PREDICTING 9TH GRADE STUDENTS' GEOMETRY ACHIEVEMENT: CONTRIBUTIONS OF COGNITIVE STYLE, SPATIAL ABILITY AND ATTITUDE TOWARD GEOMETRY

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ABSTRACT

PREDICTING 9TH GRADE STUDENTS' GEOMETRY ACHIEVEMENT: CONTRIBUTIONS OF COGNITIVE STYLE, SPATIAL ABILITY AND ATTITUDE TOWARD GEOMETRY

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The aim of the study was to investigate how well the geometry achievement is explained by field-dependency/independency cognitive styles, spatial orientation, spatial visualization and attitude toward geometry.

The sample of the study was composed of 378 ninth grade students (183 male and 195 female) from five different lycees in Eskişehir. The types of schools participating in the study were General High School, Anatolian High School, Commercial Vocational High, and Anatolian Fine Art High School.

The data were collected by using four instruments, which were Group Embedded Figure Test (GEFT), Spatial Ability Tests, Geometry Achievement Test (GAT) and Geometry Attitude Scale (GAS). GEFT developed by Witkin, Oltman, Raskin and Karp (1971) was used to determine students' cognitive styles. Another test, The Spatial Ability Test developed by Ekstrom and colleagues (1976) was composed of four sub-tests. Two of them were aimed to measure spatial orientation, which were Cube Comparison and Card Rotation test. The others were developed to measure spatial visualization, which were Paper Folding and Surface Development tests. The Turkish version of the tests translated by Delialioğlu (1996) used in the study. In order to measure geometry achievement, GAT was developed by researcher. GAS developed by Bulut, İşeri, Ekici and Helvacı (2002) was used to measure the dimension of like/dislike geometry, usefulness of geometry and anxiety about geometry.

The data conducted from the research sample through the tests and scale was analyzed by using regression analysis. The multiple regression analysis indicated that students' cognitive styles were the most significant variable in explaining their geometry achievements. The other predictive variables also made statistically significant contribution in explaining the variance in geometry achievement. Four predictive variables of the study were entered the regression model, and explained the % 47 of the variance in geometry achievement.

The findings of the study suggested that students' field dependency/ independency cognitive style had high importance in learning geometry; and it should have taken into the consideration in teaching geometry.

Keywords: Cognitive style, field dependency/ independency, spatial ability, spatial visualization, spatial orientation, geometry achievement, attitude, mathematics education

ÖZ

9. SINIF ÖĞRENCİLERİN GEOMETRİ BAŞARILARININ TAHMİNİ: BİLİŞSEL STİLİN, UZAMSAL YETENEĞİN VE GEOMETRİYE YÖNELİK TUTUMUN BAŞARIYA KATKISI

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Araştırmanın amacı, alana bağımlı/ alandan bağımsız bilişsel stil, uzamsal yetenek ve geometriye yönelik tutum ile geometri başarının ne derece açıklanacağını araştırmaktır.

Araştırmanın örneklemini Eskişehirde beş farklı liseden 378 dokuzunucu sınıf öğrenci oluşmaktadır (183 erkek ve 195 kız). Genel lise, anadolu lisesi, meslek lisesi, ve güzel sanatlar lisesi araştırmaya katılan lise türleridir.

Veriler dört araştırma aracı kullanılarak toplandı. Bu araçlar, Grup Saklı Figürler Testi (GSFT),Uzamsal Yetenek Testi, Geometri Başarı Testi (GBT), ve Geometri Tutum Ölçeğidir (GTÖ). GSFT, Witkin, Oltman, Raskin and Karp (1971) tarafından bilişsel stilleri belirlemek amacıyla geliştirilmiştir. Testin, Delialioğlu (1996) tarafından Tükçeye çevrilmiş versiyonu bu çalışmada kullanılmıştır. Ekstrom ve arkadaşları (1976) tarafından geliştirilen uzamsal yetenek testi dört farklı alt testten oluşmaktadır. Bunlardan ikisi, Küp Karşılaştırma ve Kart Çevirme, uzamsal görme yeteneklerini ölçmeyi amaçlamaktadır. Diğer alt testler Kağıt Katlama ve Yüzey Oluşturma Testleri

uzamsal yönelme yeteneğini ölçmeye yönelik geliştirilmiştir. Delialioğlu (1996) tarafından geliştirilen Tükçe versiyonu bu araştırmada kullanılmıştır. Geometri başarısını ölçmek için araştırmcı tarafından GBT geliştirildi. Geometriden hoşlanma/ hoşlanmama, geometrinin kullanılışlılığı ve geometriyle ilgili endişe boyutlarını ölçmek için Bulut, İşeri, Ekici and Helvacı (2002) tarafından geliştirilen GTÖ kullanıldı.

Bu tests ve ölçekten elde edilen veri regresiyon analizi kullanılarak analiz edildi. Regresiyon analizi, öğrencilerin geometri başarılarındaki değişimi en iyi açıklayan değişkenin bilişsel stil olduğunu göstedi. Diğer değişkenlerde öğrencilerin geometri başarılarını açıklamada istatistiksel olarak önemli katkı sağladı. Dört değişken regresiyon modeline girdi ve geometri başarısındaki değişimin %47' sini açıkladı.

Bulgular, alana bağımlı ve alandan bağımız bilişsel stilin geometri konularını öğrenemde büyük öneme sahip olduğunu ve geometri eğitiminde dikkate alınması gereken bir değişken olduğunu gösteriyor.

Anahtar Kelimeler: Bilişsel stil, alana bağımlı, alandan bağımsız, uzamsal yetenek, uzamsal görme yeteneği, uzamsal yönelme yeteneği, geometri başarısı, tutum, matematik eğitimi

to my parents

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LIST OF ABBREVIATION

GAT	: Geometry Achievement Test
GAS	: Geometry Attitude Scale
GEFT	: Group Embedded Figure Test
SAT	: Spatial Ability Test
SO	: Spatial Orientation
SV	: Spatial Visualization
PFT	: Paper Folding Test
CRT	: Card Rotation Test
SDT	: Surface Development Test
CCT	: Cube Comparison Test
ATM	: Attitude toward Mathematics
AIM	: Achievement in Mathematics
SPSS	: Statistical Packages for Social Science
TIMSS	: Third International Mathematics and Science Study
PISA	: Programme for International Student Assessment
VIF	: Variance Inflation Factor

CHAPTER 1

INTRODUCTION

> Geometry is grasping space… that space in which the child lives, breath, and moves. The space that the child must learn to know, explore, and conquer in order to live, breath, and move better in it (Freudenthal, in NCTM, 1992, p.1).

"Geometry, considered as a tool for understanding, describing and interacting with the space in which we live, is perhaps the most intuitive, concrete and reality-linked part of mathematics'' (ICMI, 1998, p. 337 as cited in Barrantes & Blanco, 2006). It is important for every student, since "it is a natural place for the development of students' reasoning and justification skills" (NCTM, 2000, p. 40). Students' learning geometry contributes to development of their' spatial perception, it prepares them for higher mathematics and sciences and for a variety of occupation requiring mathematical skills, it helps to improve general thinking skills and problem solving abilities , and helps to develop cultural and aesthetic values (Sherard, 1981). Geometry is also an important tool for describing and interpreting our physical environment and solving problems.

Although teaching geometry is very significant tool for describing and interpreting physical environment we live in and solving problems and much endeavor to improve geometry education has been made, numerous researches indicated that many students can not learn geometry as they need or they are expected to learn (Clements & Battista, 1992).

The results of some international studies and national exams have given us an idea about students' achievement level in mathematics and geometry in Turkey. One of the most comprehensive studies showing cross-national differences in students' achievements in mathematics is The Third International Mathematics and Science Study (TIMSS). Turkey was the one of 38 countries participating to TIMSS conducted in 1999. The results of the TIMSS was indicated that Turkish students' achievement level in mathematics and geometry well below the international average. Regarding the average of general mathematics achievement, the position of the Turkish students was near the bottom (31st out of 38 participating countries) (Mullis, *et. al*., 2000). Regarding the geometry achievement, students' performance was worse than this. Turkey ranked 34th before Chile¸ Morocco, Philippines, and South Africa for achievement in geometry part of the test (Mullis, et. al, 2000).

Another international comparative study on students' overall performance mathematics at elementary school level was PISA. Turkey was participated this study conducted in 2003. Turkish students performed poorly in PISA, and the mean score of Turkish students was placed in very below the international average and near the bottom (PISA, 2003) like TIMSS did.

Apart from TIMSS and PISA studies, University Entrance Examination (UEE) conducted in Turkey gave us another view about students' geometry and mathematics achievements. UEE is a nationwide test administrated to high school graduates and senior high school students who want to enroll in undergraduate programs once each year in Turkey. It contains two mathematics tests, one of which was prepared to measure fundamental mathematics and geometry concepts, the other one was prepared to measure more advance mathematics and geometry concepts. The percentage of geometry questions in mathematics tests is 30%. Approximately 1.5 million students participated to UEE in 2008. The average of their correct answers in the mathematics part was 8.6 out of 30 (Student Selection and Placement Center (SSPC), 2008). Moreover, the average of about half million students participated the mathematics test measuring achievement in advance concepts was 7.9 out of 30 (SSPC, 2008).

