THE CONTRIBUTION OF LEARNING MOTIVATION, REASONING ABILITY AND LEARNING ORIENTATION TO NINTH GRADE INTERNATIONAL BACCALAURATE AND NATIONAL PROGRAM STUDENTS' UNDERSTANDING OF MITOSIS AND MEIOSIS

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ABSTRACT

THE CONTRIBUTION OF LEARNING MOTIVATION, REASONING ABILITY AND LEARNING ORIENTATION ON NINTH GRADE INTERNATIONAL BACCALAURATE AND NATIONAL PROGRAM STUDENTS' UNDERSTANDING OF MITOSIS AND MEIOSIS

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In this study, the contributions of learning motivation, reasoning ability, learning orientation and gender to International Baccalaureate and National Program students' mitosis and meiosis achievement was investigated.

Participants of the study were 472 ninth grade students from a private high school in Ankara. Two hundred nineteen students (46%) were in International Baccalaureate Program and two hundred fifty three (54%) were in National Program. The study was conducted during the 2006-2007 Spring semester. Prior to the introduction of mitosis and meiosis topics, students' motivations toward biology learning (self efficacy, active learning strategies, science learning value, performance goals, achievement goals, learning environment stimulation), formal reasoning abilities and learning approaches were measured by Students' Motivation Towards Biology Learning Questionnaire, Test of Logical Thinking Ability scale and Learning Approach Questionnaire respectively. After the topics have been covered, a 20 item Mitosis and Meiosis Achievement Test was used to measure achievement in mitosis and meiosis topics.

Multiple regression analysis revealed that achievement was explained in positive direction by formal reasoning ability and in negative direction by active learning strategies and rote learning in National Program classes. Self-efficacy and formal reasoning ability had significant contributions to achievement for International Baccalaureate students. The main predictor of achievement was formal reasoning ability for both International Baccalaureate and National Program students, explaining 4.7% and 10.9% variance respectively. Moreover, while 2.9% of the variance in achievement was explained by self efficacy in International Baccalaureate classes, rote learning explained 2.2% of the variance in achievement in negative direction in National Program classes.

Keywords: Biology Education, gender, International Baccalaureate, National Program, learning approach, mitosis, meiosis, motivation, reasoning ability

ÖZ

ÖĞRENME MOTİVASYONU, MANTIKSAL DÜŞÜNME YETENEĞİ VE ÖĞRENME YAKLAŞIMININ DOKUZUNCU SINIF ULUSLARARASI BAKOLORYA VE ULUSAL PROGRAM ÖĞRENCİLERİNİN MİTOZ VE MAYOZ KONULARINI ANLAMALARINA KATKISI

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Bu çalışmada öğrenme motivasyonu, mantıksal düşünme yeteneği, öğrenme yaklaşımı ve cinsiyetin dokuzuncu sınıf Uluslararası Bakalorya ve Ulusal Program öğrencilerinin mitoz ve mayoz konularını anlamalarına katkıları araştırılmıştır.

Çalışmanın katılımcıları Ankara'daki bir özel lisenin 472 dokuzuncu sınıf öğrencisidir. Uluslararası Bakalorya Programı'nda iki yüz on dokuz öğrenci (%46), Ulusal Program'da ise iki yüz elli üç öğrenci (%54) bulunmaktadır. Mitoz ve mayoz konularında tüm sınıflar aynı eğitim stratejileri kullanılarak eğitim almaktadır. Çalışma 2006-2007 eğitim-öğretim yılı bahar döneminde gerçekleştirilmiştir. Mitoz ve mayoz konularının sınıfta işlenmesinden önce öğrencilerin biyoloji dersine yönelik motivasyonları (öz yeterlik, aktif öğrenme stratejileri, biyoloji öğrenimine değer verme, performans hedefleri, başarı hedefleri, öğrenme ortamının etkisi), mantıksal düşünme yetenekleri ve öğrenme yaklaşımları sırasıyla Öğrencilerin Biyoloji Öğrenimine Yönelik Motivasyonu Anketi, Mantıksal Düşünme Yetenek Testi ve Öğrenme Yaklaşımları Anketi kullanılarak ölçülmüştür. Konu bitiminde ise mitoz ve mayoz konularındaki başarıyı ölçmek amacı ile yirmi soruluk Mitoz ve Mayoz Başarı Testi uygulanmıştır.

Çoklu regresyon analizi sonucu Ulusal Program sınıflarında başarıyı mantıksal düşünme yeteneğinin pozitif yönde, aktif öğrenme stratejileri ve ezberci öğrenmenin ise negatif yönde açıklandığını göstermektedir. Uluslar arası Bakalorya öğrencileri için ise öz yeterlik ve mantıksal düşünme yeteneğinin başarıya anlamlı katkıları bulunmaktadır. Başarının temel belirleyicisi hem Uluslar arası Bakalorya hem de Ulusal Program öğrencileri için, varyansın sırasıyla %4.7 ve %10.9'unu açıklayan mantıksal düşünme yeteneğidir. Bunun yanı sıra Uluslar arası Bakalorya sınıflarında başarıdaki varyansın %2.9'unu öz yeterlik açıklarken, Ulusal Program sınıflarında ezberci öğrenme başarıdaki varyansın %2.2'sini negatif yönde açıklamaktadır.

Anahtar kelimeler: Biyoloji eğitimi, cinsiyet, uluslar arası bakalorya, ulusal program, öğrenme yaklaşımı, mitoz, mayoz, motivasyon, mantıksal düşünme yeteneği.

TO MY FAMILY

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SMTBL: Students' Motivation Towards Biology Learning

SE: Self Efficacy

ALS: Active Learning Strategies

BLV: Biology Learning Value

PG: Performance Goals

AG: Achievement Goals

LES: Learning Environment Stimulation

LAQ: Learning Approach Questionnaire

LAQ-M: Learning Approach Questionnaire- Meaningful

LAQ-R: Learning Approach Questionnaire- Rote

TOLT: Test of Logical Thinking Ability

MMAT: Mitosis and Meiosis Achievement Test

IB: International Baccalaureate

NP: National Program

CHAPTER 1

INTRODUCTION

The purpose of this chapter is to provide an insight into the rationale for the specific topic being studied and selection of the variables. Therefore, the background of the study is examined in the first part, which will be followed by an explanation of the specific study context. Significance of the study and definition of variables will be given in the following two parts. Finally, specific research questions will be stated in the last section.

1.1. Background of the Study

Mitosis and meiosis are topics taught in 9th grade in Turkish education system to all students regardless of the branch they will prefer for the rest of their high school education. Yet, they are not easy topics to understand for them (Finley, Stewart and Yarroch, 1982; Kablan, 2004; Knippels, Waarlo, & Boersma, 2005). This is mostly because students have difficulty in learning and differentiating some terms like DNA, gene, chromosome, chromatid, and they consequently develop misconceptions. Besides, they get into details of the topic too much resulting in an inability to grasp the main idea. Understanding the main idea that mitosis is necessary for producing identical copies of cells and meiosis is a reductive division necessary for keeping the chromosome number constant from generation to generation is the most crucial point in meaningful understanding of the topic. The other details are important for understanding how the processes occur, but they are meaningless unless the students understand the basic principles. Apart from being difficult topics to understand, mitosis and meiosis are also very important since they form the theoretical framework upon which students build knowledge about some future topics such as genetics and reproduction.

It is evident in many research studies that both students and teachers agree on the fact that mitosis and meiosis are two topics that are difficult to learn and they are important topics as well. One such study conducted by Finley et al. (1982) with 100 science teachers in Wisconsin showed that a majority of biology teachers think mitosis and meiosis are among the three most difficult topics in biology, moreover, they are important topics and necessary for acquisition of science knowledge by the student. A more recent study conducted by Kablan (2004) in Ankara, Turkey deserves attention since its results provide insight to the perceptions of the target population in this particular study. The study was based on the results of questionnaires applied to 11th grade students and biology teachers measuring perceptions of respondents on the importance and difficulty of 42 major concepts in Turkish high school biology syllabus in one section, and possible sources of difficulty in learning biology in the other section. According to the results obtained from these questionnaires, topics were ranked according to their difficulty level as perceived by students and by teachers. Meiosis was classified among difficult topics with 33.5 difficulty percentage and mitosis was perceived as difficult by 27.5% of the students. Moreover, genes (39.3%), Mendelian genetics (38.3%), and chromosomes (29.8%) were also classified as difficult. That is, students rated mitosis and meiosis and other topics that require knowledge related to mitosis and meiosis among the first 17 in difficulty scale. The study also shows that teachers perceive these topics as difficult as well, even with higher percentages compared to students. Moreover, above 70% of students and 90% of teachers rated mitosis and meiosis as important topics. The most important reason for difficulty turned out to be rote-memorization in Kablan's study (2004). That is, the students thought that they had to memorize lots of things in these topics. These results seem compatible with the argument in this study that students have difficulty in learning mitosis and meiosis due to the tendency to memorize steps in cell division before understanding the aim of the whole process leading to an inability to grasp the main idea. This is also indicated in the study by the fact that teachers think abstract nature of biology makes students have difficulty in visualizing the topics. As indicated before, another source of difficulty in this topic was the presence of foreign terms leading to misconceptions, and this idea is also supported by Kablan's finding (2004) that many students and teachers see foreign terminology as another obstacle in biology learning.

In a research study into the learning and teaching difficulties in genetics, Knippels et al. (2005) concluded that inadequate understanding of meiosis process and the difference between mitosis and meiosis result in a poor conceptual basis for genetics. They indicate that for understanding the abstract nature of genetics, the difference between somatic cells formed by mitosis and germ cells formed by meiosis should be distinguished, and a clear understanding of these division mechanisms is needed to accomplish this goal. Development of misconceptions regarding terms like chromosome, chromatid and genes is yet another difficulty interfering with adequate understanding of this topic. Oliva (2003) argues that conceptual change necessary to correct misunderstandings is easier for students with higher reasoning abilities. Piaget describes the changes in people's cognitive abilities as they grow older, and he attributes certain abilities to different age groups assuming that all human beings go through similar physical and neural changes throughout their life. But it is also worth noting that children differ from each other with respect to their life experience, environment, social and cultural background. Therefore, they will not go through exactly the same developmental stages and they may show variation regarding intellectual abilities. Fetsco and McClure (2005) indicate that many adolescents do not develop complete formal operational reasoning and cross-cultural studies have shown that formal operational thought is not a universal stage. They also indicate that cognitive development is a gradual process and therefore two people at the same age may have very different cognitive abilities. Keeping in mind that science requires formal operational reasoning; students with different formal reasoning abilities may also differ in their achievement in science as well. Bitner (1991) proposes that achievement in science and mathematics can be predicted using critical thinking abilities and formal operational reasoning modes of students. Therefore, it may be concluded that reasoning ability is a variable that may contribute to success in mitosis and meiosis topics since formal reasoning ability is necessary for forming the connection between mitosis and meiosis processes.

Another variable that may be related with learning difficulties in mitosis and meiosis topics is learning orientation adopted by students as indicated before. Biehler and Snowman (1997) highlight the importance of learner's thinking processes using Ausubel's suggestion that whether a student engages in meaningful or rote learning depends on the learner's intention, or learning set in addition to the nature of the learning task. They indicate that every child has unique cognitive structure and many students believe that memorization is the only way to learn. Therefore these students use rote memorization approach to learn even logically organized programs or discovery problems. Obviously, meaningful learning that will be achieved when students form logical connection between newly presented topics and their existing knowledge is a much more efficient strategy in building up permanent knowledge compared to rote learning. Venville, Gribble and Donovan (2004) stress the importance of meaningful learning in biology, by stating that instruction should not focus on teaching more facts, but on integration of knowledge and building networks for students' understanding of a big picture of biology, particularly genetics. For this general understanding of genetics to occur, meaningful learning of mitosis and meiosis topics is also necessary keeping in mind that understanding of these topics will enable students perceive genetics and reproduction topics and increase their understanding and achievement. Cavallo and Schafer (1994) indicated the presence of research showing the necessity of prior knowledge on meiosis for meaningful understanding of genetics and the relationship between meiosis and genetics. Their research extended this finding by emphasizing the need for meaningful learning orientation in addition to prior knowledge on meiosis for enabling students form meaningful relationships between these two topics. They indicate that for a meaningful understanding of genetics, having knowledge about meiosis, which is a requisite knowledge, and a tendency to integrate this knowledge into the newly presented material is necessary. However, an unanswered question in this research is whether the prior knowledge on meiosis activated meaningful learning in genetics or meaningful learning orientation already contributed to acquisition of requisite knowledge on meiosis when they were first learning the topic. This study may be helpful in answering this question by clarifying the relationship between meaningful learning orientation and achievement in mitosis and meiosis topics.

For meaningful learning to occur, active learning strategies should be used by the students more frequently. Moreover, active participation of students in the learning environment increases their motivation and self-efficacy and provides a better understanding of the topic. Klausmeier and Ripple (1971) stressed the importance of motivation for meaningful learning. They indicate that cognitive drive, which is a component of achievement motivation, is the need to know, understand and solve a problem. A cognitive drive encourages the mastery of the requirements of a specific task. Students eager to participate in the learning process will be well prepared for the lesson and will continuously ask questions so they will focus more on the topic resulting in a better academic performance. But it should be noted that successful completion of a task requires certain reasoning skills as well. Therefore motivation is not only related with meaningful learning, but also reasoning ability. Lawson, Banks and Logvin (2006) report a positive correlation between reasoning ability and self- efficacy, moreover, they indicate that reasoning ability is a good predictor of self-efficacy since completing a task requiring high reasoning skills will make the student more confident about his/her abilities. The role of the teacher here is to implement suitable active learning strategies in his/her lessons beginning with easy tasks suitable for the cognitive abilities of the student and proceed toward challenging tasks to increase their abilities, so provide a motivating environment for the students. Motivation alone does not account for academic achievement of course, but it is obviously a crucial factor. Elliot, Kratochwill, Littlefield and Travers (1996) indicate that although positive evidence that show motivation always improves learning is lacking, learning will suffer if motivation is faulty since discipline problems will arise, attention is limited, and behavior is not directed at objectives. Therefore, investigating the contribution of motivation on achievement together with cognitive variables like learning orientation and reasoning ability seems to be a reasonable attempt.

1.2. Study Context

The sample of the present study consists of students from a private high school in Ankara that applies international baccalaureate and national programs together. The International Baccalaureate (IB) is a pre-university course of studies for secondary school students. The International Baccalaureate Organization (IBO) located in Geneva, Switzerland is founded in 1968, in an attempt to establish a common curriculum for international schools and provide the opportunity for the students to enter universities abroad (Andrews, 2003). Communication and coordination between countries is a growing demand and specific programs like International Baccalaureate are desirable since they promise educating children so as to meet these demands. Raiford (1998) summarizes the goals of the IB Program as production of highly educated generations aware of the necessity of cooperation between people from different countries for solving global problems. It is also indicated that the program aims to form a world community by enhancing the acquisition of common academic experience by students of different educational systems in order to overcome cultural, linguistic and political barriers to communication. Keeping these goals in mind, the curriculum of the IB Program is designed by incorporating the best elements of many countries' secondary school programs rather than applying the educational system of a single selected country. Although the program introduces predetermined objectives to participating schools, teachers still have some flexibility regarding the selection of textbooks and laboratory activities. Candidates are required to select one subject from 6 subject areas; language, second language, individuals and societies, experimental sciences, mathematics and computer science, and arts. Biology is included in the experimental sciences category together with chemistry, environmental systems, physics and design technology. Students are assessed internally by their teachers regarding experimental work, and externally moderated by written examinations on each of the six subject areas. Training seminars and online materials are provided to teachers to help them during implementation and assessment stages. To receive the International Baccalaureate diploma, students also have to complete an interdisciplinary course called Theory of Knowledge (TOK), be involved in definite hours of Creativity, Action, Service (CAS) activities and write an extended essay of 4000 words on a topic that they are interested in. The highly comprehensive curriculum that the program applies is completed in two years and suitable for highly motivated and academically talented students (Andrews, 2003). There are over 700 IB schools all over the world and although there are arguments that achievement should not be a selection criteria for being enrolled in the program, most of these schools select potential IB candidates according to their former academic achievement. Students with medium and low academic achievement may also benefit from this program, but still this is not the case in many schools (Raiford, 1998).

The particular school subject to this study selects students willing to participate in the program based on academic achievement regarding their previous grades. Besides, students can continue in the program for the following years only if they meet some criteria predetermined by the school. These criteria are; (a) having a cumulative grade point of 3/5 at least, (b) having a minimum grade of 4/5 in English, and (c) having passed from every lesson included in the field that they will select (social, science and mathematics, or Turkish and mathematics areas). These criteria are applied as a school policy, not determined by the IB organization. Although the experimental studies and internal assessment does not start until 11th grade, there are some differences between national curriculum and IB curriculum in various disciplines during 9th and 10th grades. However, the national biology curriculum in Turkey is much more comprehensive compared to IB program, so the topics generally overlap except for a few topics, sequence of subjects and some details within the overlapping content. The school has preferred to follow national curriculum by incorporating the IB details into relevant topics and the experimental studies are carried out in 11th and 12th grades. Therefore, 9th grade biology curriculum is similar for IB and National Program (NP) classes and the difference between these two types of classes seems to be the former academic achievement of the students.

1.3. Significance of the Study

As discussed in the previous sections of this study, several research studies classify mitosis and meiosis as important topics due to their relevance to further topics like genetics. They also find these topics difficult due to the difficulty in understanding and learning numerous terms and forming a logical connection between them. Certain cognitive variables, namely formal reasoning ability and meaningful learning orientation, are required for both adequate understanding of these topics and the meaningful understanding of genetics and reproduction in the following years. These variables have been found to contribute to students' achievement in various subjects and setting.

Researchers agree on the fact that students show variation regarding cognitive and motivational variables; and meeting the specific demands of their students for improving their performance has always been a great concern for instructors. Although several studies concerning the relationship between some cognitive variables on achievement in genetics have been documented, a deeper understanding of the connection of these variables to a requisite topic, mitosis and meiosis, is lacking. Moreover, several researchers focused on the relations of cognitive variables with academic performance, but relatively few questioned motivational aspects. Despite their important contribution to achievement, motivational variables were undermined.

Achievement in high school has become increasingly important for entrance into university in Turkish educational system. Moreover, some schools offer special international programs like IB that promises education that meets the needs of a globalizing world to academically talented students. These students may be thought to differ from students with lower academic success with respect to reasoning ability, learning orientation and motivation. However, contributions of these variables to achievement in IB and NP students have not been documented.

Given that mitosis and meiosis topics are considered to be among the most important and difficult topics in biology curriculum as perceived by teachers and students, and students have difficulty in understanding these concepts, it is worth to investigate the contributions of cognitive and motivational variables to students' achievement in these topics in International baccalaureate and National classrooms.

1.4. Definition of Important Terms

The following section presents definitions of the cognitive and motivational variables that were investigated in this study.

Self-efficacy

Self-efficacy is defined as learner's beliefs about their capability of succeeding on specific tasks (Pintrich & Schunk, 2002). It involves students' perceptions related to the difficulty of a task and possibility of succeeding it (Parsons, Hinson and Brown, 2001; Fetsco & McClure, 2005). Higher self-efficacy means a stronger belief in accomplishing a task. Verbal persuasions, previous success in similar tasks and observing other students may make students believe they can be successful, that is, increase their self-efficacy (Pintrich & Schunk, 2002).

Active Learning Strategies

Active learning strategies refer to the use of learning strategies to retrieve existing knowledge to interpret new experiences in order to construct new understanding. Use of active learning strategies by the student indicate that they spend effort to find resources that help them understand concepts and they take an active role in interacting with the environment (Tuan, Chin & Shieh, 2005).

Biology Learning Value

Biology learning value is concerned with students' perception about the value of learning biology. Tuan, Chin and Shieh (2005) identified problem-solving, inquiry, thinking and relevance of knowledge to daily life as features that highlight the value of learning.

Performance Goals

"Performance goals focus on demonstrating a level of competence relative to other people." (Fetsco & McClure, 2005, p 179). Students that have performance goals have a desire to demonstrate high ability and present themselves as competent (Ormrod, 2006).

Achievement Goals

Achievement goals refer to a desire to accomplish learning tasks to increase one's own competence (Tuan, Chin & Shieh, 2005). Students are intrinsically motivated to engage in activities in an attempt to increase their ability rather than being perceived as successful by others.

Learning Environment Stimulation

Learning environment stimulation is related with how students perceive the learning environment regarding interactions of the students with each other and with their teacher, teaching strategies used by the teacher, and activities used in the class (Tuan, Chin & Shieh, 2005).

Formal Reasoning Ability

Formal reasoning ability refers to the cognitive development level of students at formal operational period. This period, beginning in ages 11-12, is characterized by the beginning of logical and abstract thinking. Students at this stage are capable of hypothetico-deductive thinking besides looking for relations, separating real from possible, generating and testing alternative mental solutions to problems, and drawing conclusions by applying rules and principles (Elliot, Kratochwill, Littlefield & Travers, 1996; Parsons, Hinson & Brown, 2001).

Meaningful Learning Approach

Meaningful learning is relating new information to ideas that are already known, and it requires relevant prior knowledge, meaningful material and learner's choice to learn meaningfully (Novak 1998). Students with meaningful learning approach tend to create meaningful links and form relationships between the concepts acquired in a course (BouJaude, 1992). This requires an analysis of what is already known and how it may be used to explain a new situation.

Rote Learning Approach

Rote learning is defined as verbatim memorization of knowledge without any link with prior knowledge by Novak (1998). Students use rote learning approach mostly because they do not know how to process new material (Cavallo, Rozman, & Potter, 2004). Unlike meaningful learning, students with rote learning orientation do not have a tendency to integrate new information with previous knowledge.

1.5. Research Questions and Hypothesis

Research Question 1. What are 9th grade International Baccalaureate and National Program students' self-efficacy, active learning strategies, biology learning value, performance goals, achievement goals, learning environment stimulation, formal reasoning ability, learning orientation and achievement level in mitosis and meiosis topics?

Research Question 2. Are there relationships between 9th grade International Baccalaureate and National Program students' self-efficacy, active learning strategies, biology learning value, performance goals, achievement goals, learning environment stimulation, formal reasoning ability, learning orientation, gender and achievement in mitosis and meiosis topics?

Null Hypothesis: There are no significant relationships between International Baccalaureate and National Program students' self-efficacy, active learning strategies, biology learning value, performance goals, achievement goals, learning environment stimulation, formal reasoning ability, learning orientation, gender and achievement in mitosis and meiosis topics.

Research Question 3. Are there significant contributions of self-efficacy, active learning strategies, biology learning value, performance goals, achievement goals, learning environment stimulation, formal reasoning ability, learning orientation and gender to 9th grade International Baccalaureate and National Program students' achievement in mitosis and meiosis topics?

Null Hypothesis: There are no statistically significant contributions of self-efficacy, active learning strategies, biology learning value, performance goals, achievement goals, learning environment stimulation, formal reasoning ability, learning orientation and gender to 9th grade International Baccalaureate and National Program students' achievement in mitosis and meiosis topics.

Research Question 4. Which variable best predicts 9th grade International Baccalaureate and National Program students' achievement in mitosis and meiosis topics?

CHAPTER 2

LITERATURE REVIEW

This study investigates the contributions of students' motivation towards biology learning, reasoning ability, learning orientation and gender on international baccalaureate and national students' achievement in mitosis and meiosis topics. Accordingly, the purpose of this chapter is to examine the studies related to the above-mentioned variables. The chapter is composed of three parts. In the fist part, research about motivation is reviewed. In the second part, studies related to reasoning ability are explained. In the third part, research related to learning orientation is studied.

2. 1. Research Related With Motivation

Several different definitions for motivation have been proposed by researchers. For example, Biehler and Snowman (1997, p. 399) define motivation as "forces that account for the arousal, selection, direction and continuation of behavior". According to Ormrod (2006, p. 365) motivation is "a state that energizes directs and sustains behavior; it gets students moving, points them in a particular direction, and keeps them going".

Accordingly, motivation can be defined as an internal condition that forces an individual to participate in an activity (Biehler and Snowman 1997; Elliot, Kratochwill, Littlefield and Travers, 2000; Pintrich & Schunk, 2002; Ormrod, 2006). Researchers stress the importance of motivation in emergence and continuation of goal directed behavior. Parsons, Hinson and Brown (2001) indicate that students will be attracted toward and engaged in activities that are perceived as having the potential to meet some need or desire. Depending on the source of this desire that directs behavior, there are mainly two types of motivation; intrinsic and extrinsic.

Extrinsic motivation involves engaging in an activity for reasons external to the task. Fetsco and McClure (2005) state that learners become extrinsically motivated when they recognize a relationship between their actions and receiving some external reward. A reward may be a good grade, praise from teachers or parents, approval of peers, or permission to work on another activity. Motivation without apparent reward on the other hand is called intrinsic motivation. Intrinsic motivation is a strong, positive force in people's lives. Intrinsically motivated students want to complete a task successfully due to an internal desire. There is no need for a reward at the end. Pintrich and Schunk (2002) state that intrinsic motivation is the motivation to engage in an activity for its own sake; and they emphasize Lepper and Hodell's (1989) belief that there are four sources of intrinsic motivation: challenge, curiosity, control, and fantasy. They also indicate that young children have intrinsic motivation to understand and control their environments, which becomes more specialized with development and progression in school. Parsons, Hinson, and Brown (2001) indicate the presence of research showing that intrinsically motivated students achieve higher than extrinsically motivated ones. Parsons et al. also state that using extrinsic motivators too often may result in decreased intrinsic motivation and interest since learning may be restricted to areas that will earn a reward. Motivation accounts for most differences in school achievement and it also determines what can be considered as a reinforcer (Cage & Berliner, 1998). The teacher should decide how to use reinforcers in the classroom. Most motivation theorists assume that motivation is involved in the performance of all learned responses; that is, a learned behavior will not occur unless it is energized. Therefore, it is very important for educators to motivate students due to the belief that students learn and perform desired behaviors only if they are motivated, in other words, energized to do so. Motivated students typically have positive attitudes toward school, cause fewer management problems and describe school as satisfying (Pintrich & Schunk, 2002). Motivated learners approach tasks eagerly and exert high levels of effort and hence all teachers would like to motivate their students. This requires a better understanding of the theories on motivation.

Theories on motivation can be classified into two as behavioral and cognitive theories. Thorndike, Pavlov and Skinner are three important theorists that explained motivation in a behaviorist view. Motivation is explained by observable behavior by behaviorists, thoughts and feelings are not considered as motivational factors. Rather than feelings, students are motivated by environmental stimuli. So it is very important to set the environmental conditions properly as a teacher to be able to motivate students. Behavioral theories view motivation as a change in the rate, frequency of occurrence, or form of behavior (response) as a function of environmental events and stimuli (Pintrich & Schunk, 2002). Motivation increases the likelihood of a behavior. If the students are motivated, they will perform desired behaviors more often and put more effort. Depending on the consequence of their actions, students may tend to pair a stimulus and response with each other, especially if they occur more often. If the student was reinforced after a response, he/she will most probably perform the same way with the same stimulus in the future. Or the reverse may also be true. That is, if the student is punished for his/her behavior, he/she will give up performing that way. Cognitive theories on the other hand, indicate that motivation is internal, so it can not be observed as direct behavior change. They emphasize the importance of internal mental processes such as values, goals, the desire to be perceived as a competent individual, or being successful in social comparisons (Pintrich & Schunk, 2002). Therefore, teachers should take students' thoughts, beliefs and emotions into consideration in order to be motivating. Humanistic theories stress the importance of cognitive processes in motivation by stating that people differ from each other with respect to their cognitive abilities in making decisions about their life. Therefore their responses will not be the same even under the same environmental conditions. Differences in feelings, thoughts, choices, and needs should be taken into account for a complete understanding of human behavior. A well known humanistic theorist is Abraham Maslow. Maslow classified human needs in a hierarchical order. A lower order need should be satisfied for moving to an upper level in the hierarchy. The desire to satisfy these needs results in motivation. Maslow classified basic human needs in two groups as deficiency needs and growth needs. Deficiency needs are physiological needs (water, food, shelter), safety needs, belonginess and love, and esteem needs. Self actualization is the growth need and defined as the need for each individual to develop his/her unique abilities and talents to the highest level possible by Fetsco and McClure (2005). They also define two cognitive needs; intellectual needs which is the tendency to try to understand and explain the world, and aesthetic needs which is the desire to experience beauty and to find or create symmetry and completeness.

