science explained the small amount of variance (11.8%) in learning cycle classrooms. So, for students in learning cycle classrooms, their approaches to learning are more important to determine achievement than their attitudes toward science.

In the traditional classrooms, however, attitude toward science was the main predictor (44%) of genetics achievement. The formal reasoning ability of students accounted for less amount of variance (9.8%) on post-test scores. Students' relevant prior knowledge and meaningful learning orientations negatively predicted their achievement in genetics indicating that students with higher relevant prior knowledge and learning approach did not necessarily have greater achievement in genetics.

Concerning gender, in learning cycle classrooms, for boys, attitudes toward science explained more amount of variance (47.5%) than meaningful learning orientation on post-test scores. Small portion of the variance (2.7%) was explained by their locus of control. However; for girls, meaningful learning orientation was the main predictor (54%) of achievement in genetics. For girls, contribution of attitude toward science on genetics achievement was less than that of boys. In traditional classrooms, attitudes of boys toward science, consistent with the results in learning cycle classrooms, explained more amount of variance (46.3%) than formal reasoning ability. On the other hand, formal reasoning ability was the main predictor of girls' achievement in genetics. Their attitudes toward science were the second variable that contributed to their achievement in genetics.

The study also indicated that, the students in the learning cycle classrooms significantly did better than the students in the traditional classrooms on the post-test. Students' active enrollment in class discussions and hands on activities, emphasizing important genetic concepts and application of new knowledge to related subjects resulted in higher achievement in learning cycle classrooms.

CHAPTER 6

DISCUSSION

This chapter presents discussion and interpretation of the results stated in the previous chapter and the implications and recommendations for further research.

6.1. Discussion

The study was conducted to identify relative predictive influences of 8th grade students' relevant prior knowledge, learning approach, reasoning ability, self-efficacy, locus of control, attitudes toward science and gender on their genetics achievement in learning cycle and traditional classrooms.

In traditional classrooms, the results of the present study indicated that, although the main predictor of achievement in genetics was students' attitudes toward science; reasoning ability and locus of control also predicted their achievement. However, it is necessary to note that the relevant prior knowledge and meaningful learning orientation significantly predicted genetics achievement in negative direction.

When examined each variable, in traditional classrooms, the findings of the present study revealed that students' attitude toward science was the main predictor of performance on post-test, explaining 44% of the variance. This means that, when students' attitude toward science increases, their achievement in genetics also increases. Participants of this study had relatively high attitude toward science (M=56.55). This result is not surprising considering the fact that in many studies students' attitude toward science was found to be highly related with their achievement (Kelly, 1978; Schibeci & Riley, 1986; Johnson, 1993). Studies showed that as attitude toward science increases, students' enrollment in science activities also increases, because attitudes is believed to be related to students' motivation, and interest (Glick, 1970; Harty, Beall & Scharmann, 1985). Increased motivation and interest may result in students' active participation in lessons and increased achievement in science. Genetics, although being reported as a difficult subject (Longden, 1982; Finley, Steward & Yarroch, 1982; Alabaladejo & Lucas, 1988; Slack & Steward, 1990; Pashley, 1994; Marbach-Ad & Stavy, 2000), positive attitude toward science at the beginning of the lesson, may be resulted in students to be interested in learning about the concepts in genetics; later may resulted in higher scores on their achievement. Similar results were found in many studies. For example, Cannon and Simpson (1985) revealed that seventh-grade students' attitudes correlated with science achievement scores. The data from the study revealed a higher correlation between positive attitudes toward science and higher achievement scores for females enrolled in the basic and advanced classes and for males enrolled in general science classes (Cannon & Simpson, 1985). The result of the present study is also consistent with the study of Johnson (1993). She stated that students' attitudes predict their biology achievement in learning cycle, and expository classes. In another study, Freedman (1997) investigating the relationship among attitude toward science and achievement in science knowledge, concluded that for both groups (laboratory experience and no laboratory instruction), students' attitudes toward science correlated with their achievement on science content examination ($r=.406$, $r=.249$), although the relationship stronger for the treatment group. Oliver and Simpson (1988) as a result of their longitidunal study, found a strong relationship between students' attitudes toward science and achievement in science. They stated that a student's self-concept of his ability to perform in science positively correlated with achievement. On the other hand, the results of the some studies contradict with the results of the present study. For example, Wilson (1983) conducted a meta-analysis about the correlation between science achievement and attitude toward science and found no consistent causal direction between attitude toward science and achievement. Besides, in the present study, students' attitudes toward science in traditional classrooms significantly correlated with their meaningful learning orientation ($r=.28$), formal reasoning ability ($r=.56$), self-efficay ($r=.30$) and locus of control ($r=.48$) means that these variables are related with each other. Students with high meaningful learning orientations who attain new knowledge by connecting it to previously acquired information will also have positive attitudes toward science related activities. Students who have high reasoning ability also have higher attitude toward science. Moreover, high self-efficacy beliefs and internal control expectancies results in higher attitude toward science.

In traditional classrooms, another predictor of students' achievement in genetics was students' formal reasoning ability explaining 9.8% of the variance. Students having higher reasoning ability had greater genetics understanding, while students with lower reasoning ability had lower understanding of genetics. As revealed in the present study, reasoning abilities of students are one of the factors that can contribute to students' failure to understand scientific conceptions (Lawson & Thompson, 1988). There are many studies that support this finding. For example, Cavallo (1996) in her study on students in laboratory based learning cycle based biology course, reported that reasoning ability (9%) best predicts students' achievement in solving genetics problems. In another study, Lawson and Thompson (1988) reported that reasoning ability limits achievement more than prior knowledge among biology students, whether they are enrolled in inquiry or expository classes. Also in the study of Johnson and Lawson (1998) reasoning ability explained more of the variance on students achievement scores for students in expository classes (18.8%) than students in inquiry classes (7.2%). Valanides (1997) claimed that the role of reasoning modes of students to predict achievement related to the nature of the subject matter and nature of the achievement measure. The pre- and post-test used in the present study, require students to have knowledge about abstract concepts in genetics, not to memorize facts but relate and comprehend concepts. Because high formal students have hypothetical and deductive reasoning patterns, they performed better than low formal students. As stated by Lawson and Renner (1975), when students face with concepts that require high formal reasoning, low formal reasoners have learning difficulties. In order for students to understand difficult concepts, such as genetics, they must have practice applying reasoning skills to specific biological concepts. In the present study, it was found that the majority of the students in this study are formal reasoners. The distribution of the students' scores on TOLT for both learning cycle and traditional classrooms revealed that majority of the students (48%) was at high formal level, while 24% of the students were at low formal level. The reason for the students' reasoning abilities to be the second predictor of achievement explaining the 9.8% of the variance may be explained by the high number of students having formal reasoning abilities. In addition, finding possible correlation between students' meaningful learning orientation and their reasoning abilities (r=.21) indicates that these variables are related to each other. Students who have high formal reasoning ability also have higher meaningful learning orientation scores.

Beside attitude toward science and reasoning ability, students' locus of control also contributed students' genetics achievement in traditional classrooms.

Participants of this study had relatively high scores on locus of control scale (M=0.61) indicating that students have internal control expectancies, and take personal responsibilities for what happens are better to relate the concepts in genetics. The studies examined the relation between achievement and locus of control and concluded that there is a positive relationship between an internal locus of control and academic success (Duke & Nowicki, 1974; Wishart, 1997; Anderson, 2005). These studies stated that students who take an internal responsibility for their academic performance have higher level of achievement than who take external responsibility. Apart from, a positive correlations between locus of control and reasoning ability (r=.45), meaningful learning orientation (r=.25), self-efficacy (r=.29) were found. These results indicate that these variables are related with each other.

Students' pre-test scores and meaningful learning approaches, however, predicted students' achievement in negative direction. This means that having higher prior knowledge and use of meaningful learning orientation resulted in low achievement in genetics in traditional classes. The mean of pretest scores (M=5.38) of participants indicates that they have low level of prior knowledge. These results can be explained by the teacher centered, textbook oriented nature of traditional instruction. In such classes, most of teachers do not consider the prior knowledge of the students and students are forced to memorize facts and information given by the teacher. This finding requires, however, further investigation. This study contradicts with the results of the previous research, indicating significant positive relationships between prior knowledge and achievement (Lawson, 1983; Johnson & Lawson, 1998; BouJaoude, Saouma & Giuliano, 2004). For example, Lawson (1983) showed that students' prior knowledge positively correlated ($r=.36$, $p<0.001$) with undergraduate students' achievement in evolution and natural selection. Also, in their study on university students, BouJaoude et al. (2004) revealed that prior knowledge, reasoning ability and meaning orientation accounted for 32% of the variance on the final examination scores on chemistry course. However, Mitchell and Lawson (1988) found that prior genetics knowledge does not account a significant amount of variance on reading comprehension and genetics achievement test. What is more, Johnson (1993) found no correlation between prior biological knowledge and students' course grade. The contribution of students' prior knowledge on students' achievement is found to be related with the subject being taught (Champagne, Klopfer & Anderson, 1980). Champagne, Klopfer and Anderson (1980) stated that if students' prior beliefs contradict subject matter, then their prior beliefs cause learning to be difficult for the students. It is necessary to note that, in this study, prior knowledge correlated with none of the variables except posttest.

The negative predictive influence of meaningful learning orientation, however, indicates students who use more rote learning orientations have higher achievement in genetics. Rote learners acquire new knowledge without connecting it to previously learned knowledge and that is consisted with the nature of traditional instruction. Another words, this negative correlation shows that high achievement scores in genetics were related to beliefs that genetics can be best learned by rote memorization for students taught traditionally.

Although attitude toward science was the main predictor of achievement in traditional classrooms, the main predictor of achievement in learning cycle classrooms was the students' meaningful learning orientation, explaining 49.6% of the variance. The finding of the present study indicates that students with more meaningful approaches to learning and tend to make connections between the concepts, have greater genetics understanding than rote learners. This finding is in line with inquiry nature of the learning cycle instruction. In the learning cycle, for example, students connect new terminology to their observations and formulated hypothesis in exploration phase of learning cycle. Therefore, we can say that, trying to relate new knowledge to prior one may enhance achievement. In this study, the result indicating the predictive influence of meaningful learning orientation is consistent with the study of Cavallo (1996), who revealed that meaningful learning orientation explained more of the variance (13%) in the genetics meaning as compared to reasoning ability (3%) in learning cycle classrooms. Cavallo and Schafer (1994) investigating the relationship between students' meaningful learning orientation, relevant prior knowledge, instructional treatment and all interactions of these variables on tenth grade students' meaningful understanding of meiosis and genetics indicated that meaningful learning orientation contributed to students' attainment of meaningful understanding independent of aptitude and achievement motivation. BouJaoude and Giuliano (1994) by investigating the relationships between students' approaches to studying, prior knowledge, logical thinking ability, gender and their performance in a nonmajors' college freshman chemistry course showed that prior knowledge, TOLT scores, and meaning orientation accounted for the 32 % of the variance on the final examination scores.

In learning cycle classrooms, students' attitude toward science also predicted genetics achievement, explaining 11.8% of the variance. Similar to traditional classes, students' attitudes are the important determinant of genetic achievement in learning cycle classes. Learning cycle by helping students to attain meaningful understanding of genetics concepts and develop problem solving skills provide students actively enroll in the lesson. As stated, genetics includes many abstract concepts and students face with difficulties while learning genetics as a whole (Longden, 1982; Smith & Good, 1984; Lawson & Thompson, 1988; Heim, 1991; Marbach-Ad & Stavy, 2000; Banet & Ayuso, 2000). However, when the students have positive beliefs and feelings toward school, their engagement in lessons also increases. Their enrollment provides better understanding of concepts by helping students to construct relationship between new concepts. Therefore, the level of understanding of abstract concepts such as the ones in genetics increases. The positive significant correlation between students' meaningful learning orientation and their attitudes toward science (r=.58) means that students who have higher meaningful learning orientations results in better construction of relationships between new concepts will have higher attitude scores toward science. Besides, students' reasoning ability was found to be significantly correlated with their attitudes toward science (r=.58). Results revealed that these two variables are related to each other. While students' locus of control contributes students' genetics achievement in traditional classrooms, it did not contribute in learning cycle classrooms. The failure of the locus of control to account for a significant amount of the variance on the students' posttest scores may be stem from the nature of the learning cycle instruction which promotes group working and require students to actively enroll in class activities. On the other hand, increased application period may reveal different results.

Although a positive correlation between self-efficacy and genetics achievement was found, self-efficacy failed to predict genetics achievement in both traditional and learning cycle classrooms. Participants of this study have moderate sense of self-efficacy (M=33.49). However, Cavallo, Rozman & Potter (2004) in their study on students' conceptual understanding of physics, revealed that physics achievement scores significantly correlated with female and male students' self-efficacy scores (r=.47, r=.58) respectively. Kang et al. (2005), in their study found no significant relationship between self-efficacy and students conception test scores about density. They stated that students' motivational characteristics toward the specific learning material may influence their performance. Pintrich (1999) stated that self-efficacy is relatively situation-specific, compared with other motivational variables. Therefore, some factors such as the type of instruction or subject being taught may influence the relationship between self-efficacy and achievement. In the present study, it was also observed that students' self-efficacy scores significantly correlated with their locus of control scores both in learning cycle and traditional classrooms (r=.282, r=.278) respectively. This result means that students having internal control expectancies also have high self-efficacy scores. This result is not surprising, considering the fact that, students' self-efficacy beliefs influence their choice of task, effort and achievement (Schunk, 1995; Bandura, 1997). When student engagement in lessons increases they learn more and they better perform, the higher their self-efficacy (Linnenbrink & Pintrich, 2003). Locus of control is the general belief that one's behavior can have an impact on the environment and that one is capable of controlling outcomes through one's own behavior (Martinez, 2003). Students' with internal control expectancies believe that when they enroll in lessons they can achieve, they can control outcomes so that they can achieve increasing their self-efficacy.