The results of all these international studies and national exams indicated students' low achievement in mathematics and especially in geometry, and also indicated the necessity to increase students' mathematics and geometry achievement. This was realized by researchers for long time ago, and much effort has been made to improve students' performance in mathematics or geometry. Some researchers have been made investigations on effectiveness of a variety of instructions for solution of the problem which is students' poor performance in geometry (e.g. Bayram, 2004; Bedir, 2005; Duatepe, 2004; Işıksal, 2002; Önder, 2001; Özdemir, 2006; Pekdemir, 2004; Takunyacı, 2007; Zenginobuz, 2005). However, mathematics ability could not be improved just by means of instructing in mathematics, it was also required to focus on abilities necessary for doing mathematics (Bishop, 1980).

One of fundamental abilities critical in learning mathematics and geometry is seen as spatial ability (Bishop, 1980; Bishop, 1983; Clements, 1999; McGee, 1979). It refers to "the ability to generate, retain, retrieve, and transform well-structured visual images" (Lohman, 1988, p.319). The researchers mentioned two different spatial abilities, which was spatial ability and spatial visualization (Linn & Peterson, 1985; Lohman, 2000; McGee, 1979; Thurstone, 1938; 1950). According to McGee (1979);

> Spatial visualization is the ability to mentally rotate, manipulate, and twist two- and three-dimensional stimulus objects. Spatial orientation ability includes the comprehension of the arrangement of elements within a visual stimulus pattern, the aptitude to remain unconfused by the changing orientations in which a spatial configuration may be presented, and an ability to determine spatial orientation with respect to one's body (p.909).

The spatial abilities are important to comprehend inherently geometric world (NCTM, 1989), and to operate geometric or non-geometric information (Clements & Battista, 1992; McGee, 1979). It also be appeared as prerequisite for success in geometry since geometry is partly "the study of spatial relations" mathematically (Battista, Wheatley & Talsma, 1982, p.333).

Mathematics educators have been interested in spatial abilities after comprehensive researches on spatial abilities were made in psychological area. The relationship between mathematics achievement and performance in spatial tests has been widely investigated, and many researchers have concluded that there has been a statistically significant relationship between mathematics achievement and spatial ability (Battista, Wheatley & Talsma, 1982; Battista, 1990; Beldwin, 1984; Ben- Chaim, Lappan & Houang, 1988; Fennema & Sherman 1977, 1978; Fennema & Tartre, 1985; Guay & McDaniel, 1977; Johnson & Meade, 1987; Noraini, 1998; Sherman, 1979). Additionally, some researchers found that performance in spatial ability tests highly associated with achievement in geometry (Ben-Chaim *et.al.* 1988; Bishop, 1983; Linn & Clements, 1981; Johnson & Meade, 1987). According to Clements and Battista (1992), since both spatial ability and geometry contains lots of visual component, a high relationship between two is exist.

One of these studies concerning with the correlation between spatial tests and achievement was conducted by Guay and McDaniel (1977). They found significant correlation with mathematics achievement and two different test results. One of which was measured spatial visualization and the other was spatial orientation at elementary level. Similarly, Fennema and Sherman (1977) found a high relationship between spatial visualization and achievement in mathematics at high school level.

Numerous researches investigated the difference in spatial ability between boys and girls spatial ability. (Baenninger & Newcombe, 1989; Baldwin, 1984; Caldera, Huston & O'Brien, 1989; Delgado & Prieto, 2004; Hyde, 1981; Johnson & Meade, 1987; Linn & Peterson, 1985; Nalon & Voyer, 2000; Voyer, Voyer & Bryden, 1995; Voyer, Quaiser-Pohl & Lehmann, 2002). Some of them revealed that there was a significant difference between boys and girls in terms of spatial ability; and, it was frequently found that boys revealed higher performance in spatial tasks than girls (Delgado & Prieto, 2004; Fennema & Sherman, 1977, 1978; Hyde, 1981; Johnson & Meade, 1987; Linn & Peterson, 1985; Quaiser-Pohl & Lehmann, 2002; Voyer, *et. al.*, 1995; Voyer, Nalon & Voyer, 2000). Battista (1990) also investigated the effect of spatial visualization on processes in problem solving in mathematics and geometry achievement. He concluded different model for boys and girls in prediction of students' geometry achievement as a result regression analysis.

While spatial visualization was only significant predictor of girls' geometry achievement, it was not entered in model as a significant predictor for boys.

On the light of these studies, it can be concluded that students' spatial ability can be a critical factor in explaining students' success or failure in geometry. Hence, it is worth to investigate students' spatial abilities because of its contribution to achievement in geometry. Additionally, since different results have been found for girls and boys with respect to performance in spatial visualization task, how well spatial ability and other dependent variables would explain students' geometry achievement was also investigated for boys and girls separately.

In addition to the spatial ability, cognitive style was seen as another significant factor related to the students' geometry achievement (Noraini, 1998; Witkin et. al, 1977; Witkin & Goodenough, 1981). In general, style can be defied as "preferred way of doing something" (Grigorenko & Sternberg, 1995 in Colls, 2007); cognitive style can be defined as the way of a person perceives, thinks, solves problems, learns or behaves to others (Witkin, Moore, Goodenough, & Cox, 1977). According to Riding and Rayner (1998), cognitive style is a complementary part between personality and cognition.

In present study, field dependence/ independence cognitive styles developed by Witkin and collages (1977) based on the results of the several laboratory studies was investigated. They asserted that cognitive styles are directly related to the way of information process, and how individuals think; perceive (Witkin & Goodenough, 1981). Therefore, some researchers assumed that it can be important in learning mathematics, and several investigated the relationship between cognitive styles and mathematics achievement (e.g. Bieri, Bradburn & Galinsky, 1958; Noraini, 1998). As a result of these studies, a significant association between field dependency and achievement in mathematics was found (Bieri, Bradburn & Galinsky, 1958; Bein, 1974; Buriel, 1978; Kagan & Zahn, 1975; Kagan, Zahn & Gealy, 1977; Noraini, 1998; Roberge & Flexer, 1983; Robinson & Gray; Satterly, 1976; Tinajero & Paramo, 1997; Vaidya & Chansky, 1980). For instance, Noraini (1998) found that field dependence/ independence cognitive style as best single predictor for students' geometry achievement as a result of the multiple regression analysis in addition to high correlated with geometry achievement and cognitive style. Additionally, some researchers found that field independent students found more successful in doing mathematics (e.g. Roberge & Flexer, 1983; Vaidya & Chansky, 1980).

All those studies indicated that cognitive style can also be a possible factor influencing doing geometry; hence, students' cognitive styles were included the present study.

Although cognitive domain found significant in explaining difference in students' learning mathematics and students' achievement in mathematics, some researchers asserted that affective domain should not be ignored (Sherman, 1979) The studies on relationship between attitude and achievement have not indicated always consistent results; however, low to moderate and statistically significant correlation was found (e. g. Aiken, 1970, 1976; Ethington & Wolfe, 1986; Ethington, 1991; McLeod, 1992; Minato, 1983; Minato & Yanase, 1984; Schiefele & Csikszentmihalyi, 1995; Ma, 1997; Ma & Kishor, 1997; Schoenfeld, 1989; Tsai & Walberg, 1983; White, 2001; Webster & Fisher, 2000)

In conclusion, students' spatial abilities, cognitive styles and attitude toward geometry were seen as significant factors related to success in geometry on the light of all these studies, and the role of these factors in explaining students' geometry achievement was investigated in the present study.

1.1 Purpose of the Study:

Students differ in their academics achievement; considerable studies have been indicated that their characteristics play a significant role in these differences (Riding, 2005). The main purpose of the study is to find out the relative criticality of students' characteristics including spatial abilities, cognitive styles, and attitudes toward geometry in explaining or predicting their geometry achievement, and how well geometry achievement is explained by these factors.

1.2 Significance of the study:

In general, students in Turkey show poor performance in geometry (Mullis, Martin, Gonzalez, Gregory, Garden, O'Connor, Chrostowski & Smith, 2000). In the most of studies on geometry education in Turkey, the researchers have been focused on the effects of various instructions on students' achievement in geometry concerning with the problem students perform poorly in geometry content area (Bayram, 2004; Bedir, 2005; Duatepe, 2004; Işıksal, 2002; Önder, 2001; Pekdemir, 2004; Takunyacı, 2007; Zenginobuz, 2005). It was also investigated the effects of the instructions on attitude toward geometry (e.g. Aksu, 2005; Bayram, 2004; Duatepe, 2004; İlgün, 2004; Özdemir, 2006). However, to investigate the effect of various instructions is not enough to solve this problem, and improve students' achievement in geometry. It is necessary to find out factors which play important role in learning geometry to understand better the problem students' low performance in geometry content area (Ünal, 2005). Additionally, identification of the influential factors affecting their achievement is the essential step in order to supply an improvement in students' mathematics or geometry performance (Chai, 1995).