One of the most important current theories of motivation is achievement motivation which can be defined as the motivation to succeed. To decide whether he/she is successful or not, an individual compares himself/herself with his/her previous status or with other people. Students are generally motivated to achieve, and are afraid of failing, so they try to do their best to be successful. Pintrich and Schunk (2002) indicate that people think being successful indicates high ability. Failure, on the other hand, is considered as an indication of low ability and it should be avoided. Therefore they point out the connection between achievement motivation and self- worth theory of Covington by indicating that students may feel themselves unworthy if they are not successful. Here, it should be noted that, the outcome should be valuable for the students to desire success. Moreover, they should believe that they can achieve the desired outcome. The outcome of a learning task should be valued and being successful should be expected at that task for the student to be motivated. Fetsco and McClure (2005) explain expectancy-value theory by stating that learners' expectation of success in a given situation will be influenced by their beliefs about the nature of the task and about themselves. They also indicate that these beliefs are influenced by their previous experiences of success or failure with similar tasks. Parsons et al. (2001) concentrate more on the expectancy component of this theory and they relate it to the self-efficacy concept defined by Bandura in their book as the belief about what one can and can not do in a particular situation. Pintrich and Schunk define self efficacy as learner's beliefs about their capability of succeeding on specific tasks. High sense of self efficacy makes learners have more positive beliefs, approach learning tasks more eagerly and spend more effort for them, therefore perform better (Eggen & Kauchak, 1999). Pintrich and Schunk (2002) list some factors that affect self efficacy as stated by Bandura (1986). These factors may be summarized as follows:

- Verbal persuasion: Verbal persuasions by the teacher before a performance, indicating the teacher's belief that the student will succeed, for example, increase self efficacy. The student will be eager to work on that task and spend more effort.

- Psychological state: Psychological constraints unrelated to the task may also influence student's performance.

- Past performance: Positive experiences; like performing well in an exam, being able to ride a bicycle without falling, etc., make the student develop a sense of self-efficacy. So that he/she can try more difficult tasks eagerly.

- Modeling: Observing other similar students for instance, and seeing that they succeed, may increase student's self efficacy since he/she will think that it is possible to complete the task. However, seeing that others fail may make the student think that the task is too difficult to be done.

Students' perceptions related to the difficulty of a task and their success is explained by attributions. These attributions impact their behavior and emotions therefore they are related with motivation since they determine a student's expectations related to future success (Parsons et al., 2001; Fetsco & McClure, 2005). Goal theory explains the relations between goals and attributions, expectations, and motivation. Students determine their goals depending on their perceptions and behave accordingly to achieve these goals. Goals can be classified in two categories as mastery (or learning) goals and performance (or egoinvolvement) goals. A mastery goal refers to knowledge, behavior, or skill that students have to acquire to meaningfully learn the assigned information and skills. Whereas, a performance goal refers to what task students are to complete to demonstrate competence and be judged as able by others (Biehler & Snowman, 1997; Pintrich & Schunk, 2002; Fetsco & McClure, 2005). Mastery oriented students want to increase their knowledge and they believe that working harder will increase success. Therefore they are more motivated to engage in a task and spend more effort. Students who exhibit performance goals on the other hand, are interested in completing tasks to show their ability. They believe that ability is the cause of success or failure and view intelligence as a fixed trait (Pintrich & Schunk, 2002). Therefore, mastery oriented students are more eager to participate in challenging tasks compared to performance oriented students. Teachers can affect student motivation and self efficacy, and hence promote learning by implementing activities that enhance mastery goals. Most strategies for motivating students focus attention on active participation of students in the learning environment. During planning and decision making processes, student characteristics should also be taken into account. Research is directed toward the impact of active learning strategies on motivation, the relationship between motivational constructs and achievement.

Due to the relative importance attributed to motivation regarding academic achievement, many researchers were attracted towards investigating motivational changes associated with the use of different instructional strategies and its ties to student performance. Some other researchers investigated the differences in motivation between different student profiles and changes throughout different stages of students' academic life. One such study is conducted by Anderman and Midgley (1997); who examined the change in student motivation during the transition from elementary school to middle school. They specifically studied the changes in personal achievement goals, perception of the classroom goal structure, and perceived academic competence. They based their study on an expectancy/value model of motivation. The study was conducted on 341 students in a major Midwestern city. Data collection was done in fifth grade (in elementary school) and the next year in sixth grade (middle school). Results indicate declines in personal task goals. Moreover, students perceived that 6^{th} grade classrooms emphasized task goals less, and performance goals more than 5^{th} grade classrooms. Furthermore, during the transition from 5^{th} grade to 6^{th} grade, there was a decline in perceptions of academic competence particularly for high ability students. These changes are attributed to changes in middle school like new academic tasks, changes in grouping and evaluation procedures and peer group relations.

Another research directed at testing the differences between students regarding motivational constructs and hence academic success was performed by Bembenutty and Zimmerman (2003). They examined the relationship between at risk college students' motivational beliefs (self-efficacy, outcome expectancy and intrinsic interest) and use of self-regulated strategies, homework completion, willingness to delay gratification and academic success. They studied with 58 college students in an introductory mathematics course at a public technical college in New York City. The students were enrolled in a 15 week intervention program designed to enhance self-regulatory strategies. Researchers thought that motivational beliefs influence use of learning strategies and hence academic achievement. Students were applied a questionnaire that measured delay of gratification with ten items, self-efficacy with four items, outcome expectancy with 2 items, intrinsic interest with five items, self-regulation with eleven items and homework completion with one item. Cronbach alpha values were all above 0.70. Midterm and final course grades were used as measures of achievement. Path analysis was conducted to examine effects of the variables. The results showed that self-efficacy has an indirect effect (via delay of gratification) and intrinsic interest (β=.45) and willingness to delay gratification (β=.34) had direct effects on self-regulation. Outcome expectancy has a direct effect on delay of gratification (β=.31). Self-regulation has a direct effect on homework completion (β=.45) and final course grade (β=.24). Self-efficacy has a direct effect on homework completion (β=.27). Homework completion has a direct effect on midterm course grade (β=.40) and indirect effect on final course grade via midterm grade. It is concluded that motivational beliefs have causal role in homework completion, delay of gratification and academic success. Students' motivational beliefs effected delay of gratification which in turn effected self-regulation homework completion and hence academic achievement. They pointed out the need for further experimental research regarding these variables.

In a recent study, Hancock (2004) explored the effects of cooperative learning and peer orientation on motivation and achievement. Subjects were 52 graduate students at a state supported university in southeast United States. Peer orientation was assessed using the Learning Style Inventory which is a 12 item measure. Achievement was measured using final examination grades in a graduate level course in educational research methods. Final examination contained fifty short answer items and 12 multiple part essay questions. Motivation to learn was measured using the motivation section of the Motivated Strategies of Learning Questionnaire (MSLQ) consisting of 31 likert type items measuring students' goals, value beliefs for a course, their beliefs about their skills to succeed in a course, and test anxiety. Results indicated a significantly higher motivation for students with high peer orientation. However, achievement scores of these students were not significantly higher than achievement scores of students with low peer orientation. Students liked cooperative learning process due to the opportunity to socialize with group members but they did not value learning as much as they do cooperative learning. They did not put enough effort on the course material. Moreover, some students dominated in the cooperative work and decreased the involvement of others.

Another study related with the impact of different instructional strategies on motivation was performed by Sungur and Tekkaya (2006). In an experimental study, Sungur and Tekkaya tested the affect of Problem Based Learning (PBL) on student's self-reported motivation (intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, test anxiety) and self-reported use of learning strategies (rehearsal, elaboration, organization, critical thinking, metacognitive self-regulation, time and study environment, effort regulation, peer learning, help seeking) as measured by MSLQ. Participants of the study were sixty–one students from two intact classes taught by the same teacher in a high school from a large urban district of Ankara. The MSLQ was administered as pretest and posttest to students in experimental and control groups to determine their motivation and use of learning strategies before and after treatment. Results based on pretest scores revealed no preexisting differences between experimental and control groups with respect to students' self-reported motivation, and self reported use of learning strategies. Posttest mean scores on the other hand, were significantly different in experimental and control groups regarding intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance, and test anxiety. Students instructed with PBL in the experimental group were shown to have a tendency to study biology due to intrinsic forces like challenge, curiosity, and mastery. Furthermore, they thought that biology is more interesting, useful and important compared to other courses. They also used self-regulatory strategies more than control group students. Moreover, although control group students' pre-MSLQ and post-MSLQ scores did not vary significantly, PBL caused an improvement in intrinsic goal orientation, task value, and self-regulatory strategies. PBL students appeared to cooperate with their peers more than students who received traditional instruction. Results from informal talks with the students revealed that these students found peer cooperation beneficial since it gave them the chance to revise their ideas and realize deficiencies in their thoughts. However, no significant positive influence of PBL on control of learning beliefs, self-efficacy and test anxiety was reported. Researchers conclude by stating that PBL improves students' academic performance by teaching students how to learn.

In an early research, Elliot and Dweck (1988) conducted an experimental study to test the hypothesis that performance goals will decrease performance since students with such goals are more concentrated on the adequacy of their ability. Learning goals on the other hand promote mastery-oriented response; make the students focus on increasing ability in case of failure. Failure provides information for them to alter their strategies, so increase performance since students with learning goals believe ability is not a fixed trait. The study was conducted on 101 fifth grade students from semi-rural schools. Students' beliefs about their ability were manipulated using feed back after completion of a task. Children were told that this task measured their ability and half were told that they had high ability and the other half were told that they had low ability after the task was completed. Students' goals (learning or performance) and perceptions about their abilities were induced experimentally and their behavior in case of failure (mastery oriented response or helpless response) was investigated. The results of this study suggest that, when the value of the performance goal was highlighted and children believed they had low ability, they responded to feedback about mistakes in characteristic learned helpless manner: making the attribution that mistakes reflected a lack of ability, responding to them with negative affect, and giving up attempts to find effective ways of overcoming those mistakes." When the value of a performance goal was highlighted and children believed their current skills were high, they responded in a mastery-oriented manner in the face of obstacles. These children persisted in attempts to find solutions and did not make attributions for failure or express negative affect. Yet, like the performance-goal children who believed their current skills were low, performance-goal children with high perceived ability also passed up the opportunity to increase their skills on a task that entailed public mistakes. When the learning goal value was highlighted on the other hand, children's beliefs about their current skills were irrelevant in determining their achievement behavior. Whether they perceived their skill as high or low, they wanted to increase competence. That is, they choose challenging tasks and did not skip opportunities to learn new skills, even with public errors. They responded to failure in a mastery oriented manner-their problem-solving strategies became more sophisticated.

The relationship between achievement and motivation was another concern in the area of motivational research. In a recent study, Kuppermintz and Roeser (2002) examined the role of motivational variables in high school students' science performance. The sample consisted of 491 high school students from a northern

California high school. Data related to the mentioned motivational variables were collected using self reported surveys related to self-efficacy, confidence, goal orientations, moods and emotions, values, effort and engagement, in the first semester; and achievement measures containing 30 multiple choice and 8 constructed response items were completed in the second semester. The items in the achievement tests were selected from National Education Longitudinal Study (NELS) of 1988 science test, National assessment of Educational Progress (NAEP) and the Third International Mathematics and Science Study (TIMSS). Students' science grades were also used as measures of achievement. The partial correlations of each achievement measure with the set of motivational variables were calculated. The results showed that scores on the constructed response portion of the science test showed less correlation with motivational variables compared to multiple choice scores and science grades. Self-efficacy was an exception since it was correlated with all three achievement measures. Students with higher value and interest in science achieved higher scores on multiple-choice test, especially on the basic knowledge and spatial-mechanical dimensions, compared to their science grades in the class. However, engagement in a science class was correlated with science grades. This was explained by the link between involvement in extracurricular science related activities and science interest since multiple choice tests in this study measure knowledge not directly related to classroom learning.

Another study that explored the connection between motivation and biology achievement was performed by Özkan (2003). Özkan explored the roles of students' motivational beliefs (self-efficacy, intrinsic value, test anxiety) and learning styles on 980 tenth grade students' biology achievement. Data were collected using Motivated Strategies for Learning Questionnaire, Learning Style Inventory and Biology Achievement Test. Data were analyzed using Analysis of Covariance to test the differences between males and females and the contributions of self-efficacy beliefs, intrinsic value and test anxiety to biology achievement test scores. Analyses of results showed significant effects of learning styles and gender on achievement. Females were slightly more successful compared to males. Moreover, females had higher intrinsic value compared to males. However, males' self-efficacy was higher than females. Positive correlations between each component of motivational belief and biology achievement were low. There were significant but low correlations between students' self-efficacy beliefs (r=.179), intrinsic value beliefs (r=.143) and test anxiety (r=.166); and their biology achievement test scores. The highest correlation was found between self-efficacy and achievement among the motivational variables studied.

Another attempt to test changes in motivation and its relationship with achievement came from Cavallo, Rozman and Potter (2004). They explored gender differences and shifts in motivational constructs and their relationship with physics understanding and achievement. The specific variables investigated in the study were learning approaches, motivational goals, self-efficacy, epistemological beliefs, reasoning ability and concept understanding from beginning to end of the course. They studied with 290 college students of varying ethnic backgrounds from a large university in the Western United states. They were enrolled in a yearlong inquiry physics course designed to promote conceptual change. The instructors followed a constructivist approach and the course included discussion laboratory sessions 5 hours and 80 minute lecture per week. Tests and questionnaires were applied to the students at the beginning of the fall academic quarter and at the end of the spring quarter. Average of the course achievement grades for fall, winter and spring quarters provided by the instructors were used as a measure of overall physics achievement. Learning Approach questionnaire was applied to classify students as meaningful and rote learners. Achievement motivation was measured using Achievement Motivation Questionnaire (AMQ) composed of 12 likert type questions measuring motivation to learn physics in three scales; learning-goal orientation, performance-goal orientation and self-efficacy. High scores in each scale represent a high desire to learn for learning, high desire to achieve high grades or high sense of self- efficacy respectively. Students' epistemological beliefs about learning science were measured using a Science Knowledge Questionnaire composed of 28 likert type items and

Reasoning Ability Test was used to measure reasoning ability. Students were classified as formal operational or concrete operational according to the results. Force Concept Inventory was applied to determine misconceptions in Newtonian physics. Science beliefs and reasoning ability changed during the course, but the change was not statistically significant and there was no difference between males and females regarding these variables. Concept understanding also increased throughout the course. Achievement was higher for males. Results showed that meaningful learning approach and learning goal orientation increases form the beginning to the end of the course for both males and females indicating that students became more interested in learning physics. Results also indicated an increase in performance goals and higher performance goals for males compared to females which means that males are interested in getting good grades more than females, which is a result contradicting with literature. There was no change in self-efficacy during the course but males had greater self- efficacy compared to females. Achievement was found to be related with self-efficacy. It is indicated that students that are confident are more successful. Males had higher self-efficacy and achieved higher than females. Moreover, females with higher self-efficacy were more successful compared to females with low self-efficacy. At this point, need for a deeper understanding of self efficacy through investigations on the factors like meaningful learning that may be the basis of self-efficacy is underlined. Learning goals were found to be positively related with meaningful learning and performance goals were positively related with rote learning. Students with meaningful learning and learning goals had higher self-efficacy and their achievement was higher. However, male students with rote learning and learning goals had lower achievement, meaning that they had the desire to learn physics but they were not able to. This result was explained by a possibility that doing what is necessary for succeeding in the course was more important for achievement compared to a strong desire to learn the material. This point was also needed to be clarified with further research.

In an attempt to develop a questionnaire called “Students’ Motivation Towards Science Learning”, Tuan, Chin, and Sieh (2005) found out self-efficacy, science learning value, learning goals, learning strategies and learning environment stimulation to be the most important constructs in motivation towards science. Based on this assumption, they designed a questionnaire consisting of six subscales (self-efficacy, active learning strategies, science learning value, performance goals, achievement goals, and learning environment stimulation) and tested its correlations with science attitude and achievement scores. They found out that the questionnaire had significant correlation with students' science achievement scores in previous and current semesters. All subscales except for the learning environment stimulation had significant correlation with achievement in the previous semester and all subscales had significant correlation with science achievement in the current semester, They specifically reported that, among the subscales of the questionnaire, learning environment stimulation had the lowest correlation (r=0.10), and self-efficacy has the highest correlation (r=0.44) with science achievement. Self-efficacy is followed by active learning strategies (r=0.37). It is stated that students with active learning strategies learn more effectively and gain better score on the tests than students that do not use these strategies.

Using the same questionnaire, Tuan, Chin, Tsai and Cheng (2005) performed another research that investigated the effect of a 10 weeks inquiry-based teaching on the motivation outcomes of 8th grade students (N=254) with different learning styles. The experimental group was treated with inquiry based science teaching and the control group was treated with traditional instruction. Information about students' motivation was obtained using SMTSL questionnaire at the beginning and at the end of the study and interviews with students with different learning styles after the treatment. The results indicated a significant increase in the motivation of students in the experimental group, specifically in self-efficacy, active learning strategies, biology learning value, not addressing on performance goal and achievement goal. Moreover, inquiry based teaching was shown to be effective on motivating students regardless of their learning styles in science learning. This finding was supported by their interview results. Most of students expressed their preference in using "laboratory" in learning due to reasons like "laboratory can facilitate comprehension," "laboratory can help memorization," "can conduct hands-on activities," and "laboratory is not boring."

To sum up, research indicated differences in motivational beliefs in different grade levels and student profiles (Anderman & Midgley, 1997; Bembenutty & Zimmerman, 2003). Bembenutty and Zimmerman also indicated an indirect effect of self-efficacy, via delay of gratification and homework completion, on self-regulation and hence academic achievement. Review of related literature also revealed that different instructional strategies like cooperative learning and Problem Based Learning have positive impacts on motivation (Hancock, 2004; Cavallo, Rozman & Potter, 2004; Sungur & Tekkaya, 2006). Although Sungur and Tekkaya reported a positive impact of peer cooperation resulting from PBL on achievement in addition to intrinsic goal orientation, task value, and self-regulatory strategies; Hancock found out that cooperative learning did not always contribute positively to achievement; and explained this by stating that students did not value learning outcomes as much as they do the opportunity to socialize with group members. Another finding of previous studies revealed that students with performance goals responded failure in helpless manner while students with learning goals responded failure in a mastery oriented manner (Elliot & Dweck, 1988). Among the motivational variables of interest, most studies pointed out self-efficacy to be the most important one in determining achievement (Kuppermintz & Roeser, 2002; Özkan, 2003; Tuan et al., 2005).

2. 2. Research Related With Reasoning Ability

Another variable thought to be related with achievement in school is reasoning ability. Piaget states that children go through various developmental stages throughout their life. They do not only undergo physical changes, but also development with respect to cognitive abilities. Knowledge into the developmental stages enables instructional designers to implement activities or learning tasks suitable for the particular capabilities of that age group. Part of this mental development is attributed to alterations in brain structure and formation of new connections between nerve cells. Therefore, there are some developmental patterns that are common to all children. However, they may show differences in physical and cognitive properties depending on their unique life experiences, the environment they come from and inherited characteristics (Parsons, Hinson & Brown, 2001). This may result in variation between children's decision making and reasoning abilities, which may account for differences in science achievement. This connection seems reasonable taking into consideration the fact that high levels of reasoning abilities are required for science process skills like hypothesizing, controlling variables and collecting and analyzing data used in science courses (Valanides, 1997).

Although there are various explanations of mental development regarding neural changes, insight into psychological theories of cognitive development is crucial for being able to understand the change in intellectual abilities of children over time and differences between them regarding reasoning ability. The most influential theory in this area is the cognitive development theory of Piaget. His theory assumes that children are motivated learners and actively construct knowledge about how the world operates by combining information gathered from experience. Hence his theory is based on constructivism (Ormrod, 2006). Learners produce simple schemes by organizing what they learn, and continuously change them into more complex bodies of knowledge by two processes emphasized in this theory; assimilation and accommodation. When the individual encounters a new situation, he/she either explains it by an existing scheme, this is called assimilation; or adapts his/her scheme into this new situation by modifying it or creating a new one, and this is called accommodation. More complex bodies of knowledge develop as new information becomes associated with the previously existing ones. Therefore, Piaget views intelligence as an actively changing trait rather than a stable one, so humans develop more complex understanding as they grow up (Gredler, 2001). This is in part due to the fact that nervous system also undergoes developmental stages throughout the life of an individual. During this progress toward more complex reasoning, experience and social relationships play a very important role, so individuals at the same age do not necessarily have the same reasoning ability. But it is still possible to attribute certain reasoning abilities to certain age groups. Piaget summarizes the changes in reasoning patterns into four successive categories; sensory motor period, preoperational period, concrete operational period and formal operational period.

In sensory motor period, children get to know their environment by observing every object using their sense organs. Ormrod (2006) states that an understanding of cause-effect relationship begins to develop at this stage. Later, in the preoperational period, children develop language skills, so they can engage in social relationships since they can express themselves using words. But they do not have the ability to understand that other people may have different opinions, and they concentrate more on their own needs and feelings. They begin to develop logical thinking ability but still not able to explain their resoning (Ormrod, 2006). The concrete operational stage is characterized by the ability to use hypothetico-deductive reasoning to test descriptive hypothesis, categorize objects and events in higher order classes (Lawson, 2004). They are able to reach logical conclusions and understand other people may have different opinions. Yet they are still able to understand only concrete events rather than abstract ideas. In the formal operational stage, they are no more dependent on concrete reality. They can understand abstract ideas, generate hypothesis and test them so they can exhibit complex scientific and mathematical reasoning skills. Bitner (1991) lists five formal operational reasoning modes as proportional reasoning, controlling variables, probabilistic reasoning, correlational reasoning and combinatorial reasoning; and stress the importance of these abilities for success in science and mathematics.

The theoretical implication that students vary from each other with respect to cognitive development raised attention and brought about research studies that concentrate on differences between students' regarding intellectual abilities and impacts on academic performance. One example for early research in reasoning ability is a study carried out by Lawson and Renner (1975) concerning concrete and formal operational concepts in secondary school biology, chemistry and physics classes. The researchers argue that a large portion of secondary schools students are concrete operational but the curriculum is mainly inappropriate for the students since it is above their level of understanding. The aim of the study was to asses the understanding of concrete and formal operational subjects by concrete and formal operational students. Researchers used four Piagetian styled tasks to determine intellectual development of 134 students from a suburban university town high school in selected biology, chemistry and physics classes. Students were classified into one of seven categories ranging from concrete to formal- operational thinkers. Percentages of students in each category were calculated for each discipline. About 64.8% of the students in biology sample were categorized as concrete operational or partially concert operational, one subject was categorized as transitional formal and no students were fully formal operational. Approximately 92% of chemistry students were post concrete, formal operational or transitional formal. Physics students were mainly between concrete operational and formal operational but the percentage of students in formal operational stage was higher than those in chemistry students. Among the whole sample, 85% of the students were above concrete operational and below formal operational, only 4.8% were formal operational thinkers. The researchers attributed this retarded development to inappropriate subject matter and teaching procedures. Students were also tested in their respective discipline with subject matter tests evaluating their understanding of concrete operational and formal operational concepts. Analysis of the relationship between these scores and the students' scores on the Piagetian tasks showed that the concrete-operational subjects were able to understand concrete concepts but not formal concepts, and formal operational subjects understood both concrete and formal concepts. The correlation between the tasks and understanding of formal concepts is more positive compared to the correlation with concrete concepts. This may be explained by the fact that the teaching procedures used are largely expository so don't provide direct concrete experiences to students. These materials are relatively abstract or formal for the student and understanding does not occur until the student enters formal stage. Researchers suggest that course contents should be evaluated and modified to fit students' intellectual level, so a progress from concrete to formal reasoning may be possible for them.

Bitner (1991) conducted a study on 101 rural students with low socioeconomic levels in grades 9 through 12 in Arkansas to test whether or not the formal operational reasoning modes are predictors of critical thinking abilities and science and mathematics grades. The selected school offered general science, earth science, biology, chemistry and physics courses in the science area. Reasoning ability was assessed by The Group Assessment of Logical Thinking, which is a paper and pencil test with 12 questions requiring multiple choice responses for both correct answer and justification was used. The test measured six modes of reasoning in concrete and formal operational levels. The Watson Glaser Critical Thinking Appraisal consisting of 80 items was used to measure critical thinking ability. The test consisted of selection-type sentence responses following reading passages. The grades assigned by teachers were used as a measure of achievement in science and mathematics. The results of the study confirmed that formal reasoning ability was a statistically significant predictor of both critical thinking abilities and achievement in science and mathematics. Probabilistic reasoning contributed the largest proportion of the variance in critical thinking abilities except for the category recognition of assumptions, where combinatorial reasoning explained the largest percentage of the variance. The type or reasoning that explained the largest percentage of the variance in grades assigned by the teachers in science and mathematics was controlling variables. The large percentage of variance in science achievement explained by formal operational reasoning modes made the researchers conclude that instructional approaches that emphasize procedural knowledge, not only declarative knowledge should be utilized.

Another early research concerned with the relationship between Piaget's theory of cognitive development and how children perform at school was carried out by Mwamwenda in 1993. This study investigated university students' cognitive development levels' relation to academic performance. The study revealed that students that have fully developed formal operations performed better than others. It was suggested that formal operational reasoning may be fostered by implementing problem solving, and discussion activities that require students to think about conflicting situations and analyze their own thinking.

Johnson and Lawson conducted a study in 1998 about the relative effects of reasoning ability and prior knowledge on Biology achievement in expository and inquiry classes. During their study, they worked with 366 students from a community college, approximately half of which received expository instruction, while learning cycle was carried out as an inquiry instruction. According to the results of the reasoning ability pretest applied at the beginning of the semester, students were categorized as empirical, transitional, and hypothetical reasoners corresponding to the concrete, transitional, and formal stages respectively within Piagetian theory. A biology pretest was also administered at the same time to assess prior knowledge. In addition, students were asked to indicate the number of biology courses they have taken previously. Students were exposed to a one-semester expository or inquiry instruction in an introductory biology course, including mitosis, meiosis and genetics topics. Scores in semester examinations and quizzes, final examination and high school biology examination were used to assess achievement. Finally, a reasoning ability posttest was administered. The researchers expected that variance in achievement should be explained by reasoning ability in inquiry instruction and prior knowledge in expository instruction. Results of the study showed that prior knowledge does not effect achievement as much as reasoning ability does in any instructional mode. Researchers explained this result by stating that students did not perform well in the prior knowledge measure and the reliability of this measure was also low. Number of previous biology courses did not predict achievement either. This was explained by the inability of the students to retain knowledge. Reasoning ability on the other hand explained achievement not only in inquiry instruction, but also in expository classes as well. Infact, it was a better predictor in expository classes. Regardless of the instructional method used, there is a positive relationship between reasoning ability and final examination scores. But the difference between hypothetical and transitional reasoners is more obvious in expository instruction. The scores for students in inquiry classes are higher in empirical and transitional stages, but they are almost equal for hypothetical reasoners. This result was explained by a possible increase in the reasoning ability in inquiry classes during the semester that caused the students to perform better by the time the final exam was applied and so decreased the reliability of the reasoning ability pretest causing it to become a less effective predictor of achievement in these classes. According to the results obtained from the study, Johnson and Lawson suggest that biology teachers should lay special emphasis on their students' progress in reasoning ability rather than trying to cover more biology concepts, since reasoning ability is a better predictor of achievement compared to prior knowledge.