Regarding gender difference, result of the stepwise multiple regression analysis indicated that, in the traditional classroom, the main predictor of boys' achievement was attitude toward science explained 46.5% of the variance. On the other hand, for girls, attitude toward science explained less variance (11.3%) on achievement score. In the experimental group, again attitude toward science was the main predictor of boys' achievement explaining 47.5 of the variance, while it explained less variance (10.9%) for girls. There are studies consistent with the present study. For example, in the study of Levin, Sabar and Libman (1991) for boys, attitude variable accounted for 20% of the variance, while for girls, attitude variables accounted for only 10% of the variance on science achievement. Johnson (1993) stated that the more positive attitudes results in the higher score on exams both for boys and girls. Murphy, Ambusaidi and Beggs (2006) claimed that boys have more positive attitudes toward science problem solving, while girls liked science more when they were doing experiments. The reason for females' lower attitudes is explained by Miller, Blessing and Schwartz (2006) as females simply do not find science interesting or relevant to their life goal. The result of the present study revealed that attitude toward science is important for students' achievement especially for boys for both learning cycle and traditional classrooms. In the present study, for girls, the main predictor of achievement was reasoning ability while for boys, reasoning ability explained less variance on students' achievement. Thus, it can be stated that, reasoning ability may have helped compensate for females' relative lack of genetics knowledge in understanding and achievement. The study of Saunders and Shaperdson (1987) that compared the development levels of reasoning abilities of sixth grades and found a significant contribution of gender on achievement favoring males. This means that in their study, males' reasoning abilities explained more of the variance. In another study, Cavallo, Rozman and Potter (2004) revealed that female students with high reasoning ability had greater understanding of Newtonian physics concepts and had higher course achievement. In the present study, for girls, students' meaningful learning orientation explained most of the variance (54%), while for boys it explained less variance (10.7%) on students' achievement scores in the learning cycle classrooms. This result means that girls' approach to learning that helps them to make meaningful links among ideas and facts results in their higher achievement scores. Also, for boys, 2.7% of the variance in the learning cycle classrooms explained by locus of control. This variance is low compared to their attitude toward science and meaningful learning orientations, indicating boys' internal control expectancies who are motivated to learn and take personal responsibility for waht happens, relatively have low contribution to their achievement.

This study also interested in measuring the effects of different teaching strategies (learning cycle versus traditional instruction) on students' genetics achievement. Results revealed that learning cycle instruction produced better acquisition of genetics concepts compare to traditional instruction. This study suggested the use of learning cycle as an alternative teaching strategy for providing students' better understanding of genetics concepts. Learning cycle by helping students to attain meaningful understanding of genetics concepts and develop problem solving skills provide students actively enroll in the lesson. In the present study, conceptual change text was used to promote conceptual change in the term introduction phases of learning cycles. Findings revealed that the students who are taught in learning cycle classrooms performed significantly better on post-test. Therefore, findings indicated that as stated by Schneider and Renner (1980), inquiry teaching, so the learning cycle, is more effective than traditional instruction.

To conclude, this study reveals that different variables may be important for 8th grade students' genetics achievement in learning cycle and traditional classes. As a result of the study, we can say that ability of variables to determine genetics achievement depends on the methods of instruction.

The present findings have also some instructional implications for elementary science teachers. Students face with considerable amount of abstract concepts in genetics instruction. Such as, different teaching strategies can be used rather than traditional instruction for providing conceptual change. Learning cycle one of these strategies. In this study, learning cycle is used as an alternative teaching strategy for providing students' better understanding of genetics concepts.

Teachers should be informed about the applications of the conceptual change texts and learning cycle and also about the efficiency of conceptual change texts and learning cycle. They should develop new learning cycle lesson plans for increasing achievement not only about genetics but also about the other subjects of science. By active enrollment in the activities in learning cycle, students can integrate new information into their existing knowledge that supports their learning. This study, presents the possible predictors of achievement. Therefore, increase in the level of these variables results in increase in the level of achievement. Educators, curriculum developers, counselors and school psychologists should consider these variables to be able to increase achievement. Counselors should focus on cognitive variables that are learning approach, prior knowledge, reasoning ability of students and also on motivational variables that are locus of control, self-efficacy and the attitudes toward science because these variables can promote academic success. Increasing positive attitudes toward school and science, results in academic success. They may focus on students' approaches to learning and their reasoning abilities, then they may contact with teachers by providing the teachers to develop instruction accordingly. They may develop some activities to develop internal locus of control so that the students may manage their studying habits accordingly. They may also use some strategies to increase self-efficacy and attitudes of students. Although, in the present study, a positive correlation between self-efficacy and achievement was found, self-efficacy did not predict achievement, as stated in many studies a positive correlation was found between self-efficacy and achievement. When teachers become more aware of the reasoning abilities of students, they would be more effective while adapting their instructional materials and strategies. So that, students with different levels of reasoning abilities can benefit equally from instruction. The instructors should consider meaningful learning orientations. Considering the effect of motivational variables on students understanding while designing lessons may provide better enrollment of students in lessons. Therefore, teachers should take into account these variables to be able to increase achievement. School administrators should inform teachers about these strategies and encourage teachers to integrate these teaching strategies into instruction by in-service training. They should also inform the counselors and teachers about the effects of these cognitive and motivational variables on students' achievement. Education faculties of universities, if they were not included, should integrate learning cycle and conceptual change texts as an alternative teaching method to their teaching method courses. Universities should train preservice and inservice teachers about these strategies. They should also integrate the effect of cognitive variables like reasoning abilities and learning approach into courses. Education faculties should also focus on the motivational variables like locus of control, self-efficacy and attitudes that are the inevitable factors affecting learning.

There may be some recommendations for further research studies. For example, learning cycle can be used during whole semester for other science topics. The influence of learning cycle instruction on retention can be investigated to measure whether it promotes long-term learning. The conceptual change learning can be investigated by ontological, social/affective and epistemological perspectives. Moreover, the contribution of other cognitive and motivational variables such as achievement motivation, goal orientation, beliefs or attitudes toward school on the understanding of genetics or other topics can be investigated. Same study can be conducted on different grade levels. In addition to learning cycle model including three phases that was used in the present study, other learning cycle models, including 5 and 7 phases can be used.

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APPENDIX A

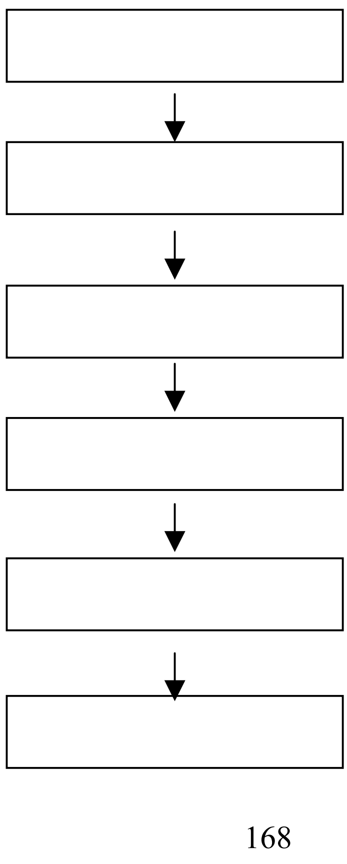
GENETİK BİLGİ ENVANTERİ

1. Aşağıda canlı vücudunda bulunan 6 tane bölüm verilmektedir.

a) Verilenlerden daha önce duyduklarınızın yanına **X** işareti koyunuz.

Hücre	
Kromozom	
Gen	
DNA	
Organizma	
Çekirdek	

b) Şimdi de bu bölümleri aşağıdaki kutularda <u>büyükten küçüğe</u> doğru sıralayınız.



2. Aşağıda hücre çekirdeği, gen, DNA, kromozom, alel, kalıtım ve gamet terimleri hakkında ne kadar bilginiz olduğunu ölçen sorular bulunmaktadır. Soruların yanlarında verilen kutucuklardan <u>sadece bir tanesini</u> işaretleyiniz.

<u>Hücre çekirdeği</u>

- Hücre çekirdeği hakkında daha önce hiçbirşey duymadım ☐
- Hücre çekirdeği kelimesini duydum ama ne olduğunu tam bilmiyorum ☐
- Hücre çekirdeği kelimesini duydum ve hakkında birşeyler söyleyebilirim ☐

Peki, şimdi de aşağıdaki soruları cevaplamaya çalışınız. Bilmiyorsanız, yanına X işareti koyunuz.

a) Hücre çekirdeği vücudunuzun hangi bölgesinde bulunur?

b) Hücre çekirdeğinin canlı için önemi nedir?

c) Hücre çekirdeğinin yapısında sizce neler vardır?

<u>Gen</u>

- Genler hakkında daha önce hiçbirşey duymadım ☐
- Gen kelimesini duydum ama ne olduğunu tam bilmiyorum ☐
- Gen kelimesini duydum ve genler hakkında birşeyler söyleyebilirim ☐

Peki, şimdi de aşağıdaki soruları cevaplamaya çalışınız. Bilmiyorsanız, yanına X işareti koyunuz.

a) Gen terimini tanımlayınız.

b) Genler vücudunuzun hangi bölgesinde bulunur?

c) Genler neden önemlidir?

b) Genlerin yapısında ne vardır?

DNA

- DNA hakkında daha önce hiçbirşey duymadım ☐
- DNA kelimesini duydum ama ne olduğunu tam bilmiyorum ☐
- DNA kelimesini duydum ve DNA hakkında birşeyler söyleyebilirim ☐

  a) DNA vücudunuzun hangi bölgesinde bulunur?

  b) DNA neden önemlidir?

Kromozom

- Kromozom hakkında daha önce hiçbirşey duymadım ☐
- Kromozom kelimesini duydum ama ne olduğunu tam bilmiyorum ☐
- Kromozom kelimesini duydum ve kromozom hakkında ☐

birşeyler söyleyebilirim

  a) Kromozomlar vücudunuzun hangi bölgesinde bulunur?

  b) Kromozomlar neden önemlidir?

  c) Kromozomların yapısında ne vardır?

Alel

- Alel kelimesini daha önce hiç duymadım ☐
- Alel kelimesini duydum ama ne olduğunu tam bilmiyorum ☐
- Alel kelimesini duydum ve hakkında birşeyler söyleyebilirim ☐

  a) Alel kelimesini tanımlayabilir misiniz?

  b) Gen, DNA, kromozom ve alel arasında bir ilişki var mıdır? Açıklayınız.

Kalıtım

- Kalıtım hakkında daha önce hiçbirşey duymadım ☐
- Kalıtım kelimesini duydum ama ne olduğunu tam bilmiyorum ☐
- Kalıtım kelimesini duydum ve hakkında birşeyler söyleyebilirim ☐

a) Kalıtım kelimesini tanımlayabilir misiniz?

Gamet

- Gamet terimini daha önce hiç duymadım ☐
- Gamet terimini duydum ama ne olduğunu tam bilmiyorum ☐
- Gamet terimini duydum ve hakkında birşeyler söyleyebilirim ☐

a) Gamet terimini tanımlayabilir misiniz?

b) Gamete bir örnek verebilir misiniz?

3. a) Aşağıda diğerlerinden farklı olduğunu düşündüğünüz kelimeyi daire içine alınız.

Mide, böbrek, kalp, sperm, kan

b) Nedeninizi açıklayınız.

4. İnsan vücudunda bulunan baskın ve çekinik özellikler hakkında ne söyleyebilirsiniz? Birer örnek vererek açıklayınız.

Baskın özellik:

Örnek:

Çekinik özellik:

Örnek:

APPENDIX B

GENETİK BAŞARI TESTİ

BÖLÜM A

Aşağıdaki sorularda doğru cevabı işaretleyiniz.

1. Canlı vücudunda genler tam olarak nerede bulunur?
   A) Her hücrede
   B) Çekirdekte
   C) Kromozomlarda
   D) DNA'nın yapısında

2. Saç rengi karakteri için heterozigot olan bir anne ile heterozigot bir babanın dört çocukları vardır. Bu ailenin çocuklarının saç rengi karakteri için aşağıdakilerden hangisi söylenebilir?

   A) Şansa bağlı olarak değişebilir
   B) Birinci çocuk kesinlikle dominant karakter özelliğine sahiptir
   C) Dört çocuktan üçü kesinlikle dominant karakter özelliğine sahiptir
   D) Tüm çocuklar kesinlikle dominant karakter özelliğine sahiptir

3. Bir ailenin arka arkaya üç çocuğu erkek olmuştur. Dördüncü çocuğun erkek olma olasılığı nedir?

   A) 1/2 B) 1/3 C) 1/4 D) 2/3

4. Canlıların yapısını belirleyen her özellik için aşağıdakilerden hangisi söylenebilir?

   A) Bir gen tarafından kontrol edilir
   B) Bir gen çifti tarafından kontrol edilir
   C) 23 gen tarafından kontrol edilir
   D) 46 gen tarafından kontrol edilir

5. Aynı canlıda bulunan deri, kas ve kemik hücre çeşitlerinden hangisi diğerlerinden **farklı** genlere sahiptir?

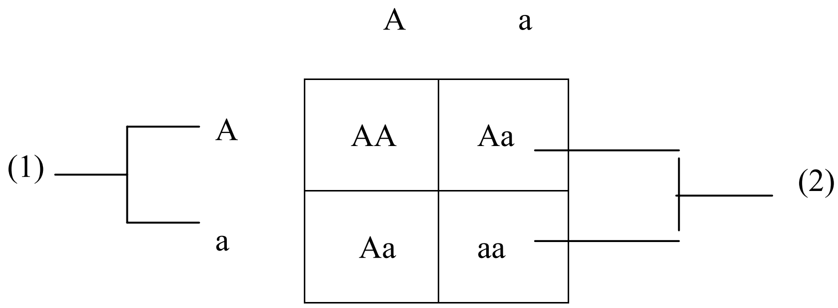
   A) Hepsi aynı genleri taşır
   B) Hepsi farklı genleri taşır
   C) Deri hücresi diğerlerinden farklıdır
   D) Deri ve kemik hücreleri aynı genetik yapıya sahiptir

6. İnsanda kan grubu üç alelle kontrol edilir. Buna göre aşağıda verilenlerden hangisi bir insanın taşıyabileceği alel sayısı için doğru bir açıklamadır?

   A) Üç alel de aynı anda taşınabilir
   B) Sadece iki alel bir araya gelebilir
   C) Sadece bir tane alel taşınabilir
   D) Anne ve babanın alellerinin hepsi taşınabilir

7. Aşağıda alel ve gen terimlerine ait açıklamalardan hangisi doğrudur?
   A) Alellerin yapısında genler bulunur
   B) Gen ile alel aynı şeydir
   C) Genlerin yapısında aleller bulunur
   D) Alel gen çeşididir

8 ve 9 numaralı soruları aşağıda verilen şemaya (Punnet karesi) göre doldurunuz.



8. Yukarıdaki Punnet karesine göre (A) ve (a) harfleri aşağıdakilerden hangisini temsil etmektedir?

   A) Anne ve babanın kromozomları
   B) Annenin ve babanın verilen özellik için homozigot olduğu
   C) Anne ve babanın DNA yapısı
   D) Anne ve babanın gametlerindeki aleller

9. Punnet karesinin dışına (1) numara ile gösterilen (A) ya da (a) harfleri neden karenin içindeki gibi yan yana değil de tek yazılmıştır?