In several studies, the relation between some factors like socio-economic status, perception of success, interest toward mathematics, student-centered activities, teacher-centered activities in the classroom (Altun, 2007; Gokce, 2005) out of school activities, school climate (Altun, 2007), spatial visualization , spatial orientation (Karaman, 2000) and mathematics or geometry achievement were investigated. Furthermore, Altun (2007) was investigated how well some student and school related factors would explain students' mathematics achievement, and found about 30% variance of the mathematics achievement explained by these factor. On the other hand, in the present study, different student-related factors like spatial abilities, cognitive styles and attitude were took into consideration; and it was aimed to find out how well geometry achievement would be account for by these factors.

Several international research studies similar to the present study were conducted. For instance, Naroni (1998) investigated the relative importance of spatial visualization, field dependence/independence, and van Hiele level of geometric thought in predicting achievement in geometry, and found that cognitive style as the best significant predictor for achievement in geometry. However, she ignored students' attitudinal characteristics toward geometry and did not take spatial orientation, another type of spatial ability, into consideration. Another similar research was conducted by Sherman (1979) investigated the role of attitude and spatial visualization in predicting mathematics achievement, and found spatial visualization a significant variable in predicting girls' geometry grades. However, students' cognitive style, which found as the only best single predictor of students' geometry achievement by Naroni (1998), was not included to his study. On the light of these studies, the common predictive variables found significant was investigated in the study.

Consequently, this study is important due to several reasons. Firstly, the predictors of the study were found separately important in explaining students' achievement (e.g. Aiken, 1970, 1976; Battista, Wheatley & Talsma, 1982; Battista, 1990; Bein, 1974; Buriel, 1978; Ethington, 1991; Fennema & Sherman 1977, 1978; Guay & McDaniel, 1977; Sherman, 1979; Ethington & Wolfe, 1986; Ma, 1997; Roberge & Flexer, 1983; Robinson & Gray; Satterly, 1976; Vaidya & Chansky, 1980); however field dependence/ independence cognitive style, spatial orientation, spatial visualization, and attitude toward geometry were not investigated together in order to predict students' geometry achievement. Secondly, the results can be helpful in explain the problem of students' low performance in geometry. The results also can contribute to improvement in students' geometry achievement by investigating relative importance of these predictors. Lastly, although some student-related factors were investigated in explaining students achievements (Altun, 2007), the predictive value of the factors were taken into consideration in this study has not been investigated in Turkey.

1.3 Research Questions:

The present research addresses the following questions and hypothesis;

P.1: “How well can 9th grade students’ geometry achievement be explained in terms of their cognitive style, spatial ability and attitude toward geometry?"

P1.1: “What is the extent to which 9th grade students’ cognitive style, spatial orientation, spatial visualization and attitude toward geometry could account for their geometry achievement?”

H1.1: The four variables together (cognitive style, spatial orientation, spatial visualization and attitude toward geometry) do not explain a significant amount of variance in 9th grade students’ geometry achievement.

P1.2: “What is the extent to which cognitive style, spatial orientation, spatial visualization and attitude toward geometry could account for 9th grade girls’ geometry achievement?”

H1.2: The four variables together (cognitive style, spatial orientation, spatial visualization and attitude toward geometry) do not explain a significant amount of variance in 9th grade girls’ geometry achievement.

P1.3: “What is the extent to which cognitive style, spatial orientation, spatial visualization and attitude toward geometry could account for 9th grade boys’ geometry achievement?”

H1.3: The four variables together (cognitive style, spatial orientation, spatial visualization and attitude toward geometry) do not explain a significant amount of variance in 9th grade boys’ geometry achievement.

1.4 Definitions of Term:

In the present study following terms were used by taking into account their definitions.

Spatial ability*:* "Spatial abilities are mental skills related to imagining, perceiving, manipulating, reorganizing, and retrieving visual images of objects" (Carroll, 1993 as cited in Hiede, 2006). The subjects' spatial ability score refers to their total scores on SAT, which is the sum of the spatial visualization score and spatial orientation score.

Spatial visualization: Spatial visualization is "the ability to mentally manipulate, rotate, twist, or invert a pictorially presented stimulus object" (McGee, 1979). Subjects with high spatial visualization ability are able to perform succesfully on Paper Folding Test (PFT) and Surface Development Test (SDT). In this study, the sum of PFT score and SDT score refer to participants' spatial visualization ability.

Spatial orientation: Spatial orientation is the ability to understand the positions of objects in space with respect to one's own position (McGee, 1979). This ability requires imagining an object different position. In this study, Participants' the sum of Card Rotation Test (CRT) score and Cube Comparison Test (CCT) score refers to their spatial orientation ability.

Cognitive Style: Cognitive style defined as "a measure of one's ability to dissemble relative information from an irrelevant background and to analyze and cognitively restructure information" (Witkin & Goodenough, 1981). Cognitive style is categorized as field dependent and field-independent. According to GEFT scores, participants' cognitive style defined.

Field-Dependent Cognitive Style: Field dependent individuals show less ability in disembedding simple figure within complex design, they are more influenced by the complex design, and tend to perceive stimulus more global and as presented (Witkin, Moore, Goodenough & Cox, 1977)

Field-Independent Cognitive Style: Field independent individuals show more ability to extract simple figure within complex design, tent to be more analytical, and less influenced by irrelevant information (Witkin, Moore, Goodenough & Cox, 1977).

Geometry Achievement: It is the measure of how well students attained objectives stated in National Mathematics Curriculum (MEB, 2000). It also refers to 9th grade students' score on GAT for present study.

Attitude toward Geometry: It refers to students' affective responses to liking geometry, usefulness of geometry, anxiety about geometry (Neale, 1969 as cited in Ma & Kishor, 1997).

CHAPTER 2

LITERATURE REVIEW

The purpose of this chapter was to present literature related to independent variables and dependent variable of the present study. The independent variables were spatial ability, cognitive style, attitude toward geometry, and dependent variable was geometry achievement.

The chapter consists of three sections, and each section is related to one of independent variables. The chapter begins with literature on spatial ability. In this section, it will be mentioned about how spatial abilities, spatial visualization and spatial orientation were defined and which spatial factors were identified by researchers, and how this ability is related with students' academic performance. A brief discussion on gender differences in spatial ability and possible explanations for those differences will also be presented in this section. In the second section, literature on field-dependent/ independent cognitive style will be presented. This section contains what cognitive style is, how field dependence/ independence cognitive style was developed, characteristics of field-dependent and field-independent individual and lastly its relation to academic achievement. Finally, students' attitudes toward geometry and its effects on students' achievement will be discussed.

2.1 Spatial Ability

Spatial ability has been widely studied by many researchers from different fields like psychology, neurological sciences, and education. The researchers studied on this subject agreed that spatial ability is a significant intellectual ability, and it composes of multiple mental processes (Linn & Peterson, 1985). However, there is little agreement among them concerning what spatial ability really is and which term should be used to express this ability and how this ability can be defined (Caplan et. al.1985)

Firstly, there have been two different suggestions in the literature regarding to the nature of spatial ability. For instance, Lohman (2000) claimed that spatial ability was not integration of different components; instead there are various spatial abilities related with image generation, storage, retrieval, and transformation processes. On the contrary, John and Meade (1987) claimed that spatial ability as a unitary facility or trait composing of different component.

Secondly, there is a termonolgy complexity in the literature in addition that there is a vague about the nature of spatial ability. The terms or labels differ from one researcher to another. The terms like spatial ability, visualization, spatial skill, visuospatial ability, spatial reasoning and spatial intelligence has been used. Nevertheless, among these, the number of researchers using spatial ability term is relatively higher than the researchers using other terms or label.

In addition to usage of different terms, different definition has been made for the same term, which made literature on spatial ability more complex. Altought there has been different definition of spatial ability, similarities exisist among definition. For instance, Lohman (1988) defined it as "generate, retain, retrieve, and transform well-structured visual images" (p.319). Similarly, spatial ability was also defined by Caroll (1993) as " the ability to generate, maintain and manipulate mental visual images" (p.315).

Another definition for spatial ability made by Tarte (1990), and he defined spatial skill as "mental skills concerning with understanding, manipulating, recognizing, or interpreting relationships visually" (p.216). A similar definition was given by Linn and Peterson (1985), and they defined it as "skill in representing, transforming, generating, and recalling symbolic, nonlinguistic information" (p.1482).

Moreover, the definition of spatial ability was made by Carpenter and Just (1986). They defined spatial ability as the ability to generate “a mental representation of a two or three dimensional structure and then assessing its properties a transformation of the representation” (p.221).

In addition to these researchers using the term of spatial ability; another researcher, Gardner (1983) used a spatial intelligence. He explained the term called spatial intelligence as “the capacities to perceive the visual world accurately, to perform transformation and modification upon one's initial perceptions, even in the absence of relevant physical stimuli” (p.173).