To compare the relationships of self-efficacy and reasoning ability to achievement in introductory college biology, Lawson, Banks and Logvin (2006) conducted a study with a sample of 459 students taking introductory biology nonmajor's course at a Carnegie Level I University. At the second week of the semester, student self-efficacy was measured using a test that includes 16 science-oriented tasks using a 5-point Likert-type scale ranging from 1= not at all confident to 5= very confident. Students will get scores ranging from 16 (not at all confident for all tasks) to 80 (very confident for all tasks). These 16 tasks required different reasoning skills, so they were classified into three different levels as concrete, formal or post formal to enable calculation of a composite self-efficacy score for each category. Reasoning ability was also measured at the second week using a modified version of The Classroom Test of Scientific Reasoning which contained 22 item multiple-choice test based on reasoning patterns associated with hypothesis testing (the identification and control of variables, correlational reasoning, probabilistic reasoning, proportional reasoning, and combinatorial reasoning). Students were classified as concrete operational (not able to test hypotheses involving observable causal agents), formal operational (inconsistently able to test hypotheses involving observable causal agents) or post formal (consistently able to test hypotheses involving observable causal agents or able to test hypotheses involving unobservable entities) based on the scores they got from the test. Both self- efficacy and reasoning ability were assessed again at the end of the semester as part of the course final examination. Final course grades which were calculated using scores from three semester examinations, laboratory quizzes and reports and final examination consisting of 45 multiple- choice questions were used as the achievement measure. Some of the questions in the final examination matched with specific self-efficacy tasks. These questions were also classified into concrete, formal, and post formal operational levels. Researchers expected a positive correlation between reasoning ability and self- efficacy since developing formal and post formal reasoning ability contributes to self-efficacy. If students successfully complete tasks that require high reasoning ability, their self-efficacy will also increase. For this same reason, reasoning ability was expected to be a good predictor of self-efficacy (but not the reverse). In addition, they predicted higher correlation of achievement with reasoning ability rather than self-efficacy since high reasoning ability enables the student understand the subject better. To test this hypothesis, stepwise multiple regression analysis was used. First three analyses were done by selecting course grade, total score on the 45 question final examination or partial final examination score on the 22 questions matching with self-efficacy tasks as the dependent variables respectively and post reasoning and post self-efficacy as independent variables. In all cases, regardless of the achievement measure selected, post reasoning accounted for far more variance in achievement (32-35% for all tests) compared to post self-efficacy (1-2%). So, the hypothesis that reasoning ability was a better predictor of achievement was supported. Further analysis were done using pre and post self-efficacy and reasoning scores and the results showed that there is not a significant contribution of self-efficacy to increase in reasoning ability, whereas reasoning ability has considerable impact on both self-efficacy and achievement. Another prediction was that reasoning ability, and hence self-efficacy should increase throughout the semester. This prediction seems reasonable since one aim of this introductory biology course is to enable students develop reasoning patterns via several activities that encourage students to generate questions, try find explanations for them and test these possible explanations. The results supported this hypothesis; both reasoning ability and self- efficacy scores in posttests were higher than pretests. Moreover, post self-efficacy and post reasoning were more correlated with achievement than pretest scores on these variables. Researchers also expected that students at the one reasoning level should have higher self-efficacy for tasks suitable for that particular level (since they have developed the reasoning patterns required), compared to the tasks at higher levels (since these tasks require higher reasoning patterns), and post formal level students would exhibit high self-efficacy for all tasks if three levels of intellectual development really exist. Analysis of relevant data indicated that post formal students had higher self efficacy compared to formal and concrete students, and mean self efficacy scores were higher for concrete and formal tasks compared to post-formal tasks. These results support the hypothesis. But self-efficacy of concrete students was higher than expected for post formal tasks, showing that students overestimated their ability. Researchers explained these results by an argument of Kruger and Dunning (1999) stating that if students do not have the abilities required for a task, they may also be unable to judge their competence for that task. They conclude by saying that challenging tasks that will make students believe they have to put more effort may be implemented into lesson plans to be able to improve these students' reasoning ability.

More recently, Elliot (2006) tested whether differences between students regarding reasoning ability level can explain the variation between students in AP Physics B exam scores and general physics performance. The sample of the study consisted of 15-18 year old students from five public high schools in California. Schools differed from each other with respect to the economic and ethnic makeups of students and academic performance. All 141 students who took the 2005 year AP Physics B exam after completing the course were included in the sample. These students are considered to be academically more talented compared to other students in their schools. The instructions in these schools showed similarities; teacher-led lectures, problem solving, small group problem solving and demonstrations were common teaching strategies used. Reasoning ability was measured using TOLT and students are classified as concrete, transitional or formal thinkers according to the results. AP Physics B exam was used to assess physics achievement. This is a norm-referenced test composed of two parts, a multiple-choice test and a free response questions. Students graded from 1 (no recommendation) to 5 (extremely well qualified). Correlations between the two assessment measures were analyzed using Kendall's Tau-b Test. Chi-square analysis was used to find differences in AP Physics B Exam passing frequencies for students with different reasoning levels. Results showed a significant positive correlation between exam score and total TOLT score. Students with higher TOLT scores were more likely to pass the AP Physics B Exam. Moreover, TOLT subsets- proportional reasoning, isolation and control of variables, probabilistic reasoning, combinatorial reasoning and correlational reasoning- were also correlated significantly with exam score. That is, each of these reasoning abilities is necessary for success on the AP Physics B exam.

Reasoning ability has been subject to some studies in Turkey as well. In their study, Sungur and Tekkaya (2003) investigated the effect of reasoning ability in addition to gender on achievement and attitude in human circulatory system topic. They used Group Assessment of Logical Thinking (GALT), Attitude Toward Biology scale (ATBS), and the Human Circulatory System Concepts Test (HCSCT) to measure reasoning ability, attitude toward biology and achievement respectively. Sample of the study consisted of 47 tenth grade students' from an urban secondary school. Results were analyzed using two-way MANOVA. The results showed that reasoning ability had significant influence on achievement. Formal level students had better scores in HCSCT compared to concrete level students. However, there were no significant differences between transitional level students and formal and concrete level students. It is stated that this result was expected due to the abstract nature of the test content. Another result of this study was that students with higher reasoning abilities had more positive attitude toward biology as well. Therefore, it is suggested that integration of activities that promote scientific reasoning into lesson plans will positively influence both achievement and attitude toward biology.

To be brief, researchers found significant contribution of reasoning ability to achievement. Moreover, they found it be a better predictor of achievement compared to other variables like prior knowledge and self efficacy (Lawson & Renner, 1975, Johnson & Lawson, 1998, Bitner, 1991, Elliot, 2006). It is stated that course contents should be evaluated and modified to fit students' intellectual level, so a progress from concrete to formal reasoning may be possible for them. More emphasis should be given to increasing reasoning ability rather than trying to cover more biology concepts (Johnson & Lawson, 1998) and challenging tasks that will make students believe they have to put more effort may be implemented into lesson plans (Lawson, Banks & Logvin, 2006).

2. 3. Research Related With Learning Orientation

Apart form reasoning ability, another cognitive variable that contributes to success is learning orientation. Learning orientation represents students' approaches to learning which can be classified as meaningful or rote (BouJaude, 1992). Meaningful learning is relating new information to ideas that are already known. Rote learning on the other hand, is memorizing them without any link with prior knowledge (Novak, 1998). BouJaude (1992) indicates that rote learning tend to generate misconceptions or misunderstandings of the science concepts, while creating meaningful links between the concepts acquired in course reduces memory overload and increase the amount of information that can be processed simultaneously resulting in an ability to correct misunderstandings and solve problems. Rote memorization increases the amount of information that has to be dealt with, however meaningful learning reduces knowledge into manageable units, so makes it easier for the learner to cope with new information input. Novak (1998) lists the requirements of meaningful learning as follows:

1. Relevant prior knowledge
2. Meaningful material
3. The learners' choice to learn meaningfully.

That is, although the learner has prior knowledge related to the newly presented material, the learner may not choose to learn meaningfully. This is mostly because the learner does not know how to process new material. If any of these criteria are not met, learners may resort to using rote learning (Cavallo, Rozman, & Potter, 2004). Therefore, teachers may help students develop such skills by using active learning strategies in their classes that foster questioning skills and force the individual to analyze what he/she already knows and how it may be used to explain this new situation.

BouJaude (1992) conducted a research to find the relationship between learning approaches, prior knowledge and attitudes of students with their performance in misconceptions test in a high school chemistry course. The research aimed to analyze how student responses on the same test differed depending on learning strategies. The study was conducted on 49 suburban students with a mean age of 16.8 from two classes in a chemistry course instructed by the same teacher who had 19 years of experience in teaching chemistry and physics. The researcher observed 80 lessons in these classes during a 16 week study. Throughout the course, the instructor used demonstrations and computer simulations to introduce the concepts in four periods of lectures, than laboratory activities were carried out to on these concepts once in a week. A Misunderstandings Test composed of 13 multiple choice questions was developed by the researcher depending on literature information and the results of an interview carried out with 20 junior high school students. Students were asked to select a choice in the test and then explain the reason why they chose that answer in the open ended section that follows. Students' learning approaches were determined using a 39 items questionnaire. The questionnaire used a 5-point likert scale and consisted of two subscales measuring meaningful orientation and surface orientation. To validate the instrument with the sample, the teacher was asked to rate his/her students from 1 to 20 according to his/her perception of their meaningful learning approaches, and classify his/her students as meaningful learners and rote learners. The scores correlated with the results of the questionnaire. Attitude toward chemistry was assessed with a 10 item questionnaire. The results showed that learning approach explained a significant variance in the misunderstanding scores. Meaningful learners performed much better than rote learners in the Misunderstanding test and their results in the explanation part of the test showed that they were able to develop a better understanding of concepts included in the questions. As a result, BouJaude indicates that teachers should pay more attention to help their students relate new information to their existing knowledge and everyday experiences to enable them become meaningful learners, and stresses the need for further research on learning orientation for possibilities of training teachers to become meaningful teachers.

The same year, Cavallo (1992) investigated the retention of meaningful understanding of the biological topics of meiosis, the Punnet square method and the relation between these two topics. Moreover, the predictive influences of students' general tendency to use meaningful or rote learning approaches, prior knowledge of meiosis, and instructional treatment on retention were also investigated. Instructional treatment was different in that, one group was told the relations between concepts, whereas, the other group was asked to construct relations themselves. The results showed that there was a significant positive relationship between attainment of meaningful understanding of students measured immediately after instruction and their retention of meaningful understanding. Moreover, meaningful learning orientation and prior knowledge in meiosis predicted retention of meaningful understanding of meiosis. However, none of these variables predicted retention of meaningful understanding of the punnet square method. They suggest that other variables such as logical thinking ability may also have role in the retention of this method, therefore, they should be investigated further.

Later, Cavallo and Schafer (1994) investigated the relationships between students' meaningful learning orientation and their understanding of genetics topics. More specifically the study aimed to determine if meaningful learning is related to the students' understanding of meiosis and genetics independently from achievement motivation and aptitude. The relationship between learning orientation and the acquisition of meaningful understanding of two different but related biology topics, meiosis and genetics is also being investigated. The study is important in that it also explores the relationship between meiosis and genetics topics, specifically punnet square, in addition to the relative importance of relationships between meaningful learning orientation, relevant prior knowledge and instructional approach. The sample of the study consisted of 140 tenth grade students from college preparatory biology classes in a suburban high school in New York. Learning Approach Questionnaire which is a 24 item likert type scale measuring meaningful or rote learning was used to determine students' learning approaches. Students' scores were listed in order and divided into four categories ranging from 1= more rote learners to 4= more meaningful learners. In addition to the questionnaire, students were also rated by their teachers into 4 categories similarly. Teacher ratings and questionnaire results matched for 94 students, so these students were used in the major analysis. General aptitude was measured using Differential aptitude Test scores obtained from school guidance counselor. Achievement motivation was measured using a likert type questionnaire which consisted of 30 items measuring motivation toward performance goals (high grades, praise and favorable judgments of their work). Following an instructional period on meiosis, students were given two different self- tutorial instructional packets on punnet square method. Researchers thought that traditional testing procedure would not detect the conceptual understanding of the topics meiosis and punnet squares, so a mental model assessment in which students were asked open ended questions in which they would write everything they know about meiosis, punnet square and the relationship between the two. Conceptual knowledge and process or procedural knowledge was scored. Analysis of results showed meaningful learning orientation to be a significant predictor of meaningful understanding of meiosis and the punnet square method and its contribution was much more than aptitude and motivation. However, although students' mental model scores of the procedural and conceptual relationships between the topics were also predicted by learning orientation, aptitude and achievement motivation explained these scores better. Researchers explain this result by stating that forming relationships between topics may require skills beyond meaningful learning orientation or alternatively meaningful learning orientation may be linked to aptitude and motivation. Another result of the study is that both prior knowledge and the ability to relate it to new information are necessary for the meaningful understanding of genetics. But whether prior knowledge activated meaningful learning or meaningful learning of meiosis initially activated prior knowledge is not clear.

In Turkey, Yenilmez (2006) explored the relationship among prior knowledge, meaningful learning orientation, and reasoning ability with understanding of photosynthesis and respiration in plants in traditional and conceptual change classrooms. The participants of the study were two hundred eighty three 8th grade students from Ankara. LAQ was used to measure learning approach, reasoning ability was measured using TOLT, and students' understanding of photosynthesis and respiration in plants was assessed using a concept test. The most important predictor of achievement was found as prior knowledge in experimental group and reasoning ability in the control group. Surprisingly, meaningful learning orientation explained a small amount of variance in experimental group and did not have any contribution to understanding in control group that received traditional instruction. The study also showed that reasoning level of boys was higher than girls as indicated by the lower number of girls at formal reasoning level compared to boys (N= 5 and N= 14 respectively. On the other hand, girls had more meaningful approach (M=34.13) compared to boys (M=32.37). Moreover, a statistically significant, yet small difference in achievement was reported in favor of girls (M=5.83 for girls and M=5.47 for boys).

In another recent study, Atay (2006) investigated the relationships of 8th grade students' achievement in genetics with cognitive variables, including prior knowledge, learning approaches and reasoning abilities, motivational variables including self efficacy, locus of control and science attitude, and gender in learning cycle and traditional classrooms. Sample of the study was 213 students from 2 public elementary schools in Yenimahalle district of Ankara. Students' learning approaches were measured using "Learning Approach Questionnaire", “Test of logical Thinking Ability was used to detect reasoning level, and “Motivational Strategies for Learning” questionnaire was used to assess self efficacy. “Locus of Control” scale and “Attitude toward Science” scale were also used. All these instruments were applied prior to the treatment, in addition to a pretest measuring pre-existing knowledge in genetics. Classes included in the study were randomly assigned into two groups as experimental and control groups. Learning cycle instruction was used in the experimental group and teacher centered traditional instruction was used in the control group. Learning cycle instruction was applied using three lesson plans with two activities for each. Students were required to generate hypothesis and questions, and perform experiments throughout these activities. Following four weeks of instruction, students’ achievement was assessed using “Genetics Achievement Test”. Analysis of results showed that science attitude and meaningful learning orientation contribute achievement positively in learning cycle classrooms; and science attitude, reasoning ability and locus of control contributed achievement positively in traditional classrooms. Interestingly, relevant prior knowledge and learning orientation had negative contribution to success in traditional classrooms. The main predictor of success was learning orientation in learning cycle, and attitude in traditional classes. Formal reasoning ability also explained some variance and meaningful learning had negative contribution to success in traditional classes. When data was analyzed regarding gender differences, it was shown that attitude was the best predictor of achievement of boys in both groups. Whereas, meaningful learning orientation best predicted girls’ achievement in learning cycle classes while the best predictor was reasoning ability for girls in traditional classes. Atay attributed the significant positive contribution of attitude to achievement in learner cycle to classes to the relation of attitude with motivation and interest. She highlights research findings showing that higher motivation and interest will end up with active involvement of the student in lesson and will result in better achievement. The study also showed a positive correlation between reasoning ability and meaningful learning indicating that students with high formal reasoning ability had higher meaningful learning orientation as well.

To conclude, research results showed meaningful learning orientation to be an important predictor of achievement in different instructional settings (BouJaude, 1992; Cavallo & Schafer, 1994; Atay 2006). BouJaude showed a learning approach explained a significant variance in students' misunderstandings in a high school chemistry course and showed that meaningful learners performed much better than rote learners since they were able to develop a better understanding of concepts included. Cavallo and Schafer (1994) showed meaningful learning orientation to be a significant predictor of meaningful understanding of meiosis and the punnet square method. Moreover, they stated that contribution of meaningful learning was much more than aptitude and motivation. However, there was a contradictory study indicating that meaningful learning orientation explained a small amount of variance in understanding of photosynthesis and respiration topics in conceptual change classrooms and did not have any contribution to understanding in control group that received traditional instruction (Yenilmez, 2006). Regarding gender differences, Atay (2006) showed that attitude was the best predictor of achievement of boys in traditional and learning cycle classrooms. On the other hand, the best predictor of girls' achievement was meaningful learning orientation in learning cycle classes, and reasoning ability in traditional classes.

2.4. Research Related With Mitosis and Meiosis

Many research studies have shown mitosis and meiosis topics as difficult and important topics in biology. One such study is conducted in Turkey recently by Kablan (2004). The sample of the study consisted of 369 eleventh grade students and sixteen biology teachers. Participants' perceptions about the difficult and important topics in biology were determined in addition to reasons of difficulty through a questionnaire and interview results. The results showed that 33.5% of students and 87.5% of teachers perceived meiosis as a difficult topic. Moreover, mitosis and meiosis were selected as important topics by 71.5% and 75.3% of the students respectively. Besides, 93.8 percent of the teachers also thought that mitosis and meiosis were important topics. Rote memorization, abstract nature of the concepts and foreign terminology were the most important sources of difficulty. These topics were perceived as important topics since they were thought to be fundamental concepts for the biology curriculum.

In another study by Finley, Stewart and Yarroch (1982), mitosis and meiosis were identified as difficult and important topics by teachers. The sample of the study consisted of 100 teachers in Wisconsin from various disciplines including biology. Data collected through questionnaires reveled that biology teachers rated mitosis and meiosis among the most important and difficult three topics in biology.

Since they are perceived as difficult and important topics by both students and teachers, mitosis and meiosis were also subject to research studies that aim to determine deficiencies related to these topics in textbooks and learning difficulties that students have. Balls and Godsell (1973) stated that although mitosis is a fundamental topic in cell biology, many textbooks ignored this topic and had defects. Researchers thought that although textbooks described stages of mitosis in detail, discussion of interphase events was insufficient. Moreover, discussions about DNA structure and DNA replication were contained in sections much before cell division. Researchers suggest that these topics shouldn't be separated from cell division. They also pointed out that, use of mitosis to indicate cell division a source of confusion for students. Finally, use of resting stage instead of interphase was identified as another defect in textbooks.

Other researchers attempted to identify difficulties in learning mitosis and meiosis in addition to the connection of these topics to a further topic in biology, genetics. An early research conducted by Stewart, Hafner and Dale (1990) investigated students' understanding of meiosis, chromosomes and genes. The results revealed that without a clear understanding of meiosis mechanisms, solutions to genetics problems will be difficult, even impossible. Although students have learned some details like doubling and dividing of chromosomes, they could not relate this information to genetics problems. Therefore, during meiosis instruction, information about how these concepts relate to genetics should be emphasized and areas like homologous chromosomes and crossing-over must be made explicit.

Other research studies were interested in determining learning difficulties regarding mitosis and meiosis topics. Kindfield (1994) investigated the misunderstandings related to meiosis in a college genetics course. Research participants were individuals from different expertise levels in genetics; experts, experienced novices and inexperienced novices from a research university genetics department. The study reported individual interview results related to meiosis models utilized by the participants. Results revealed that inexperienced novices had misunderstandings related to chromosomes and all expertise levels showed process misunderstandings like the timing of replication, alignment and segregation, and crossing-over. Comparison of mitosis and meiosis during instruction contributed to some misunderstandings. It is suggested that chromosome movements and interactions should be emphasized during mitosis and meiosis instruction rather than phase names. Moreover, differences between mitosis and meiosis regarding pairing of chromosomes should be clarified. Researcher also suggests that nuclear division should be taught from a cell cycle perspective and opportunities for direct reasoning about meiosis process should be provided to students.

More recently, Lewis, Leach, and Wood- Robinson (2000) studied students' understanding of the processes of cell division and fertilization. They identified students' difficulties and the reasons for these difficulties in these topics. They collected data using two question sets that focused on students' understanding of the processes and purposes of mitotic and meiotic cell divisions and fertilization. The results of this study indicated that students had limited, and inconsistent understanding of cell division. Researchers explained the inconsistency in student's answers by suggesting that although students understood some aspects, they were unable to explain the whole processes of mitosis and meiosis due to a lack of coherent conceptual framework. Students were aware of the general functions of mitosis, meiosis and fertilization, but they did not understand the processes clearly. They were also aware of the differences between mitosis and meiosis, but unable to clarify the nature of these differences regarding chromosome numbers and genetic information. Some students did not understand that meiosis is a division and confused it with fertilization. The study also revealed that terminology was an important problem in understanding these topics. Students were confused with and unable to differentiate some terms used to describe processes and did not understand the relationship between genes and chromosomes clearly. Researchers concluded that identification of the similarities and differences between mitosis and meiosis regarding purpose, process and product would be helpful for students.

Briefly, research related with mitosis and meiosis topics revealed that students had difficulties in understanding the processes and were unable to form a consistent conceptual frame work for the topic (Stewart, Hafner & Dale, 1990; Kindfield, 1994, Lewis, Leach & Wood-Robinson, 2000). Another difficulty in understanding these topics was terminology, including phase names, terms used to define processes and differences between genes and chromosomes, was also an important problem in understanding these topics (Kindfield, 1994; Lewis et al., 2000). Moreover, students were not able to differentiate between mitosis and meiosis clearly and they did not understand the products and purposes of these processes (Lewis et al., 2000). It was also stated that a clear understanding of meiosis is necessary for success in genetics (Stewart et al. 1990).

2.5. Research Related With Gender Differences

Gender is a widely investigated issue in science education. Scientific discourses are perceived to be more suitable for boys; and girls separate themselves from science, particularly physical sciences and engineering as they mature, although they do well in early grades (Brickhouse, 2001). Brickhouse states that girls have difficulty in constructing scientific identities. Research shows that high school males like science courses more than females, select science courses more often as their favorite course and more often planned to major science in college

(Miller, Blessing & Schwartz, 2006). Moreover, boys are found to achieve better than girls in science (Steinkamp & Maehr, 1983, Becker, 1989). However, Lee and Burkham (1996) reported a modest advantage for girls in life sciences although boys had a large advantage in physical science. Miller et al. claimed that biology was one science subject females are interested in, possibly because they believe biology is a helping, human related science compared to more abstract scientific principles and methods that they find uninteresting. Moreover, they are more interested in health carriers such as medicine, which is consistent with the finding that they are interested in biology. Boys on the other hand, prefer applied science carriers in engineering, computer science and medicine, but not for helping people.

For many years, a considerable body of research across a number of countries has addressed the gender issue in science education. For example, Stark and Gray (1999) studied children's responses to a questionnaire measuring their preferences for some common science topics and their views on the kinds of learning experiences in school. The sample of the study consisted of grades 4 and 7 primary school (P4 and P7, respectively), and grade 2 secondary school (S2) students in Scotland. The results showed some clear patterns for age and gender. When students' preferences for biology, physics and chemistry topics were examined, in all three stages, approximately 50% of girls chose topics from biological sciences. For boys on the other hand, there was not a clear preference for science topics, their choices were evenly distributed. Moreover, girls' preferences were consistent across year groups; there was only a slight increase in biology topics from P4 to S2. Boys on the other hand were less likely to select biology topics with age. Their preferences shifted from biology topics to physics. Regarding enjoyment of learning activities in science, girls and boys gave similar responses. Boys enjoyed discussing in science groups more than girls. Girls on the other hand liked teacher demonstrations and writing about science activities more than boys.

There are studies that show no significant gender differences as well. Sungur and Tekkaya (2003) investigated the effect of gender on achievement and attitude in human circulatory system topic in addition to reasoning ability. The study was conducted on 47 tenth grade students' from an urban secondary school. The results showed no significant difference between boys and girls regarding achievement and attitude ($p > .05$).

There are more recent studies that show differences between boys and girls regarding science attitude. Murphy, Ambusaidi and Beggs (2006) compared primary school students' attitudes to science in Middle East and West. The specific focus of the study was on the change in students' attitudes as they grow older and the differences between boys and girls regarding attitude. Participants were 944 students from 45 primary schools in Oman and 979 students from 44 primary schools in Northern Ireland. The age range was 9-12 years old. Both samples were composed of 50.2% female and 49.8% male students. The attitude to science questionnaire was used to measure students' attitude, and smaller samples of 30 students were selected based on gender, age and ability from different schools for teacher-pupil discussions with their science teachers. Regarding popularity of science topics, only two topics showed significant differences between boys and girls in Oman. Girls preferred plants, and boys preferred forces and friction. However, there were six topics that showed significant gender related difference in Northern Ireland; healthy living, plants, ourselves and materials were favored by girls and electricity and forces and friction were favored by boys. Regarding science attitude, girls were more positive overall toward science compared to boys in Northern Ireland. However, there were significant differences between boys and girls for only 6 of the 18 statements in the scale in Oman, Girls believed that boys were better compared to girls in science. Girls thought practical work they do is not enough, and they claimed that they liked science more when doing experiments. More boys compared to girls thought that problem-solving is enjoyable, they could talk more in science compared to other subjects, and writing about science was easier than talking about it. Girls were more positive toward practical work, but boys were more positive toward problem-solving. Teacher-pupil discussions revealed that practical work was preferred more than text book learning in science in both countries.

A recent study by Soylu (2006) explored the attitude difference between boys and girls in a biology topic. A survey was conducted to investigate the effect of gender and reasoning ability on understanding of ecological concepts and science attitudes of 8th grade students. The sample of the study consisted of 600 elementary school students in Tosya. Data were collected using Test of Ecology Concepts (TEC), the Attitude Scale Towards Science (ASTS), the Test of Logical Thinking Ability (TOLT) and interviews. Analysis of results was done using Multivariate Analysis of Covariance (MANCOVA). Results showed a significant gender difference with respect to collective dependent variables in favor of girls when the effect of reasoning ability was controlled. Female students' had higher understanding of ecological concepts and their attitude towards science was more positive compared to males. The study also showed that the number of girls at low formal reasoning ability was more than boys, but there were more boys compared o girls at medium formal reasoning ability. The numbers of boys and girls at high level of formal reasoning ability were few.

Recently, Yenilmez, Sungur and Tekkaya (2006) investigated the relationship between students' prior knowledge, reasoning ability, gender and achievement in photosynthesis and respiration topics. Participants were 117 eighth grade students, 59 female and 58 males. Achievement was measured by a 13-item two-tier multiple-choice test. Results showed that reasoning ability, prior knowledge and gender were significant predictors of achievement. Reasoning ability was the main predictor of achievement indicating that understanding photosynthesis and respiration in plant concepts require high reasoning ability. Moreover, there was a statistically significant difference between mean scores for boys and girls. Girls performed better than boys on the test. However, the difference was not large.