   A) Homolog kromozomlu döllenmiş yumurta hücresi olduğu için
   B) Homolog kromozom çiftinden sadece birini taşıyan yumurta ya da sperm hücresi olduğu için
   C) Anne ya da babanın vücut hücresini temsil ettiği için
   D) Oğul döllerin genotipini temsil ettiği için

10. Aşağıda verilen, insana ait hücrelerden hangisinin yapısında homolog kromozom **bulunmaz?**

   A) Sinir
   B) Deri
   C) Döl yatağı
   D) Sperm

11. Bezelyelerde yuvarlak tohum buruşuk tohuma baskındır. Bir çaprazlama sonucu oluşan bezelyelerden 4 tanesi buruşuk, 12 tanesi yuvarlaktır. Bu bezelyeler aşağıdaki çaprazlamalardan hangisi sonucu oluşabilir? (Yuvarlak tohum: Y, Buruşuk tohum: y)

   A) YY x yy   B) Yy x Yy   C) Yy x yy   D) Yy x YY

12. Aşağıdakilerden hangisi bir bireyin sahip olduğu alel çiftlerinden biri **olamaz?**

   A) Kırmızı çiçek-beyaz çiçek
   B) Miyop göz-mavi göz
   C) Yeşil tohum-sarı tohum
   D) Yapışık kulak memesi-ayrık kulak memesi

13. A ve B kan gruplarına sahip bir çiftin birinci çocukları 0 kan grubundandır. İkinci çocuklarının AB grubundan olma olasılığı nedir?

   A) 1/2   B) 1/4   C) 1/8   D) 1/16

14. Bir organizmanın aşağıda verilen yapılarından hangisinde aynı gen grubu **bulunmaz?**

   A) Deri hücresi
   B) Sinir hücresi
   C) Yumurta hücresi
   D) Kalp hücresi

15. Aşağıdakilerden hangilerinin çaprazlanmasından fenotipi farklı bireyler oluşabilir?

    A) Melez baskın x Arı döl baskın
    B) Arı döl baskın x Arı döl çekinik
    C) Melez baskın x Melez baskın
    D) Arı döl baskın x Arı döl baskın

16. Aşağıdaki hücrelerden hangisinin kromozomlarında her özellik için iki alel bulunur?

    A) İnsan yumurtası
    B) Kurbağa spermi
    C) Bakteri sporu
    D) Balina döl yatağı epitel hücresi

17. Mendelin çaprazlamalarından elde edilen sonuçlar dikkate alındığında aşağıdakilerden hangisi **söylenemez?**

    A) Her karakter bir gen çifti tarafından kontrol edilmiştir
    B) Gametler oluşurken aleller birbirinden ayrılır
    C) Gametler alellerin her ikisini de taşır
    D) Gametlerin birleşmesi rastgeledir

18. Bir canlıya ait herhangi bir özelliğin kalıtsal olduğu aşağıdakilerden hangisi ile anlaşılır?

    A) Ortam koşullarından etkilenmesiyle
    B) Canlının yaşama şansını arttırmasıyla
    C) Canlının yaşamı boyunca devam etmesiyle
    D) Canlının bazı döllerinde ortaya çıkmasıyla

BÖLÜM B:
Aşağıdaki soruların cevaplarını soruların altında verilen boşluklara yazınız.

1. D: Kıvırcık saç
   d : Düz saç
   A: Kahverengi göz rengi
   a : Mavi göz rengi

   Yukarıda insanda iki özellik için baskın ve çekinik aleller verilmiştir. Bu iki karakterin ikisi içinde heterozigot olan canlı kaç çeşit gamet oluşturabilir?

2. Hayatınızda yakın akrabalarından hiçbirine benzemeyen, ya da yakın akrabalarına çok fazla benzeyen bir kişi ile karşılaştınız mı? Bu iki durumun nasıl mümkün olabileceğini açıklayınız.

APPENDIX C

ÖĞRENME YAKLAŞIMI ANKETİ

	Kesinlikle Katılmıyorum	Katılmıyorum	Katılıyorum	Kesinlikle Katılıyorum
1. Genellikle ilk bakışta zor gibi görünen konuları anlamak için çok çaba sarfederim.				
2. Bir konuyu çalışırken öğrenciğim yeni bilgileri eskisi ile ilişkilendirmeye çalışırım.				
3. Ders çalışırken, öğrendiğim bilgileri günlük hayatta nasıl kullanabileceğimi düşünürüm.				
4. Konuları en iyi, öğretmenin anlattığı sırayı düşünüdüğümde hatırlarım.				
5. Öğrenmek zorunda olduğum konuları ezberlerim.				
6. Önmeli konuları tam olarak anlayana kadar tekrar ederim.				
7. Öğretmenler, öğrencilerinden, sınavda sorulmayacak konular üzerinde çok fazla zaman harcamalarını **beklememelidirler.**				
8. Birkez çalışmaya başladığımda, her konunun ilgi çekici olacağına inanırım.				
9. Derslerde duyduğum ya da kitaplarda okuduğum bazı bilgiler hakkında sık sık düşünürüm.				
10. Konuların birbirleri ile nasıl ilişkilendiğini anlayarak, yeni bir konu hakkında genel bir bakış açısı edinmenin benim için faydalı olduğunu düşünürüm.				
11. Anladığımdan iyice emin olana kadar dersten ya da laboratuvardan sonra notlarımı tekrar tekrar okurum.				
12. Bir konu hakkında çok fazla araştırma yapmanın zaman kaybı olduğunu düşündüğümden, sadece sınıfta ya da ders notlarında anlatılanları ciddi bir şekilde çalışırım.				
13. Okumam için verilen materyalleri, anlamını tam olarak anlayıncaya kadar okurum.				
14. Gerçek olaylara dayanan konuları, varsayıma dayanan konulardan daha çok severim.				
15. Bir konuda öğrendiğim bilgiyi başka bir konuda öğrendiğimle ilişkilendirmeye çalışırım.				
16. Benim için teknik terimlerin ne anlama geldiğini anlamanın en iyi yolu ders kitabındeki tanımı hatırlamaktır.				
17. Bulmaca ve problemler çözerek mantıksal sonuçlara ulaşmak beni heyecanlandırır.				
18. Genelde okumam için verilen materyalin bana sağlayacağı faydayı düşünmem.				
19. Konuları ezberleyerek öğrenirim, yani öğrendiğime inanana kadar ezberlerim.				
20. Çoğunlukla, konuları gerçekten anlamadan okurum.				
21. Bir konuyla ilgili verilen fazladan okumalar kafa karıştırıcı olabileceğinden sadece derste öğrendiklerimize paralel olarak tavsiye edilen birkaç kitaba bakarım.				
22. Ekstra birşeyler yapmanın gereksiz olduğunu düşündüğüm için, çalışmamı genellikle derste verilen bilgiyle sınırlarım.				

APPENDIX D

MANTIKSAL DÜŞÜNME 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. $\boxed{b}$ AÇIKLAMASI $\boxed{2}$

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)

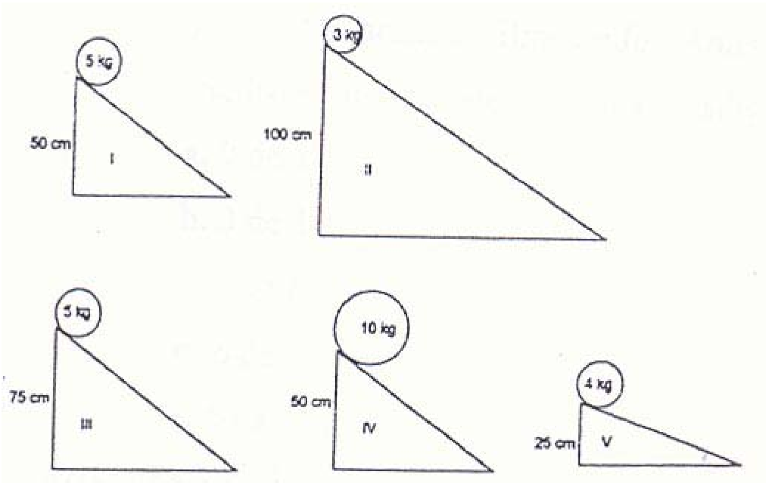
- **a.** 5 kutu
- **b.** 7 kutu
- **c.** 8 kutu
- **d.** 9 kutu
- **e.** Hiçbiri

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?

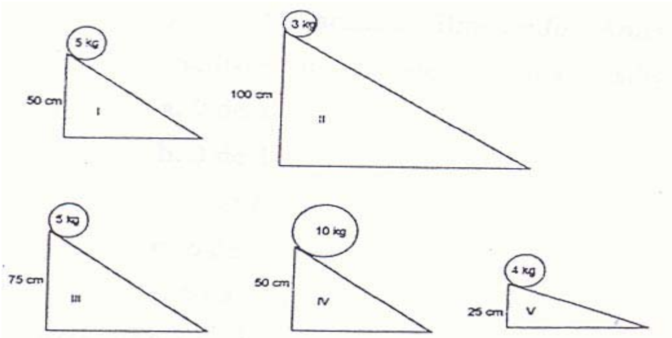


a. I ve IV
b. II ve IV
c. I ve III
d. II ve V
e. Hepsi

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.

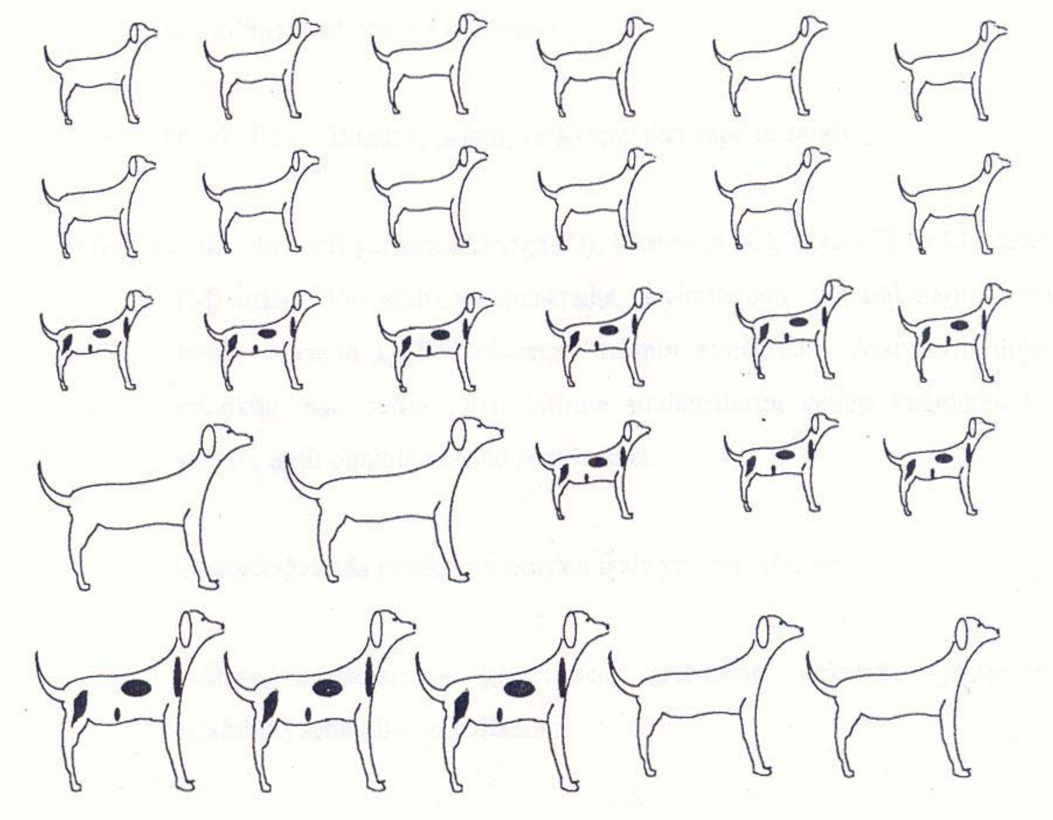
SORU 8: 7 büyük ve 21 tane küçük köpek şekli aşağıda verilmiştir. Bazı köpekler benekli bazıları ise beneksizdir. Büyük köpeklerin benekli olma olasılıkları küçük köpeklerden daha fazla mıdır?

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 E

GÜDÜSEL İNANÇ ÖLÇEĞİ

Açıklama: Bu ölçekte, Fen Bilgisi dersine ait güdüsel inancınızı ilişkin 9 cümle ile her cümlenin karşısında KESİNLİKLE KATILMIYORUM, KATILMIYORUM, KARARSIZIM, KATILIYORUM, KESİNLİKLE KATILIYORUM olmak üzere beş seçenek verilmiştir. Her cümleyi dikkatlice okuduktan sonra kendinize uygun seçeneği √ işareti ile belirleyiniz.

	Tamamnen Katılıyorum	**Katılıyorum**	**Kararsızım**	**Katılmıyorum**	**Hiç Katılmıyorum**
1) Sınıftaki diğer öğrenciler ile karşılaştırıldığında Fen Bilgisi dersinde başarılı olmayı beklerim.					
2) Fen Bilgisi dersinde öğretilen konuları anlayabildiğime eminim.					
3) Fen Bilgisi dersinde başarılı olacağımı düşünüyorum.					
4) Sınıftaki diğer öğrenciler ile karşılaştırıldığında, iyi bir öğrenci olduğumu düşünüyorum.					
5) Fen Bilgisi dersi için belirlenen görevleri ve problemleri en iyi şekilde yapabileceğime eminim.					
6) Fen Bilgisi dersinden iyi bir not alacağımı düşünüyorum.					
7) Sınıftaki diğer öğrenciler ile karşılaştırıldığında, çalışma becerilerim mükemmeldir.					
8) Sınıftaki diğer öğrenciler ile karşılaştırıldığında, Fen Bilgisi konuları hakkında daha fazla bilgiye sahip olduğumu düşünüyorum.					
9) Fen Bilgisi dersinde verilen bilgileri öğrenebileceğime inanıyorum.					

APPENDIX F

DENETİM ODAĞI ÖLÇEĞİ

Aşağıda a ve b olarak verilen çift cümlelerin hangisinin daha doğru olduğunu düşünüyorsanız onun önüne bir çarpı (X) işareti koyunuz. Bazı çift cümlelerin her ikisi de fikrinize uygun olmayabilir. Böyle bir durumda bu iki cümleden düşüncenize biraz daha uygun olanı seçiniz. Her çift cümleyi kendi başına ele alınız; ona cevap verirken diğer çift cümlelerin etkisi altında kalmayınız.