As a result of all these definitions, it can be concluded that a large variety of description of spatial ability has been made. According to Voyer and others (1995), the variety of the definitions may stem from the large variety of spatial test based on various operational definitions. The common point of all these description or definitions was that most of them contained the generation of mental images, and manipulation these created images (e.g. Caroll, 1993; Carpenter & Just, 1986; Linn & Peterson, 1985; Lohman, 1988). Therefore, spatial ability was seen as the quality of managing those various cognitive processes like generate, transform, and recall.

Although lots of definitions has been made, Bishop (1983) asserted that a "true" description can be never made for spatial ability, Nevertheless, spatial ability was accepted as the ability to generate, recall and manipulate mental images for this study since it contains common part of all the definition mentioned above.

2.1.1 Theoretical background of Spatial Ability, Spatial Visualization and Spatial Orientation

The fact that mechanical ability and practical ability were seen as prerequisite for success in technical occupations led to emergence of spatial testing and numerous researches on these abilities (Hegarty & Waller, 2005). According to McGee (1979), researches on these abilities were composed of a base for identification of spatial ability.

As a result of some factor analytic studies, a factor distinct from verbal skill was distinguished statistically by researchers. One of these researchers, Kelly (1928) labeled this separate factor as spatial factor and defined it simply as mental manipulation of shapes (as cited in McGee, 1979). Another researcher, Thurstone (1938) also isolated a spatial factor in his study, and he defined this spatial factor as a facility to manipulate an object mentally in two or three dimension (as cited in Boakes, 2006). Although the researchers have not agree on the exact definition of the separate factor called spatial factor, and various definitions was made; they has agreed on the existence of spatial factor (Hiede, 2006).

After composition of a consensus among researchers concerning existence of spatial factor or ability separated from verbal ability, factor-analytic studies have been conducted to clarify what spatial ability really is, and to understand its nature (e.g. McGee, 1979; Linn & Peterson, 1985; Lohman, 1988). These factor analytic studies were based on the investigation of correlations among different spatial tasks in order to figure out factors in spatial ability (Linn & Peterson, 1985).

According to McGee (1979), the first clear evidence for existence of the factors in spatial ability began with L.G. Humphreys of the Army Air Force (AAF), and the identification of different spatial factors or abilities continue with Thurstone’s (1938,1950) studies. As a result of factor analysis of the data collected trough AAF test, two spatial factors defined, which are spatial visualization and spatial relation (McGee, 1979). While spatial visualization involved ability to construct imagination of rotated form an object, and to image how to look an object from different position, spatial relations involved ability to recognize the arrangement of elements within a visual stimulus pattern (McGee, 1979).

Beside, Thurstone had described a spatial factor in his study conducted in 1938, and then found several abilities related to spatial thinking in his further study conducted in 1950 (McGee, 1979). The first ability is the ability to image the form of an object when it was turned into different positions or to recognize a moved form of object. The second ability was the ability to image the displacements or movements of the components of a configuration, and the last ability was the ability to visualize how a configuration looks when observer's position or orientation change (McGee, 1979).

Additionally, in his comprehensive study, McGee (1979) reviewed those factor analytic-studies results and proposed the existence of two different spatial abilities, which was spatial visualization and spatial orientation. He defined spatial visualization factor as "the ability to mentally rotate, manipulate, and twist two- and three-dimensional stimulus objects" and defined orientation factor as " the comprehension of the arrangement of elements within a visual stimulus pattern and the aptitude to remain unconfused by the changing orientation in which a spatial configuration may be presented." (p. 897). The factor called by McGee as spatial orientation was also described by Thurstone as "ability to think spatial relations in which the body orientation of the observer is essential part of the problem" (p.892). Addtionally, another researcher, Lohman (2000) defined the same factor as "the ability to image how a stimulus array will appear from different perspective"(p.319). Lohman agreed with McGee's spatial visualization definition as a spatial factor; however, his spatial orientation definition is more bounded than McGee's one (Hegarty & Waller, 2005). In addition, different from McGee and Thurstone, Lohman defined a third factor and called it as speed rotation.

Linn and Peterson (1985) made another comprehensive study on spatial factors. They acknowledged spatial ability as general label for several distinct abilities and defined three distinct spatial ability categories, which were spatial perception, mental rotation and spatial visualization. Spatial perception was defined by these researchers as the ability to "determine spatial relationship with respect to the orientation of their own bodies."(p.1482), this ability required to ignore distracting parts. This category is similar to spatial orientation described by Lohman (2000) and McGee (1985). Mental rotation was defined as the ability to rotate presented stimuli correctly and quickly (Linn & Peterson, 1985), which is similar with speed rotation factor described by Lohman (1988). Spatial visualization was defined by Linn and Peterson (1985) as "spatial ability tasks which involve complicated multi-step manipulation of spatially presented information "(p.1484). According to Linn and Peterson (1985) this ability was required multiple manipulation of more complex stimulus, which could involve both spatial perception and mental rotation.

Spatial visualization and spatial orientation were different abilities each other, so measurement of them was required different type of task. The tasks aim to measure spatial visualization and spatial orientation is distinguished from each other according to what is to be moved. If tasks required respondent to reach solution by conducting more than one step and is required mentally move or alter a configuration as a whole or part of it, these tasks measure spatial visualization ability (Tarte,1990). For instance, Paper Folding Test, Surface Development Test (Ekstrom, French, Harmon, & Dermen, 1976) measures spatial visualization ability. On the other hand, spatial orientation tasks involve changing perspective of a person looking object; the ability to visualize how an object would look from different perspective is necessary for spatial orientation tasks, tasks do not involve mentally alter the configuration or spatial information (Tarte, 1990). For example, Card rotation test was developed for measuring subjects' spatial orientation ability (Ekstrom *et al*., 1976, as cited in Tarte, 1990).

Consequently, the literature related to spatial ability began wtih being distinguished a factor differed from verbal ability as a result of factor analytic studies, and attempts to predict success in technical occupations (Hegarty & Waller, 2005). Then, the researchers were interested in the nature of this separate factor. They were agreed on the existence of spatial ability; however there has been a debate regarding its nature and spatial ability, labels of identified factors. (Voyer, et. al., 1995). Nevertheless, although the factors were labeled various names and were defined variously by different researchers, it is accepted that spatial ability is general name of distinct spatial abilities (Linn & Peterson,1985); and there have been enough evidence to existence at least two distinct spatial abilities, which were spatial visualization and spatial orientation (McGee, 1979). The various definitions for two types of spatial abilities were presented above; however, Ekstrom, French, Harman and Dermen (1976) description of spatial orientation and spatial visualization was accepted for presented study since the spatial ability test developed by these researchers was used to measure students spatial visualization and spatial orientation abilities. According to, Ekstrom, French, Harman and Dermen (1976):

> Spatial orientation is an ability to perceive spatial patterns or to maintain orientation with respect to objects in space; requires that a figure be perceived as a whole. Spatial visualization is an ability to manipulate or transform the image of spatial patterns into other arrangements; requires either the mental restructuring of a figure into components for manipulation or the mental rotation of a spatial configuration in short term memory, and it requires performance of serial operations, perhaps involving an analytic strategy (as cited in McGee,1979, p.891).

2.1.2 Gender Difference in Spatial Ability

Factor analytic studies aiming to explain the nature of spatial ability turned into the studies aiming to investigate individual differences in spatial ability in terms of gender or age group.

Numerous researches compared males and females in terms of their spatial abilities, the results of studies indicated that males were superior to females on all spatial ability measures, especially in mental rotation task (Delgado & Prieto, 2004; Ehrlich, Levine, & Goldin-Meadow, 2006; Hyde, Fennema, & Lamon, 1990; Johnson & Meade, 1987; Quaiser-Pohl & Lehmann, 2002; Scali et al., 2000; Levine, Huttenlocher, Taylor, & Langrock, 1999; Voyer, Nolan, & Voyer, 2000; Voyer, Voyer, & Bryden, 1995). Although existence of differences between females and males in spatial ability was widely accepted by researchers, magnitude of differences, the age of first appearance of those differences, the reasons for those differences are controversial (Linn & Peterson, 1985). Meta-analysis studies were used in order to clarify these issues by researchers (e.g. Hyde, 1981; Linn & Peterson, 1985; Voyer, *et. al.,* 1995).

One of these meta-analyses was made by Linn and Peterson (1985). They were interested in magnitude of sex difference in spatial abilities, and the ages which differences become appear firstly. At the beginning, they classified spatial ability tests into three categories, which were spatial perception, mental rotation and spatial visualization, and then investigated the magnitude of gender difference for each spatial category by using meta-analysis. Their results contradicted with the assertion that gender difference in spatial ability emerge in adolescence, and they found that gender difference in spatial perception favoring males first emerged about 8 age. However it was only found significant for about 18 ages. In addition, they were not able to find evidence for the magnitude of difference in spatial perception increase during adolescence. At all age groups, which were under 13, between 13 and 18, over 18, there was a significant sex difference in performance in mental rotation, favoring males. The gender difference discovered spatial task required to find solution rapidly, so the researchers proposed that a possible reason for this difference might be females responded test items slowly and cautiously. Although they found sex difference in spatial perception and mental rotation, the study results showed that there was no difference between male and female in spatial visualization performance at any age.