To sum up, research has shown that girls are more interested in biology related topics, while boys were interested in physics and chemistry (Stark & Gray, 1999; Miller, Blessing & Schwartz, 2006; Murphy, Ambusaidi & Beggs, 2006). Moreover, girls' preference in favor of biology was consistent across year groups with a slight increase; however boys' preferences in biology decreased and shifted towards physics as they proceed from middle school to secondary school (Stark & Gray, 1999). Regarding carrier choice, girls were more interested in medicine since they thought that they could help people in this area, whereas boys preferred engineering and computer science (Miller, Blessing & Schwartz, 2006). Among science activities, boys preferred science discussions and problem-solving, while girls favored teacher demonstrations, doing experiments and writing about science activities (Stark & Gray, 1999; Murphy, Ambusaidi & Beggs 2006). Boys are found to achieve better than girls in science (Steinkamp & Maehr, 1983, Becker, 1989). However, girls had advantage in life sciences (Lee & Burkham, 1996; Soylu, 2006; Yenilmez, Sungur & Tekkaya, 2006).

2.6. Research Related With International Baccalaureate

The International Baccalaureate Organization (IBO) is a non-profit educational foundation located in Geneva, Switzerland, founded in 1968 (Andrews, 2003). The general mission of the International Baccalaureate (IB) program, which is a pre-university program for academically talented secondary school students, may be stated as development of caring, inquring and knowledgeable generations that are capable of lifelong learning and intercultural understanding (Jackson, 2006). The internationally oriented curriculum of the program is based on a coherent philosophy, yet extremely flexible in its range of topics (Peterson, 1977). IB curriculum incorporates the best elements of many countries' secondary school programs that fulfills the requirements of many national education systems and gives IB diploma holders the opportunity to enter leading universities all over the world (Jackson, 2006). Students select one subject from each of the six subject areas; language A1, second language, experimental sciences, mathematics and computer sciences, individuals and societies, and arts. Moreover, they complete another course called Theory of Knowledge (TOK). This course allows students to focus on critical thinking and develop a coherent approach to learning by examining the process of knowledge acquisition in an interdisciplinary study (Nugent & Karnes, 2002). Moreover, they write an extended essay of 4000 words on a topic that they are interested in. (Andrews, 2003). They also have to be involved in Creativity, Action, Service (CAS) activities that allow students share their talents with others by participating in school productions, sports or community service outside the classroom (Nugent & Karnes, 2002). CAS activities are monitored but do not get any points (Laurent-Brennan, 1998).

Evaluation is done by external examinations prepared by IB office and internal assessment by classroom teachers in each subject area on certain prescribed activities like portfolios and guided coursework. IB exams are given in May and grades are on a 1to 7 scale, 4 considered passing (Laurent-Brennan, 1998). Teachers' grading of the students' work is evaluated by IB examiners as well to ensure common standards for all IB schools worldwide, and they become part of the final IB mark in that subject (Tookey, 2000). Tookey lists the benefits of the IB program for students as follows:

- High international standards help establish a task-oriented classroom with a team atmosphere with the teacher as coach.

- Positive consequences for excellence, rigor, and hard work. 3. Diverse abilities like organizing, planning, interpreting data, evaluating success and failures and presenting results effectively, are rewarded by the various sets of criteria for each subject.

- The valuing of different abilities as indicated above permits gifted students to realize their abilities and the areas that they could develop further.

- Encourages students to try things they might not be particularly good at, thus freeing them from the need to be perfect.

- The opportunity for personal work is provided. IB students spend a good deal of time on projects that they find personally interesting.

- Motivation is developed. The IB student is encouraged to be active, contribute to the group, and be individually productive all through the program. Hence, any problems a student has with motivation quickly surface.

The achievement of biology, physics and chemistry students in IB program was compared with achievement of students in regular program in a study conducted by Poelzer and Feldhusen (1996). The sample of the study consisted of 708 students at grades 11 and 12 enrolled in seven high schools in Canada. Achievement was measured using Advanced Placement (AP) test developed by the College Entrance Examination Board and normed for placement to first or second year university and college in the United States. Results showed that IB students scored significantly higher than regular program students in all sciences. Moreover, interviews with teachers revealed that IB students have higher motivation, task commitment, questioning, desire to understand and management skills compared to students in regular program. Teachers also indicated that they deal with concepts at a more complex level and at a faster pace in IB classes.

Hayden and Wong (1997) explored the extent to which IB actually achieves its aims like providing an appropriate curriculum that will be accepted internationally in addition to support geographic and cultural mobility and promotion of international understanding. They studied the views of a sample of ex-IB students, IB teachers, and university staff that have direct experience of the IB program. The study revealed that as long as appropriate factors are arranged, IB can actually favor mobility and contribute to the development of international understanding in addition to supporting preservation of individual cultures and national identities. Teachers and admission tutors thought that IB students are open minded and knowledgeable, and they are equipped with research skills and the ability to work in teams. Extended essay, language studies and TOK course in addition to the broad range of subjects were identified as the most important causes of these properties and the most successful features of the IB program.

A recent study that explored the benefits of the IB program was carried out by Taylor and Porath (2006). They conducted a survey on IB graduates from two public schools in Canada in an attempt to determine their retrospective views of the program and their beliefs about its long-lasting benefits of the whole program, if any. The study was conducted on 1996 and 2000 graduates in 2005. Their responses to 20 statements on a 4 point likert-type scale and 7 open ended questions. Most respondents thought that they proceeded at a faster pace compared to students not in the IB program. Moreover, they were exposed to a richer curriculum that required in depth discussion of a wide range of topics. Therefore, they had to rush sometimes, but they still felt that the pace was appropriate. They indicated that the program contributed to their development of good critical thinking skills. Minority of respondents thought that the workload was excessive and stressful sometimes since they were worried about not being able to get IB diploma and gain entrance to a university. Yet, many believed that the program helped them develop time management strategies to overcome time constraints and they felt that the workload was not detrimental to their well-being. Over 80% reflected their opinion that they were able to be involved in extracurricular activities as well, mostly due to the CAS activities they were obliged to complete. Although the curriculum was stressful sometimes, they thought that they were intellectually stimulated and they valued the rich curriculum that armed them with skills that helped them in postsecondary school and beyond. A great majority of the respondents thought that they were prepared to introductory level postsecondary courses better than students not in IB. Moreover, many were awarded extra credit at postsecondary institutions. Most IB graduates thought that the IB experience was worthwhile in achieving their career goals.

Thinking that participation in the rigorous IB curriculum may have positive and negative correlates, psychological well-being of IB and general education students were compared in a study by Shanessy, Suldo, Hardesty and Shaffer (2006). They worked with 122 gifted and high-achieving students enrolled in IB program and 176 general education students in a public high school in Southeastern United

States. The school contains an IB high school and a general education high school in the same building. School Climate Scale (SCS) and Self-Efficacy Questionnaire for Children (SEQ-C) were used as data collection instruments in addition to indicators of academic functioning from school records. The study showed that IB students' perceptions of the school climate were more positive; they had higher grade point averages and academic self-efficacy, and less affiliation with negative peers. Moreover, they had good attendance, and did not have behavior problems.

Another study that investigated the perceptions of IB students about the program was that of Vanderbrook (2006), who examined the secondary school experience of five intellectually gifted females enrolled in AP and IB programs in two public high schools in a large city in the Western United States. Data were collected through phenomenological interviews that are lengthy and in depth unlike other qualitative research interviews. A series of three interviews were conducted with each participant. Participants' educational history including their self-reflections on their experiences was investigated in the first interview. The focus of the second interview was current educational experiences of participants. Third interview was focused on the participants' reflection on the impact of those experiences for creating meaning from previous interviews. The results of the study revealed that participants of the study thought that both AP and IB programs are appropriately challenging. However, they felt insufficiently challenged academically and intellectually in some classes. Mostly, teachers of these classes determined students' feelings and beliefs. Therefore, it is stated that teacher training is very important in gifted and talented education in AP and IB programs. Moreover, teachers should be encouraged to participate in professional development in gifted education and to practice specific teaching strategies suitable for these students. They should also be provided with flexibility to adjust curriculum to the individual needs of their students. This will be beneficial for non-gifted, high-achieving students in these classes as well.

To date, few studies have concentrated on comparing IB students with non-IB students. One such study is conducted by Jackson (2006) to examine the achievement of students participating in an International Baccalaureate Middle Years Program (IBMYP) in standardized achievement measures and compare them with the achievement of students of similar ability in schools that do not offer the Middle Years Program (MYP). IBMYP students were learning in a different and more holistic manner, and the study aimed to determine whether these students were still competitive with their counterparts or not. Standards of Learning (SOL) test scores of students in IBMYP and students not in an IBMYP were compared. Students' scores on grade 8 mathematics, English, history/social science, science, and reading SOL tests were used as dependent variable and membership, as an IBMYP member or non-IBMYP member. Since the data were collected from existing student SOL scores available to the school, no other research instrument was used. The SOL tests were administered in March and May and scored by Virginia Department of Education. Results are received by the school electronically from the state. Scores were coded as Fail (0-399), Proficient 400-499), and Pass Advanced (500-600). To compare the scores of students in IBMYP and non-IBMYP, independent samples *t* test was performed. The results showed that average achievement scores in SOL for IBMYP students were higher than non-IBMYP students, however the difference was not statistically significant ($p<.05$). Researcher indicates that IBMYP goals include life long learning, good citizenship, and holistic thinking. However, standardized achievement test scores that do not measure these learning behaviors are still important for parents and school administrators. Since the results of the study showed no statistically significant difference between IBMYP and non-IBMYP students' SOL scores, it is stated that pursuing IBMYP goals does not result in any degradation in standardized test scores. Moreover, although not statistically significant, IBMYP students' scores were higher indicating that programs such as the IBMYP can improve achievement on standardized tests together with providing a more holistic approach to education. It is suggested that IBMYP students may have greater gains in later years, therefore studies to determine whether IBMYP program gains are sustained over time or not may be conducted by other researchers. Research may also be expanded beyond measures of test gains by giving special attention to measures of attitude, motivation and self-image.

Another study conducted by Kyburg, Hertberg-Davis and Callahan (2007) examined if teachers and environments in Advanced Placement (AP) and International Baccalaureate (IB) classrooms in high-poverty urban schools provide appropriate educational opportunities for gifted students. They also investigated the modifications to curriculum; instruction and scaffolding that allow students experience a sense of success and develop readiness to take on new challenges in college in these schools. Sample of the study included 75 students, 9 administrators and 4 counselors from three urban high schools from two Mid-Atlantic States. One school offered both AP and IB, and two schools offered only AP. Each school was visited at least twice by the researchers during the academic year. Participating classrooms were observed for approximately 90 minutes during each visit and observations were recorded using semi-structured protocols. Field notes included recordings of teacher-student interactions, instructional resources used and degree of challenge/rigor evidenced. After classroom observations, interviews were done with small focus groups of three to five students and individually with teachers, administrators and coordinators using semi-structured interview protocols. Documents consisted of teacher planning documents, instructional materials, specific program literature, and student artifacts. Data analysis revealed that gifted learners who were traditionally underserved were provided with educational opportunities in environments where their diverse and complex backgrounds were recognized by teachers. These teachers were able to adopt their instruction to their students' learning styles, interests and backgrounds. Especially the extended essay students are required to complete in the IB program gives the student the freedom to choose topics of their interest and the Theory of Knowledge course encourages them to challenge traditional approaches to problems. Cooperative network of support between administrators, teachers, parents and students increased the expectation that adequate scaffolding and internal motivation would make each student succeed. Students trusted that their teachers would help them succeed, so they were ready to take on the challenges of future schooling in such environments. On the other hand, in environments where support was not present, teachers did not view their students as individuals and tended to design their instruction for homogenous groups without considering students' individual needs. The resulting mismatch was seen as the failure of the student. This approach to AP and IB curriculum was ineffective, and many students dropped out of AP and IB programs in these environments since they believed that these classes were not suitable for their individual needs. The study revealed that, although AP and IB programs are the primary options for talented high school students, heavy reliance upon AP and IB programs ignoring individual needs of students is not wanted. Flexible programming options and instructional strategies that meet advanced learners' needs for cognitive challenge are required within AP and IB programs.

To be brief, research has shown that IB can contribute to the development of international understanding, and promote research and critical thinking skills as well as the ability to work in teams and time management strategies (Hayden & Wong, 1997; Taylor & Porath, 2006). Although the work load is excessive and stressful, this is not detrimental to IB students' well-being, moreover, they have more positive perceptions of the school climate and do not have behavior problems (Poelzer & Feldhusen, 1996; Taylor & Porath, 2006; Shanessy, Suldo, Hardesty & Shaffer, 2006). Research also reveals that IB program does not cause a decrease in achievement in standardized tests, infact, IB students are shown to have higher grade point averages and academic self-efficacy (Shanessy, Suldo, Hardesty & Shaffer, 2006; Jackson, 2006). Extended essay, language studies and TOK course in addition to the broad range of subjects were identified as the most successful features of the IB program (Hayden & Wong, 1997). Rather than heavy reliance upon IB programs ignoring individual needs of students, diverse and complex backgrounds of the students should be realized and flexible programming options and instructional strategies should be implemented for better results (Vanderbrook, 2006; Kyburg, Hertberg-Davis & Callahan, 2007).

2.7. Summary

General results from previous research may be summarized as follows:

- Students differ from each other in motivational beliefs in different grade levels (Anderman & Midgley, 1997; Bembenutty & Zimmerman, 2003). Bembenutty and Zimmerman also indicated an indirect effect of self-efficacy (via delay of gratification and homework completion) on self-regulation and hence academic achievement. Different instructional strategies like cooperative learning and Problem Based Learning have positive impacts on motivation (Hancock, 2004; Cavallo, Rozman & Potter, 2004; Sungur & Tekkaya, 2006).

- Among the motivational variables of interest, most studies pointed out self-efficacy to be the most important one in determining achievement (Kuppermintz & Roeser, 2002; Özkan, 2003; Tuan et al., 2005).

- Significant contribution of reasoning ability to achievement is reported in many research studies. Moreover, it is a better predictor of achievement compared to other variables like prior knowledge and self efficacy (Lawson & Renner, 1975, Johnson & Lawson, 1998, Bitner, 1991, Elliot, 2006).

- Research results showed meaningful learning orientation to be an important predictor of achievement in different instructional settings (BouJaude, 1992; Cavallo & Schafer, 1994; Atay 2006).

- There was contradictory evidence indicating that meaningful learning orientation explained a small amount of variance in understanding of photosynthesis and respiration topics in conceptual change classrooms and did not have any contribution to understanding in control group that received traditional instruction as well (Yenilmez, 2006).

- It is stated that course contents should be evaluated and modified to fit students' intellectual level, so a progress from concrete to formal reasoning may be possible for them. More emphasis should be given to increasing reasoning ability rather than trying to cover more biology concepts (Johnson & Lawson, 1998) and challenging tasks that will make students believe they have to put more effort may be implemented into lesson plans (Lawson, Banks & Logvin, 2006).

- Teachers should pay more attention to help their students relate new information to their existing knowledge and everyday experiences to enable them become meaningful learners (BouJaude, 1992).

- Related literature stresses the need for further research on motivation, reasoning ability and learning orientation in different subject areas to provide better understanding of relationships that have shown to be present.

- Research related with mitosis and meiosis topics revealed that students had difficulties in understanding mitosis and meiosis topics mainly due to terminology, and abstract nature (Kindfield, 1994; Lewis et al., 2000; Kablan, 2004). They were unable to form a consistent conceptual frame work for the topic (Stewart, Hafner & Dale, 1990; Kindfield, 1994, Lewis, Leach & Wood-Robinson, 2000). Differentiating between mitosis and meiosis understanding the products and purposes of these processes were also difficult for students (Lewis et al., 2000).

- Regarding gender differences in science, research indicates that girls favor biology and boys favor physics and chemistry among science topics (Stark & Gray, 1999; Miller, Blessing & Schwartz, 2006; Murphy, Ambusaidi & Beggs, 2006). This result is consistent with the finding that girls were more interested in health related carriers since they thought that they could help people in this area, while boys preferred engineering and computer science, and maybe medicine but not due to a consideration of its relation to human (Miller, Blessing & Schwartz, 2006).

- Science activities, preferred by boys were science discussions and problem-solving, while girls favored teacher demonstrations, doing experiments and writing about science activities (Stark & Gray, 1999; Murphy, Ambusaidi & Beggs 2006).

- Although boys achieve better than girls in science (Steinkamp & Maehr, 1983, Becker, 1989), girls performed better than boys in biology (Lee & Burkham, 1996; Soylu, 2006; Yenilmez, Sungur & Tekkaya, 2006).

- IB program has shown to be successful in development of international understanding, critical thinking skills, the ability to work in teams and time management strategies (Hayden & Wong, 1997; Taylor & Porath, 2006). The most successful features of the program are extended essay, language studies, TOK course and the broad range of subjects (Hayden & Wong, 1997). Flexible programming options and instructional strategies increase te success of the program (Vanderbrook, 2006; Kyburg, Hertberg-Davis & Callahan, 2007).

- Despite the excessive workload, IB students have more positive perceptions of the school climate and do not have behavior problems (Taylor and Porath, 2006; Shanessy, Suldo, Hardesty & Shaffer, 2006). Moreover, they have higher grade point averages and academic self-efficacy (Shanessy, Suldo, Hardesty & Shaffer, 2006, Jackson, 2006).

CHAPTER 3

METHOD

3.1. Introduction

This chapter focuses on the method that was utilized in this study. In the first part, design of the study will be explained briefly. The second part presents the characteristics of the sample of the study. In the next part, the variables of the study are mentioned and following section includes information about the instruments that were used. After explaining the procedure that is applied in this study, data collection and analysis will be explained next. Finally, the last part will focus on the assumptions and limitations of the study.

3.2. Design of the Study

The design of this study was correlational research design that explores the relationship between self-efficacy, active learning strategies, biology learning value, performance goals, achievement goals, learning environment stimulation, formal reasoning ability, learning approach, and gender on 9th grade International Baccalaureate and National Program students' achievement in mitosis and meiosis topics. Data were analyzed using correlation coefficients to interpret relationships between the variables of the study; and multiple regression analysis for a deeper understanding of the contributions of independent variables on the dependent variable, achievement.

3.3. Sample of the Study

The target population of this study was all 9th grade students in Ankara. The research was conducted with an accessible population of 491 ninth grade students from a private high school in Gölbaşı district of Ankara. This particular school was selected since it is the only school in Ankara that offers both International Baccalaureate Diploma Program and National Program to different classes. Students in the school are either enrolled in National Program (NP) classes that introduce regular national program of Ministry of Education, or in International Baccalaureate Program classes that introduce an international curriculum in addition to the national program to voluntary students meeting the requirements of the program as determined by school policy. Students are obliged to have an average grade of 4/5 and no lessons that they fail in elementary school to be able to enter the program, and have to achieve an average grade of 3/4, and an English grade of 4/5 at the end of 9th grade to be able to proceed in the program in the following years of their secondary school education. There were twenty 9th grade classes in the school. Ten of these classes were IB classes and the other ten were NP classes. All 9th grade IB and NP classes were included in the sample of the study. The age of the students included in the study was 15 years old. Two hundred thirty seven students were included in the International Baccalaureate program and two hundred fifty four were attending National Program classes. Of 491 students in the school, 19 students did not wish to participate in the study; therefore the sample size was reduced to 472. The frequencies and percentages of IB and NP students and boys and girls are presented in Table 3.1.

Table 3.1. Distributions of Students Regarding Program Type and Gender

		Frequency (N)	**Percent (%)**
Program	IB	219	46
	NP	253	54
Gender	Boys	260	55
	Girls	212	45
	Total	472	100

IB and NP students showed variations in previous science grades and first term biology grades. For IB students, mean science and first term biology grades of students were *M*=4.6 and *M*=4.1 respectively. For NP students, mean science grade was *M*=4.0 and mean fist term biology grade was *M*=2.8.

3.4. Variables of the Study

There were two types of variables in this study; dependent variable and independent variables.

3.4.1. Dependent Variable

The dependent variable of the study was student's achievement in mitosis and meiosis topics as indicated by their scores on "Mitosis-Meiosis Achievement Test" (MMAT). Achievement was considered a continuous variable and measured on interval scale.

3.4.2. Independent Variables

The independent variables of the study were; gender, program that the student attends (international baccalaureate or national program), formal reasoning ability, learning approach and motivation towards biology learning (self efficacy, active learning strategies, biology learning value, performance goal, achievement goal and learning environment stimulation). Gender and program that the student attends were considered as discrete variables and measured on nominal scale. Motivation towards biology learning, learning approach and reasoning ability were considered as continuous variables and measured on interval scale.

3.5. Instrumentation

The instruments used in this study are Students' Motivation Toward Biology Learning Questionnaire (SMTBL) for measuring students' motivational constructs, Test of Logical Thinking Ability (TOLT) for measuring their formal reasoning ability and Learning Approach Questionnaire (LAQ) for measuring students' approaches to learning. Mitosis and Meiosis Achievement Test (MMAT) were administered for measuring achievement in mitosis and meiosis topic. Detailed descriptions of the instruments are provided below.

3.5.1. Students' Motivation Toward Biology Learning Questionnaire (SMTBL)

A 32 item 5 point likert type instrument called "Student's Motivation Towards Biology Learning" questionnaire was used to assess motivational variables in this study. The questionnaire was translated and adapted from Student's Motivation towards Science Learning (SMTSL) questionnaire developed by Tuan et al. (2005). The original questionnaire consists of 35 items categorized under 6 subscales; self-efficacy (SE), active learning strategies (ALS), science learning value (SLV), performance goal (PG), achievement goal (AG) and learning environment stimulation (LES). There is a five point scale ranging from "strongly disagree" to "strongly agree". The Cronbach alpha ranged between .87-.70 indicating a satisfactory internal consistency. Discriminative validity ranged between .09-.51, showing independence of each scale for their study.

The questionnaire was translated into Turkish and further adapted to Biology by the researcher (See appendix A). The adapted version of the questionnaire was called "Students' Motivation Toward Biology Learning" (SMTBL). Pilot testing of this questionnaire was done on 214 students in September. The items were revised according to the factor analysis results of the pilot study and a second pilot study was performed in February with 137 students. In these pilot studies, all items except for three (items 14, 30, 34) correctly fit into their components. However; item 14 in ALS subscale, and items 30 and 34 in LES subscale in the original questionnaire were included in different subscales. Therefore, these three items were eliminated. This final form of the questionnaire consisting of 32 items is applied to the sample of the study. Table 3.2 presents the results of initial factor extraction.

Table 3.2. Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	9.10	28.44	28.44	9.10	28.44	28.44
2	3.02	9.45	37.89	3.02	9.45	37.89
3	1.60	4.99	42.88	1.60	4.99	42.88
4	1.49	4.64	47.52	1.49	4.64	47.52
5	1.27	3.96	51.49	1.27	3.96	51.49
6	1.12	3.49	54.98	1.12	3.49	54.98
7	1.00	3.14	58.11	1.00	3.14	58.11
8	0.93	2.90	61.02			
9	0.82	2.57	63.59			
10	0.80	2.50	66.09			
11	0.75	2.36	68.44			
12	0.74	2.30	70.75			
13	0.71	2.21	72.96			
14	0.69	2.15	75.11			
15	0.65	2.03	77.14			
16	0.61	1.91	79.04			
17	0.57	1.77	80.81			
18	0.55	1.73	82.55			
19	0.54	1.69	84.23			
20	0.51	1.58	85.82			
21	0.49	1.53	87.34			
22	0.48	1.50	88.84			
23	0.45	1.42	90.26			
24	0.43	1.34	91.61			
25	0.42	1.31	92.92			
26	0.39	1.23	94.15			
27	0.37	1.16	95.31			
28	0.36	1.13	96.44			
29	0.34	1.05	97.50			
30	0.30	0.93	98.42			
31	0.25	0.80	99.22			
32	0.25	0.78	100.00			

Extraction Method: Principal Component Analysis.

According to the results of the initial factor extraction, seven components had Eigen values greater than one and 58.11% of the variance is explained by these seven factors. In addition to factor extraction statistics, the screeplot was also used to decide the number of factors that will be extracted. Figure 3.1. presents the screeplot for the eigenvalues.

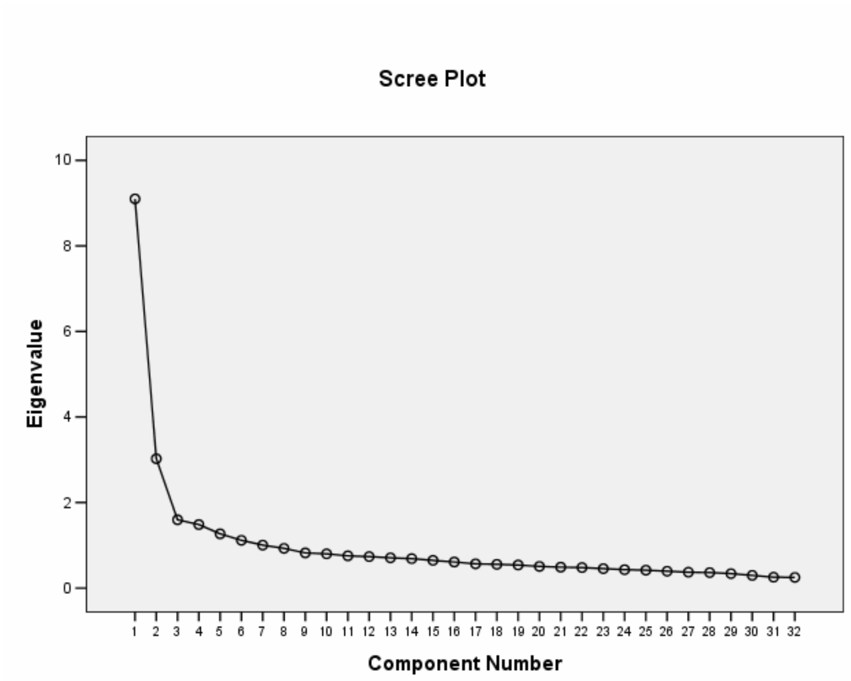

Figure 3.1. Screeplot for Eigen values

Looking at the results, it was decided that extracting six factors is possible. These 6 factors explained 54.98% of the variance in total. The result of the rotated component matrix showing the loadings of each item in these components is presented in table 3.3. These results show that all items fit into their components correctly. The 6 subscales in the questionnaire are termed self-efficacy (SE), active learning strategies (ALS), biology learning value (BLV), performance goal (PG), achievement goal (AG), and learning environment stimulation (LES). Explanations of each subscale, corresponding reliabilitiy values, and example items for the SMTBL questionnaire are presented in Table 3.4.