( )	a	İnsanların yaşamındaki üzüntülü olayların çoğuna kısmen kötü talih sebep olur.
( )	b	İnsanların talihsizlikleri tamamen kendi yaptıkları hataların sonucudur
( )	a	Bu dünyada insanlar eninde sonunda hakettikleri saygıyı görürler
( )	b	Bir insan ne kadar uğraşırsa uğraşsın onun değeri maalesef genellikle farkedilmez
( )	a	Başarı sağlamak çok çalışmaya bağlıdır, şansla hemen hemen hiç ilgisi yoktur
( )	b	İyi bir işi elde etmek esas olarak doğru zamanda doğru yerde olmaya bağlıdır
( )	a	Herhangi bir vatandaşın devlet kararlarına etkisi olabilir
( )	b	Bu dünyayı başta bulunan az sayıda insan idare eder ve herhangi bir kimsenin bu konuda yapabileceği pek bir şey yoktur
( )	a	Planlar yaptığım zaman o planları uygulayabileceğimden hemen hemen eminimdir
( )	b	Çok önceden plan yapmak her zaman akıllıca bir iş değildir, çünkü birçok şey zaten iyi veya kötü şans işi oluyor
( )	a	Dünya meselelerinde çoğumuz anlayamadığımız ve kontrol edemediğimiz kuvvetlerin kurbanı oluyoruz
( )	b	İnsanlar siyasi ve sosyal olaylara aktif olarak katılarak dünya olaylarını kontrol edebilirler

( )	a	İnsanların çoğu hayatlarının ne dereceye kadar tesadüfi olaylarla kontrol edildiğinin farkında değiller
( )	b	Gerçekte şans diye birşey yoktur
( )	a	Birisinin bizi gerçekten sevip sevmediğini bilmek zordur
( )	b	Kaç tane arkadaşımız olduğu bizim ne kadar iyi bir insan olduğumuza bağlıdır
( )	a	Çok zaman başıma gelen iyi ve kötü olaylarda rolümün çok az olduğunu hissederim
( )	b	Şans veya talihin hayatımda önemli bir rol oynadığına inanmak benim için imkansızdır

APPENDIX G

FEN BİLGİSİ TUTUM ÖLÇEĞİ

Açıklama: Bu ölçekte, Fen Bilgisi dersine ilişkin tutum cümleleri ile her cümlenin karşısında TAMAMEN KATILIYORUM, KATILIYORUM, KARARSIZIM, KATILMIYORUM, VE HİÇ KATILMIYORUM olmak üzere beş seçenek verilmiştir. Her cümleyi dikkatlice okuduktan sonra kendinize uygun seçeneği √ işareti ile belirleyiniz.

	Tamamen Katılıyorum	Katılıyorum	Kararsızım	Katılmıyorum	Hiç Katılmıyorum
1) Fen Bilgisi çok sevdiğim bir alandır					
2) Fen Bilgisi ile ilgili kitapları okumaktan hoşlanırım					
3) Fen Bilgisinin günlük yaşantıda çok önemli bir yeri yoktur					
4) Fen Bilgisi ile ilgili ders problemlerini çözmekten hoşlanırım					
5) Fen Bilgisi konuları ile ilgili daha çok şey öğrenmek isterim					
6) Fen Bilgisi dersine girerken sıkıntı duyarım					
7) Fen Bilgisi dersine zevkle girerim					
8) Fen Bilgisi dersine ayrılan ders saatinin daha fazla olmasını isterim					
9) Fen Bilgisi dersine çalışırken canım sıkılır					
10) Fen Bilgisi konularını ilgilendiren günlük olaylar hakkında daha fazla bilgi edinmek isterim					
11) Düşünce sistemimizi geliştirmede Fen Bilgisi öğrenimi önemlidir					
12) Fen Bilgisi çevremizdeki doğal olayların daha iyi anlaşılmasında önemlidir					
13) Dersler içinde Fen Bilgisi dersi önemsiz gelir					
14) Fen Bilgisi konuları ile ilgili tartışmalara katılmak bana cazip gelmez					
15) Çalışma zamanımın önemli bir kısmını Fen Bilgisi dersine ayırmak isterim					

APPENDIX H

KAVRAMSAL DEĞİŞİM METNİ-GENETİK

GENETİKLE İLGİLİ TEMEL KAVRAMLAR

AKTİVİTE 1-a

Öğretmeniniz tarafından verilen aile resmini inceleyiniz. Aile bireylerinin her birini inceleyerek benzerliklerini ve farklılıklarını belirlemeye çalışınız. Gözlemlerinizi sınıfla paylaşınız.

Biyolojik yapınızla ilgili özellikler her zaman anne ya da babanıza mı benzer? Boyları uzun olan anne ve babanın kısa boylu çocukları olabilir mi? Negatif kan grubuna sahip olmayan bir anne babanın çocukları negatif kan grubu taşıyabilir mi?
Bütün bu soruların cevaplarını kalıtım ile cevaplayabiliriz.

Peki kalıtım nedir?

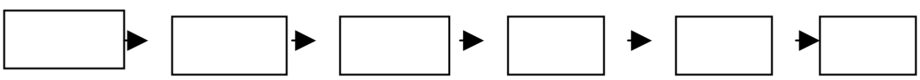
Bazı öğrenciler kalıtım kelimesini insanın DNA'sında bulunan sahip olduğumuz özellikler olarak tanımlamaktadır.

Bazı öğrenciler ise kalıtım ve genetik terimlerini ayırt edememektedirler.

Uzun boy, kıvırcık saç, renkli göz gibi anne ve babanın sahip olduğu karakterlerin yavrulara aktarılmasına **kalıtım**, kalıtsal özellikleri, bu özelliklerin nesilden nesile nasıl aktarıldığını, soylar arasındaki benzerlik ve farklılıkları inceleyen biyoloji dalına **genetik** denir.

Genetik konusunu daha iyi kavrayabilmek için gen, kromozom, DNA gibi temel kavramları ve bu kavramlar arasındaki ilişkileri bilmemiz gerekmektedir.

Hücre, gen, kromozom, organizma, DNA ve çekirdek kavramlarını aşağıdaki kutularda büyükten küçüğe doğru sıralayabilir misiniz?



Yukarıdaki soruda öğrenciler organizmanın diğer terimleri kapsadığını bilmekle beraber hücre, kromozom, gen, DNA ve çekirdek terimlerini sıralamakta zorlanmışlar ve şu cevapları vermişlerdir:

Organizma, DNA molekülünden daha büyüktür. DNA molekülü ise hücreden, hücre çekirdekten, çekirdek kromozomdan, kromozomlar ise genlerden daha büyüktür.

Organizm → DNA → Hücre → Çekirdek → Kromozom → Gen

Organizma DNA molekülünden daha büyüktür. DNA molekülü ise genlerden, genler hücreden, hücre çekirdekten, çekirdek ise kromozomlardan daha büyüktür.

Organizma → DNA → Gen → Hücre → Çekirdek → Kromozom

Organizma kromozomlardan daha büyüktür. Kromozomlar ise DNA molekülünden, DNA molekülü genlerden, genler hücreden, hücre ise çekirdekten daha büyüktür.

Organizma → Kromozom → DNA → Gen → Hücre → Çekirdek

Öğrencilerin birçoğu ise organizmanın hücrelerden oluştuğunu, hücrelerin ise çekirdeği olduğunu bilmektedir; ancak sıralamayı aşağıdaki gibi yapmaktadır.

Organizma hücreden, hücre ise çekirdekten büyüktür. DNA molekülü ise genlerden, genler de kromozomlardan daha büyüktür.

Organizma → Hücre → Çekirdek → DNA → Gen → Kromozom

Ya da;

Organizma hücreden, hücre ise çekirdekten büyüktür. Çekirdek ise genlerden, genler, DNA molekülünden, DNA molekülü ise kromozomlardan daha büyüktür.

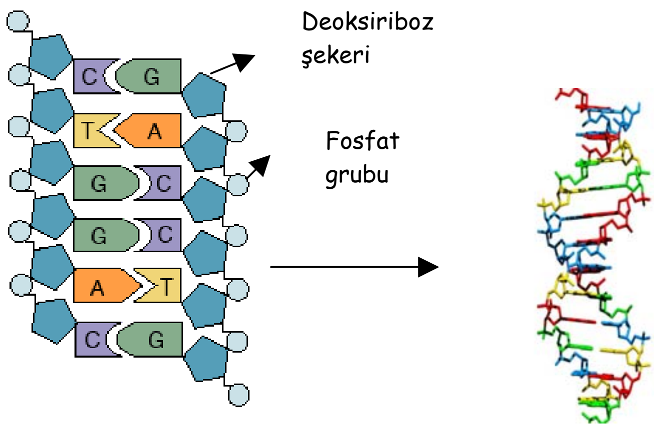
Organizma → Hücre → Çekirdek → Gen → DNA → Kromozom

Organizmanın verilen terimler içinde en büyüğü olduğu öğrenciler tarafından bilinse de verilen sıralamalardan hiçbiri doğru değildir.

Bu terimler arasındaki ilişkiyi açıklayalım:
Yeryüzünde yaşayan ve solunum, sindirim, boşaltım, üreme ve benzeri yaşamsal faaliyetleri gerçekleştiren hayvan, bitki gibi canlılara genel olarak **organizma** adı verilir. Organizmanın canlılık özelliği gösteren en küçük yapı birimi ise **hücredir.** Yani sistemler, sistemleri oluşturan dokular hücrelerden meydana gelir. Dolayısıyla organizma hücrelerden oluşur. **Çekirdek** ise hücredeki büyüme, bölünme, onarım gibi yaşamsal faaliyetlerin denetlendiği yapıdır.

Hücrede kalıtım bilgisi çekirdekte bulunur. Hücre bölünmediği zaman çekirdek içinde dağınık, uzun, ipliksi şekilde görülen yapılara **kromatin ağı** denir. Hücre bölünmesi sırasında kromatin iplikleri kısalıp kalınlaşarak **kromozom** denilen yapıları meydana getirir. Kromozomların yapısında **DNA** (deoksiribonükleik asit) ve protein vardır. DNA'nın yapısında ise 4 azotlu organik baz (Adenin (A), Timin (T), Guanin (G), Sitozin (S)), deoksiriboz şekeri ve fosfat grubu bulunur.

Kromozomun sayısı, büyüklüğü, şekli türden türe farklılık gösterirken bir türün bireylerinde bulunan kromozom sayısı ise aynıdır. Kromozomların sayısı ile canlıların gelişmişlikleri arasında bir ilişki yoktur. Mesela insanın vücut hücrelerinde 46 kromozom bulunurken, eğrelti otunda 500 kromozom bulunur.



Şekil 1-DNA molekülünün yapısı

Peki gen nedir?

Öğrencilerin birçoğu gen kavramını tam olarak tanımlayamamaktadır. Gen kavramını tanımlamaları istendiğinde ise,

- Yapısında DNA bulunan bizi diğer canlılardan farklı kılan yapıdır
- Anneden ya da babadan çocuğa geçen kalıtsal hücrelerdir, yapısında kromozom vardır.
- Anne ve babanın karışımıdır ve yapısında DNA ve RNA vardır.
- İnsanların fiziki özelliklerinin oluşmasını sağlayan DNA ve RNA gendir.

Birçok öğrenci alel kelimesinin ne anlama geldiğini tam olarak bilmemekte veya alel ve gen terimlerini karıştırmaktadır.

- Bazı öğrenciler alellerin yapısında genlerin olduğunu düşünür.
- Kimi öğrenci de gen ile alelin aynı şey olduğunu düşünür.
- Bazıları da genlerin yapısında alellerin bulunduğunu düşünür.

Bu tanımlamalardan öğrencilerin genlerin canlıların belli özelliklerini belirlediklerini bildikleri ama yapısı hakkında tam olarak bilgi sahibi olmadıkları anlaşılmaktadır.

- Kalıtsal özellikleri kontrol eden ve yavru döllere aktarılmasını sağlayan kalıtsal birim **gen**'dir. Her insanın bir kimliği vardır. Kimliğinizde adınız, soyadınız ve size ait, sizi anlatan bilgiler bulunur. Saç rengi, göz rengi, kan grubu ya da sahip olduğumuz herhangi bir genetik hastalık gibi birçok özelliğimiz genlerimiz tarafından belirlenir. Dolayısıyla bizim özelliklerimizi belirleyen kimliğimiz genlerimizdir. Harflerin farklı kombinasyonları ile milyonlarca kelime oluşması gibi DNA molekülünün yapısını oluşturan 4 azotlu organik bazın (A, T, G, S) farklı dizilmesi sonucu binlerce gen oluşur. Sonuç olarak genler, canlının belli özelliklerinden sorumlu DNA bölgeleridir. Uzun bir DNA molekülünde farklı özellikleri belirleyen birçok gen bulunur.

Her canlı belirli sayıda ve belirli çeşitte gene sahiptir. Canlının diğer organizmalardan görünüm, kimyasal yapı ve davranış olarak farklı olmasını sağlayan sahip olduğu genleridir.

Boy uzunluğu, çiçek rengi gibi herhangi bir özellik için canlının görünüşü bir genin **alel** adı verilen farklı şekilleriyle belirlenir. Örneğin kırmızı ve sarı, gül renginin alelleridir. Bir genin farklı alellerinin olması da canlıların çeşitliliğini açıklar. Çünkü sahip olduğumuz binlerce gen ve bu genlerin binlerce aleli vardır. Mesela uzun kirpik ve kısa kirpik, düz ya da kıvırcık saç bir genin farklı alelleridir.

Aynı canlıda bulunan farklı çeşit (sinir, deri ve kas gibi) vücut hücrelerinde farklı genler mi bulunur?

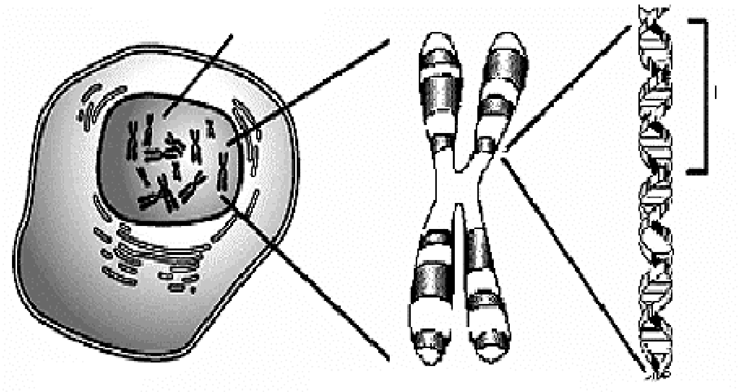
Birçok öğrenci bu soruya şöyle cevap vermektedir;

Hepsi farklı genleri taşır

Benzer dokularda aynı genler, farklı dokularda ise farklı genler bulunur.