Another meta-analysis study was made by Voyer and colleague (1995). They criticized Linn and Peterson's (1985) categorization of spatial tests into three groups. Voyer and his collagues accepted that sex difference in spatial perception and mental rotation categories were evident; however, they asserted that the magnitude of gender difference would differ from one spatial test to the other in the same category of tests. Therefore, they investigated magnitude of sex difference both each spatial test and each spatial test category defined by Linn and Peterson (1985). Voyer and others (1995) proposed that Linn and Peterson’s spatial tests were categorized just by focusing on similarities, and differences among them were ignored. Furthermore, they criticized that the criteria of the effect size used for decision in homogeneity was not clear. Even though Voyer et.al. (1995) critiqued Linn and Petersons’ categorization of spatial tests; they did not suggest different categorization in their study. They replicated Linn and

Peterson categorization and found similar result. Similarly, the largest difference between males and females found mental rotation category, and the smallest in spatial visualization category. They also concluded that the magnitude of gender difference increase with age. In addition, they analyzed previous researches results and concluded that gender difference in various measures of spatial ability tent to be declined over time.

Johnson and Meade (1987) investigated the stage of life span (prior, during or after adolescence) the advantage of males in spatial ability become appears. However, differently than Linn and Peterson's (1985) study, they considered spatial ability as a unitary trait instead of relatively distinct components and they did not use meta-analysis. They administrated three spatial tests appropriate for wide range of age, and approximately 1800 public school students in different grade level were enrolled. The results indicated that males were superior to female in spatial ability existed at the age 10 (fourth grade), and gender difference nearly duplicated at the tenth grade. This result is consistent with the conclusion of Voyer *et. al.* (1995) in which the difference tends to increase with age.

Since gender difference in spatial abilities is generally acknowledged by researcher, several possible reasons for these differences have been investigated. For instance, biological and environmental factors like identified gender-role, maturation rate, hormones have been proposed to explain gender differences in spatial abilities by different researchers (Voyer, *et. al.*, 2000). On the other hand, some researcher stated that biological explanations ignored the differences life experience of genders, and males and females do not involve in spatial task equally. These researchers have found positive correlations between experience with spatial-type activities and performance on tests that measure ability (Caldera, Huston, & O'Brien, 1989; Baenninger & Newcombe, 1989; Quaiser-Pohl & Lehmann, 2002; Voyer, *et. al.*, 2000).

Gender difference in mathematics performance has been extensively investigated like gender difference in performance in spatial tasks. Many researches indicated that males outperform than females in mathematics performance (e.g. Fennema & Sherman, 1977; Hyde et al., 1990). Fennema and Sherman (1977) proposed that gender difference in spatial abilities may account for gender difference in mathematics performance. They concluded that differences in mathematics achievement nearly become disappear when spatial ability factor is controlled (Fennema & Sherman, 1977; Casey, Nuttall, & Benbow, 1995; Casey, Nuttall, & Pezaris, 1997). That is, gender difference in spatial ability contribute to gender difference in mathematics performance (Linn & Hyde, 1989)

Consequently, gender differences in spatial ability widely investigated in literature, and numerous studies indicated the males' obvious superiority over females (e.g. Linn & Petersen, 1985; Scali et al., 2000; Voyer & Hou, 2006; Voyer, Voyer, & Bryden, 1995).The researchers also interested in what age this superiority emergence (e.g. Johnson& Meade, 1987) and what factors related to this difference (e.g. Quaiser-Pohl & Lehmann, 2002). There was a consensus among researchers regarding existence of the gender differences in spatial ability. On the contrary, there has not been a consensus concerning which age the difference appeared. Most concluded that this difference emergence in early age and it was evident in adolescence. Additionally, the differences decrease over time. The reasons of this difference have not been clear but some researcher was focused on some biological factors like gender-role, maturation rate, hormones and others environmental factors like type of spatial task (Meiling Tang, 2006).

2.1.3 Relationship between Achievement in Geometry and Spatial Ability

Although factor analysts have involved in spatial abilities intensively for many years, mathematics educator did not show interest in this field at first, than they began to investigate relationship between mathematics and spatial abilities (Bishop,1983; Wheatley,1990), and numerous researches were conducted on investigation of the relationship between spatial ability and mathematics achievement (e.g. Baldwin, 1984; Battista & Clements, 1990; Battista, Wheatley & Talsma, 1982; Ben-Chaim, Casey, Nuttall, & Benbow, 1995; Lappan & Houang,1988; Fennema & Sherman, 1977, 1978; Fennema

& Tarte, 1985; Guay & McDaniel,1977; Johnson & Meade, 1987; Linn & Clement,1981; Tarte, 1990; Voyer & Sullivan, 2003).

According to Clements and Battista (1992), the existence of relationship between spatial ability and mathematics or geometry, containing lots of visual component, is predictable. There are many studies confirming this predictions (e.g. Battista, 1990; Battista, Wheatley & Talsma, 1982; Casey, Nuttall, & Benbow, 1995; Fennema and Sherman 1977, 1978; Guay & McDaniel, 1977; Noraini, 1998; Sherman, 1979).

For instance, Fennema and Sherman (1977) conducted their study in high school level, and they found correlation coefficient between spatial visualization and mathematics achievement as .48, which was statistically significant. Their research result also indicated that correlation between spatial visualization and achievement in mathematics almost as high as the correlations between mathematics achievement and verbal ability.

Another study was conducted by Guay and McDaniel (1977), and they asserted that most studies on spatial ability were conducted on high grade level; and correlation between mathematics achievement and spatial ability at elementary level was vague. Contrary to Fennema and Sherman, they investigated the association between spatial ability and mathematics achievement at elementary school level. They administrated four different spatial tests, two of which were Surface Development (SD) and Coordination of Viewpoints (CV). The CV used by researchers was required ability to visualize the how three-dimensional objects would appear from various viewpoints. It was used to measure students' spatial visualization abilities. In SD test, students were expected to visualize folded version of unfolded three-dimension objects surface and select it among options. The students' spatial visualization ability was measured by SD. They found a high positive correlation between mathematics achievement and spatial test scores. For instance, correlation coefficient between CV and mathematics achievement was .50 and .54 for 6th and 7th grade level, respectively. Similarly, correlations between SD and mathematics achievement found positive and statistically significant. They also found that high-mathematics achievers got higher scores in spatial ability tests than low-mathematics achievers.

Although many studies has been indicated that spatial abilities and achievement in mathematic strongly correlated (Battista, 1990; Battista, Wheatley & Talsma, 1982; Fennema and Sherman 1977, 1978; Guay & McDaniel, 1977; Noraini, 1998; Sherman, 1979), there has been also some contradicted result. For instance, Pandiscio (1994) criticize other research because they investigated correlation between a comprehensive construct involving several spatial abilities and generally mathematics achievement and he investigated relationship between mental rotation ability and relatively narrowed content of school geometry. He found the correlation coefficient between mental rotation and achievement in calculation of volume and surface area concept as .23. This was the only significant correlation, and relation between mental rotation and achievement in the remains concepts, similarity of objects and congruence figures, was not significant.

Numerous studies have been indicated the association between spatial ability and achievement in mathematics; even if there have been some contradictory results in the literature. However, how critical role spatial ability plays in learning geometry has not been clarified still (Battista et. al., 1982). In addition to calculation correlation coefficient between spatial visualization and geometry achievement, Battista, Wheatley and Talsma (1982) determined cognitive development and spatial visualization as significant factors for doing mathematics, and investigated relatively importance of these two variables in learning geometry. Cognitive development was a better predictor of geometry achievement than spatial visualization; however, the variance in geometry achievement explained by spatial visualization was significant. That is, both cognitive development and spatial visualization ability important in geometry achievement. Moreover, they found correlation between two different spatial visualization tests and geometry course scores as.39 and .42, which was also statistically significant.

Another researcher, Tarte (1990) asserted that there has been a great deal of discussion related to the possible relationship between spatial skills and mathematics in the educational literature; however, how and why these skills are related with mathematics was unclear. Therefore, she conducted a study aiming to comprehend the nature of relation spatial orientation ability and processes involved in problem solving. In the study, spatial orientation skill involved "organizing, recognizing, making sense out of a visual representation" (p.217) and visualizing an object how look in different position except for moving it mentally (Tarte, 1990). She concluded that spatial orientation may be a skill requiring to organize processes involved in problem solving and to connect new information with former one. She also found that students with low spatial orientation ability were able to solve fewer problems that students with high spatial ability, they made more mistakes in representation of the problems, and they were able to comprehend problems correctly fewer times.

On the other hand, contradicting research results exist regarding assertion that learners with high spatial ability are more successful in mathematical problem solving. For instance, Fennema and Tarte (1985) discriminated subjects as high spatial and low verbal or low spatial and high verbal and investigated how students differed in their ability to solve mathematical problems. They conclude that students with high spatial ability use more pictorial representations while they solve problems than students with low spatial ability. However, they could not solve more problems than students with low spatial ability.