Table 3.3. Rotated component matrix

	Component					
Item	**SE**	**BLV**	**ALS**	**AG**	**LES**	**PG**
2	**0.77**	0.19	0.08	0.05	0.16	-0.03
1	**0.72**	0.22	0.06	0.06	0.26	-0.10
4	**0.70**	0.16	0.09	0.19	0.00	0.07
5	**0.67**	0.11	0.13	-0.03	0.07	-0.03
3	**0.67**	0.26	0.11	0.10	0.11	-0.06
6	**0.64**	0.15	0.11	-0.08	-0.01	0.12
7	**0.62**	0.05	0.33	0.04	0.05	0.17
16	0.25	**0.69**	0.22	0.06	0.19	-0.05
17	0.28	**0.68**	0.16	0.17	0.13	-0.03
18	0.25	**0.65**	0.18	0.12	0.20	-0.06
15	0.24	**0.60**	0.31	0.10	0.14	-0.02
19	0.35	**0.59**	0.26	0.14	0.01	-0.05
13	0.16	0.20	**0.63**	0.13	0.11	-0.01
11	0.06	0.18	**0.60**	0.06	0.24	-0.22
12	0.29	0.38	**0.54**	0.12	0.06	0.03
14	0.23	0.33	**0.54**	0.24	0.11	0.00
8	0.35	0.12	**0.48**	0.30	0.19	0.07
9	0.38	0.33	**0.41**	0.17	0.15	-0.01
10	0.16	0.37	**0.39**	0.07	0.19	-0.13
27	-0.06	0.28	0.00	**0.67**	0.24	-0.15
26	0.17	0.10	0.28	**0.65**	0.07	-0.05
25	0.15	0.13	0.38	**0.60**	0.14	0.08
24	0.03	-0.11	0.19	**0.59**	-0.11	-0.34
28	-0.01	0.42	-0.13	**0.57**	0.09	-0.29
30	0.17	-0.03	0.09	0.17	**0.78**	-0.05
31	0.13	0.22	0.10	0.19	**0.71**	-0.06
29	0.18	0.19	0.20	0.01	**0.59**	-0.19
32	0.02	0.33	0.23	-0.07	**0.52**	-0.05
22	0.06	-0.16	0.20	0.00	-0.09	**0.73**
21	0.00	-0.22	-0.06	-0.08	-0.12	**0.73**
20	-0.02	0.21	-0.30	-0.11	0.10	**0.65**
23	0.09	0.02	-0.06	-0.27	-0.22	**0.60**

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a Rotation converged in 8 iterations.

Table 3.4. Explanations, item numbers, example items and reliability values for SMTBL subscales

Subscale	Number of Items	Explanation	Example	alpha
SE	7	Students' perception of his/her ability to accomplish biology tasks successfully.	Whether the biology content is difficult or easy, I am sure that I can understand it.	.85
ALS	7	Students' motivation to engage in active learning strategies to construct knowledge while learning biology.	When I do not understand a biology concept, I find relevant resources that will help me.	.81
BLV	5	Students' perception of the value of biology learning.	I think that learning biology is important because it gives me the opportunity to satisfy my own curiosity.	.84
PG	4	Students' desire to be perceived as able in biology.	I participate in biology courses to get good grades.	.68
AG	5	Students' desire to increase competence in biology tasks.	During biology course, I feel most fulfilled when the teacher accepts my ideas.	.72
LES	4	Students' motivation to learn biology resulting from teacher generated environment.	I am willing to participate in biology course because the teacher uses a variety of teaching methods.	.71

A high score in the SE subscale indicates that the student has a strong belief in his/her ability to perform well in biology. A high score in ALS means that the student takes an active role in biology learning in using many ways to construct new knowledge. High BLV score indicates that the student is motivated to learn biology since he/she perceives biology learning as valuable. High PG score means that student engages in academic tasks to perform better than others in biology. High AG score means that student engages in academic tasks to increase his/her ability in biology. Finally, a high score in LES indicates that the student has willingness to learn biology due to the motivation resulting from classroom learning environment.

3.5.2. Test of Logical Thinking Ability (TOLT)

In this study, students' formal reasoning ability was measured by the Test of Logical Thinking Ability (TOLT) in this study. This test, developed by Tobin and Capie (1981), measures five reasoning modes: Controlling variables, proportional, correlational, probabilistic, and combinatorial reasoning. The test consisted of 10 items, 2 items for measuring each reasoning mode. In items 1- 6 measuring control of variables, proportional reasoning and probabilistic reasoning, students were provided with 5 possible answers and 5 justifications for their choice explaining the reason for selecting that answer. They are not only required to select the correct choice, but also have to select the correct justification for their answer to be considered right. This eliminates the possibility of guessing, so increases the reliability of the test. In items 7 and 8 measuring correlational reasoning, students answer as true or false and select among 5 justifications again. The last two questions measure combinatorial reasoning. Students are asked to list possible combinations for the given situations. Depending on the results to the test, students are classified into low (scores from 0 to 3), medium (scores from 4 to 6) and high (scores from 7 to 10) level of formal reasoning categories (Oliva, 2003). Adaptation of the test into Turkish was done by Geban, Aşkar and Özkan (1992) (See appendix B). Cronbach alpha reliability was found as .71 for this study.

3.5.3. Learning Approach Questionnaire (LAQ)

Learning Approach Questionnaire was used to measure students' learning approach and classify them as meaningful or rote learners (Cavallo & Schafer, 1994). The test consisted of two subscales; meaningful learning (referred to as LAQ-M) and rote learning (referred to as LAQ-R). Students selected from four choices ranging from "never true" to "always true". A high score in meaningful scale indicated that the student has a high meaningful learning approach. A high score in rote scale indicated that the student has a high rote learning approach. Yenilmez (2006) translated the test to Turkish. This version of the questionnaire consists of 22 items (See appendix C). Students select from four responses ranging from "strongly disagree" to "strongly agree". The Cronbach alpha reliability was .81 for the meaningful scale and .76 for the rote scale.

3.5.4. Mitosis and Meiosis Achievement Test (MMAT)

A 20 item multiple choice "Mitosis and Meiosis Achievement Test" was used to assess students' achievement in mitosis and meiosis topics (See appendix D). Students are required to select from five choices for each question. The test was prepared using multiple choice questions selected upon university entrance exam (ÖSS) questions. According to Bloom's taxonomy, there are 6 questions in knowledge, 9 questions in comprehension, 2 questions in analysis and 3 questions in synthesis levels. The test was further examined by 8 experienced Biology teachers for content validity and format. The teachers teaching the classes included in the sample of this study were also in this group, and they agreed that the content of the test was appropriate for the instructional objectives they applied. The Kuder-Richardson reliability coefficient was calculated as .79 indicating that the test's level of discrimination is better than average. Most of the items were in comprehension level. Mean item difficulty was calculated as .6, which is within acceptable range, and mean item discrimination is .5 indicating that the items discriminate high and low achieving students successfully.

3.6. Procedure

The study started with definition of research questions. Detailed review of related literature was done following the determination of key words next. Relevant sources were gathered from Educational Resources Information Center (ERIC), Social Science Citation Index (SSCI), Science Direct, Google Scholar and International Dissertation Abstracts. Following the detailed review of these sources, instruments were selected. Necessary permission was taken from the Ministry of education for the administration of instruments.

Pilot testing of the SMTBL questionnaire was done in September 2006. The questionnaire was improved according to the results obtained from pilot study.

The study was conducted in 2006- 2007 spring semester. At the beginning of the study, students were given the Test of Logical Thinking Ability, Students' Motivation Toward Biology Learning Questionnaire and Learning Approach Questionnaire in separate class hours. Teacher support was necessary due to time limitations and the high number of classes included in the study. Teachers were informed about the application of the tests and necessary directions. The purposes of the instruments and the study were explained to the students. They were informed that the results of the study were going to be used only by the researcher and yet they were free to choose not participating in the study. Nineteen students were not willing to participate in the study; therefore they did not complete the questionnaires.

Instruction on mitosis and meiosis topics was done regularly as part of the 9th grade Biology curriculum. Each class was instructed by their Biology teacher and there were not differences in the instructional strategies and materials used in the classes. Classroom instruction consisted of two 45-minute periods each week. After completion of the mitosis and meiosis topic, Mitosis and Meiosis Achievement Test was applied in each class by their teachers in one class hour.

3.7. Data Analysis

All the students were given the same instruments measuring cognitive and motivational variables being studied prior to the instruction about mitosis and meiosis topics. After the topics are completed, they were given achievement test. Following the application of instruments, data obtained were analyzed quantitatively for IB and NP students.

For descriptive analysis, means, standard deviations, possible and actual ranges, skewness and kurtosis values were calculated for each variable in the study separately for International Baccalaureate and National Program students. Histograms were also used to investigate the distribution of scores.

Correlations between all variables in the study were examined for understanding the relationships between them and separate Multiple Regression Correlation Analysis (MRC) were conducted to further investigate data related to the research questions. Contribution of each variable to achievement for IB and NP students were investigated. Analysis was done using SPSS (Statistical Package For Social Sciences) program. The results are summarized in tables and histograms.

3.8. Limitations and Assumptions of the Study

This study was conducted with 9th grade IB and NP students at a private high school in Ankara, so the results can not be generalized to all high school students.

Data obtained relied on self-reported questionnaire results. Students were told to reflect their real thoughts in their responses. Yet, it is possible that some students may have responded in accordance with common beliefs of the society.

Nineteen students were not willing to participate in the study. Therefore all students in the school were not included in the results.

Because of time constraints, teachers were not willing to apply the questionnaires and tests. This is why questionnaire and test items are intended to be short and to the point.

It is assumed that students responded items sincerely and questionnaire results reflect the real ideas of the students.

Instruments were administered under standard conditions and teachers were not biased during the study.

CHAPTER 4

RESULTS

4.1. Introduction

The findings of statistical analysis conducted to answer the research questions are presented in this chapter. The descriptive statistics explaining the characteristics of the sample regarding the variables studied are explained in the first part. The results showing the relationships among these variables are given in the second part.

4.2. Descriptive statistics

The following section provides information about the general characteristics of the sample regarding the variables being studied. Using descriptive statistics, research question 1 was answered.

Research Question 1. What are the self-efficacy, active learning strategies, biology learning value, performance goal, achievement goal, learning environment stimulation, reasoning ability, learning orientation and achievement level of 9th grade International Baccalaureate and National Program students?

Descriptive statistics calculated for both International Baccalaureate and National Program students are presented in table 4.1. The table includes information about possible and actual ranges, mean, standard deviation, skewness and kurtosis values for each variable being studied for IB and NP students.

Table 4.1. Descriptive Statistics for the Variables of the Study

Program	Statistic	SE	ALS	BLV	PG	AG	LES	TOLT	LAQM	LAQR	MMAT
IB	**Mean**	26.43	25.51	17.58	12.87	17.58	12.41	7.80	30.25	27.57	12.99
	SD	5.24	5.05	4.27	3.42	4.06	3.29	1.99	4.92	3.88	3.42
	Possible Range	7-35	7-35	5-25	4-20	5-25	4-20	0-10	11-44	11-44	0-20
	Actual Range	10-35	11-35	5-25	4-20	5-25	4-20	2-10	11-44	18-37	2-18
	Skewness	-0.73	-0.48	-0.68	-0.15	-0.39	0.02	-0.69	0.04	0.02	-1.06
	Kurtosis	0.12	0.16	0.81	-0.42	0.41	0.16	-0.31	0.84	-0.45	1.05
NP	**Mean**	25.03	24.85	16.76	12.10	17.56	12.41	5.82	29.76	28.47	9.26
	SD	5.67	4.48	4.00	2.89	3.40	3.11	2.21	4.47	3.91	3.72
	Possible Range	7-35	7-35	5-25	4-20	5-25	4-20	0-10	11-44	11-44	0-20
	Actual Range	7-35	9-35	5-25	4-20	5-25	4-20	1-10	16-43	11-44	2-20
	Skewness	-0.52	-0.31	-0.58	0.06	-0.31	-0.34	-0.08	0.05	0.26	0.36
	Kurtosis	0.36	0.74	0.84	0.14	0.70	0.23	-0.71	0.79	1.72	-0.38

The dependent variable of the study was achievement in mitosis and meiosis topics. "Mitosis Meiosis Achievement Test" (MMAT) consisting of 20 multiple choice items was used for measuring achievement of students in these topics. Higher scores in the test indicate higher achievement in mitosis and meiosis. Student scores may vary between 0-20 which is the possible range for the test. For IB students, mean score in MMAT was *M*=12.99, which is a score slightly higher than half, indicating that IB students scored above mid-value in the test. MMAT score for IB students is negatively skewed (-1.06) showing that students were successful in mitosis meiosis achievement test and most students had higher scores in the test. The distribution of MMAT scores for IB students ranged from moderate to high.

For National Program students on the other hand, mean score in MMAT was *M*=9.26 which is slightly lower than half, indicating that NP students' achievement was below mid-point. Scores are positively skewed (.36) indicating that most students performed lower in the test. The distributions of scores for IB and NP students are shown in figure 4.1. These results show that IB students performed better in MMAT compared to NP students indicating that their achievement in mitosis and meiosis topics was better.

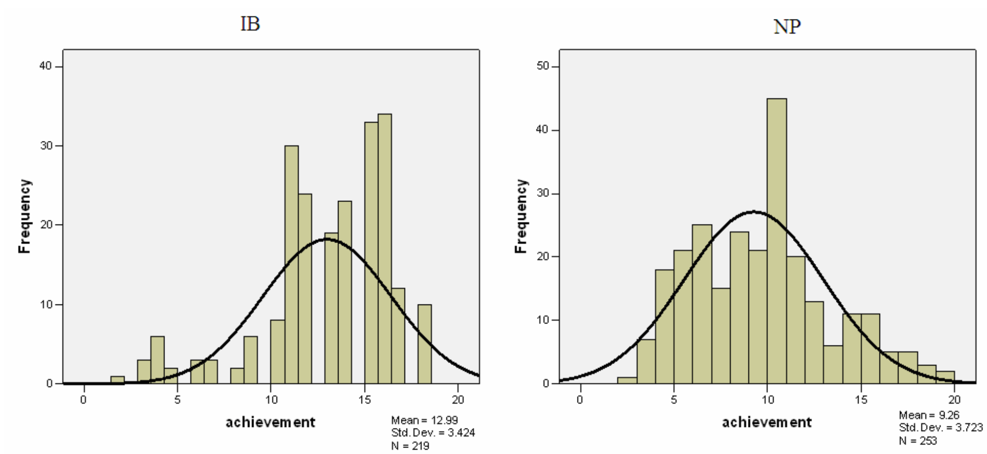

Figure 4.1. Range of MMAT scores for IB and NP students

The figure below compares the numbers of correct responses for each test item for IB and NP students.

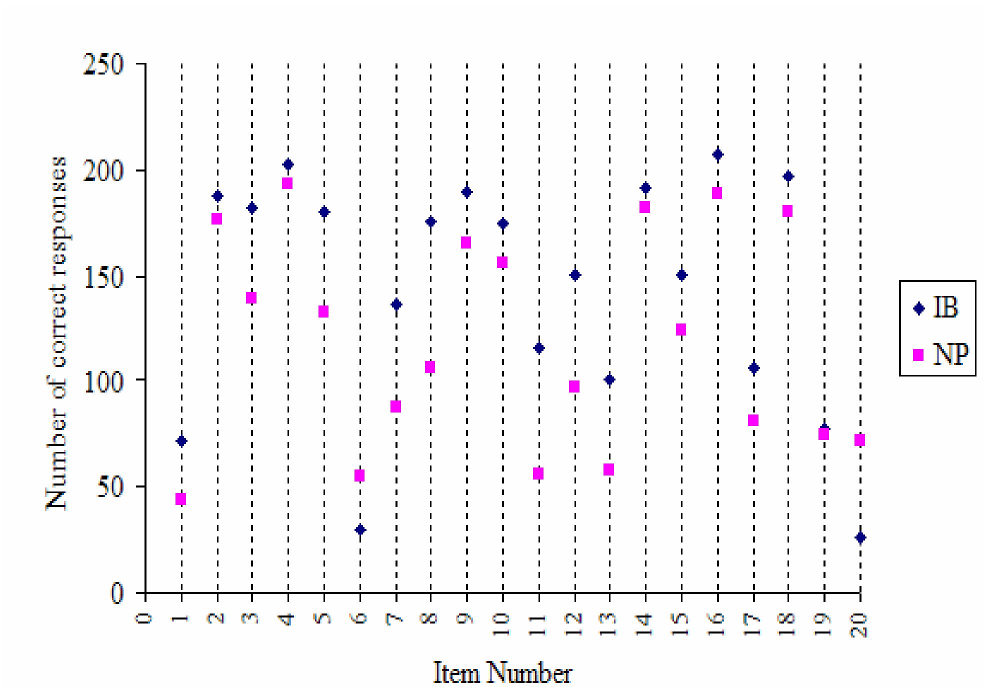

Figure 4.2. Numbers of correct responses for items in MMAT

Figure 4.2 shows that IB students' correct responses were higher than NP students' in MMAT items except questions 6 and 20. NP students responded higher than IB students only in these two items. Question 6 was a comprehension question that requires students to identify the most important reason for mitosis to produce identical cells. Question 20 was an analysis level question that requires the student to conclude about the results of a series of cell divisions. This indicates that although NP students achieved lower scores in MMAT and their correct responses in most items were lower than IB students, more NP students were able to answer these two items correctly compared to IB students. For a deeper analysis of the results in MMAT, table 4.2 presents the frequencies and percentages of correct responses to MMAT items for IB and NP students.

Table 4.2 Frequencies and percentages of correct responses to MMAT items for IB and NP students

	IB		NP	
Item #	**Frequency (N)**	**Percent (%)**	**Frequency (N)**	**Percent (%)**
1	72	33	44	17
2	188	86	177	70
3	182	83	139	55
4	203	93	193	76
5	180	82	133	53
6	30	14	55	22
7	137	63	87	34
8	176	80	107	42
9	190	87	165	65
10	175	80	156	62
11	116	53	56	22
12	151	69	98	39
13	101	46	58	23
14	191	87	182	72
15	151	69	125	49
16	207	95	189	75
17	107	49	81	32
18	197	90	180	71
19	77	35	74	29
20	26	12	72	28

For both IB and NP, highest response rates were seen in items 4 and 16. Item 4 is at knowledge level and requires the student to know the type of cell that will be formed by meiosis. Item 16 was at analysis level and requires the student to identify the correct figure resulting from meiosis. The lowest response rate was for item 20 for IB and item 1 for NP. Both items are at comprehension level.

Independent variables of the study are self efficacy (SE), active learning strategies (ALS), biology learning value (BLV), performance goals (PG), achievement goals (AG) and learning environment stimulation (LES), reasoning ability and learning approach as measured by SMTBL, TOLT and LAQ. Data related to each of these dimensions were analyzed separately. Self efficacy (SE) subscale of the questionnaire consisted of seven items. A high score in this dimension indicates that the student has a strong belief in his/her ability in learning biology regardless of the difficulty of the topic. Means and standard deviations of students in this subscale are summarized in table 4.1. The mean score for IB students was *M*=26.43. This value indicates that IB students' self-efficacy was higher than the mid-value indicating that students have moderate to high belief in their ability in accomplishing biology tasks successfully. They believe they can understand the material presented in biology lessons and perform well in tests whether the topic is easy or not. NP students on the other hand have a mean score of *M*= 25.03. This score is slightly above mid-value indicating NP students have moderate belief in their ability in biology. Mean score for self-efficacy for IB students was slightly higher than NP students. This indicates that IB students' belief in their ability in learning biology is more compared to NP students. Both distributions were negatively skewed indicating moderate to high self efficacy measurements for both groups. The distributions of self-efficacy scores are seen in Figure 4.3 below.

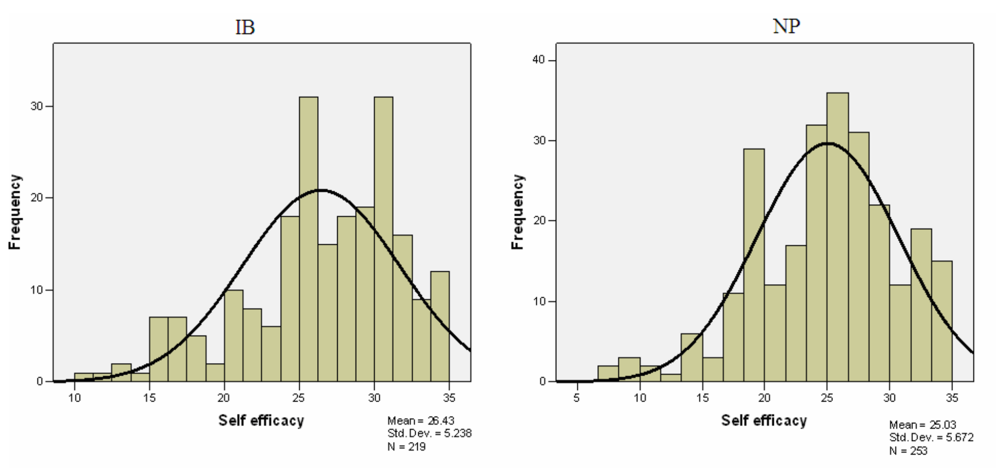

Figure 4.3. Range of SE scores for IB and NP students

The next seven items in the questionnaire measured active learning strategies (ALS). A high score in this scale indicates that the student is motivated to taking an active role in biology learning in using many ways to construct new knowledge. He/she is motivated to find relevant resources that will help him/her, relate the newly presented material with previous experiences and discuss with teacher and peers, and try to find reasons of his/her mistakes. Mean score for ALS was M=25.51 for IB students indicating that students' motivation is above mid-value for using various strategies that will help them construct better understanding of the topic being presented. NP students had a mean score of M=24.85. This value is also slightly above mid-value. This indicates that NP students' tendency to use active strategies to learn biology is slightly lower than IB students' tendency. Scores were negatively skewed for both groups indicating that most students have high ALS scores. The distributions of ALS scores for IB and NP students are demonstrated in figure 4.4.

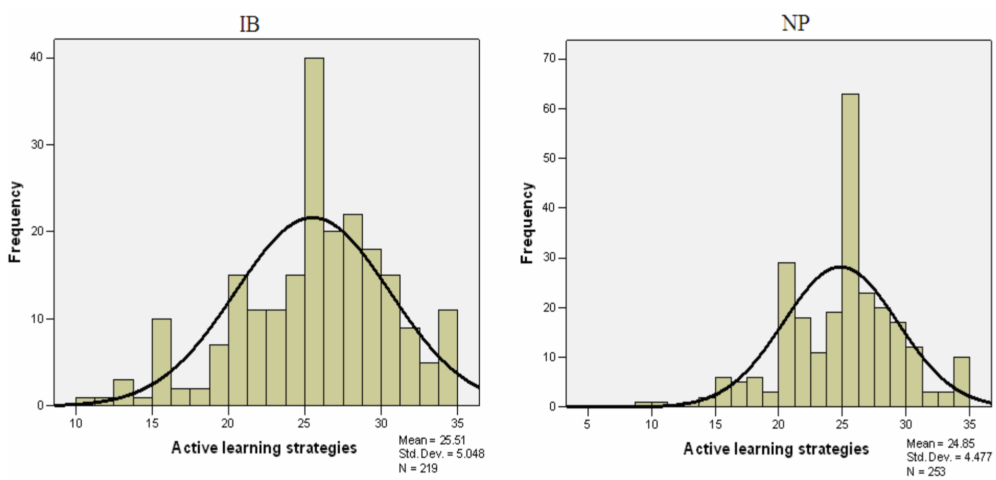

Figure 4.4. Range of ALS scores for IB and NP students

Another motivational variable measured by SMTBL questionnaire was biology learning value (BLV). This subscale contained 5 items and measured student's perception of the value of biology learning. Higher scores in BLV indicate that students believe that the material they learn in this lesson is related to daily life, allows use of inquiry activities and development of scientific thinking, and makes them satisfy their curiosity, so biology learning is valuable. Mean score in this subscale for IB students was *M*= 17.58. This value indicates that IB students' perception of the value of biology learning was above mid-value. For NP students, mean value was *M*=16.76 which is also above average, but slightly lower compared to IB students. This indicates that IB students' motivation to learn biology due to its perceived value is slightly higher. They believe the value of biology in relation to daily life, students' curiosity and contribution in development of problem solving abilities slightly more compared to NP students. BLV scores were negatively skewed for both IB and NP students, indicating that most scores are above average. The distributions of biology learning value scores for IB and NP students are compared in figure 4.5.

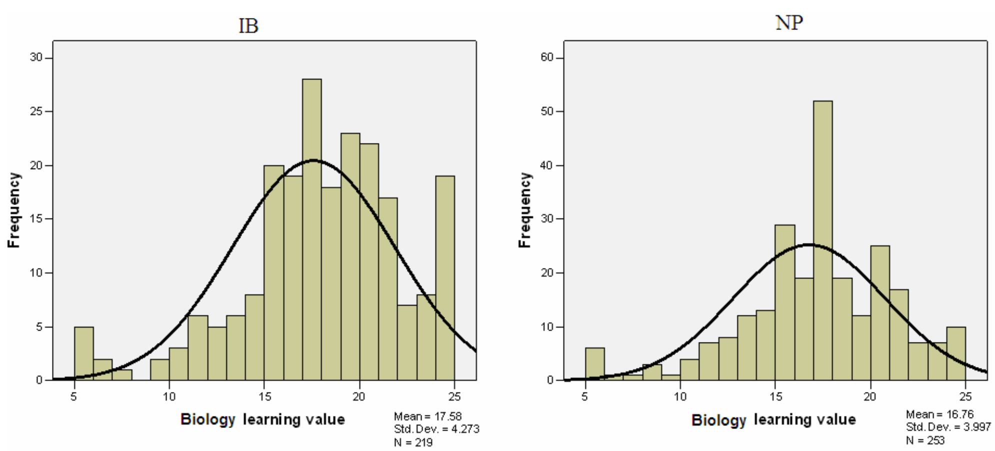

Figure 4.5. Range of BLV scores for IB and NP students

Performance goal (PG) was measured by 4 items in the questionnaire. A high score in performance goals indicates student's tendency to engage in biology activities to be perceived as able by others. Mean score was 12.87 for IB students. This value is slightly above mid-value indicating that IB students agree that they participate in biology activities to be perceived as able by their teachers and peers, to get good grades, and perform better then other students, but not strongly. For NP students, mean score for PG was 12.10. This value is also above mid-value indicating that NP students were also concerned about demonstrating competence. Mean score was slightly lower for NP students. This means that NP students were less concerned about being perceived as able by their peers and teachers. In other words, IB students have slightly more tendency to demonstrate competence. The distribution of scores is represented in Figure 4.6.

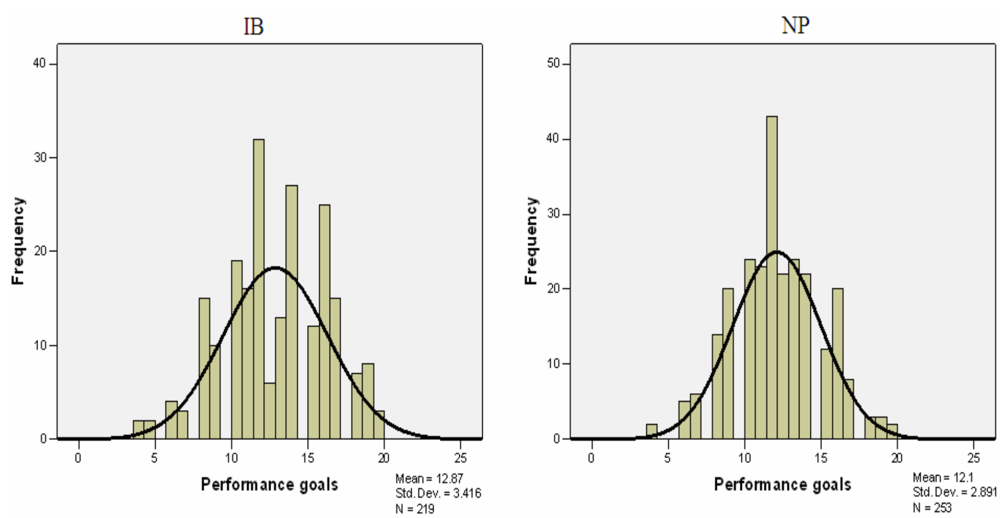

Figure 4.6. Range of PG scores for IB and NP students

Achievement goal (AG) subscale also consisted of 5 items. High AG score means that student engages in academic tasks to increase his/her ability in biology. Mean scores were 17.58 for IB and 17.56 for NP students. These scores are slightly above mid-value. This means that intrinsic motivation for IB and NP students was not much high, indicating moderate tendency for engaging in academic tasks to increase ability in biology. Skewness was slightly negative for both groups (-.39 and -.31) respectively indicating that most students have high scores in AG subscale, that is, higher desire to increase ability in biology tasks for most students. Figure 4.7 demonstrates the distribution of AG scores.