Oysaki vücut hücrelerimizin tamamında aynı genler bulunur. Vücudumuz annemiz ve babamızın üreme hücrelerinin birleşmesi ile meydana gelen zigotun bölünerek milyarlarca hücre oluşturması ile meydana gelir. O halde tek bir hücrenin farklılaşması ve çoğalması ile oluşan bir canlının tüm hücrelerinde aynı DNA molekülü vardır. Hücrelerin kemik, deri, sinir hücresi gibi farklılaşmasının nedeni ise DNA molekülünde bulunan genlerden bazılarının hücrenin görevine göre aktif halde olmasından kaynaklanmaktadır.

Genlerin DNA molekülünün yapısında bulunduğunu ve kromozomların da DNA molekülünden oluştuğunu öğrendik.



Şekil 2-Şekilde hücre, çekirdek, kromozom, DNA ve gen arasındaki ilişkiyi görmektesiniz.

Yukarıdaki şekilde de görüldüğü gibi sizin kromozomlarınızda **DNA** var. DNA'larınız genlerinizi içerir. Genler hücrelerimizi oluşturan proteinleri belirler. Hücreler de canlı varlıkları yani organizmayı oluşturur.

Sonuç olarak organizma, hücre, kromozom, DNA, çekirdek ve gen kavramlarının büyükten küçüğe doğru sıralanması aşağıdaki gibi olacaktır.

Organizma ▶ Hücre ▶ Çekirdek ▶ Kromozom ▶ DNA ▶ Gen

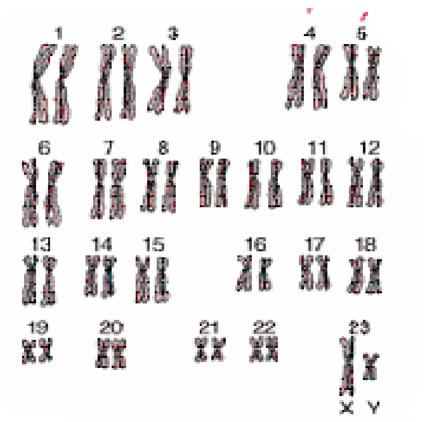
AKTİVİTE 1-b

Beşer öğrenciden oluşan gruplar oluşturarak öğretmeninizden kromozom, gen, DNA, organizma, hücre ve çekirdek kavramlarını sembolize eden şekilleri alınız ve büyükten küçüğe doğru sıralayınız. Grup olarak yaptığınız sıralamayı arkadaşlarınızla paylaşınız.

Kromozom, DNA, gen ve alel kavramlarını öğrendiniz peki anne ve babadan gelen aleller oğul döllerde nasıl bir araya gelir?
15 çift çorap olan bir çekmece düşününüz. Sağ ve sol tekten oluşan çoraplara bir çift çorap dediğiniz gibi ökaryot canlıların yapısında da bir çift kromozom

bulunur. Biri anneden diğeri babadan gelen, aynı karakteri belirleyen genleri taşıyan benzer şekil ve yapıdaki bu kromozomlara **homolog kromozom** denir.

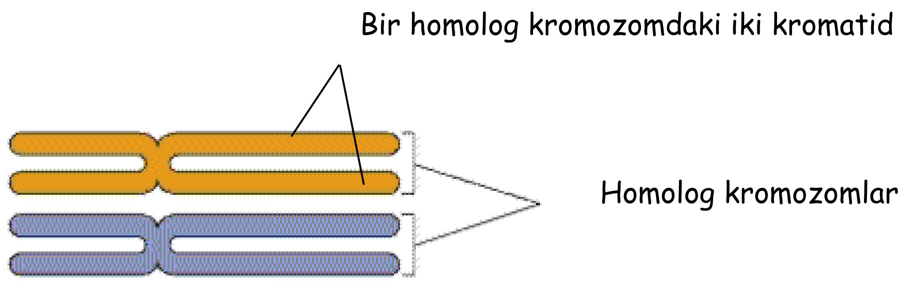
İnsanın her bir hücresinde Şekil-3'te görüldüğü gibi 23 çift kromozom bulunur. Her bir çiftte bulunan iki kromozom aynı boya ve aynı şekle sahiptir ve bu kromozomlar homolog kromozomlardır. Homolog kromozomların aynı bölümlerinde aynı karakterleri belirleyen genler bulunur. Sonuç olarak her çeşit kromozomdan iki tane, her hücrede de her gen çeşidinden iki tane bulunur. Döllenme sırasında 23 kromozom anneden, 23 kromozom babadan gelir ve 46 kromozom sayısı elde edilir. Dolayısıyla anne ve babadan gelen 23 kromozom birbirinin homoloğudur.



Şekil 3- İnsanda bulunan 23 çift kromozom

Her kromozom çiftinde bulunan iki kromozom homolog kromozomlardır

Şekli inceleyiniz.



Şekil 4- Homolog kromozomlar

Sizce sinir, deri, döl yatağı ve sperm hücrelerinden hangisinde homolog kromozom bulunmaz?

Bu soruya birçok öğrenci döl yatağı cevabını vermektedir.

Döl yatağı üreme sisteminin bir parçasıdır ve kromozom sayısı vücut kromozom sayımıza eşittir. Sinir ve deri ise döl yatağı ve diğer vücut hücrelerimiz gibi 23 anneden ve 23 babadan olmak üzere 46 kromozoma sahiptir. Doğru cevap sperm olmalıdır. Sperm hücreleri kromozom sayımızın yarısına sahiptir. Dolayısı ile vücut hücrelerimizde 46 kromozom var ise sperm ve yumurta olarak farklılaşan üreme hücrelerimiz 23 kromozoma sahiptir. Zigot oluşumu sırasında üreme hücrelerinin içerdikleri kromozomların bir araya gelmesi ile canlının sahip olduğu vücut hücrelerindeki kromozom sayısı elde edilir.

AKTİVİTE 2-a Aktivite kağıdınızı alarak beşer öğrenciden oluşan gruplar oluşturunuz.

İnsan vücudunda bulunan baskın ve çekinik karakterler için ne söyleyebilirsiniz?

Öğrenciler insanın sahip olduğu tüm özelliklerin ya baskın ya da çekinik olduğunu düşünmektedirler.

Bazı öğrenciler bu soruya şöyle cevap vermektedirler.

Anne karakteri baskınsa çocuk anneye benzer, baba karakteri baskınsa çocuk babaya benzer.

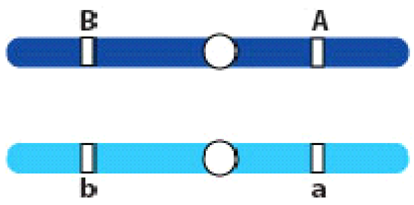
Oysaki baskın ya da çekinik olan alellerdir, bireyler değildir. Baskın olan, çekinik alelle birlikte bulunduğu zaman etkisini gösteren alele **baskın alel (dominant)** denir. Baskın olan alellerin belirlediği özellikler baskın özellik ya da baskın karakter adını alır. Örneğin, insanda ayrık kulak memesi yapışık kulak memesine baskın olan bir karakterdir. Bu durumda ayrık kulak memesi aleli ile yapışık kulak memesi aleli bir araya geldiğinde ortaya çıkan birey ayrık kulak memesine sahip olur.

Dominant alelle birlikte bulunduğunda etkisini göstermeyerek gizli kalan alele **çekinik alel (resesif)** denir. Çekinik aleller küçük harfle gösterilir. Çekinik alellerin belirlediği özellikler çekinik özellik ya da çekinik karakter olarak adlandırılır.

Genetikle ilgili çalışmalarda farklı özellikleri belirleyen aleller harflerle gösterilir. Baskın aleller büyük harfle çekinik aleller ise küçük harfle gösterilir. Örneğin, insanda kıvırcık saç düz saça baskındır. Kıvırcık saç alelini D harfi ile, düz saç alelini ise d harfi ile gösterebiliriz.

Homolog kromozomların karşılıklı gelen bölgelerinde bir karakterin belirlenmesinde etkili olan bir gen çifti bulunur. Bu gen çifti aynı aleli içerebileceği gibi farklı alelleri de içerebilir.

Aşağıdaki şekilde baskın ve çekinik aleller homolog kromozomlar üzerinde gösterilmiştir.



Şekil 5- Homolog kromozomlarda taşınan aleller

Şekil 5'te görüldüğü gibi her iki kromozomda da aynı iki gen bulunmaktadır. Babanın taşıdığı A ve B alelleri, annenin taşıdığı a ve b alellerine baskındır. Dolayısı ile bu kromozomları taşıyan birey baskın özelliğe sahip olur. Bir canlı bir özellik için aynı aleli içeriyorsa yani hem annesinden hem de babasından aynı aleli aldıysa böyle canlılara **homozigot (arı döl)** adı verilir. Örneğin anne ve babasından kıvırcık saç alelini alan bir çocuk 'saçın biçimi' için homozigottur.

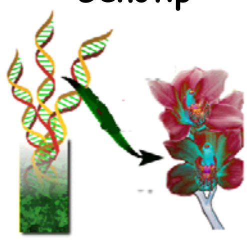
Örnek: Farelerde siyah tüy rengi (S) kahverengi tüy rengine (s) baskındır. Hem annesinden hem de babasından kahverengi tüy alelini alan fare (ss) kahverengi tüylü olur. Bu fare tüy rengi özelliği için homozigottur.

Resesif karakterler ancak homozigot durumda ortaya çıkar. Yukarıdaki örneğe göre annesinden siyah tüy aleli (S), babasından kahverengi tüy aleli (s) alan bir fare siyah tüylü olacaktır. Farklı alelleri içeren birey **heterozigot (melez=hibrit)** olarak adlandırılır. Bu durumda annesinden siyah tüy aleli (S), babasından kahverengi tüy aleli (s) alan bir fare (Ss) siyah tüylü olur. Bu durumda fare tüy rengi özelliği için heterozigottur. Bir canlının sahip olduğu genlerin toplamına o canlının **genotipi** denir. Bir canlının belirli yaş ve çevredeki dış görünüşüne ise o canlının **fenotipi** denir. Fenotip, canlının yaşına ve çevre koşullarına göre değişebilir.

Örneğin,
D: Kıvırcık saç
d: Düz saç
B: Kahverengi göz
b: Mavi göz ise, DdBB genotipine sahip bir birey:

- Saçın biçimi için heterozigot, göz rengi için homozigot çekiniktir.
- Fenotipi ise kıvırcık saç ve siyah göz olur.

Genotip



Fenotip

Şekil 6- Bir bitkinin genotip ve fenotipi

AKTİVİTE 2-b

Aktivite kağıdınızı öğretmeninizden alarak tek başına çalışınız.

ÇAPRAZLAMA: Döllenme olayı ile genlerin çeşitli kombinasyonlar oluşturmasıdır. Mesela homozigot düz saçlı bir anne ile kıvırcık saçlı bir babanın oluşturduğu kombinasyonlara ve çaprazlamaya bakalım.
D: Kıvırcık saç
d: Düz saç

DD X dd

Dd Dd Dd Dd

Şekil 7- Saçın biçimi özelliği için homozigot iki bireyin çaprazlanması

Şekil 7'de de görüldüğü gibi homozigot düz saçlı bir anne ile kıvırcık saçlı bir babanın çocuklarının hepsi heterozigot kıvırcık saçlı olur.

MENDEL İLKELERİ VE GENETİK ÇAPRAZLAMALAR

Kalıtımla ilgili pek çok sorunun cevabını bulabilmek için Mendel'in çalışmalarını öğrenmemiz gerekir.

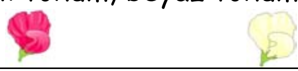
Gregor Mendel (1822-1884), Avusturyalı bir bilim adamıaynı zamanda papazdır. Mendel manastırın bahçesinde yetiştirdiği bezelyeler üzerinde çalışarak kalıtımın ana ilkelerini ortaya koymuştur. Mendel çalışmalarında neden bezelyeleri seçmiştir, hiç düşündünüz mü?

Şekil 1- Gregor Mendel

- Bu bitkilerin yetiştirilmesi kolaydır
- Kısa sürede çok döl verir
- Bir çok çeşidi vardır
- Bu çeşitler arasındaki çaprazlamalardan elde dilen oğul döller kolayca ürerler
- Başka bir bezelye çiçeğinin çiçek tozlarıyla kolayca tozlaşma yapamayacak çiçek yapısına sahiptir

Mendel ilk çaprazlamalarında tek bir karakter bakımından fark gösteren bezelyeleri kullanmıştır. Aşağıda Mendel'in bezelyelerde incelediği karakterler ile ilgili olarak elde ettiği sonuçlardan bazıları tablo 1'de gösterilmiştir.

Tablo 1- Bezelyelerde baskın ve çekinik karakterler

Karakterler	Baskın ve çekinik karakterler
Tohum şekli	Yuvarlak tohum, buruşuk tohuma baskın 
Tohum rengi	Sarı tohum, yeşil tohuma baskın 
Tohum kabuğu rengi	Renkli tohum, beyaz tohuma baskın 
Meyve rengi	Yeşil meyve, sarı meyveye baskın 
Meyve şekli	Şişkin meyve, buruşuk meyveye baskın 

Mendel, deneylerinde kullandığı özellik bakımından farklı olan iki arı döle ata anlamına gelen 'Parental kuşak (P)' adını vermiştir. Bunların çaprazlanmasından elde ettiği döllere de oğul anlamına gelen 'Filial (F)' demiştir. İlk çaprazlamalarından elde ettiği döle birinci döl (F_1), F_1'in kendi arasında yapılan çaprazlama sonucu oluşan döle de ikinci döl (F_2) adını vermiştir.
Mendel'in çalışmaları sonucunda bulduklarını Mendel İlkeleri adı altında özetleyelim.

MENDEL İLKELERİ

- Özellikler atadan yavruya genlerle geçer. Bezelye bitkisinde bir özellik için birbirine benzer ya da farklı olan bir çift alel vardır. Bu aleller farklı olursa biri baskın diğeri çekinik kalır.
- Bir çift alel genden herbiri gametlere eşit olasılıkla bağımsız olarak geçer. Oluşan her gamet alel çiftinden sadece bir tane alabilir. Buna 'Bağımsız ayrılma kuralı' denir.
- Gametler rastgele birleştiği için melezlerin kendi aralarında çaprazlanmasıyla belirli özellikler önceden tahmin edilen oranlarda ortaya çıkar.