In addition to the research studies covering calculation of correlation coefficient between spatial abilities and achievement and trying to understand the nature of this relation, some educational research including regression analysis has been conducted. In these researches, it was accepted that spatial ability was a significant factor to predict achievement. For instance, Sherman (1979) conducted a comprehensive study in which he firstly investigated whether affective and cognitive variables measured 9th grade could predict higher grade mathematics performance. These independent variables were three cognitive, which were spatial visualization, verbal skill and math achievement at 9th grade, and eight attitude variables measured by the Fennema-Sherman Mathematics Attitudes Scales. The regression analysis results indicated that these independent variables explained statistically significant variance in geometry achievement at 10th grade. Additionally, it was investigated whether spatial visualization would predict geometry performance in the same study. The results indicated that spatial visualization was third most significant predictor of geometry achievement after previous math achievement and verbal ability predictors. Moreover, it was investigated that whether the variables predicting mathematics performance could predict problem solving performance in mathematics, and it was concluded that 9th grade variables could predict problem solving performance in mathematics and spatial visualization also a significant predictor of this. The only significant affective predictor was confidence in learning math, usefulness of mathematics predicted geometry achievement but negatively.

Another comprehensive study including regression analysis conducted by Battista (1990), he hypnotized that mathematical processes used by students differ with respect to their mental abilities, and he investigated how spatial visualization affect the mathematical processes students used when doing mathematics. Battista (1990) administrated four paper-pencil tests, which were on spatial visualization, to measure the ability to mentally rotate three-dimensional objects, logical reasoning, geometry achievement, and geometric problem solving /strategies test. Geometry achievement test contained the concepts of angle relations and measures, parallel lines, properties of triangles, area and perimeter, circles, properties of polygons, the Pythagorean Theorem, congruence, similarity, proof, and coordinate geometry. Geometric problem solving/strategies test with nine questions, asked students to solve the problems and to choose their problem solving strategies among options or to describe their strategy if it was one of options. The researcher classified problem solving strategies students used as drawing, visualization without drawing, nonspatial, or none of the above. One of results of his study was that spatial visualization was significantly correlated with geometry achievement scores and number of solved geometry problem correctly for both boys and girls. Moreover, boys get significantly higher scores than girls on spatial visualization, geometry achievement, and geometric problem solving tests. In stepwise regression, different equations for boys and girls were found. While spatial visualization was only factor when geometry achievement predicted for girls, it was a critical factor for males. Logical reasoning was found an important predictor of males' geometry achievement.

In most research, regression analysis was resulted different for girls and boys. For example, Sherman (1980) conducted regression analysis and used about 16 predictors including attitudes and spatial visualization in order to predict high school students' success in mathematical problem solving and knowledge regarding mathematics concepts. The researcher found that a statistically significant amount of variance in students' mathematics performance was explained by their spatial visualization ability. That is, it was a significant predictor for the performance in mathematics. Additionally, the spatial visualization was a significant predictor of geometry performance for girls but not boys and also significant predictor of mathematical problem solving for senior girls. "Spatial visualization contributed more uniquely to the prediction of math performance for females than for males" (Sherman, 1980, p.481). She proposed that this is probably because of the slight male advantage in spatial visualization. Spatial visualization skill is thus less likely to be problematic for males than females. Another researcher, Noraini (1998) aimed to investigate the significance of spatial visualization, field dependence/independence, and van Hiele level of geometric thought in prediction of achievement in geometry of middle school students, and found that field dependence/independence is the best single predictor of geometry achievement as a result multiple regression analysis. When the researcher compared t-values and fond that van students' Hiele level was second best predictor, and spatial visualization was third best predictor of geometry achievement scores; however both had very close t-values. Additionally, the result indicated that that correlation between geometry achievement and cognitive style was .566 and correlation between spatial ability and geometry achievement was .351; and relation between van Hiele levels and geometry achievement was .336.

Consequently, a great deal of investigations indicated that spatial abilities are critical factor for mathematic and geometry achievement. Some researchers were interested in these abilities predictive role in students' achievement, and used regression analysis. While Noraini (1998) has been examining predictive role of students' spatial abilities and other cognitive student characteristics, he ignored affective domain role in achievement. On the other hand, Sherman (1980) considered both cognitive and affective domain; however, students' cognitive style, which found as best predictor of achievement, was not took into consideration. In the present study, both cognitive and affective domain took in to account and on the light previous researches mentioned above we decided to include spatial ability as a predictor variable.

2.2 Cognitive style

Cognitive style has been attracted researchers' attention and it has been investigated both theoretically and empirically in numerous researches. As a result of a large body of investigation, lots of conceptualizations and terms arose like cognitive style, learning style, and thinking style (Broeck, Vanderheyden & Cools, 2003).

Most frequently the terms of cognitive style and learning style has been used, but the meaning of the terms differentiated by one researcher to another (Riding & Cheema, 1991). While some researchers used learning style and cognitive style as interchangeable, others considered them as different from each other (Broeck,*et. al.*, 2003).

According to Riding and Sadler-Smith (1997), cognitive style is a core characteristic of the individual; however, learning styles are the strategies and ways of adapting the material to use it effectively as possible. Another main distinction between two is related to the number of style elements that is considered (Riding & Cheema, 1991). Cognitive style has a bi-polar nature, that is usually contains two opposite components; on the other hand, learning style entails many components, and existence of one element does not mean that opposite element does not exist (Riding & Cheema, 1991). Moreover, when compared with learning style, cognitive style is much more "pervasive, stable and deep seated" (Riding & Sadler-Smith, 1997, p. 200).

Along with cognitive style is different from the term of learning style, it is usually accepted that cognitive style lies under the term of learning style. Although the terms used by researchers vary, many agreed on cognitive style refers to relatively consistent individual distinction in the way to encode, store and process information (Atkinson, 2003). The term cognitive style was defined by Witkin, Moore, Goodenough, and Cox (1977) as differences in the way individuals perceive, think, solve problems, learn, and relate to others. Additionally, Witkin and Goodenough (1981) asserted that the concept of cognitive style is a pervasive dimension of individual functioning, manifesting itself entire perceptional, intellectual, social and personal dimension.

Similarly, Morgan (1997) described cognitive style as the individual differences in preferred ways of organizing and processing information. Moreover, Grigorenko and Sternberg (1995) asserted that individuals' preference in processing information occurs without their awareness.

Riding and Rayner (1998) defined cognitive styles as "an individual's preferred and habitual approach to organizing and representing information" (p.9). Another definition was made by Broeck and others (2003), as an individual's way of perception stimuli in the environment, and the way of to organize and to utilize information. Cools (2007) made a similar definition as the way an individual perceive stimuli and how this perception or information is used to direct his thinking, feeling, actions..

In brief, in the light of this definition it can be said that cognitive styles as a part of individuals' characteristics are composed of preferences in perceiving, organizing, processing information. These preferences are mostly consistent and unconscious, and guide person's behaviors, thinking, and feeling.

In the literature regarding cognitive style, differences between cognitive style and ability has been discussed recurrently. The researchers usually have agreed that intellectual ability and cognitive style are two distinct constructs (Riding & Cheema, 1991; Witkin *et al*., 1977). Firstly, differences between two is related to the way of effect on performance in a given task. According to Hunter and Schmidt (1989), both ability and style have an effect on performance in a task; and generally as ability is improved, performance in a task increases (as cited in Riding & Sadler-Smith, 1997). On the other hand, “the effect of style on performance will be either positive or negative depending on the nature of the given task” (Riding & Sadler-Smith, 1997, p.200). It is most probably that an individual will learn or perform best in the situation that cognitive style match with the information-processing requirements of task (Hayes & Allinson, 1998, p.851). Secondly, while having more ability is better and more desirable, there is no superiority between cognitive styles, and they are equally valuable. (Broeck, *et. al*., 2003).

Another distinction between intellectual ability and cognitive styles was proposed by Messick (1984). According to Armstrong (2000) Messick’s distinction, “intellectual ability refers to what kind of information is being processed by what operation, in what form and how well, whereas cognitive styles refer to the manner or mode of cognition— to the question of how” (p.325). Consequently, while abilities indicate quantitative variety in individuals’ thinking processes, cognitive styles are concerned with qualitative differences among individuals in the cognitive functioning (Riding & Sadler-Smith, 1997).

Along with an agreement concerning with distinction of styles from abilities, there has been an agreement among researchers on substantially stability of cognitive style and agreement that it is not totally fixed (e.g. Hayes & Allinson, 1998; Riding & Cheema, 1991). Cognitive styles may not be easily modified through training or experience (Hayes & Allinson, 1994), but it may change over time.

2.2.1 Field Dependence/Independence Cognitive Style

Cognitive style has been studied by different researchers from different point of view. Researchers used different instruments to determine individual’s cognitive styles, and labeled these styles differently (Broeck *et. al.,* 2003). Riding and Cheema (1991) investigated the relationship among various label proposed by different researchers, and they grouped the labels into two main cognitive style groups, which were wholist-analytic and verbialiser-imager dimensions. Sadler-Simth and Riding (1999) describe the wholist-analytical dimension as the habitual way in which an individual processes and organizes information as a whole or by separating it into parts. On the other hand, they describe verbaliser-imager dimension as “habitual mode of representation of information in memory during thinking” (p. 358). This dimension involves whether individual process information in words or mental pictures.