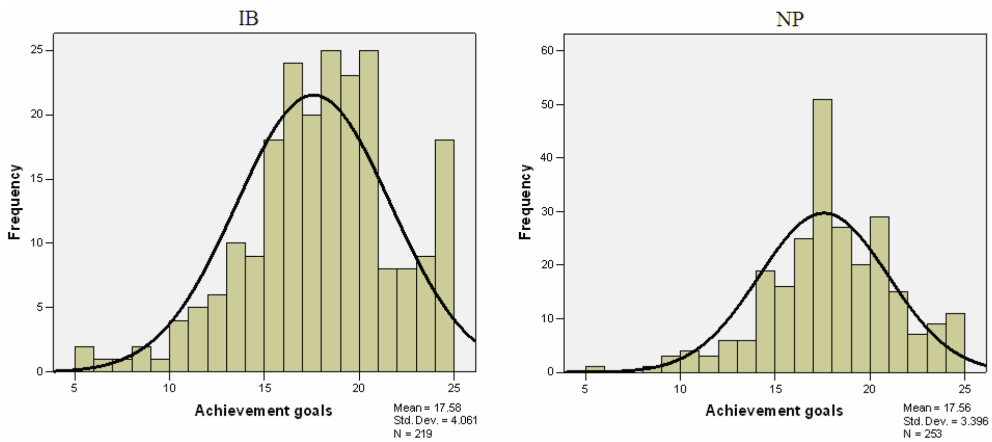

Figure 4.7. Range of AG scores for IB and NP students

Last four items in the test measured learning environment stimulation (LES). A high score in LES indicates student is motivated to learn biology resulting from classroom learning environment, teacher-student, student-student interactions. Mean values for both groups were 12.41, only slightly above mid-value, indicating that both IB and NP students are motivated only slightly due to the stimulation caused by the learning environment in their biology classes. Skewness was nearly zero for IB students, but negative for NP students indicating higher scores for most students. That is, most NP students had higher motivation resulting from learning environment. Figure 4.8 shows distribution of LES scores.

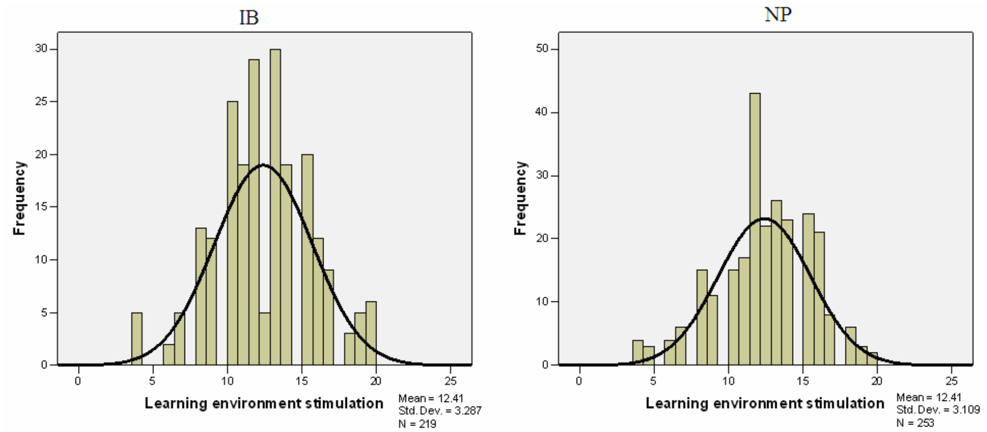

Figure 4.8. Range of LES scores for IB and NP students

To sum up, IB students had slightly high mean SE score students indicating that they had a strong belief in their ability in completing biology tasks successfully. Their perception of themselves regarding the ability to understand biology and perform well in tests whether the topic is easy or not was high. NP students had mean score in SE slightly above mid-value indicating that they believe in their ability in accomplishing biology tasks, but not so strongly. Both IB and NP students had means above mid-value indicating positive perceptions of their ability in biology. IB students had high mean score in ALS subscale as well, indicating that they use active strategies like finding relevant sources, discussing with other students, and trying to form connections between new and previous knowledge often. NP students had mean score in ALS which was only slightly above mid-value, indicating that they use active learning strategies for learning biology but not so often. Mean BLV for both IB and NP classes were above mid-value. This means that both IB and NP students perceived biology learning as valuable since they found materials learned in biology relevant to their daily life and beneficial for developing problem solving and inquiry skill in addition to an opportunity to satisfy their curiosity. Mean scores for both PG and AG were above average but higher in AG for both IB and NP students, indicating that their intrinsic motivation, that is, tendency to accomplish biology tasks for increasing their ability in biology, was more than the tendency to demonstrate competence in the eyes of teachers and peers in biology lessons. Mean LES score for both groups were slightly above average indicating moderate motivation resulting from the teacher generated learning environment in biology lessons.

Another variable investigated in this study was formal reasoning ability. Students' level of formal reasoning ability was measured using TOLT. Table 4.1 showed that IB students' TOLT scores had a mean of *M*=7.8, which is a quite high score indicating that most IB students have developed formal reasoning skills like the ability to solve abstract problems, and to reason and construct logic. Skewness was -.69 indicating that students were successful and most students had higher scores in TOLT. NP students' TOLT scores had a mean of *M*=5.82, which is a score near mid-value indicating that their ability in abstract thinking and reasoning and constructing logic was average. Skewness value for NP students was -.08, meaning that most scores were above the mean. Mean score for NP students was lower than IB students. This indicates that IB students had a high level of formal operational thought, high ability in abstract thinking and using formal logic. Figure 4.9 demonstrates the distribution of TOLT scores for IB and NP students.

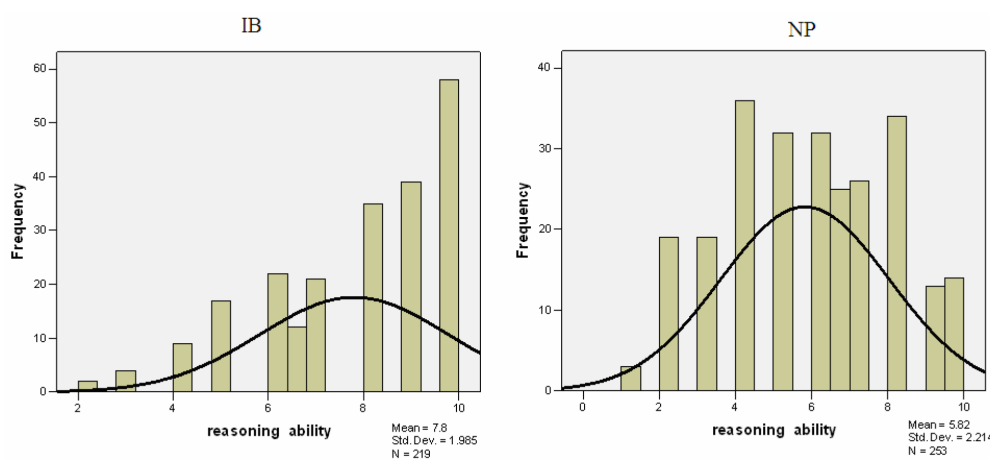

Figure 4.9. Range of TOLT scores for IB and NP students

Table 4.3 shows the numbers and percentages of IB and NP students' TOLT scores. For IB students, the highest percentage of students, which is 26%, scored 10, which is the highest score that may be achieved in TOLT. This indicates that the highest percentage of students in IB classes have developed high levels of formal reasoning patters. In NP however, highest percentage of students, that is, 20% scored 7, indicating that most of the NP students were at earlier stages of cognitive development.

Table 4.3. Frequencies and percentages of IB and NP students' TOLT scores

	International Baccalaureate		**National Program**	
TOLT score	**Frequency (N)**	**Percent (%)**	**Frequency (N)**	**Percent (%)**
0	0	0.00	0	0.00
1	0	0.00	3	1.19
2	2	0.91	19	7.51
3	4	1.83	19	7.51
4	9	4.11	36	14.23
5	17	7.76	32	12.65
6	22	10.05	32	12.65
7	33	15.07	51	20.16
8	35	15.98	34	13.44
9	39	17.81	13	5.14
10	58	26.48	14	5.53
Total	219	100	253	100

A much clearer picture of IB and NP students' formal reasoning level may be obtained by classifying their scores in categories. Students can be classified as having low, medium, and high level of formal thought according to their results in TOLT (Oliva, 2003). Scores from 0 to 3 are classified as low level, scores from 4 to 6 are classified as medium level and scores from 7 to 10 are classified as high level of formal thought. Table 4.4 presents the frequencies and percentages of students in each level for boys, girls and for all students in IB and NP classes.

The results showed that majority of the students were at medium and high level of formal reasoning, whereas only small percentage of students were at low level in both IB and NP classes.

Table 4.4. Distribution of IB and NP students with respect to level of formal thought

		International Baccalaureate		**National Program**	
	Formal Reasoning Level	**Frequency (N)**	**Percent (%)**	**Frequency (N)**	**Percent (%)**
Boys	Low	4	3.96	30	18.87
	Medium	21	20.79	64	40.25
	High	76	75.25	65	40.88
	Total	101	100	159	100
Girls	Low	2	1.69	9	9.57
	Medium	27	22.88	40	42.55
	High	89	75.42	45	47.87
	Total	118	100	94	100
Total	Low	6	2.74	39	15.42
	Medium	48	21.92	104	41.11
	High	165	75.34	110	43.48
	Total	219	100	253	100

The percentage of IB students at low level of formal reasoning was quite low, only 2%. A higher percentage of students were found to be at medium level with a percentage of 21.92. The highest percentage of IB students, 75% were at high level of formal reasoning. This is quite a high percentage indicating that a great majority of IB students have developed high levels of ability in abstract thinking, formulating and testing hypothesis, reasoning and constructing logic. Similar distributions of low, medium and high level of formal thought were observed among boys and girls, indicating that IB girls and boys had similar formal reasoning abilities. For NP students, the lowest percentage of students was in low reasoning level (15%). Percentages of students in medium and high level were 41% and 44% respectively. These results indicate that majority of NP students were at medium and high level of formal reasoning, and a smaller percentage was at low reasoning level indicating that most of the students have acquired and above average formal reasoning ability. Moreover, a greater percentage of girls were at high formal reasoning level (47.87%) compared to boys (40.88%) in NP classes.

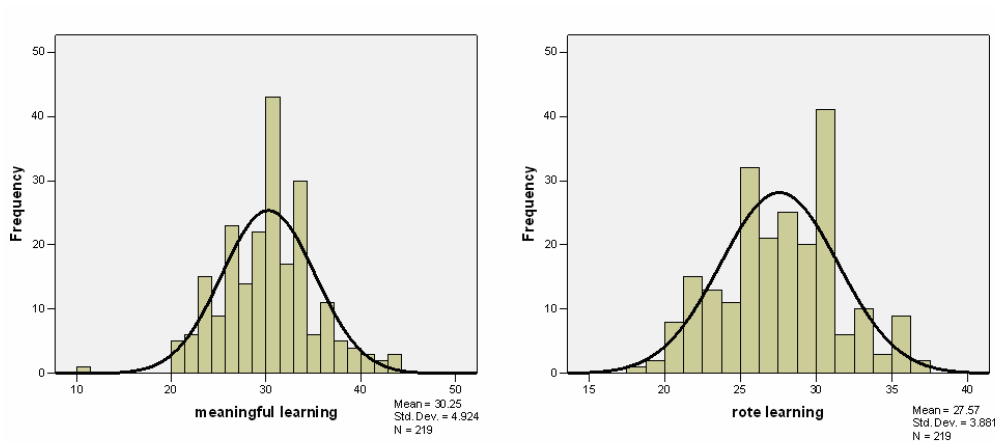

Figure 4.10. Range of LAQ-M and LAQ-R scores for IB students

The other cognitive variable investigated in this study was learning approach. Students' approaches to learning were classified as meaningful or rote depending on the results they obtained. Regarding learning approaches, Table 4.1, shows that IB students' mean LAQ-M score was *M*= 30.25 and LAQ-R score was *M*= 27.57. That is; IB students had higher mean LAQ-M score compared to mean LAQ-R score indicating that meaningful learning approaches were adapted more than rote learning approaches by IB students. This means that IB students try to form meaningful links between the topics they learn and between newly presented material and existing knowledge rather than memorizing them as separate identities. LAQ scores were almost normally distributed with skewness values of .04 for LAQ-M and .05 for LAQ-R (see Figure 4.10).

For National Program students on the other hand, mean LAQ-M score was 29.76 and LAQ-R score was 28.47, indicating that meaningful learning approaches were adapted slightly more than rote learning approaches. Figure 4.11 shows the distribution of LAQ-M and LAQ-R scores for National Program students. Both distributions were positively skewed but skewness was slightly larger in LAQ-R (.26) compared to LAQ-M (.02) indicating that most students had lower LAQ-R scores.

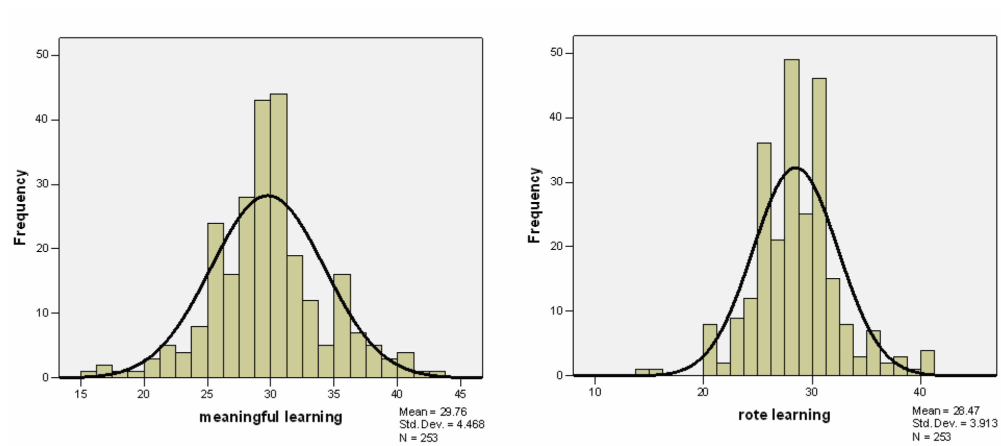

Figure 4.11. Range of LAQ-M and LAQ-R scores for NP students

Results indicated higher LAQ-M scores compared to LAQ-R scores for both IB and NP students. This means that students in both groups tend to use meaningful learning strategies rather than rote memorization. Moreover, it is worth noting that mean scores for LAQ-R for both groups were above mid-value although they were lower than LAQ-M. This indicates that these students have slight tendency to use rote memorization in learning science concepts.

4.3. Relationships among Variables

This part of the study focuses on the relationships among the variables of the study by answering research questions 2 and 3.

Research Question 2. Are there relationships between 9th grade International Baccalaureate and National Program students' self-efficacy, active learning strategies, biology learning value, performance goals, achievement goals, learning environment stimulation, formal reasoning ability, learning orientation, gender and achievement in mitosis and meiosis topics?

Null Hypothesis: There are no significant relationships between International Baccalaureate and National Program students' self-efficacy, active learning strategies, biology learning value, performance goals, achievement goals, learning environment stimulation, formal reasoning ability, learning orientation, gender and achievement in mitosis and meiosis topics.

In order to detect the relationships, if any, between the variables of the study, Pearson correlation analysis was done for both groups. Results are summarized in table 4.5. For IB students, achievement was positively correlated with self efficacy (r=.166, p=.014) and reasoning ability (r=.215, p=.001). There was no significant correlation between achievement and active learning strategies, biology learning value, performance goals, achievement goals learning environment stimulation, meaningful learning and rote learning (p>.05). Among the variables being studied; only self-efficacy and formal reasoning ability have positive correlation with IB students' achievement. That is; students that have a higher belief in their ability in performing biology activities have higher scores in mitosis and meiosis achievement test as well. Similarly, higher level of formal reasoning ability was also correlated with higher achievement scores. Reasoning ability was not correlated with any of the variables other than achievement (p>.05) for IB students. Regarding the relationships of the other cognitive variables of the study, learning approaches, with other variables, results indicate that rote learning was negatively correlated with self efficacy (r=-.381, p=.000), active learning strategies (r=-.342, p=.000), biology learning value (r=-.285, p= .000), performance goal (r=-.180, p=.007), learning environment stimulation (r=-.197, p=.003) and meaningful learning (r=-.284, p=.000). Meaningful learning on the other hand, had positive correlation with self efficacy (r=.435, p=.000), active learning strategies (r=.647, p=.000) biology learning value (r=.585, p=.000) achievement goals (r=.387, p=.000) and learning environment stimulation (r=.484, p=.000). Students that have adapted rote learning approaches indicating a higher tendency to memorize material presented without relating it to existing knowledge, have lower belief in their ability to perform well in biology activities and also less motivated to use active learning strategies, like finding resources and discussing with teachers and peers to interpret new experiences and do not perceive biology as an important topic that relates to daily life and they do not think that biology content satisfies their curiosity. Students who adopted rote learning approach also had less tendency to demonstrate their ability in biology tasks and do not perceive the learning environment in biology lessons as motivating. Students with meaningful learning approaches, that have a tendency to relate newly presented material with previous experiences to construct meaningful links between them, on the other hand, are also more self-efficaus indicating higher belief in their ability to perform well in biology, more motivated to use active learning strategies to retrieve their knowledge, have a higher desire to increase their ability in biology rather than being perceived as able and find the teacher generated learning environment in biology lessons motivating.

Table 4.5. Correlation coefficients for the variables of the study for IB and NP students

GROUPS		SE	ALS	BLV	PG	AG	LES	TOLT	LAQ-M	LAQ-R	MMAT
IB CLASSES	GENDER	-.030	-.209**	-.136*	-.174*	-.056	-.094	-.014	-.105	.189**	-.093
	SE		.606**	.597**	.019	.217**	.392**	-.024	.435**	-.381**	.166*
	ALS		-	.697**	-.126	.455**	.546**	.009	.647**	-.342**	.031
	BLV		-	-	-.164*	.418**	.524**	-.003	.585**	-.285**	.092
	PG		-	-	-	-.315**	-.179**	.020	-.130	-.180**	.098
	AG		-	-	-	-	.321**	.050	.387**	-.021	-.074
	LES		-	-	-	-	-	-.048	.484**	-.197**	.057
	TOLT		-	-	-	-	-	-	.048	-.084	.216**
	LAQ-M		-	-	-	-	-	-	-	-.284**	.055
	LAQ-R		-	-	-	-	-	-	-	-	-.126
NP CLASSES	GENDER	-.004	.022	-.111	-.028	-.110	.043	-.107	.026	-.059	-.060
	SE		.545**	.543**	-.006	.280**	.348**	.181**	.275**	-.174**	.134*
	ALS		-	.643**	-.234**	.562**	.471**	.065	.376**	-.097	.001
	BLV		-	-	-.186**	.452**	.487**	.064	.309**	-.077	.094
	PG		-	-	-	-.449**	-.342**	.084	-.025	-.162**	.030
	AG		-	-	-	-	.395**	.064	.156*	.071	.083
	LES		-	-	-	-	-	-.038	.249**	-.018	-.019
	TOLT		-	-	-	-	-	-	-.014	-.148*	.331**
	LAQ-M		-	-	-	-	-	-	-	-.073	.048
	LAQ-R		-	-	-	-	-	-	-	-	-.193**

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

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

As indicated by the negative correlation between meaningful learning and rote learning, students that have more meaningful approaches to learning indicating their tendency to use meaningful learning patters that form a connection between what they already know and what they learn, do not have tendency to use rote learning that involves the verbatim memorization of new material without any link to prior experiences.

Table 4.5 presents the correlations between the motivation subscales as well. Learning environment stimulation was positively correlated with self efficacy (r=.392, p=.000), active learning strategies (r=.546, p=.000), biology learning value (r=.524, p=.000) and achievement goals (r=.321, p=.000); negatively correlated with performance goals (r=-.179, p=.008). These results suggest that students that perceive the learning environment in biology lessons as motivating also have higher belief in their ability in biology tasks, use active learning strategies more in biology lessons, perceive biology learning as valuable and engage in academic tasks in order to increase their ability rather than being perceived as able by others as indicated by negative correlation with performance goal. There were positive correlations between achievement goals and self efficacy (r=.217, p=.001), active learning strategies (r=.455, p=.000) and biology learning value (r=.418, p=.000), and negative correlation with performance goals (r=-.315, p=.000). This indicates that students that want to participate in biology activities in order to increase their competence are nor eager to demonstrate their ability to others and they believe in their ability in biology, value biology learning more and try active strategies to construct new knowledge in biology. Performance goal showed negative correlation with biology learning value as well (r=-.164, p=.015). That is, students perceiving biology as an important topic that contributes to development of problem solving and inquiry skills in addition to satisfying his/her curiosity are less concerned with impressing other people by demonstrating competence in biology. There were also positive correlations of biology learning value with self efficacy (r=.597, p=.000) and active learning strategies (r=.697, p=.000). This means that perceiving biology as an important topic is associated with having higher belief in ability to perform well in biology and using active learning strategies to increase knowledge in biology. Finally, self efficacy is positively correlated with active learning strategies (*r*=.606, *p*=.000) as well. To sum up, all motivational variables except for performance goal are positively correlated indicating that different aspects of motivation are interrelated with each other.

Gender was positively correlated with rote learning approach (*r*=.189, *p*=.005). Girls are designated "0" and boys are designated "1" in this study. Therefore, a positive correlation indicates that boys have a higher score in that variable compared to girls. A positive correlation between gender and rote learning approach indicates that boys use rote memorization more than girls in IB classes. In other words, boys' tendency to memorize topics without connecting them to previous experiences is more. On the other hand, gender was negatively correlated with active learning strategies (*r*=-.209, *p*=.005), biology learning value (*r*=-.136, *p*=.002) and performance goal (*r*=-.174, *p*=.010). These results indicate that boys use active learning strategies like discussions with teachers and peers and searching for additional sources that will help them in biology less compared to girls in IB classes. Moreover, their perception of the value of biology learning regarding its contributions to problem solving skills, relationship with daily life, and satisfying curiosity is less compared to girls. Boys are also less eager to be perceived as able and demonstrate competence to other people.

For National Program students, achievement was positively correlated with self efficacy (*r*=.134, *p*=.033) and formal reasoning ability (*r*=.333, *p*=.000) similar to IB students. Students believing in their ability to perform well in biology and have developed higher levels of formal reasoning abilities including logical thinking and reasoning patterns are more successful in biology in national program classes as well. Moreover, achievement was negatively correlated with rote learning (*r*=-.193, *p*=.002) for NP students. This result indicates that students that prefer rote memorization in mitosis and meiosis topics without linking it to what they already know and form a logical connection between them are less successful in achievement test.

Formal reasoning ability was also positively correlated with self efficacy (*r*=.180, *p*=.004) for NP students. Moreover, results demonstrated a negative correlation between reasoning ability and rote learning(*r*=-.152, *p*=.016). This indicates that students that have developed formal operational thought that enables them understand abstract concepts and use hypothetical reasoning have stronger belief in accomplishing biology tasks successfully, and they have not adapted rote learning approach indicating that they have less tendency to memorize materials presented without a link to prior knowledge.

Regarding learning approach, the results show that rote learning was negatively correlated with self efficacy (*r*=-.174, *p*=.006) and performance goals (*r*=-.162, *p*=.010) as well. This means that students that tend to use verbatim memorization more believe their competence in accomplishing biology activities less, and they are not eager to demonstrate competence. Meaningful learning on the other hand was positively correlated with self efficacy (*r*=.275, *p*=.000), active learning strategies (*r*=.376, *p*=.000), biology learning value (*r*=.309, *p*=.000), achievement goals (*r*=.156, *p*=.013) and learning environment stimulation (*r*=.249, *p*=.000). This indicates that the tendency to organize knowledge into meaningful units by providing connection between them is associated with higher belief in ability in biology activities, use of active strategies for learning biology, a stronger belief in the value of biology, more desire to develop competence in biology and higher motivation resulting from the learning environment.

When the interactions between motivational variables are investigated, results sow that learning environment stimulation was positively correlated with self efficacy (*r*=.348, *p*=.000), active learning strategies (*r*=.471, *p*=.000), biology learning value (*r*=.524, *p*=.000) and achievement goals (*r*=.321, *p*=.000) and negatively correlated with performance goals (*r*=-.179, *p*=.008). These results suggest that students that have higher positive perceptions regarding the learning environment in biology lessons believe their ability in accomplishing biology tasks more, tend to use active learning strategies more in biology lessons, think that biology learning is important and engage in academic tasks in order to increase their ability rather than being perceived as able by others. There were positive correlations between achievement goals and self efficacy (r=.280, p=.000), active learning strategies (r=.562, p=.000) and biology learning value (r=.452, p=.000), and negative correlation with performance goals (r=-.449, p=.000). This means that students that are eager to develop competence in biology activities have stronger belief in their ability in biology, use active learning strategies more, value biology learning and are less eager to demonstrate their ability in the eyes of other people. Performance goals showed negative correlation with active learning strategies (r=-.234, p=.000) and biology learning value as well (r=-.164, p=.015), indicating a decrease in efforts to use active learning strategies and the perceived value of the benefits of biology learning associated with higher desire to demonstrate competence in biology activities. Similar to IB results, biology learning value was positively correlated with self efficacy (r=.543, p=.000) and active learning strategies (r=.643, p=.000). Self efficacy was positively correlated with active learning strategies (r=.545, p=.000) for NP students. This can be interpreted by stating that having a stronger belief in ability in biology is associated with the increased use of active learning strategies and the perceived value of biology learning.

There were no correlations between the variables being studied and gender in NP classes. That is; there is no difference between boys and girls in NP classes regarding motivation, formal reasoning ability and learning approach. Boys and girls demonstrate similar patterns regarding their motivation toward biology learning, their cognitive development and choices in learning approach.

To sum up, the results obtained from correlational analysis indicate that achievement in mitosis and meiosis topics was related with formal reasoning ability and self-efficacy in both International Baccalaureate and National Program classes. In other words, the cognitive development level of the student regarding abstract thinking, reasoning and constructing logic was associated with better achievement in mitosis and meiosis topics as well as a belief in ability in dealing with biology tasks regardless of the difficulty level of the task. Students with higher sense of self efficacy resulting from a stronger perceived ability in accomplishing biology activities were more successful in understanding mitosis and meiosis. In NP classes, rote learning was negatively correlated with achievement. Therefore it is reasonable to conclude that students that use rote memorization were less successful in this topic. Gender did not have any significant correlation with other variables for NP students. However, in IB classes there were differences between students regarding gender. Boys use rote memorization more than girls indicating that their tendency to memorize topics without connecting them to previous experiences is more. Girls have adapted performance goals more, so they are more eager to demonstrate their competence. Moreover, boys use active learning strategies like discussions with teachers and peers and searching for additional sources that will help them in biology less compared to girls. Their perception of the value of biology learning regarding its contributions to problem solving skills, relationship with daily life, and satisfying curiosity is less compared to girls.