AKTİVİTE 3-a

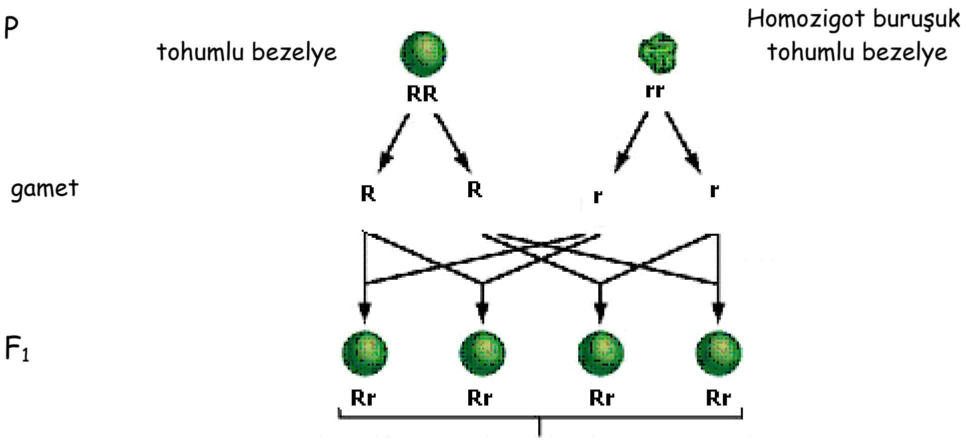
Aktivite kağıdınızı alarak beşer öğrenciden oluşan gruplar oluşturunuz.

Gametler meydana gelirken aleller birbirinden ayrılır. Her gamet alel çiftinden sadece bir tanesini alır ve hangi genlerin bir arada toplanacağı tamamen tesadüflere bağlıdır.

Homozigot dominant karakter taşıyan bir bireyle homozigot resesif karakter taşıyan bir birey çaprazlandığında F_1 dölü %100 melezdir.

Örnek:
Tek özellik için (tohum şekli) homozigot baskın ve çekinik olan iki bireyin çaprazlanması sonucunda yuvarlak tohumlu heterozigot bireyler ortaya çıkar.

R: Yuvarlak tohumlu bezelye
r: Buruşuk tohumlu bezelye



%100 heterozigot yuvarlak tohumlu bezelye

Şekil 2-Tek özellik için (tohum şekli) homozigot olan iki ayrı bireyin çaprazlanması

Tek özellik için (tohum rengi) homozigot baskın ve çekinik olan iki bireyin çaprazlanmasını **Punnet karesi** ile de gösterebiliriz.

A: sarı tohum, a: yeşil tohum

dişi / erkek	a $\frac{1}{2}$	a $\frac{1}{2}$
A $\frac{1}{2}$	Aa	Aa
A $\frac{1}{2}$	Aa	Aa

Tablo 2-Punnet karesinde tek özellik için homozigot olan iki bireyin çaprazlanması

Punnet karesi ile döllenme sırasında gametlerde bulunan alellerin nasıl bir araya geldiği rahatlıkla gözlenebilir.

Punnet karesinin dışında bulunan (A) ve (a) harfleri neyi temsil etmektedir ve neden karenin içindeki gibi yan yana değil de ayrı ayrı yazılmıştır?

Öğrencilerin bir kısmı bu harflerin kromozomları temsil ettiğini düşünmektedir

Bazıları ise zigot olarak düşünürler.

Öğrencilerin bir kısmı da bu harflerinin anne veya babanın vücut hücresini temsil ettiğini düşünmektedir

Bazıları ise bu harfleri oğul döllerin genotipi olarak algılar

A harfi annenin oluşturduğu gametin taşıyabileceği olası aleli ve B harfi ise babanın oluşturduğu gametin taşıyabileceği olası aleli gösterir. Sonuç olarak harflerin Punnet karesinin dışında tek yazılmasının nedeni her bir gametin sadece bir aleli taşıması ve bu harflerin bu gametleri temsil etmesidir. Punnet karesinin içinde ise oluşacak yavru bireylerin sahip olduğu genotip verildiği için yan yana yazılmıştır.

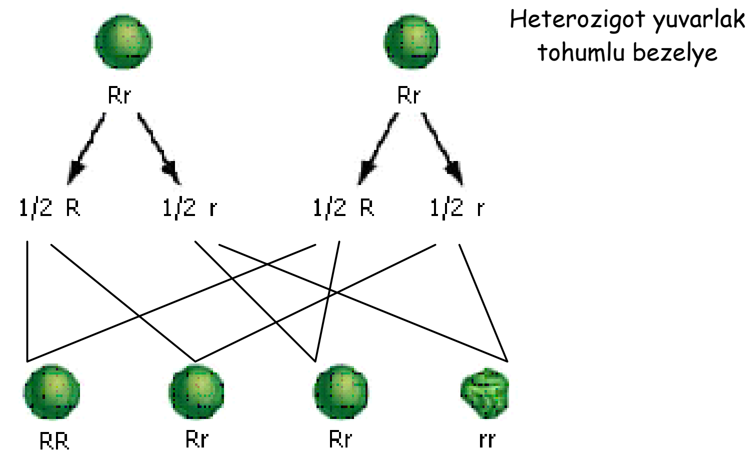
Punnet karesinde yatay sıraya dişinin sahip olduğu aleli taşıyan gametler, düşey sütuna ise erkeğin sahip olduğu aleli taşıyan gametler yazılır.

Tek bir özellik için heterozigot iki birey kendi arasında çaprazlanırsa (F_1xF_1), F_2 dölünde karakterler ayrılır. Daha önce gizli kalan karakterler etkisini 1/4 oranında gösterir. Böyle tek bir özellik için heterozigot iki bireyin çaprazlanmasına **monohibrit çaprazlama** adı verilir. (Aa x Aa)

Örnek: Tek özellik için homozigot olan yuvarlak ve buruşuk tohumlu iki bezelyenin çaprazlanması ile elde edilen F_1 dölünü kendi arasında çaprazladığımızda F_2 dölünü elde ederiz. Tek özellik için (tohum şekli) heterozigot olan iki bireyin çaprazlanması sonucunda yuvarlak ve buruşuk tohumlu bireyler ortaya çıkar.

R: Yuvarlak tohumlu bezelye
r: Buruşuk tohumlu bezelye

F_1



F_2

Genotip: %25 homozigot yuvarlak tohumlu — %50 heterozigot yuvarlak tohumlu — %25 homozigot buruşuk tohumlu

Fenotip: $\frac{3}{4}$ yuvarlak tohumlu — $\frac{1}{4}$ buruşuk tohumlu

Şekil-3 Tek özellik bakımından heterozigot olan iki bireyin çaprazlanması

Tek özellik bakımından homozigot baskın ve çekinik olan iki bireyin çaprazlanması ile oluşan fenotiplerin dağılım oranı 1:1; heterozigot iki bireyin çaprazlanması ile oluşan fenotiplerin dağılım oranı 3:1, genotipteki dağılım oranı ise 1:2:1' dir.

AKTİVİTE 3-b

Bezelyelerde renkli tohum beyaz tohuma baskındır. Buna göre heterozigot iki renkli tohuma sahip bezelyenin çaprazlanması ile oluşacak bireylerin genotiplerinin dağılım oranını Punnet karesi kullanarak belirleyiniz. Heterozigot renkli tohumlu bezelye ile beyaz tohumlu bezelye çaprazlanırsa beyaz tohumlu bezelye çıkma olasılığını hesaplayınız. (R: Renkli tohum, r: beyaz tohum)

Saç rengi karakteri için heterozigot olan bir anne ile heterozigot olan bir babanın dört çocukları vardır. Bu çocukların saç karakteri için ne söyleyebilirsiniz?

Bazı öğrenciler bu soruya şöyle cevap vermişlerdir;

Birinci çocuk kesinlikle dominant karakter özelliğine sahip olur.

Dört çocuğun üçü kesinlikle dominant karakter özelliğine sahip olur.

Tüm çocukların kesinlikle dominant özelliğe sahip olur.

Heterozigot olan iki bireyin çaprazlanması ile oluşan bireylerin sahip olacakları özellikler şansa bağlı olarak değişir, kesin birşey söyleyemeyiz. Anne ve babanın oluşturacağı gametlere baskın mı yoksa çekinik karakterin mi gideceğini bilemeyiz. Dolayısı ile tüm çocuklar dominant özelliğe sahip olacağı gibi tamamı çekinik özelliği de taşıyor olabilir.

Arka arkaya üç kız çocuk doğuran bir annenin dördüncü çocuğunun kız olma olasılığı nedir?

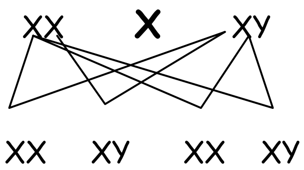
Birçok öğrenci arka arkaya üç kız çocuk doğurulduğu için dördüncü çocuğun erkek olma olasılığının daha fazla olacağını düşünmektedir.

Olasılık kurallarına göre bir annenin kız ya da erkek çocuk doğurma olasılığı her zaman % 50'dir.

İnsanın sahip olduğu 46 kromozomun 44'ü vücut, 2'si cinsiyet kromozomudur. Cinsiyeti belirleyen X ve Y kromozomlarıdır.

44 + XX ⟶ Dişi
44 + XY ⟶ Erkek

Gamet oluşurken anne ve baba arasındaki çaprazlamaya bakalım:



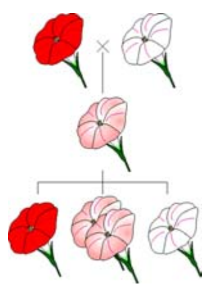
Şekil 4- Dişi ve erkek bireylerde eşey kromozomlarının çaprazlanması

Görüldüğü gibi kız ya da erkek olma olasılığı hep % 50 ise cevap kaçıncı çocuk olursa olsun oran hep 1/2 olacaktır.

EKSİK BASKINLIK:

Bir karakteri belirleyen bir alel çiftinin üyelerinden her birinin diğerine baskın olmadığı durumdur. Eksik baskınlıkta bir karakterle ilgili üçüncü bir fenotip ortaya çıkar.

Örnek: Akşam sefası bitkisinde kırmızı ve beyaz renk eksik baskındır.
Kırmızı renk geni: A
Beyaz renk geni: B



Şekil 5- Akşam sefası

Buna göre kırmızı ve beyaz aslanağzı bitkisi çaprazlanırsa bütün oğul döller pembe olacaktır.

Kırmızı **Beyaz**

AA **X** BB

AB AB AB AB

% 100 Pembe

Şekil 6-Kırmızı ve beyaz aslanağzı bitkisinin çaprazlanması

Aslanağzı bitkisinde kırmızı ve beyaz renk eksik baskındır. Pembe ve beyaz renkli aslan ağzı bitkilerinin çaprazlanmasından, beyaz renkli aslan ağzı bitkisinin meydana gelme olasılığı ise aşağıdaki gibi olacaktır.

Pembe **Beyaz**

AB **X** BB

AB AB BB BB

% 50 Pembe

% 50 Beyaz

Şekil 7- Pembe ve beyaz aslanağzı bitkisinin çaprazlanması

EŞ BASKINLIK

Bir karakteri belirleyen bir alel çiftinin üyelerinden her birinin diğerine baskın olmadığı durumdur ve eş baskınlıkta her iki fenotipte bireyde etkisini gösterir. Eş baskınlığa örnek olarak insanda M ve N kan grubunu verebiliriz. MN kan grubuna sahip bireyler iki kan grubuna ait özelliği de taşır.

ÇOK ALELLİK

Bazı durumlarda bir özelliği etkileyen gen sayısı ikiden fazla olabilir. Buna çok alellik denir. Bir özelliği etkileyen alel gen sayısı ne kadar fazla çeşitte olursa olsun, her bireyde bu alellerden yalnızca ikisi bulunur; çünkü bir gamet bu alellerden sadece birini taşır.

Çok alelliğe en iyi örnek kan gruplarıdır.

İnsanlarda 4 çeşit kan grubu vardır. Bunlar: ------------------

Alellerden----------- ve ----------- baskın ------------- ise çekiniktir.

İnsanda kan grubunun üç alel genle kontrol edildiğini öğrendiniz. Buna göre bir insan bu alellerden kaçını taşıyabilir?

Öğrencilerden bazıları bir insanın üç alelide taşıyabileceğini düşünürler.

Bazı öğrencilerde sadece birini taşıdığımızı düşünür.

Oysa bir canlı bir özellik için sadece iki alel taşıyabilir. Bu alellerden biri anneden biri babadan gelir. Dolayısı ile sahip olunan aleller bireyde üç farklı kombinasyonda bir araya gelebilir. Annenin gametinde ve babanın gametinde kan grubu için bulunan aleller bir araya gelir ve bireyin kan grubunu belirler.

Aşağıda kan gruplarının genetiğini gösteren bir tablo verilmiştir (Tablo 3).

Tablo 3-Kan grupları

	Alyuvarda	**Serumda**	**Fenotip**	**Genotip**
A	A antijeni var	B antikoru	A	AA veya A0
B	B antijeni var	A antikoru	B	BB veya B0
AB	A ve B antijeni	Antikor yok	AB	AB
0	Antijen yok	A ve B antikoru	0	00

Antijen alyuvarların yüzeyinde bulunan bir çeşit proteindir. Antikor oluşumuna neden olur. İnsanlardaki Rh faktörü biri baskın, diğeri çekinik iki alel tarafından kontrol edilir. Rh^+ kanda Rh antijeni vardır. Rh^- kanda ise antijen yoktur.

Rh faktörü insan kanında 2 çeşit fenotip, 3 çeşit genotip oluşturur.

APPENDIX I

GELENEKSEL METİN-GENETİK

GENETİKLE İLGİLİ TEMEL KAVRAMLAR

Biyolojik yapımızla ilgili özellikler her zaman anne ya da babamıza benzemezler. Boyları uzun olan anne ve babanın kısa boylu çocukları olabileceği gibi, negatif kan grubuna sahip olmayan bir anne babanın çocukları negatif kan grubu taşıyabilir.

İşte anne ve babadaki karakterlerin yavrulara aktarılmasına **kalıtım**, kalıtsal özellikleri ve bu özelliklerin nesilden nesile nasıl aktarıldığını inceleyen biyoloji dalına **genetik** denir.