Tablo 2.1: Riding and Cheema’s (1991) categorization of cognitive style labels

Wholist-Analytic dimension	Verbaliser-Imager dimensions
• Field dependence-independence (Witkin, 1962) • Impulsivity-reflectivity (Kagan, 1965) • Holist-serialist (Pask, 1972) Leveller-sharpener (Holzman & Klein, 1954) • Simultaneous-successive (Des, 1988) • Diverging-converging (Hudson, 1966)	• Sensory modality preferences (Bartlett, 1932) • Verbalizer—imager (Riding & Taylor, 1976) • Verbalizer-visualiser (Richardson, 1977)

Field dependency is one of most studied cognitive style model, which was developed by Witkin and his collages in the 1940s (Tang, 2003). It was categorizied by Riding and Cheema (1991) as wholistic-analytic dimension. Accutally, the base of wholist-analitic dimension derived from field dependency/ independecy cognitive style (Sadler-Simth & Riding, 1999)

The principles of field dependent/ independent cognitive style model, concerning with an individual’s dependency on his/her organization of the surrounding perceptual field, was based on the results of some laboratory studies on human perception of the upright direction (Witkin *et.al.,* 1977). In these laboratory studies, Witkin and his collages investigated individuals’ perception of upright and how individuals perform on orientation tasks. One of these laboratory studies was Body Adjustment Test, and it was developed to measure how rapidly and accurately individuals locate the upright direction by using physical senses. In this test, participants were seated on a chair in a slightly tilted room to the left or right, and chair and room could be moved separately. Subjects were asked to correct the chair tilted position to gravitational upright position. Some subjects oriented the chair or themselves to the tilt of the room while others more or less correctly oriented the chair to the gravitational upright direction.

According to Witkin and others, some subjects used external visual field while adjusting the tilted chair while others used their bodies' position as primary referent (Witkin & Goodenough, 1981). Despite misleading physical and visual cues generated by a tilted floor in a room, some participants were able to locate more or less the chair (or themselves) along the correct upright position by using internal referent (their bodies) as primer. On the contrary, individuals who oriented themselves wrongly or perform poorly in tasks were more influenced by the misleading environment clues since they used external visual field as primer referent (Witkin & Goodenough, 1981).

Witkin's another laboratory test was rod and frame test. In this test, the participant was seated in a dark room, and a tilted luminous square showed to them. There was a luminous rod in the center of square frame, which could be rotated clockwise or counterclockwise. Participants were asked to adjust this rod to the upright position. In this experiment, the subjects had an opportunity to use external (field) or internal (body) referents while adjusting the rod (Witkin & Goodenough, 1981). In this experiment, while some participant adjusted the rod more or less correct upright position regardless of the position of surrounding square, and some tilted it according to the position of surrounding frame. Participants who tilted the rod more or less correct gravitational upright position used the felt positions of their body (internal referent) and could discrete the rod from surrounding prevailing frame (Witkin *et. al.*,1977)

As a result these two laboratory studies, Witkin and colleague (1977) concluded that participants were significantly differed from each others, and used a consistent pattern in strategies from one upright task to another. They asserted that there is an individual difference in “tendency to use external visual field or the body itself as a primer referent for perception of the upright” (Witkin & Goodenough, 1981, p.13).

The Embedded Figure Test (EFT) is perceptual task requiring disembed an item from a complex organized design involving it. According to Witkin and Goodenough (1981), body adjustment test and rod- frame test could be also considered as a perceptual task since they were required to separate an item (e.g. rod or body) from a background (frame or room) similar to EFT.

After the EFT administration, Witkin and others concluded that it was easy to separate simple figure from confusing complex patter involving it for subjects who preferred to use internal referents previous tests, but it was difficult to overcome prevailing effect of the complex patter involving simple figure subjects who preferred to use external referents (Witkin & Goodenough, 1981).

As a result of these tests, it was concluded that there was self-consistency in performance across body adjustment, rod-frame and EFT. That is, the person who tails the rod correct vertical position is likely to adjust the chair correctly in the tailed floor, and is likely to find simple shape in complex design in a short time (Witkin *et.al.,* 1977).

Consequently, these test findings was consisted a significant base for field dependent/ independent cognitive style model and the description of these terms. At first, the terms of field-dependent/ field-independent was used to refer to “individual differences in tendency to rely primarily on visual field or the body as referents for perception of the upright” (Witkin & Goodenough, 1981, p.56). Individuals who prefer to use external visual field as primer referent was labeled as field-dependent; on the contrary individuals who prefer to use their body as primer referent was labeled as field-independent (Witkin & Goodenough, 1981).Their further studies indicated that field dependency cognitive style was not limited to perception of the upright. Witkin and colleague used these terms to refer “individual differences in ease or difficulty in separating an item from an organized field or overcoming embedding context" (Witkin & Goodenough, 1981, p.15). While people with the ability to separate simple figure from organized design easily was labeled as field-independent, people being force to separate simple figure from complex pattern involving it was labeled as field-dependent (Witkin *et. al,* 1977).

2.2.2 Characteristics of Field Dependency/Field Indepency

Field dependency cognitive style refer to individual differences regarding how they perceive, acquire, and act on knowledge of their surroundings (Witkin *et al.*, 1977). It should be emphasized that field- dependence or field-independence is not a measure of intelligence or ability (Linn & Kyllonen, 1981).

Field-dependence (FD) and Field-independence (FI) are two opposite poles of Witkin's bi-polar cognitive style model, and they are distinct from each other by perceptual, intellectual, and psychological features (Witkin *et al.*, 1977). According to Witkin and collages (1977), an individual could not be categorized either field-dependent (FD) or field independent (FI). Actually, there is a continuous distribution between FD and FI, an individual's cognitive style is at the range of these extreme modes. "FD/I reflect a tendency in varying degrees of strength, towards one mode of perception or the other" (Witkin *et. al.*, 1977, p.7).

When Witkin and his colleague (1981) compared FD with FI, found that relatively FD individuals have more interpersonal competence, while FI persons have more cognitive reconstructing skill. FD individuals' openness to information of external sources and tendency to use it primarily may lead to possess greater interpersonal competence; on the contrary, the fact that FI individuals are more independent from external resources may lead to foster their cognitive reconstructing skills (Witkin & Goodenough, 1981).

According to Witkin and Goodenough (1981), a relatively FD individual have a tendency to leave the stimulus material as it is given. Moreover, they indicate more passive manner in disembeding and structuring. On the other hand, a relatively FI person tend to restructure the stimulus material (Witkin *et. al.*, 1977).

Briefly, relatively field-independent individuals, are autonomous from external references, are more capable of cognitive restructuring and disembedding skills; and tent to be analytic; on the contrary, field-independent individuals show less ability to separate objects from their environment, tend to adhere to external referents, have more interpersonal competence, tent to be more global in their perception, and they perceive environment or situation as presented (Witkin & Goodenough, 1981).

Daniel (1996) summarized the characteristics of FD and FI individuals as presented in Table 2.1. (p.38)

Table 2.2: Characteristics of Field-dependents and Field independents

Field-Dependents	Field-independents
• Rely on the surrounding perceptual field. • Have difficulty attending to, extracting, and using non salient cues. • Have difficulty providing structure to ambiguous information. • Have difficulty restructuring new information and forging links with prior knowledge. • Have difficulty retrieving information from long-term memory.	• Perceive objects as separate from the field. • Can disembed relevant items from non-relevant items within the field. • Provide structure when it is not inherent in the presented information. • Reorganize information to provide a context for prior knowledge. • Tend to be more efficient at retrieving items from memory.

2.2.3 Relationship between Field Dependence/Field Independence and Achievement in Mathematics/ Geometry

It has been suggested by many researchers that cognitive style is a significant variable in learning and learning outcomes (Witkin *et al.*, 1977) since it is a characteristic directly related to information processing (Dwyer & Moore, 1998). There are Considerable amount of studies that have been investigate the relationship between cognitive styles and mathematics achievement (Bieri, Bradburn & Galinsky, 1958; Bein, 1974; Buriel, 1978; Kagan & Zahn, 1975; Kagan, Zahn & Gealy, 1977; Noraini, 1998; Renninger & Snyder, 1983; Roberge & Flexer, 1983; Robinson & Gray; Satterly, 1976; Vaidya & Chansky, 1980;)

For example, Bieri, Bradburd and Galinsky (1958) was made a investigation with collage level students, and found a significant association between collage students' cognitive style measured by EFT and mathematics ability measured by mathematical scholastic aptitude test (Math SAT). They also investigated difference between male and females students, and found differences on EFT in favor of male students. Additionally, students getting extreme scores, ten highest and lowest EFT scores, was grouped and these two extreme group were compared in terms of math SAT scores. It was concluded that students perform better on EFT get higher mathematics aptitude scores.