The next research question that was investigated in this study was research question3.

Research Question 3. Are there significant contributions of self-efficacy, active learning strategies, biology learning value, performance goal, achievement goal and learning environment stimulation, formal reasoning ability, learning orientation and gender to 9th grade International Baccalaureate and National Program students' achievement in mitosis and meiosis topics?

Null Hypothesis: There are no statistically significant contributions of self-efficacy, active learning strategies, biology learning value, performance goal, achievement goal and learning environment stimulation, formal reasoning ability, learning orientation and gender to 9th grade International Baccalaureate and National Program students' achievement in mitosis and meiosis topics.

Following the analysis of correlations among variables, contribution of each variable to achievement was investigated in this part of the study. Multiple Regression Analysis is used to evaluate the contributions of each variable to achievement in mitosis and meiosis topics. MMAT scores are used as the dependent variable and the independent variables are gender, SE, ALS, BLV, PG, AG, LES, TOLT, LAQ-M and LAQ-R scores. There were ten independent variables in this analysis. According to Tabachnick and Fidell (1996), the sample size should be larger than N=130 for ten variables. The sample size in the study was N=219 for IB, N=253 for NP students and N=472 for the total sample.

Before proceeding with the results, assumptions of Multiple Regression are checked. First assumption is multicollinearity. Correlations between independent variables should not be too high. As seen in table 4.5, none of the correlations exceed r=.7. Moreover, collinearity diagnostic performed by SPSS resulted in Tolerance values that were all large enough to conclude that (.338 minimum) multiple correlations with other variables are not high, therefore all the variables are retained. Other assumptions are outliers, normality, linearity, homoscedasticity and independence of residuals. These assumptions may be controlled looking at residuals scatterplot and Normal Probability Plot (figures 4.12 and 4.13).

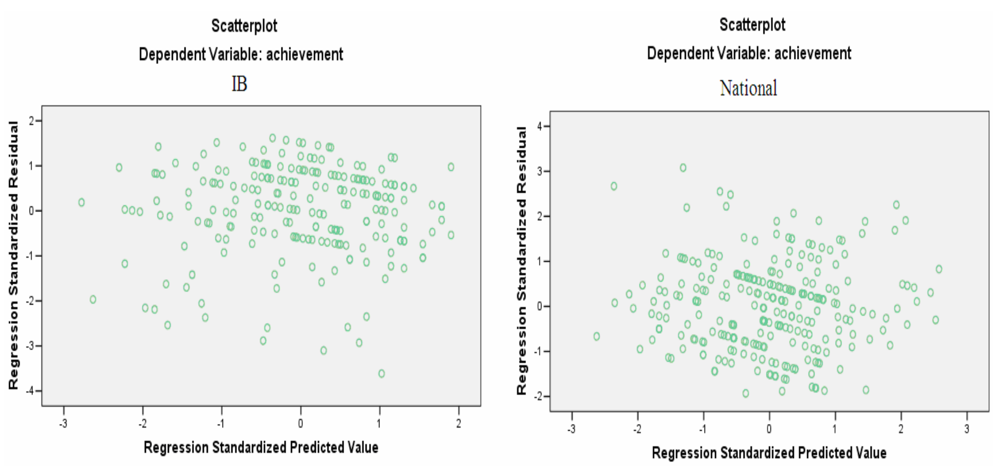

Figure 4.12. Scatterplots of the residuals for IB and NP

Standardized Residuals Scatterplots seen in figures 4.12 and 4.13 showed roughly rectangular distributions without clear systematic patterns like curvilinear distribution. This shows that the homoscedasticity and independence of residuals assumptions are met. Again in the scatterplots, it can be seen that there were only few outliers. Investigation of mahanabolis distances also revealed that there were few outliers, and the values were not too large, therefore these subjects were not removed from data. Pallant (2001) suggests that outliers are common in samples and it may not be necessary to take any action if only few are found.

Normal Probability plots were used to check the assumptions of normality and linearity. As seen in figure 4.13, points were fairly in a straight diagonal line indicating linearity and no major deviations from normality.

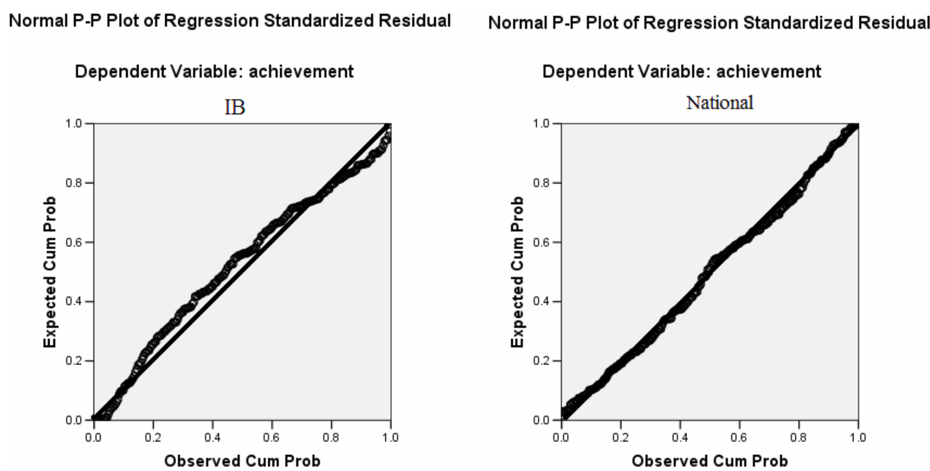

Figure 4.13. Normal probability plots for IB and NP

Having checked the assumptions, analysis of the contributions of the variables of the study to achievement in mitosis and meiosis was done using multiple regression analysis. Results are indicated in table 4.6 for both IB and NP students.

For International Baccalaureate students, the multiple correlation was R=.335 and R^2=.113 indicating that the model explained 11.3% of the variance in achievement scores of IB students (F=2.637, p=.005).

Table 4.6. Independent contributions of GENDER, SE, ALS, BLV, PG, AG, LES, TOLT, LAQ-M and LAQ-R to achievement in mitosis and meiosis in IB and NP

	International Baccalaureate				National Program			
Variables	***B***	***β***	***t***	***p***	***B***	***β***	***t***	***p***
GENDER	-.654	-.095	-1.368	.173	-.044	-.006	-0.093	.926
SE	.136	.208	2.289	.023*	.053	.081	1.057	.291
ALS	-.114	-.169	-1.501	.135	-.182	-.219	-2.380	.018*
BLV	.060	.075	0.734	.464	.099	.106	1.242	.215
PG	.039	.039	0.536	.593	-.009	-.007	-0.104	.917
AG	-.087	-.104	-1.314	.190	.152	.139	1.739	.083
LES	.057	.055	0.672	.502	-.071	-.059	-0.809	.419
TOLT	.389	.225	3.406	.001*	.485	.290	4.730	.000*
LAQ-M	.014	.020	0.226	.821	.050	.061	0.939	.349
LAQ-R	-.022	-.025	-0.333	.740	-.150	-.157	-2.560	.011*

*Significant at the 0.05 level

The results indicate that students' self efficacy and reasoning abilities had significant positive contribution to the achievement in mitosis and meiosis topics for IB students (Table 4.6). These results show that, as a student's belief in his/her ability in accomplishing biology activities increases, his/her achievement in mitosis and meiosis topics increases as well. Moreover, having acquired more complex reasoning patterns characteristic to formal operational stage like hypothesize testing, abstract thinking and constructing logic results in increased achievement. However, other motivational variables did not have any significant contribution to achievement of IB students. Gender, meaningful and rote learning approach did not have significant contribution to achievement in mitosis and meiosis topics either.

For National Program students on the other hand, the multiple correlation was R=.403 and R^2=.162. This means that the model explained 16.2% of the variance in achievement (F=4.695, p=.000). While formal reasoning ability had significant positive contributions to the achievement of National Program students, active learning strategies and rote learning had significant negative contribution. Students who have adapted rote learning approach meaning that they preferred memorizing material directly, achieve less in mitosis and meiosis. Moreover, tendency to use active learning strategies like discussing peers and teachers while learning biology decreases achievement as well. Higher formal reasoning ability on the other hand influences achievement positively. Gender did not have any significant contribution to achievement in NP classes.

To sum up, reasoning ability had significant positive contribution to achievement of both IB and NP students. This means that more complex reasoning skills like thinking logically and abstractly, acquired at higher stages of cognitive development contribute positively to 9th grade IB and NP students' achievement in mitosis and meiosis topics. Self efficacy contributed positively to achievement for IB students. Therefore, it can be concluded that as students become more confident in their ability in biology, their achievement will increase. Active learning strategies had negative contribution to achievement in mitosis and meiosis topics for NP students indicating that as they prefer active strategies while learning biology, their achievement decreased. Rote learning approach was showed to have negative contribution to achievement resulting in lower achievement scores in NP classes. Gender did not have significant contribution to achievement either in IB or in NP classes.

Research Question 4. Which variable best predicts 9th grade students' achievement in mitosis and meiosis topics?

The variable that best predicted 9th grade students' achievement in International Baccalaureate and National Program students was determined using stepwise multiple regression analysis. Results are presented in table 4.7.

Table 4.7. Multiple regression results for IB and NP students.

		β	R^2	F	p
IB	**TOLT**	.380	.047	8.883	.000
	SE	.112	.029		
NP	**TOLT**	.517	.109	18.794	.000
	LAQ-R	-.140	.022		

Results of the stepwise regression analysis showed that 4.7% of the variance in achievement was explained by formal reasoning ability and the remaining 2.9% was explained by self efficacy in IB classes. For NP classes, formal reasoning ability explained 10.9% of the variance. Rote learning explained 2.2% of the variance in achievement in negative direction. This indicates that the main predictor of achievement was formal reasoning ability for both IB and NP students. The contribution of formal reasoning ability to achievement was higher for NP students compared to IB students.

Briefly, results of stepwise multiple regression analysis revealed that the main predictor of achievement in mitosis and meiosis topics among the variables in the study was formal reasoning ability for both International Baccalaureate and National Program students.

4.4 Summary of Results

The results of this study may be summarized as follows:

- IB students performed slightly above mid-value in MMAT indicating that they were successful. NP students on the other hand, performed slightly below mid-value indicating that they were not successful in mitosis and meiosis topics.

- IB students' perception of themselves regarding the ability to understand biology and perform well in tests whether the topic is easy or not was high. NP students also had mean SE score slightly above mid-value indicating positive perceptions of their ability in biology.

Both IB and NP students use active strategies like finding relevant sources, discussing with other students, and trying to form connections between new and previous knowledge as indicated by mean scores slightly above average for both groups.

- Students in both IB and NP classes think that materials learned in biology lessons are relevant to their daily life and beneficial for developing problem solving and inquiry skills and satisfy their curiosity.

- Students' intrinsic motivation as indicated by tendency to accomplish biology tasks for increasing their ability in biology was more than their tendency to demonstrate competence in the eyes of teachers and peers in biology lessons for both IB and NP students.

- Mean LES score for both groups were slightly above mid-value indicating moderate motivation resulting from the teacher generated learning environment in biology lessons.

- Achievement in mitosis and meiosis topics was positively correlated with formal reasoning ability and self-efficacy in both IB and NP classes. Students with higher cognitive level, increased ability in abstract thinking, reasoning and constructing logic have increased achievement in mitosis and meiosis topics as well.

- Self-efficacy was also correlated with achievement in IB classes. IB students that have a stronger belief in their ability in accomplishing biology activities were more successful in understanding mitosis and meiosis.

- In NP classes, rote learning was negatively correlated with achievement. Students that use rote memorization without connecting newly presented material to previous experiences were less successful.

- Performance goal was not correlated with self-efficacy indicating no relationship between students' belief in their ability in performing well in biology and the desire to demonstrate competence.

- Performance goal was not correlated with active learning strategies in IB classes indicating that the desire to be perceived as able by other people is not related with the use of active strategies to learn biology.

- All other motivational variables were correlated significantly indicating that they are interrelated to some extent although they measure separate aspects of motivation.

- No correlation between gender and achievement was detected for NP students. However, in IB classes boys were shown to use rote memorization more than girls indicating that their tendency to memorize topics without connecting them to what they already know was more.

- Girls in IB classes were more eager to demonstrate their competence and be perceived as able by their peers and teachers. Moreover, boys use active learning strategies like discussions with teachers and peers and searching for additional sources that will help them in biology less compared to girls. They also value biology learning less than girls do.

- Formal reasoning ability had significant positive contribution to achievement of both IB and NP students, formal reasoning skills like thinking logically and abstractly, and hypothetico-deductive reasoning patterns acquired at higher stages of cognitive development had positive contribution to achievement in mitosis and meiosis topics.

- Self efficacy had positive contribution to IB students' achievement. Students that were more confident about their ability in accomplishing biology activities are more successful.

- Active learning strategies contributed negatively to NP students' achievement in mitosis and meiosis topics. Use of active learning strategies like looking for resources that help understand the topic, seeking for the reasons of mistakes and discussing topics with teachers and peers decreased achievement.

- Rote memorization contributed negatively to NP students' achievement indicating that memorizing mitosis and meiosis topics without forming meaningful links between the existing knowledge and previous experiences resulted in decreased performance.

- Formal reasoning ability was the most important predictor of mitosis meiosis achievement for both IB and NP students.

CHAPTER 5

DISCUSSION

The results are presented in the previous pages of this study. These results will be discussed in this chapter in addition to the educational implications and suggestions for further research.

The aim of this study was to investigate the contributions of self efficacy, active learning strategies, biology learning value, performance goal, achievement goal, and learning environment stimulation, formal reasoning ability and learning approach on 9th grade International Baccalaureate and National Program students' achievement in mitosis and meiosis topics.

Findings of the present study revealed that formal reasoning ability was the most important predictor of achievement in mitosis and meiosis topics for both IB and NP classes. Moreover, self-efficacy was also a predictor of achievement in International Baccalaureate classes. Still another result of the study was that active learning strategies and rote learning approach predicted mitosis and meiosis achievement in negative direction in NP classes.

Results of the present study indicated that formal reasoning ability was the main predictor of mitosis and meiosis achievement in both program types. For IB students, 4.7% of variance in mitosis and meiosis achievement test scores was explained by formal reasoning ability. For NP students on the other hand, formal reasoning ability explained 10.9% of the variance in achievement scores. This result indicates that students with higher formal reasoning ability have higher achievement scores in mitosis and meiosis topics. This is an expected result taking into consideration the perceived difficulty of mitosis and meiosis topics by the students mainly due to the presence of many terms that led to an inability to form a logical connection and see the steps as the components of a whole process toward a goal of producing new cells (Finley, Stewart & Yarroch, 1982; Kablan, 2004; Knippels, Waarlo & Boersma, 2005). This is a rather abstract topic and understanding such abstract topics requires high levels of formal reasoning ability (Parsons, Hinson & Brown, 2001). The IB students participating in this study had relatively high levels of formal reasoning ability (M=7.80). Moreover, a great majority of these students were at high level formal reasoners (75%). NP students on the other hand had lower levels of formal reasoning ability (M=5.82) and a lower percentage of them were high level formal reasoners (44%) compared to IB students. The fact that formal reasoning ability explained a greater percentage of variance in achievement scores of NP students compared to IB students may be due to the higher percentage of students in high formal reasoning level in IB classes. Mitosis and meiosis achievement test which was used to assess achievement in this study was composed of questions that seek an understanding of the rather abstract processes of mitosis and meiosis, forming a logical connection between stages and dealing with hypothetical situations that are beyond concrete reality and students' experiences. Such cognitive processes develop at formal operational period and therefore difficult for low formal level students to understand (Elliot, Kratochwill, Littlefield & Travers, 1996; Fetsco & McClure, 2005). This idea is supported by the study of Lawson and Renner (1975) which revealed that concrete operational students were not able to understand formal concepts. Moreover, they indicate that understanding of abstract materials does not occur until the students enter the formal stage. Lawson, Banks and Logvin (2006) state that students at higher formal reasoning level are consistently able to test hypothesis involving unobservable entities in addition to observable casual agents, unlike students at lower formal reasoning level who are inconsistently able to test hypothesis involving only observable casual agents. Results of the present study indicated that IB students had an above average score in mitosis and meiosis achievement test with a mean of M=12.99, which is higher compared to the below average achievement score (*M*=9.26) for NP students. Therefore, results of the study indicate a difference in not only formal reasoning levels, but also achievement scores of IB and NP students. These results support the finding that reasoning ability predicted achievement in mitosis and meiosis topics.

This finding is not surprising given that many other research studies pointed out reasoning ability to be the most important predictor of achievement in science (Bitner, 1991; Lawson, Banks & Logvin, 2006, Johnson & Lawson, 1998; Elliot, 2006). For example, Bitner (1991) confirmed that formal reasoning ability was a statistically significant predictor of both critical thinking abilities and achievement in science and mathematics. In another study, Lawson and Johnson (1998) proved reasoning ability to be the best predictor of achievement in an introductory biology course including mitosis and meiosis topics. Reasoning ability explained achievement in both inquiry (7.2%) and expository classes (18.8%). Positive relationship between reasoning ability and final examination scores was shown regardless of the instructional strategy used.

Lawson et al. (2006) indicated that reasoning ability was not only a good predictor of achievement, but also a better predictor compared to self-efficacy. The results of their study in a university introductory biology course revealed that, regardless of the achievement measure being used, reasoning ability explained much more variance in achievement (32-35% for all tests) compared to self-efficacy (1-2%). This result is consistent with the finding of the present study that indicates reasoning ability to be a better predictor of achievement in IB classes compared to self-efficacy.

Although it is not as good a predictor as reasoning ability, self-efficacy contributed positively to achievement in IB classes in the present study. Moreover, although it is not shown to be explaining variance significantly, self-efficacy was positively correlated with achievement in NP classes as well (*r*=.134). Pintrich and Schunk (2002) state that students with higher senses of self-efficacy were more motivated to work on particular tasks and spend more effort for them. Moreover, Bembenutty and Zimmerman (2003) found out an indirect effect of self-efficacy on achievement via self regulation, homework completion and delay of gratification. Therefore, it is stated that students with higher belief in their ability in a particular task are more successful. This result is consistent with the finding of present study that showed a significant contribution of self-efficacy to achievement (2.9%) in IB classes and correlation with achievement in NP classes. This indicates that students with stronger belief in their ability in successfully accomplishing with biology activities have higher achievement in mitosis and meiosis topics. This result is consistent with other research findings. For example, Kuppermintz and Roeser (2002) indicated that self-efficacy was correlated with different measures of science achievement like multiple choice tests and science grades. In another study, Özkan (2003) investigated the connection between motivation and achievement in 10th grade biology students and reported significant positive correlation of achievement with self-efficacy (r=.179), but the correlation was low, similar to the results of the previous study. Nevertheless, self-efficacy was the motivational variable that showed the highest correlation with achievement. A similar result was indicated in a study conducted by Tuan, Chin, and Sieh (2005). They showed that science achievement had the highest correlation with self-efficacy (r=.44) when compared with science learning value, performance goal, achievement goal, active learning strategies and learning environment stimulation. Self-efficacy is followed by active learning strategies (r=.37). Learning environment stimulation had the lowest correlation with achievement (r=.10). The result of this study contradicts with this finding, because only self efficacy in IB classes were correlated with achievement. Self efficacy was positively correlated with achievement in NP classes as well. Other motivational variables failed to explain variance in achievement in mitosis and meiosis. It is interesting to note that self-efficacy was also the highest correlate of achievement in the study of Tuan et al. Moreover, self-efficacy was significantly correlated with other motivational variables of the study namely active learning strategies, biology learning value, achievement goal and learning environment stimulation with correlation coefficients ranging between r=.21 and r=.60.

Therefore, it may be thought that other motivational variables have indirect effects on achievement via self-efficacy. Moreover, performance goal has no significant correlations with either self-efficacy or achievement in IB and NP cases. This is also a surprising result because previous research findings indicate negative correlation between achievement and performance goals. Students that have performance goals want to be perceived as competent. These students attribute failure to low ability and develop helpless response in case of failure (Biehler & Snowman, 1997; Pintrich & Schunk, 2002; Fetsco & McClure, 2005). Therefore, it was expected that students with higher PG scores, that is, students having a stronger desire to display their ability that would have lower achievement scores. However, it is surprising that PG scores not only failed to explain variance in achievement, but also did not correlate with achievement either positively or negatively. This may explained by relatively low scores in performance goals (M=12.87 for IB, M=12.10 for NP) which are only slightly over the average PG score 10, indicating that students' desire to be perceived as able was no so high, therefore it did not interfere with achievement, they still put effort. Another unexpected result in the study was that active learning strategies contributed negatively to achievement in NP classes. This result contradicts with the findings of Tuan et al. who determined active learning strategies as the second highest correlate of achievement following self- efficacy. The result of the present study indicates that students that have higher motivation to use active learning strategies like discussions with peers and teachers, and searching for additional resources or seeking for reasons for their mistakes, achive lower in mitosis and meiosis topics. This surprising result indicates that, although these students are motivated to use these active learning strategies, they fail to apply them properly or adequately, resulting in an inability to understand the topic better.

The inability of motivational variables other than self-efficacy to contribute achievement in mitosis and meiosis topics is an unexpected result of the present study. This may be because other student characteristics which have not been investigated in the present study may have more important contribution to achievement compared to motivational variables studied for this sample.

Another cognitive variable investigated in this study other than formal reasoning ability was learning orientation. Creating meaningful links between the concepts acquired in course reduces memory overload and increase the amount of information that can be processed simultaneously, whereas rote memorization increases the amount of information that has to be dealt with (BouJaude, 1992). Therefore, it is expected that students with meaningful learning orientation would have higher achievement and students with rote learning orientation would have lower achievement in mitosis and meiosis topics. The results of the present study surprisingly did not indicate any correlation between meaningful learning and achievement in any group. This result is inconsistent with many previous research findings (BouJaude, 1992; Cavallo & Schafer, 1994; Atay, 2006; Yenilmez, 2006). For example, Cavallo and Schafer showed meaningful learning orientation to be a significant predictor of meaningful understanding of meiosis and punnet square method, and its contribution was much more than motivation. The reason for the inability of meaningful learning to explain achievement in mitosis and meiosis may be the fact that students perceive mitosis and meiosis as a topic that requires rote memorization (Kablan, 2004). Although they tended to adopt meaningful learning approach while studying science in general, they may resort from meaningful learning since they don't know how to process new information and believe rote memorization is the only way to learn mitosis and meiosis topics (Cavallo, Rozman, & Potter, 2004). Another possible explanation may be the achievement measure used in this study. Mean item difficulty was 0.6 and mean item discrimination was 0.5 for MMAT. Moreover, 30% of the test items were knowledge level questions. These results may be due to the relatively low number of MMAT items measuring meaningful learning of mitosis and meiosis topics. However, there are some other research findings that show no significant correlation of meaningful learning with achievement, consistent with the results of the present study as well. Saunders (1998) showed that no significant effect of meaningful orientation is seen on learning in a study that investigated relationships between instruction with student's beliefs and learning approaches. Although meaningful learning failed to explain achievement in mitosis and meiosis topics, the results of the present study showed that rote learning orientation contributed achievement negatively (2.2%) in NP classes, in line with previous research findings. This indicates that students that prefer rote memorization are less successful in mitosis and meiosis topics. Rote memorization will result in an inability to form logical connections between processes and converting newly presented material into permanent body of knowledge. Hence, this will result in decreased academic performance. Students that do not organize and connect their existing knowledge with the newly presented material will have lower achievement in mitosis and meiosis.

As a conclusion, it can be stated that different motivational and cognitive variables are effective in determining 9^{th} grade students achievement in mitosis and meiosis topics. Formal reasoning ability was shown to be the most important predictor of achievement regardless of the type of program that the student is enrolled in. However, the contributions of other variables differ to achievement in IB and NP classes vary. Therefore, it can be stated that IB and NP students show variations in general characteristics regarding cognitive and motivational variables.

5.1. Threats to Internal and External Validity

Data collection and instruments may be a possible threat for the study due to possible effects of characteristics of the settings in which the study is conducted. To overcome this threat, all teachers administering the instruments were informed about the content and application of these instruments. Besides, all instruments were administered under identical conditions regarding time and duration.

Another threat is mortality that may be caused by lose of subjects. Missing data analysis was used to deal with this threat.

Another point worth mentioning is the fact that all classes were instructed by different teachers and these teachers may differ from each other with respect to ability and experience. But this was not considered to be a threat for this study because all teachers taught both IB and NP classes and they shared their instructional materials with each other and applied similar strategies.

In case of a possible effect of gender on results, this variable was also used in data analysis.

5.2. Instructional Implications

There may be some instructional implications of the present study for science teachers.

- The results of the study showed IB and NP students to differ from each other with respect to formal reasoning ability. Moreover, formal reasoning ability was the most important predictor of achievement among the variables of the study. Therefore, instruction may be designed to meet the reasoning levels of students. Activities that promote development of reasoning ability may be preferred in NP classes.

- Students show variation regarding their cognitive development as indicated by differences within the groups as well. Therefore teachers should be aware that formal operational thinking is a gradually developing trait and realize the cognitive variances between their students even in the same age and grade level (Parsons, Hinson & Brown, 2001). Accordingly, they should design their instruction in order to meet the reasoning levels of different students within the same classroom and use challenging tasks that will force their students to improve their logical thinking ability.

- Another finding of the present study is that self efficacy was also an important predictor besides reasoning ability. Previous research indicates that positive experiences, modeling and praise are among the factors that increase self-efficacy (Pintrich & Schunk 2002). Starting with tasks that students can successfully accomplish, for increasing self efficacy, and proceeding with challenging ones that increase their formal reasoning ability may be a suitable strategy for classroom teachers.

- Taking into consideration the negative contribution of rote learning on achievement, attention to developing meaningful learning strategies of students is another important issue that teachers should keep in mind. (Cavallo, Rozman, & Potter, 2004) claim that learners may not choose to learn meaningfully mostly because they do not know how to process new material. Therefore, the teacher should implement strategies that seek the student question what he/she already knows about the topic and how it is related to the newly presented material to facilitate meaningful learning.

- The finding that achievement goals are positively correlated with all the variables in the motivation questionnaire other than performance goals supports the argument in this study stating that teachers can affect student motivation and self efficacy, and hence promote learning by implementing activities that enhance mastery goals. Positive correlations of self-efficacy learning environment stimulation and active learning strategies have also been demonstrated in the present study.

5.3. Implications for Further Research

Some recommendations for further research studies may be stated depending on the results of the present study.

- A similar study may be conducted using achievement test that includes open ended questions that will allow in depth analysis of the understanding of mitosis and meiosis topics and a test that seeks an explanation for the answer selected to reduce the effect of guessing on achievement scores.

- Qualitative research methods may also be used in a smaller sample for a much more detailed comparative analysis of student characteristics in International

Baccalaureate and National Program classes including open ended questionnaires and interviews. The learning orientation of students regarding mitosis and meiosis topic may be further assessed in such a study to understand whether the general learning approaches of students in science are the same as their approach to learning mitosis and meiosis specifically. Any inconsistency between the two may clarify whether students resort from meaningful learning in these topics or not.

- Contribution of relevant prior knowledge may also be assessed for a complete understanding of achievement in mitosis and meiosis topics.

- Identification of differences between IB and NP students regarding cognitive and motivational variables in the following years of high school education, and contributions of these variables to success in these years may also be the subject of a further research study.