Anne ve baba ile oğul döller arasındaki benzerlik ve farklılıklar kalıtım ve çevrenin etkisindedir. Bazı karakterler ise sadece kalıtsal faktörlerin etkisi altındadır. Örnek: Kan grubu

Kalıtsal özelliklerimizin nesilden nesile nasıl aktarıldığını anlayabilmek için ilk olarak kalıtımla ilgili temel kavramları bilmemiz gerekir:

GEN: Kromozomların yapısında bulunan ve DNA molekülünün belirli bir genetik özellik hakkında bilgi içeren kesitine **gen** denir. Örneğin saçımızın kıvırcık ya da düz olacağını belirleyen genlerimiz gibi...

Kromozomlarda bulunan herbir gen kendisini diğer genlerden farklı kılacak kusursuz bir kod oluşturacak biçimde bir araya gelmiş binlerce A (Adenin), T (Timin), G (Guanin), C (Sitozin) nükleotidi içerir. Farklı genler bir araya gelerek gözlerimizi, kulaklarımızı, saçımızı, tırnaklarımızı kısaca bütün vücudumuzu oluşturur.

Vücut hücrelerimizin tamamında aynı genler bulunur. Vücudumuz annemiz ve babamızın üreme hücrelerinin birleşmesi ile meydana gelen zigotun bölünerek milyarlarca hücre oluşturması ile meydana gelir. O halde tek bir hücrenin farklılaşması ve çoğalması ile oluşan bir canlının tüm hücrelerinde aynı DNA molekülü vardır. Hücrelerin kemik, deri, sinir hücresi gibi farklılaşmasının nedeni DNA molekülünde bulunan genlerden bazılarının hücrenin görevine göre aktif halde olmasından kaynaklanmaktadır.

HOMOLOG KROMOZOM: Biri anneden diğeri babadan gelen, aynı karakteri belirleyen genleri taşıyan benzer şekil ve yapıdaki kromozomlara denir.

ALEL: Homolog kromozomlar üzerindeki biri anneden diğeri babadan gelen genlerdir. Aleller benzer ya da farklı olabilirler ve bir karakter üzerine aynı veya zıt yönde etki edebilirler.

HOMOZİGOT (ARI DÖL): Karakterleri ortaya çıkaracak alel çifti birbirinin aynı ise böyle alel çiftlerine homozigot alel çifti denir. (AA ve aa)

HETEROZİGOT (MELEZ=HİBRİT): Karakterleri ortaya çıkaracak alel çifti birbirinden farklı ise böyle alel çiftlerine heterozigot alel çifti denir. (Aa)

GENOTİP: Bir canlının sahip olduğu genlerin toplamıdır.

Örnek: AA ve aa genotipi homozigot, Aa genotipi ise heterozigottur.

FENOTİP: Bir canlının belirli yaş ve çevredeki dış görünüşüdür. Fenotip, canlının yaşına ve çevre koşullarına göre değişebilir.

Örnek: Sarı saç, mavi göz gibi.

DOMİNANT (BASKIN) ALEL: Baskın olan, çekinik alelle birlikte bulunduğu zaman etkisini fenotipte gösteren alele denir. Baskın aleller büyük harfle gösterilir.

Örnek: Farelerde siyah tüy rengi (S) kahverengi tüy rengine (s) baskındır. Annesinden siyah tüy (S), babasından kahverengi tüy (s) alelini alan fare (Ss) tüy rengi özelliği için heterozigottur.

RESESİF (ÇEKİNİK) ALEL: Çekinik olan, dominant alelle birlikte bulunduğunda fenotipte etkisini göstermeyerek gizli kalan aleldir. Çekinik aleller küçük harfle gösterilir. Resesif alellerle belirlenen karakterler ancak homozigot durumda fenotipte görülür.

ÇAPRAZLAMA: Döllenme olayı ile genlerin çeşitli kombinasyonlar oluşturmasıdır.

F_1 ⟶ birinci oğul döl

F_2 ⟶ ikinci oğul döl

Parental döl (P) ⟶ anne ve baba çaprazlanması

MONOHİBRİT ÇAPRAZLAMA: Bir alel çifti bakımından heterozigot iki bireyin çaprazlanmasıdır. (Aa x Aa)

Kalıtımla ilgili terimleri öğrendiniz. Vücudumuzda kaç kromozom olduğunu hatırlayınız. Bu kromozomların sayısının belirlenmesinde anne ve babanın rolü nedir?

Eğer bir çocuk, aynı özellik için annesinden ayrı, babasından ayrı alel alırsa fenotipi baskın alele göre belirlenir.

MENDEL İLKELERİ VE GENETİK ÇAPRAZLAMALAR

Gregor Mendel (1822-1884), Avusturyalı bir bilim adamıdır aynı zamanda papazdır. Mendel, manastırın bahçesinde yetiştirdiği bezelyeler üzerinde çalışarak kalıtımın ana ilkelerini ortaya koymuştur. Mendel çalışmalarında bezelyeleri seçmiştir, çünkü;

Şekil 1- Gregor Mendel

- Bu bitkilerin yetiştirilmesi kolaydır
- Kısa sürede çok döl verir
- Bir çok çeşidi vardır
- Bu çeşitler arasındaki çaprazlamalardan elde dilen oğul döller kolayca ürerler
- Başka bir bezelye çiçeğinin çiçek tozlarıyla kolayca tozlaşma yapamayacak çiçek yapısına sahiptir.

Mendel ilk çaprazlamalarında tek bir karakter bakımından fark gösteren bezelyeleri kullanmıştır. Mendel'in bezelyelerde incelediği karakterler ile ilgili olarak elde ettiği sonuçlardan bazıları tablo 1'de gösterilmiştir.

Tablo 1- Bezelyelerde baskın ve çekinik karakterler

Karakterler	**Baskın ve çekinik karakterler**
Tohum şekli	Yuvarlak tohum, buruşuk tohuma baskın  
Tohum rengi	Sarı tohum, yeşil tohuma baskın  
Tohum kabuğu rengi	Renkli tohum, beyaz tohuma baskın  
Meyve rengi	Yeşil meyve, sarı meyveye baskın  
Meyve şekli	Şişkin meyve, buruşuk meyveye baskın  

MENDEL İLKELERİ

- Özellikler atadan yavruya genlerle geçer. Bezelye bitkisinde bir özellik için birbirine benzer ya da farklı olan bir çift alel vardır. Bu aleller farklı olursa biri baskın diğeri çekinik kalır.

- Bir çift alel genden herbiri gametlere eşit olasılıkla bağımsız olarak geçer.Oluşan her gamet alel çiftinden sadece bir tane alabilir. Buna 'Bağımsız ayrılma kuralı' denir.

- Gametler rastgele birleştiği için melezlerin kendi aralarında çaprazlanmasıyla belirli özellikler önceden tahmin edilen oranlarda ortaya çıkar.

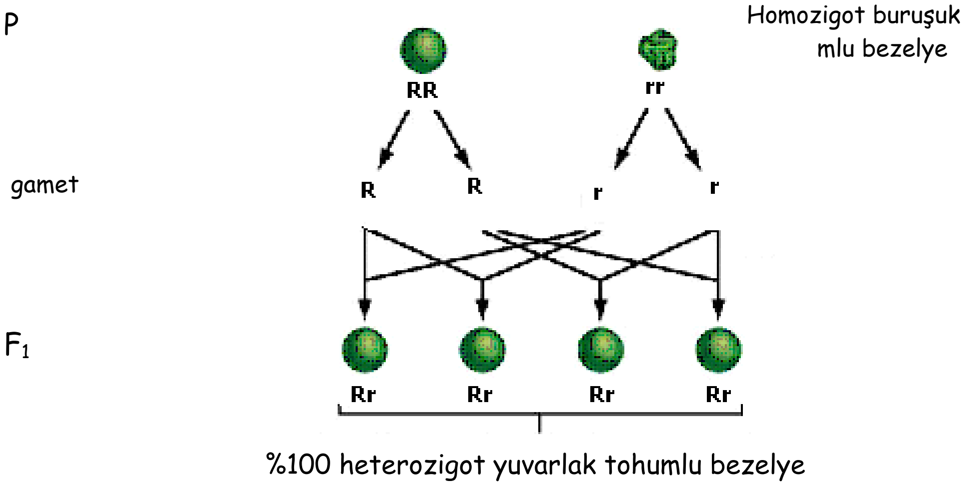
Gametler meydana gelirken aleller birbirinden ayrılır. Her gamet alel çiftinden sadece bir tanesini alır ve hangi genlerin bir arada toplanacağı tamamen tesadüflere bağlıdır.
Homozigot dominant karakter taşıyan bir bireyle homozigot resesif karakter taşıyan bir birey çaprazlandığında F_1 dölü %100 melezdir.

Örnek:

Tek özellik için (tohum şekli) homozigot baskın ve çekinik olan iki bireyin çaprazlanması sonucunda yuvarlak tohumlu heterozigot bireyler ortaya çıkar.

R: Yuvarlak tohumlu bezelye

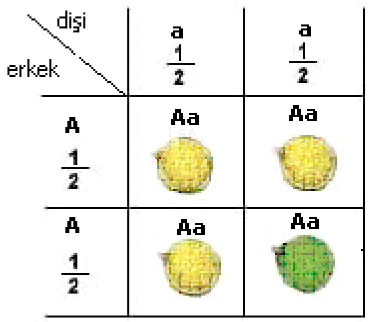
r: Buruşuk tohumlu bezelye



Şekil 2-Tek özellik için (tohum şekli) homozigot olan iki bireyin çaprazlanması

Tek özellik için (tohum rengi) homozigot baskın ve çekinik olan iki bireyin çaprazlanmasını **Punnet karesi** ile de gösterebiliriz.

A: sarı tohum, a: yeşil tohum



Tablo 2-Punnet karesinde tek özellik için homozigot olan iki bireyin çaprazlanması

Punnet karesi ile döllenme sırasında gametlerde bulunan alellerin nasıl bir araya geldiği rahatlıkla gözlenebilir. Punnet karesinde yatay sıraya dişinin sahip olduğu aleli taşıyan gametler, düşey sütuna ise erkeğin sahip olduğu aleli taşıyan gametler yazılır.

Örnek: Tek özellik için homozigot olan yuvarlak ve buruşuk tohumlu iki bezelyenin çaprazlanması ile elde edilen F_1 dölünü kendi arasında çaprazladığımızda F_2 dölünü elde ederiz. Tek özellik için (tohum şekli) heterozigot olan iki bireyin çaprazlanması sonucunda yuvarlak ve buruşuk tohumlu bireyler ortaya çıkar.

APPENDIX J

GENETİK DERS PLANI

DERS: Fen Bilgisi

KONU: Kalıtımla ilgili temel kavramlar ve Mendel yasaları

SEVİYE: 8. sınıf

SÜRE: 8 x 40 dakika

DERSİN HEDEFLERİ:

HEDEF 1:

❖ Kalıtımın temellerini, kalıtım ile ilgili temel terimleri, kalıtımın ve canlılarda çeşitliliğin kalıtsal nedenlerini kavrayabilme

DAVRANIŞLAR:

- Hücre, çekirdek, kromozom, DNA, gen ve alel kavramlarını açıklar
- Hücre, çekirdek, kromozom, DNA, gen ve alel kavramları arasındaki ilişkiyi açıklar
- Hücre, çekirdek, kromozom, DNA, gen ve alel kavramlarını örneklerle bütünleştirir
- Alel ve gen kavramları arasındaki ilişkiyi örneklerle açıklar
- Canlıların farklı dokularında bulunan hücrelerin aynı genleri taşıdığını örneklerle açıklar
- Homolog kromozom kavramını açıklar
- Homolog kromozoma sahip hücrelere örnek verir
- Baskın ve çekinik alel kavramlarını açıklar

- İnsan vücudunda bulunan baskın ve çekinik özelliklere örnek verir
- Kalıtsal özelliği sembollerle gösterir
- Homozigot ve heterozigot kavramlarını açıklar
- Bir bireyin bir özellik için homozigot ve heterozigot olmasına gore fenotip ve genotipini açıklar

HEDEF 2:

❖ Mendel yasalarını ve genetik çaprazlamaları kavrayabilme

DAVRANIŞLAR:

- Mendelin kalıtım bilimine katkılarını açıklar
- Mendel kanunlarını açıklar
- Basit olasılık kurallarını açıklar
- Kalıtımda basit olasılık hesaplamalarını yapar
- Bir özelliğin kalıtımı ile ilgili örnekler verir
- Bir kalıtsal özellikle ilgili çaprazlama yaparak problem çözer
- Bir özelliğin kalıtımı ile ilgili çaprazlamayı punnet karesinde gösterir
- Kalıtımda eksik baskınlık durumunu açıklar
- Eksik baskınlık olayına örnek verir
- Kalıtımda eş baskınlık durumunu açıklar
- Eş baskınlık olayına örnek verir
- Kalıtımda çok alellik durumunu açıklar
- Bir özelliği belirleyen alel sayısı ikiden fazla bile olsa bireyin sadece iki alel taşıyabileceğini açıklar
- İnsanda kan grubunun üç alelle belirlendiğini açıklar

ÖĞRENME EVRESİ I

KALITIMLA İLGİLİ TEMEL KAVRAMLAR

ARAÇ VE GEREÇLER:

- Aile resmi
- Kavramsal değişim metni
- DNA, hücre, kromozom, gen, çekirdek ve organizma kavramlarını sembolize eden resimler
- Renkli karton
- Yapıştırıcı

DERSİN İŞLENİŞİ :
KEŞFETME (Exploration):

1. Öğrencilere anne, baba, çocukları gösteren bir aile resmi gösterilir. Resimde aile bireylerinin saç rengi, göz rengi, ten rengi, saç biçimi gibi özellikleri ayırt edilebilmektedir.

2. Öğrencilerden gösterilen resme dikkatlice bakmaları ve defterlerine aile bireyleri için gözlemleyebildikleri özellikleri yazmaları istenir. Böylece aile bireyleri için dış görünüşlerinde ortak ya da farklı olan özellikler ortaya çıkar.

3. Öğrencilerden gözlemledikleri ve defterlerine yazdıkları ortak ve ayırt edici özellikleri sınıfla paylaşmaları istenir.

KAVRAMI TANITMA (Term Introduction):

1. Öğrencilere kavramsal değişim metinleri dağıtılır. Bu metinde öğrencilerin genetik konusunda karşılaştıkları belli başlı kavram yanılgıları ve bu kavram yanılgılarını gidermeye yönelik konu anlatımları vardır.
2. Genetikle ilgili temel kavramlar, ve bu kavramlar arasındaki ilişkiler öğrencilere anlatılır. Kalıtımın tanımı yapılır, hücre, DNA, gen, alel, organizma, kromozom çekirdek arasındaki ilişki açıklanır.