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APPENDIX A

ÖĞRENCİLERİN BİYOLOJİ ÖĞRENİMİNE YÖNELİK MOTİVASYONU ANKETİ

Sevgili öğrenci,

Bu anket sizin bu biyoloji dersine katılmaktaki istekliliğinizi ölçmektedir. Her bir ifadeye ne kadar katıldığınızı belirtmeniz istenmektedir. Doğru ya da yanlış bir cevap yoktur. İstenen sizin görüşünüzdür. Her bir ifadenin sizin bu derse katılmaktaki istekliliğinizi ne kadar yansıttığını düşünün. Size en uygun seçeneği işaretleyin. Her soruya bir cevap verdiğinizden emin olun. Bu anketteki bazı sorular diğerlerine benzemektedir. Bu konuda endişelenmeyin.

Çalışmaya katılım tamamiyle gönüllülük temelinde olmalıdır. Cevaplarınız tamamiyle gizli tutulacak ve sadece araştırmacılar tarafından değerlendirilecektir; elde edilecek bilgiler bilimsel yayımlarda kullanılacaktır. Anket, genel olarak kişisel rahatsızlık verecek soruları içermemektedir. Ancak, katılım sırasında sorulardan ya da herhangi başka bir nedenden ötürü kendinizi rahatsız hissederseniz cevaplama işini yarıda bırakmakta serbestsiniz. Böyle bir durumda anketi uygulayan kişiye, anketi tamamlamadığınızı söylemek yeterli olacaktır. Anket sonunda, bu çalışmayla ilgili sorularınız cevaplanacaktır. Bu çalışmaya katıldığınız için şimdiden teşekkür ederiz.

Kişisel Bilgiler

1. Adınız - Soyadınız: ____

2. Sınıfınız: ___________

3. Cinsiyetiniz: ❑ Kız ❑ Erkek

4. Doğum tarihiniz (yıl): _______________

5. Sekizinci sınıf Fen Bilgisi karne notunuz: _________

6. Birinci dönem Biyoloji Karne Notunuz: __________

	Kesinlikle katılmıyorum	Katılmıyorum	Fikrim yok	Katılıyorum	Kesinlikle katılıyorum
1. Kolay ya da zor her türlü biyoloji konusunu anlayabileceğimden eminim.	1	2	3	4	5
2. Zor biyoloji konularını anlamak konusunda kendime güvenmiyorum.	1	2	3	4	5
3. Biyoloji testlerini iyi yapabileceğimden eminim.	1	2	3	4	5
4. Ne kadar çaba sarf etsem de biyolojiyi öğrenemem.	1	2	3	4	5
5. Biyoloji aktiviteleri çok zor olduğunda ya yalnızca kolay kısımları yaparım ya da yapamayacağımı düşünerek vazgeçerim.	1	2	3	4	5
6. Biyoloji aktivitelerinde yer alan soruların cevabını düşünmek yerine bilemeyeceğime inandığım için başkalarına sormayı tercih ederim.	1	2	3	4	5
7. Biyoloji dersinin içeriğini zor bulduğumda anlayamayacağımı düşündüğüm için öğrenmeye çalışmamın faydasız olacağına inanırım.	1	2	3	4	5
8. Yeni biyoloji kavramlarını öğrenirken onları anlamlı bir şekilde öğrenmeye gayret ederim.	1	2	3	4	5
9. Yeni biyoloji kavramlarını öğrenirken onları daha önceki deneyimlerimle ilişkilendiririm.	1	2	3	4	5
10. Bir biyoloji kavramını anlamadığımda bana yardımı olacak ilgili kaynaklar bulurum.	1	2	3	4	5
11. Bir biyoloji kavramını anlamadığımda daha iyi anlamak için konuyu öğretmenimle veya diğer öğrencilerle tartışırım.	1	2	3	4	5
12. Öğrenme süreci içinde öğrendiğim kavramlar arasında ilişki kurmaya çalışırım.	1	2	3	4	5
13. Bir hata yaptığımda nedenini bulmaya çalışırım.	1	2	3	4	5

	Kesinlikle katılmıyorum	Katılmıyorum	Fikrim yok	Katılıyorum	Kesinlikle katılıyorum
14. Yeni öğrendiğim biyoloji kavramları daha önce öğrendiklerimle çelişirse nedenini bulmaya çalışırım.	1	2	3	4	5
15. Biyoloji öğrenmenin önemli olduğunu düşünüyorum çünkü bu derste öğrendiklerimi günlük hayatta kullanabilirim.	1	2	3	4	5
16. Biyoloji öğrenmenin önemli olduğunu düşünüyorum çünkü bu dersin içeriği beni düşünmeye sevk ediyor.	1	2	3	4	5
17. Biyoloji öğrenmenin önemli olduğunu düşünüyorum çünkü bilimsel düşünmeyi öğrenmemi sağlıyor.	1	2	3	4	5
18. Biyoloji öğreniminin sorgulayıcı aktivitelere katılımımı sağlayacağı için önemli olduğunu düşünüyorum.	1	2	3	4	5
19. Biyoloji dersinde öğrendiklerimin kendi merakımı giderme şansı verdiği için önemli olduğunu düşünüyorum.	1	2	3	4	5
20. Biyoloji derslerine iyi notlar alabilmek için katılırım.	1	2	3	4	5
21. Biyoloji derslerine diğer öğrencilerden daha iyi bir performans gösterebilmek için katılırım.	1	2	3	4	5
22. Biyoloji derslerine katılırım böylece diğer öğrenciler zeki olduğumu düşünürler.	1	2	3	4	5
23. Biyoloji derslerine katılırım böylece öğretmen bana ilgi gösterir.	1	2	3	4	5
24. Biyoloji dersi sırasında kendimi en çok bir testte iyi bir not aldığım zaman mutlu hissederim.	1	2	3	4	5
25. Biyoloji dersinde kendimi en çok bir biyoloji konusu hakkında bilgimden emin olduğum zamanlar mutlu hissederim.	1	2	3	4	5
26. Biyoloji dersi sırasında kendimi en çok zor bir soruyu çözebildiğim zaman mutlu hissederim.	1	2	3	4	5

	Kesinlikle katılmıyorum	Katılmıyorum	Fikrim yok	Katılıyorum	Kesinlikle katılıyorum
27. Biyoloji dersi sırasında kendimi en çok öğretmenim fikirlerimi kabul ettiği zaman mutlu hissederim.	1	2	3	4	5
28. Biyoloji dersi sırasında kendimi en çok diğer öğrenciler fikirlerimi kabul ettiği zaman mutlu hissederim.	1	2	3	4	5
29. Biyoloji derslerine katılmaya istekliyim çünkü öğretmenim çok çeşitli öğretim yöntemleri kullanıyor.	1	2	3	4	5
30. Biyoloji derslerine katılmaya istekliyim çünkü öğretmenim bana çok fazla baskı yapmıyor.	1	2	3	4	5
31. Biyoloji derslerine katılmaya istekliyim çünkü öğretmenim benimle ilgileniyor ve bana önem veriyor.	1	2	3	4	5
32. Biyoloji derslerine katılmaya istekliyim çünkü bu derste öğrenciler sınıf içi tartışmalara katılıyor.	1	2	3	4	5

APPENDIX B

MANTIKSAL DÜŞÜNME YETENEK TESTİ

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

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

12. $\boxed{b}$ 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.

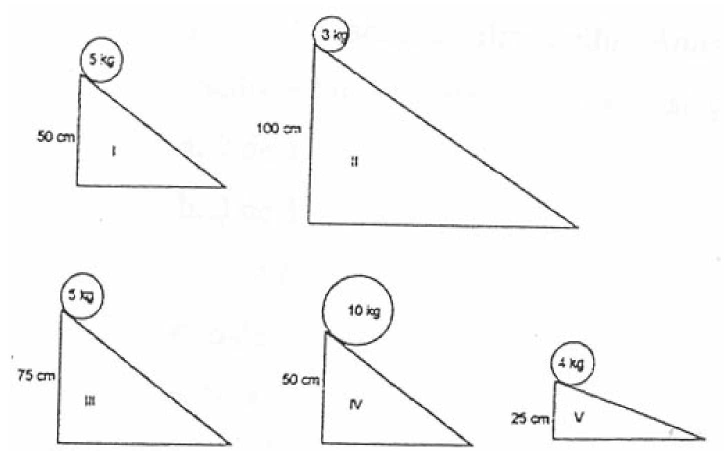
SORU 2: On bir odayı boyamak için kaç kutu boya gerekir? (Birinci soruya bakınız)

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?

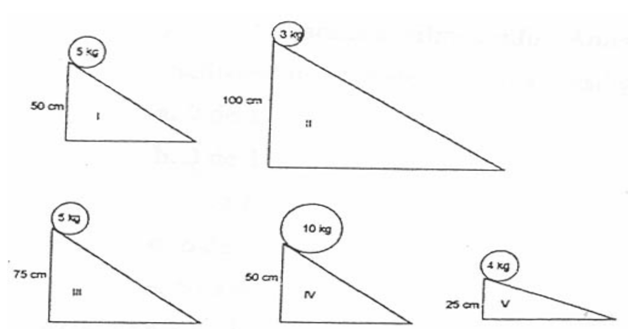


a. I ve IV
b. II ve IV
c. I ve III
d. II ve V
e. Hepsi

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 Ekspresi'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. Ardı ardına 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 yanı sıra, 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:

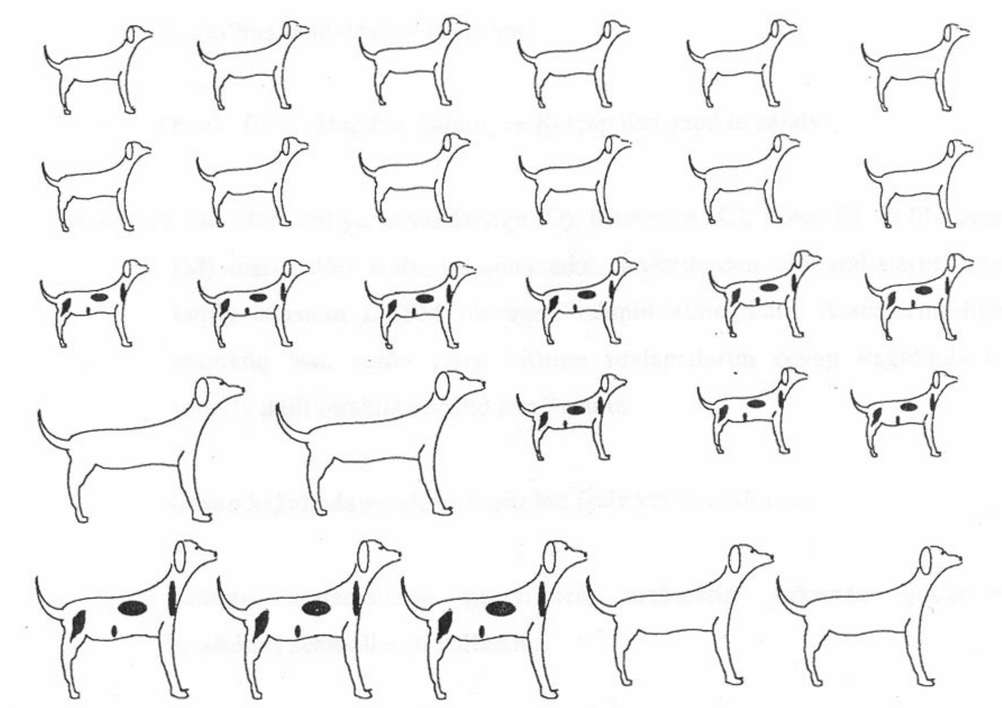
1. Birinci kutuda 30, ikincisinde ise yalnızca 20 kırmızı şeker vardır.
2. Birinci kutuda 20 tane daha fazla sarı şeker, ikincisinde ise yalnızca 10 tane daha fazla sarı şeker vardır.
3. Birinci kutuda 50, ikincisinde ise yalnızca 30 sarı şeker vardır.
4. İkinci kutudaki kırmızı şekerlerin oranı daha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

<u>Ekmek Çeşitleri</u>	<u>Et Çeşitleri</u>	<u>Sos Çeşitleri</u>
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 ve bir sos 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 Ketçapsan 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 boşluklara 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 C

ÖĞRENME YAKLAŞIMLARI ANKETİ

Sevgili Öğrenci,

Bu anket sizin Fen Bilgisi derslerine karşı yaklaşımınızı ölçmek amacı ile hazırlanmıştır. Bu sorulara vereceğiniz yanıtlar, araştırma amacıyla kullanılacak ve gizli tutulacaktır. Görüşleriniz bizler için çok önemlidir.

Yardımlarınız için teşekkür ederiz.

	Kesinlikle	Katılmıyorum	Katılıyorum	Kesinlikle
1. Genellikle ilk bakışta zor gibi görünen konuları anlamak için çok çaba sarf ederim.	1❑	2❑	3❑	4❑
2. Bir konuya çalışırken, öğrendiğim yeni bilgileri eskileriyle ilişkilendirmeye çalışırım.	1❑	2❑	3❑	4❑
3. Ders çalışırken, öğrendiğim konuları günlük hayatta nasıl kullanabileceğimi düşünürüm.	1❑	2❑	3❑	4❑
4. Konuları en iyi, öğretmenin anlattığı sırayı düşündüğümde hatırlarım.	1❑	2❑	3❑	4❑
5. Öğrenmek zorunda olduğum konuları ezberlerim.	1❑	2❑	3❑	4❑
6. Önemli konuları tam olarak anlayana kadar tekrar ederim.	1❑	2❑	3❑	4❑

	Kesinlikle	Katılmıyorum	Katılıyorum	Kesinlikle
7. Öğretmenler, öğrencilerden, sınavda sorulmayacak konular üzerinde çok fazla zaman harcamalarını **beklememelidirler.**	1❑	2❑	3❑	4❑
8. Bir kez çalışmaya başladığımda, her konunun ilgi çekici olacağına inanırım.	1❑	2❑	3❑	4❑
9. Derslerde duyduğum ya da kitaplarda okuduğum bazı bilgiler hakkında sık sık düşünürüm.	1❑	2❑	3❑	4❑
10. Konuların birbirleri ile nasıl ilişkilendiğini anlayarak, yeni bir konu hakkında genel bir bakış açısı edinmenin benim için faydalı olduğunu düşünürüm.	1❑	2❑	3❑	4❑
11. Anladığımdan iyice emin olana kadar dersten ya da laboratuardan sonra notlarımı tekrar tekrar okurum.	1❑	2❑	3❑	4❑
12. Bir konu hakkında çok fazla araştırma yapmanın zaman kaybı olduğunu düşündüğümden, sadece sınıfta ya da ders notlarında anlatılanları ciddi bir şekilde çalışırım.	1❑	2❑	3❑	4❑
13. Okumam için verilen materyalleri, anlamını tam olarak anlayıncaya kadar okurum.	1❑	2❑	3❑	4❑
14. Gerçek olaylara dayanan konuları, varsayıma dayanan konulardan daha çok severim.	1❑	2❑	3❑	4❑
15. Bir konuda öğrendiğim bilgiyi başka bir konuda öğrendiğimle ilişkilendirmeye çalışırım.	1❑	2❑	3❑	4❑

	Kesinlikle	Katılmıyorum	Katılıyorum	Kesinlikle
16. Benim için teknik terimlerin ne anlama geldiğini anlamanın en iyi yolu ders kitabındaki tanımı hatırlamaktır.	1❑	2❑	3❑	4❑
17. Bulmaca ve problemler çözerek mantıksal sonuçlara ulaşmak beni heyecanlandırır.	1❑	2❑	3❑	4❑
18. Genelde okumam için verilen materyalin bana sağlayacağı faydayı **düşünmem.**	1❑	2❑	3❑	4❑
19. Konuları ezberleyerek öğrenirim, yani öğrendiğime inanana kadar ezberlerim.	1❑	2❑	3❑	4❑
20. Çoğunlukla, konuları gerçekten anlamadan okurum.	1❑	2❑	3❑	4❑
21. Bir konuyla ilgili verilen fazladan okumalar kafa karıştırıcı olabileceğinden sadece derste öğrendiklerimize paralel olarak tavsiye edilen birkaç kitaba bakarım.	1❑	2❑	3❑	4❑
22. Ekstra bir şeyler yapmanın gereksiz olduğunu düşündüğüm için, çalışmamı genellikle derste verilen bilgiyle sınırlarım.	1❑	2❑	3❑	4❑

APPENDIX D

MİTOZ VE MAYOZ BAŞARI TESTİ

Adınız Soyadınız: ………………………………… **Sınıfınız:** …………

1. n= 8 olan diploid bir hücrede mitoz bölünme sırasında kaç tane kromatid bulunması gerekir?

   A) 4 B) 8 C) 16 D) 32 E) 64

2. Aşağıdaki olaylardan hangisi mayoz bölünmeye has bir özellik olup mitoz bölünmede görülmez?

   A) Kromozomların kendini eşlemesi
   B) Homolog kromozomların birleşerek tetradları oluşturması
   C) Kromatidlerin birbirinden ayrılması
   D) Kromozomların kısalıp kalınlaşması
   E) Kromozomların ekvator bölgesinde sıralanmaları

3. Aşağıdakilerden hangisi mayoz bölünmeyi mitoz bölünmeden ayırt eden özelliklerden biridir?

   A) Kromozomların kendi kendilerini eşlemesi
   B) Metafaz evresinde kromozomların ekvator düzleminde dizilmesi
   C) Kromatidlerin oluşması
   D) Bölünme sırasında çekirdekçiğin (nükleolus) kaybolması
   E) Homolog kromozomların bir araya gelmesi

4. Aşağıdakilerden hangisi mayoz bölünme ile sağlanır?

   A) Planaryada yenilenme
   B) Eğreltilerde yenilenme
   C) Memelilerde gamet oluşumu
   D) İnsanda yaraların iyileşmesi
   E) Omurgalılarda büyüme ve gelişme

5. Bir hücredeki mayoz bölünme sırasında aşağıdakilerden hangisi görülmez?

   A) Homolog kromozomların tetratlar oluşturması
   B) Monoploid hücrelerin oluşması
   C) Homolog kromozomların birbirlerine değerek sinaps yapmaları
   D) Bölünme sırasında çekirdek ve çekirdekçiğin kaybolması
   E) Diploid hücrelerin oluşması

6. Mitoz bölünme ile aynı kalıtım materyaline sahip iki hücrenin oluşmasının temelini teşkil eden en önemli neden aşağıdakilerden hangisidir?
   A) Her kromozomun iki kromatid hale gelmesi
   B) DNA moleküllerinin kendini eşlemesi
   C) Kromatidlerin birbirinden ayrılması
   D) Sitoplazmanın iki eşit parçaya bölünmesi
   E) Bir çekirdekten iki çekirdek oluşması

7. Sirke sineklerinin vücut hücrelerinde dört çift kromozom bulunur. Aşağıdaki sperm ve yumurta çiftlerinin hangisinden sirke sineklerinin dişi bireyleri meydana gelir?

   A) (7 + X) + (7 + X)
   B) (3 + X) + (3 + X)
   C) (7 + X) + (7 + Y)
   D) (3 + X) + (3 + Y)
   E) (4 + X) + (4 + X)

8. Kromozomları (22 + X) olan bir insan hücresi için aşağıdakilerden hangisi söylenebilir?

   A) Döllenmiş yumurtadır
   B) Mayoz geçirmiş bir hücredir
   C) Vücut hücresidir
   D) Mitoz geçirmekte olan bir hücredir
   E) Döl yatağının hücresidir

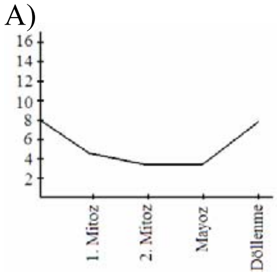
9. Çocuklar kalıtsal özelliklerini ana- babadan aldıkları halde, aynı anne ve babadan olan kardeşlerin kalıtsal materyalleri çok farklı olabilir. Bunun nedeni aşağıdakilerden hangisidir?

   A) Eşey hücrelerinin mayoz bölünmeyle meydana gelmesi
   B) Doğumdan sonraki büyüme ve gelişmenin farklı olması
   C) Çocuklarda kalıtsal özelliklerin çevre koşullarına bağlı olarak değişmesi
   D) Ana- babadan çocuğa geçen kromozom sayısının farklı olması
   E) Embriyo evresindeki gelişmelerinin farklı olması

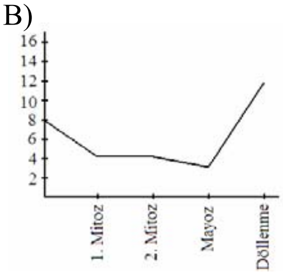
10. Sekiz kromozomlu bir hücre iki defa mitoz, bir defa da mayoz bölünme geçiriyor. Oluşan hücrelerden biri dölleniyor.

Yukarıda sözü edilen evrelerden geçen bir hücrenin kromozom sayısında görülen değişmeler hangi grafikte gösterilmiştir?

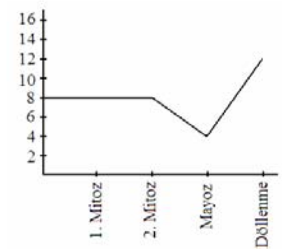
A)



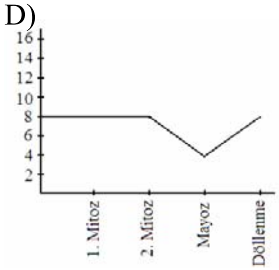
B)



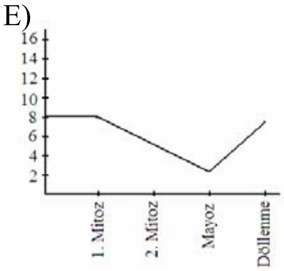
C)



D)



E)



11. Normal bir mayoz bölünmenin profaz evresi, aşağıdakilerden hangisi gerçekleştikten sonra başlar?

A) Ribozomlarda protein sentezinin başlaması
B) Sentrozomun kendini eşlemesi
C) Hücrede DNA miktarının iki katına (4n) çıkması
D) Kromatidlerin birbirinden ayrılması
E) İğ iplikçiklerinin oluşması

12. Canlılarda görülen mitoz bölünme, mayoz bölünme ve döllenme olayları sonucunda 1n ve 2n kromozomlu hücreler oluşabilir.
Bu olayla ilgili,

I. 2n kromozomlu hücreler, mayoz, 2n kromozomlu hücreler, mitoz, 1n kromozomlu hücreler, döllenme, 2n kromozomlu hücreler
II. 2n kromozomlu hücreler, mitoz, 2n kromozomlu hücreler, mayoz, 1n kromozomlu hücreler, döllenme, 2n kromozomlu hücreler
III. 1n kromozomlu hücreler, mayoz, 2n kromozomlu hücreler, mitoz, 1n kromozomlu hücreler, döllenme, 2n kromozomlu hücreler

ifadelerinden hangilerinde, olayların gerçekleşme sırası ve kromozom sayıları doğru olarak verilmiştir?

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

13. Aşağıdakilerden hangisi mitoz bölünme ile mayoz I bölünmesinin ortak özelliklerinden biridir?

A) Homolog kromozomların aynı kutuplara çekilmesi
B) Kromatidler arasında parça değişiminin gerçekleşmesi
C) Tetradların oluşması
D) Başlangıçtaki kromozom sayısının iki katına çıkması
E) Bölünme tamamlandığında kromozomların taşıdığı tüm özelliklerin yavru hücrelere eşit olarak aktarılmış olması

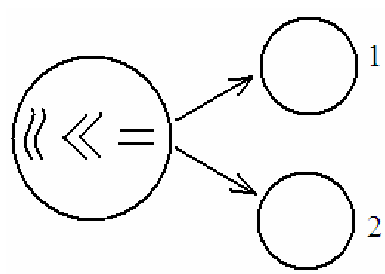
14. Mayoz bölünme hangi özelliği ile mitoz bölünmeye benzer?

A) DNA'nın kendi kendini eşlemesi
B) Tetradların meydana gelmesi
C) Kromozom sayısının yarıya indirgenmesi
D) Hayvanlarda gametleri oluşturması
E) Homolog kromozomların birbirine sarılması

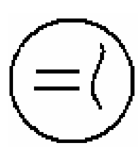
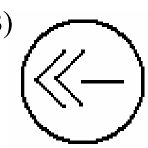
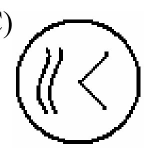
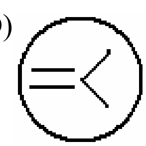
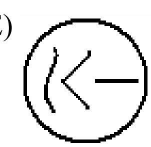
15. Soğan bitkisinin zigotunda 16 kromozom vardır. Bu zigottan meydana gelen soğan bitkisinin yaprak hücrelerinde kaç kromozom bulunur?

A) 4 B) 8 C) 16 D) 32 E) 64

16.



3 çift kromozomlu bir A hücresi bölünerek 1 ve 2 numaralı hücreleri oluşturuyor. Bu bölünme normal bir mayozun birinci evresi ise 1 ve 2 numaralı hücreler hangi kromozomları taşıyacaktır?

A)  B)  C)  D)  E) 

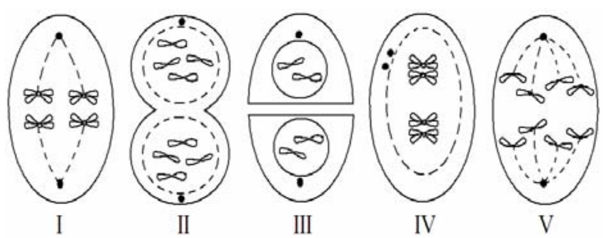
17. Diploid (2n) kromozomlu canlılarda Monoploid normal hücreler oluşurken meydana gelen aşağıdaki olaylardan hangisi sadece bazı canlı gruplarında gerçekleşir?

A) Sentriollerin kutuplardaki yerlerini alması
B) Tetradların oluşması
C) Endoplazmik retikulumun yıkılması
D) Kromozomların kendilerini eşlemesi
E) Homolog kromozomların farklı kutuplara çekilmesi

18. Aşağıdakilerden hangisi, yalnızca bitkilerin hücre bölünmesinde görülür?

A) Ara lamel oluşması
B) İğ ipliklerinin oluşması
C) Bölünme sırasında çekirdek zarının kaybolması
D) Sitoplazmanın boğumlanarak bölünmesi
E) Sentriyolün işlevi

19. Aşağıda, mitoz ve mayoz isimli hücre bölünmelerinin bazı evreleri şematik olarak gösterilmiştir.



Bu şekillerden mayoz bölünmeye ait olanlar, aşağıdakilerden hangisinde gerçekleşme sırasına göre verilmiştir?

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

20. Diploid (2n) kromozomlu bir hücre; önce mitoz bölünme, ardından mayoz bölünme, mayoz bölünme tamamlandıktan bir süre sonra ise yeniden bir mitoz bölünme gerçekleştirmiştir.
Buna göre, tek bir ana hücreden oluşan hücrelerle ilgili olarak aşağıdakilerden hangisi yanlıştır?

A) İlk mitozda oluşan iki diploit hücre aynı genotiptedir
B) Mayoz bölünme tamamlandığında, ilk hücreden dört haploit hücre oluşur
C) Mayoz bölünme tamamlandığında, ilk hücreden oluşan hücreler 4 ayrı genotipte olabilir
D) Son mitoz bölünmeyle ilk hücreden 16 haploit hücre oluşur.
E) Son mitoz bölünmeyle ilk hücreden oluşan haploit hücreler, 4 ayrı genotipte olabilir.

APPENDIX E

BLOOM'S TAXONOMY FOR MMAT ITEMS

Item	Knowledge	Comprehension	Analysis
1		X	
2	X		
3		X	
4	X		
5	X		
6		X	
7		X	
8		X	
9			X
10			X
11	X		
12		X	
13		X	
14	X		
15		X	
16			X
17		X	
18	X		
19			X
20			X