3. Öğrencilere canlılarda gözlemlediğimiz özelliklerin genler tarafından belirlendiği söylenir. Resimde gözlemledikleri aile bireyleri arasındaki benzerliklerin kalıtım sayesinde anneden ve babadan oğul döllere aktarıldığı söylenir. Ailedeki bireylerin saç rengi geninin mavi, yeşil gibi alelleri olduğu söylenir. Bu genlerin DNA'da gizli olduğu ve DNA 'nın da kromozomlarda bulunduğu söylenir. Anne ve babanın sadece çocukların dışarıdan gözlenebilen değil kan grubu, renk körlüğü gibi dışarıdan gözlemlenemeyen özelliklerinin de belirlenmesinde etken olduğu belirtilir.

KAVRAMI UYGULAMA (Concept Application):

1. Yapılan aktivitede öğrenciler kalıtımla ilgili gen, alel, kalıtım, gamet gibi belli kavramları kullanmışlar, anne ve babanın sahip olduğu karakterlein oğul döllere aktarılması hakkında bilgi sahibi olmuşlardır. Keşfetme safhasında insanın göz rengi, saç rengi, saç biçimi gibi karakterlerin aktarılması için geçerli olanların her canlıda karakterlerin aktarılmasında geçerli olup olmadığı sorulur.

2. Beş öğrenciden oluşan gruplar oluşturulur. Her bir gruba aktivite 1-b kağıtları verilir. Kağıtlarda DNA, hücre, kromozom, gen, çekirdek ve organizma kavramlarını sembolize eden resimler vardır.

3. Öğrencilerden bu resimleri büyükten küçüğe doğru sıralamaları ve bu sıralamalarını kendilerine verilen kartonlara sırayla yapıştırmaları istenir.

4. Öğrenciler sıraladıkları her resmin altına yanındaki diğer resimlerle ilişkilerini açıklayıp, resimleri tanımlarlar.

5. Aktivite sonunda sıralamayı en doğru yapan ve tanımlamaları en güzel yazan gruba ödül verilir.

ÖĞRENME EVRESİ II

KALITIMLA İLGİLİ TEMEL KAVRAMLAR

ARAÇ VE GEREÇLER:

- ❖ Kavramsal değişim metni
- ❖ Pipet
- ❖ Renkli yapışkanlı kağıt
- ❖ Madeni para

DERSİN İŞLENİŞİ:

KEŞFETME (Exploration):

1. Öğrenciler beşli gruplar oluşturur ve her gruba iki tane pipet verilir. Gruplara verilen pipetlerin üzerinde farklı renklerde yapışkanlı kağıt bulunmaktadır. Öğrencilere verilen pipetler anne ve babanın sahip olduğu homolog kromozomları, pipetlerin üzerindeki renkli bantlar ise homolog kromozomlar üzerinde aktarılan karakterin alellerini temsil etmektedir.

2. Öğrencilerden pipetlerdeki renkli bantlara bakarak ikişerli kaç farklı grup oluşturabileceklerini belirlemeleri istenir.

3. Öğrenciler belirledikleri olasılıkları gruplarına verilen boş pipetler için uygulamaları istenir. Böylece anne ve babanın sahip olduğu homolog kromozomlar üzerinde taşınan alellere bakarak oğul döllerin alellerini tahmin ederler.

4.Öğrenciler sonuçlarını tabloya yazarak sınıfla tartışırlar.

3. Grupların elde ettiği sonuçlar sınıfla paylaşılır ve tartışılır.

KAVRAMI TANITMA (Term Introduction):

1. Öğrencilerin kavramsal değişim metinlerini okumaları sağlanır. Bu metinde öğrencilerin genetik konusunda karşılaştıkları belli başlı kavram yanılgıları ve bu kavram yanılgılarını gidermeye yönelik konu anlatımları vardır. Öğrencilere mavi, turuncu, pembe, sarı gibi renkli yapışkanlı bantların göz rengi, saç rengi gibi farklı alelleri temsil ettiği söylenir. Anne ve babanın sahip olduğu homolog kromozomları temsil eden pipetlerdeki renklerin baskın ya da çekinik alellerin söyösterdiği belirtilir.

2. Baskın ve çekinik özelliklerin bireyin fenotipine nasıl yansıdığının, anne ve babanın bireyin fenotipinin belirlenmesinde nasıl rol oynadığının aktivite 2-a ile nasıl anlaşıldığı öğrencilere anlatılır.

KAVRAMI UYGULAMA (Concept Application):

1. Yapılan aktivitede öğrenciler kalıtımla ilgili çekinik alel, baskın alel, genotip ve fenotip gibi belli kavramları kullanmışlardır. Öğrencilere anne ve babanın

sahip oldukları bir homolog kromozom çifti için yaptıklarının diğer canlılar içinde geçerli olup olmadığı sorulur.

2. Her bir öğrenciye bir adet metal para ve aktivite kağıtları (aktivite 2-b) verilir. Aktivite kağıtlarında anne ve babasının genotipleri belli olan yavru bir kopek vardır. Öğrencilere metal paranın tura yüzünün baskın özelliği, yazı yüzünün ise çekinik özelliği temsil ettiği ve anne ve babanın her özellik için heterozigot olduğu söylenir. Anne babanın taşıdığı tüy yapısı ile ilgili dört farklı özellik için yavru köpeğin sahip olabileceği olası aleller ve hangi alellerin baskın ya da çekinik olduğu belirtilir.

2. Öğrencilerden metal paralar atılmadan once yavru köpeğin sahip olabileceği fenotip ve genotipleri tahmin etmeleri ve sınfla paylaşmaları istenir.

4. Öğrencilerin aktivite kağıtlarında bulunan her bir özellik için metal paraları atmaları ve anne ve babaların gametlerindeki alelleri belirlemeleri istenir. Sonuçta her öğrenci bir yavru köpeğin verilen dört özellik için sahip olacağı fenotip ve genotipi belirler ve tabloya yazar.

5. Aktivite sonunda en güzel ve doğru yavru kopek resmini çizen öğrenci seçilir.

ÖĞRENME EVRESİ III

MENDEL İLKELERİ VE UYGULAMALARI

ARAÇ VE GEREÇLER:

❖ Kavramsal değişim metni
❖ İki torba
❖ 50 barbunya fasulyesi, 50 kuru fasulye

DERSİN İŞLENİŞİ:

KEŞFETME (Exploration):

1. Beş öğrenciden oluşan gruplar oluşturulur. Aktivite 3-a kağıtları öğrencilere dağıtılır.

2. Her gruba içinde 25 barbunya fasulyesi , 25 kuru fasulye bulunan torbalar verilir. Öğrencilerden torbalara bakmamaları ve içindeki fasulye sayılarını değiştirmemeleri istenir.

3. Bir torbadan 1 tane fasulye çekilir ve rengi not edilir. Daha sonra bu fasulye torbaya geri atılır ve bir tane fasulye daha çekilir. Bu fasulyenin de rengi not edilir. Öğrencilerden 50 fasulye çekimi için tahminde bulunmaları istenir.

4. Öğrencilerin aktiviteyi yapmaları istenir. Her grup aktivitesini tamamladıktan sonra tahtaya bulduğu sonuçları yazar.

5. Daha sonra öğrencilere ikişer torba verilir ve her ikisinin içinde de 25 kuru fasulye ve 25 barbunya fasulyesi bulunur.

6. Öğrencilere aynı anda her iki torbadan da barbunya fasulyesi, her iki torbadan da kuru fasulye ya da bir torbadan barbunya fasulyesi, bir torbadan kuru fasulye çekilebileceği söylenir. Gruplardan toplam 50 deneme sonunda olası sonuçları tahmin etmeleri istenir.

7. Daha sonra her grup aktiviteyi yapar. Öğrenciler her iki torbadan da aynı anda fasulye çekerler ve buldukları sonuçları tahtaya yazarlar.

8. Her grup çalışmasını bitirdiğinde tahminlerini ve buldukları sonuçları karşılaştırır.

KAVRAMI TANITMA (Term Introduction):

1. Öğretmen eşliğinde sınıf olarak her ebeveynin oğul döllere sahip olduğu özellikleri belirleyen iki alelden sadece bir tanesini aktarabileceği tartışılır. Kavramsal değişim metninin Mendel Kanunları ve genetik çaprazlamalarla ilgili bölümü okunur ve tartışılır. Yapılan aktivitenin ilk bölümünde torbadaki barbunya fasulyeleri ve kuru fasulyelerin bir bireyin (anne ya da baba) sahip olduğu iki aleli temsil etmektedir. İlk aktivitede barbunyaların kuru fasulyeye beklenen oranı 1:1 olduğu, deneme sayısı ne kadar fazla olursa oranın o kadar doğru çıkacağı söylenir.

2. Aktivitenin ikinci bölümünde barbunya fasulyesi ve barbunya fasulyesi; kuru fasulye ve barbunya fasulyesi ya da kuru fasulye ve kuru fasulye çekme olasılığı 1:2:1 olarak beklendiği söylenir.

KAVRAMI UYGULAMA (Concept Application):

1.Yapılan aktivite ile Mendel'in bezelyeler üzerinde yaptığı çalışma kavranmaktadır. Öğrencilere bezelyelerde renkli tohumun beyaz tohuma baskın olduğu söylenir. Buna göre öğrencilerden heterozigot iki renkli tohuma sahip bezelyenin çaprazlanması ile oluşacak bireylerin genotiplerinin dağılım oranını Punnet karesi kullanarak belirlemeleri istenir.

2. Öğrenciler heterozigot renkli tohumlu bezelye ile beyaz tohumlu bezelye çaprazlanırsa beyaz tohumlu bezelye çıkma olasılığını hesaplarlar .

3. Sonuçlar sınıfla tartışılır.

APPENDIX K

AKTİVİTE KAĞIDI 2-a

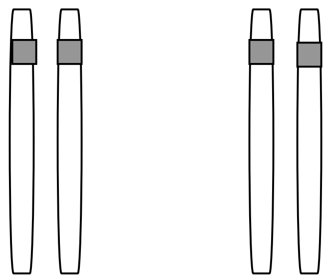
KONU: KALITIM

Amaç: Kalıtsal karakterlerin nesilden nesile nasıl aktarıldığını kavrayabilme

Araç-Gereç:
12 Pipet
Renkli yapışkanlı kağıt

- Grubunuza verilen pipetler anne ve babanın sahip olduğu homolog kromozomları, pipetlerin üzerindeki renkli bantlar ise homolog kromozomlar üzerinde aktarılan bir karakterin alellerini temsil etmektedir.

ANNE BABA



- Pipetlerdeki renkli bantlara bakarak ikişerli kaç farklı grup oluşturabileceğinizi belirleyiniz.

- Belirlediğiniz olasılıkları grubunuza verilen boş pipetler için uygulayınız.

- Sonuçlarınızı tabloya yazarak sınıfla tartışınız.

	ANNE (I. grup pipetler)	BABA (II. grup pipetler)	I. Grup boş pipetler	II. Grup boş pipetler	III. Grup boş pipetler	IV. Grup boş pipetler
Renk						

APPENDIX L

AKTİVİTE KAĞIDI 2-b

KONU: KALITIM

Amaç: Kalıtsal karakterlerin nesilden nesile nasıl aktarıldığını kavrayabilme

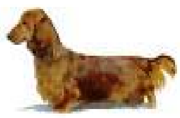
Araç-Gereç:
Madeni para

Yeni bir yavru köpek doğdu ve sahip olduğu özellikleri anne ve babası belirliyor. Yavru köpeğin anne ve babasının sahip olduğu özelliklerden dört tanesi aşağıda verilmiştir. Anne ve baba her özellik için heterozigot ise madeni paranızı anne ve babanın sahip olduğu her özellik için bir kere atarak yavru köpeğinizin dış görünüşünü bulunuz. Aktivite sonunda ortaya çıkan yavru köpeğinizin resmini çiziniz.

	Baskın		**Çekinik**
Özellikler :	Uzun tüy (U)	&	Kısa tüy (u)
	Sert tüy (S)	&	Yumuşak tüy (s)
	Kıvırcık tüy (K)	&	Düz tüy (k)
	Benekli tüy (B)	&	Koyu tüy (b)


Yumuşak tüylü


Sert tüylü


Uzun tüylü


Kısa tüylü


Kıvırcık tüylü


Düz tüylü


Benekli tüylü


Koyu tüylü

	1. özellik	2. özellik	3. özellik	4. özellik
Anneden gelen alel				
Babadan gelen alel				
Yavrunun genotipi				
Yavrunun fenotipi				

***Ortaya çıkan yavru köpeğinizin resmini çiziniz.

APPENDIX M

AKTİVİTE KAĞIDI 3-a

KONU: KALITIM

Amaç: Kalıtsal karakterlerin nesilden nesile nasıl aktarıldığını kavrayabilme

Araç-Gereç:
İki torba
50 kuru fasulye
50 barbunya fasulyesi

Deneyin Yapılışı:

I. BÖLÜM:

- Bir torbaya 25 kuru fasulye, 25 barbunya fasulyesi koyunuz.
- 50 kere torbadan bir fasulye çekiniz, ancak her defasında çektiğiniz fasulyeyi torbaya geri atınız.
- Her fasulye çekişinizde I. tabloya hangi tür fasulye çektiğinizi işaretleyiniz.

II. BÖLÜM:

- Her iki torbaya da 25 kuru fasulye, 25 barbunya fasulyesi koyunuz.
- 50 kere her iki torbadan da birer fasulye çekiniz, ancak her defasında çektiğiniz fasulyeleri torbaya geri atınız.
- Her fasulye çekişinizde II. tabloya hangi tür fasulye çektiğinizi işaretleyiniz.

DEĞERLENDİRME:

1. I. Tabloda toplam kuru fasulye sayısının toplam barbunya fasulye sayısına oranı nedir?

2. II. Tabloda toplam kuru fasulye çekme sayısı, toplam barbunya fasulye çekme sayısı ve bir torbadan kuru fasulye birinden barbunya çekme sayısı nedir?

3. Yapılan bu deneyi genetik konusu ile ilişkilendiriniz.

CURRICULUM VITAE

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EDUCATION

Degree	Institution	Year of Graduation
MS	METU Secondary Science and Mathematics Education	2002
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High School	Kırıkkale High School, Kırıkkale	1994

WORK EXPERIENCE

Year	Place	Enrollment
2000- Present	METU Development Foundation Private Elementary School	Science and Biology Teacher
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Painting, Movies, Theatre, Handcrafts