In another study, Satterly (1976) investigated interrelationships between field-independence and achievement in mathematics. The findings of his/her study indicated that there is a significant relationship between mathematics performance and field independency even after difference in intelligent have been statistically controlled. In same study, Satterly grouped students as FD, FI and intermediate (I) with respect to EFT score. Each group was composed of 30 boys. The only significant difference in mathematic attainment test score was found between I/FD when differences in intelligence held constant, and highest mean was belong to I boys. contrary to other studies (e. g.

Bein,1974, Bieri, Bradburd & Galinsky,1958; Roberge & Flexer, 1983; Renninger & Snyder, 1983) , he asserted that the differences between FD and FI stemmed from FD boys' to be low in mathematics rather than FI boys to be better in mathematics.

Vaidya and Chansky (1980) aimed to investigate that the roles of cognitive development and cognitive style in mathematics achievement separately in order to explore the relation between mathematics achievement and individual difference in field dependence/ independence, and cognitive development level. Their subjects were 102 second, third and fourth grade students. Researchers used Children Embedded Figure Test (CEFT) to determine students' cognitive style, Stanford Achievement Test (SAT) to measure their mathematics achievement, and Conservation Test Battery to determine their cognitive development level as high operational or low operational. In each grade level, high operational students got higher scores in mathematics than low operational ones, and field-independent students got higher scores than field-dependent students. Moreover, the significant association between mathematics achievement and field-independent cognitive style at all grade level was found.

Roberge and Flexer (1983) made a similar study with Vaidya and Chansky's in which it was aimed to investigate the effect field dependence/ independence cognitive styles and cognitive development levels on mathematics, However, they conducted their study at upper elementary grades, and used formal operational tasks to measure students' operational development level and Group Embedded Figure Test (GEFT) to identified their cognitive styles because of their ages. The result of this study was consistent with previous. As expected, field-independent students obtained higher scores in mathematics than field-dependent ones; high operational level students obtained higher scores than low operational students. Moreover, researchers found that cognitive style had a significant influence on mathematics achievement at sixty, seventy and eight grade level.

Beside these studies, Feij (1976) investigated relationship between academic achievement and performance in field-independence test, impulsiveness, previous education or training. The researcher used hidden figure test and hidden pattern test as a measure of field-independence. He found math-trained subjects obtained high scores in field-independence tests than their counterparts, and assumed that there is relation between training and field-independence. There was not a relationship between scores on field-independence tests and academic achievement in course related psychology.

On the other hand, Renninger and Snyder (1983) found significant a relationship between field dependence/independence and academic achievement at secondary school level. They found correlation between GEFT scores and mathematics achievement measured by a standardized test as .41. They also found that field-independent students get higher scores on both verbal and mathematics section of the standardized achievement test that field- independent ones.

Tinajero and Paramo (1997) investigated also the relationship between academic achievement and field dependence/independence cognitive style. Like Satterly (1976), they assigned intelligence as covariate; however, they measured FD/I by using two distinct tests, which was GEFT and Portable Rod Frame Test. researchers determined students' academics achievements by means of their mark obtained in the foreign language, mathematics, science and social science at 8th grade. When students' intelligence scores was hold statistically constant, it was concluded that field dependence-independence as identified by using the GEFT was a significant source of variance in overall marks; on the other hand, it was found that field dependence-independence as identified by using Rod and Frame Test was not a significant source of variance. Researchers asserted that GEFT was also a significant source of variance in students' mathematics marks. As a sequence, they concluded that that the existence of a statistically significant association between academic achievement and cognitive style depends on the test used to identify cognitive style, and they accepted the thing identified by the EFT as field dependence-independence.

Lastly, as mentioned in the section on spatial ability, Naroini (1998) included field dependence/independence cognitive style into regression analysis as a predictor of students' performance in geometry. The results were indicated that cognitive style was best single predictor of achievement in geometry.

The researchers were proposed some possible reasons for why cognitive style is a significantly related to achievement in mathematics. According to Roberge and Flexer (1983), requirements asked for field-independence task is similar to those of mathematics achievement tests. Another explanation was made by Bein (1974). He asserted that field independence-independence variable is a significant factor for the success in mathematics since both field independence and achievement in mathematics demanded analytic ability involving perceptually disembedding, reorganizing and reconstructing information (Vaidya & Chansky, 1980). In a similar way, Witkin and collages (1977) were asserted that analytic skills as the feature of field-independence cognitive style may make easier to be successful in mathematics for field independent students.

In conclusion, tought there are many cognitive style models cognitive style model developed by Witkin and collages, was interested in the presents study since the studies indicated that field-dependency/ independency cognitive styles was related to achievement (Bein,1974, Bieri, Bradburd & Galinsky,1958; Roberge & Flexer, 1983; Renninger & Snyder, 1983; Naroni, 1998).

2.3 Attitude toward Mathematics and Geometry

Individual differences in learning mathematics partially are explained by affective domain (Fennema and Sherman, 1976). The majority of studies indicated that a large part of the observed variance in achievement explained by cognitive students characteristics instead of affective characteristics (Schiefele and Csikszentmihalyi, 1995). Although affective factors like attitudes have been found less important in student mathematics achievement when compared with other cognitive factors like abilities (Aiken, 1970, 1976; Schiefele & Csikszentmihalyi, 1995), this does not mean that affective domain are able to be neglected (Schiefele & Csikszentmihalyi, 1995). Therefore, despite that affective characteristics explain less variance in achievement than cognitive ones, affective domain is still important in learning, and ignoring this domain would be mistaken. Since including and trying to measure all affective factors would be very tough and nearly impossible while measuring other students' characteristics, just attitude was included as an affective factor in this study.

In general, attitude definition has been made by different researchers. Aiken (1970) described attitude as "a learned predisposition or tendency on the part of an individual respond positively or negatively to some object, situation, concept or another person" (p.551). A similar definition of attitude was made by Ajizen, which was "a disposition to respond favourably or unfavourably to an object, person, institution or event" (as cited in Rufell, 1998, p.3). Similarly, Mouly defined attitude as learned patterns of manner which predispose an individual to behave to certain circumstances in a particular way (as cited in Thompson, 2003). Likewise, Sherif and Cantrel (1965) described attitudes as preparedness determining how an individual respond to particular stimuli.

On the other hand, Remmers and Gage (1955) were stressed on feelings, and asserted that attitudes are closely associated with feelings of pleasant and unpleasant (as cited Thompson, 2003). Duatepe (2004) also mentioned feeling and defined attitudes as one's feelings related to certain situation and these feelings influence individual's reaction to this situation.

Eventually, in the light of those definition, generally attitudes could be defined as individual's tendency to act in a specific way to certain circumstances or stimulus, and as a predisposition that influence an individual how to think, behave, feel or react.

Many different kinds of attitudes have been made by different researchers in addition to general definitions of attitude. One of various attitude definitions was attitude toward mathematics. Haladyna *et.al* (1983) was definition of attitude toward mathematics as "emotional disposition toward school subject of mathematics" (p.20). Other researchers Ma and Kishor (1997) also made a definition by extending Neale's definition of attitude toward mathematics. Neale’s (1969) definition was containing liking and disliking of mathematics, a disposition to involve in or avoid mathematical activities, a belief that one is good or bad at mathematics and a belief that mathematics is useful or useless (as cited in Ma & Kishor, 1997), and they added “students’ affective responses to easy/difficult as well as important/ unimportant of mathematics” (p.27).

This research only covered attitude toward geometry, an adapted version of Neale’s definition was used in the present study. In present study, attitude toward geometry refers to students’ affective responses to liking geometry, usefulness of geometry and anxiety about geometry.

2.3.1 Attitude toward Mathematics and Achievement in Mathematics

In the literature, investigations regarding to the relationship between attitudes and performance in mathematics has been not always concluded in similar way (Aiken, 1970). Nevertheless, low to moderate but statistically significant positive correlations between attitudes and achievement in mathematics usually has been found (e.g. Aiken, 1970, 1976; Aiken & Drager, 1961; Ethington & Wolfe, 1986; Ethington, 1991; Ma, 1997; Ma & Kishor, 1997; McLeod, 1992; Minato, 1983; Minato & Yanase, 1984; Schiefele & Csikszentmihalyi, 1995; Schoenfeld, 1989; Tağ, 2000; White, 2001).

For instance, Minato (1983) collected attitudinal data from 8th grade students by using attitude toward school mathematics test. This test was prepared by researcher and it was an adapted version of attitude test prepared to measure prospective elementary school teachers’ attitude. Achievement test used in the study was cover mainly four fundamental operations. The researcher found correlation coefficient value between the attitude toward school mathematics scores and school mathematics achievement test scores as 0.5142 (0.4985 for boys 0.5335 girls)

In another study, Minato and Yenese (1984) found correlation coefficient between attitudes toward school mathematics and mathematics test scores as .50, .52 and .47 for three different school types when they used same attitude scale previous research. Additionally, they investigated association between attitude to mathematics and achievement in mathematics for different ability group. At first, they grouped four high school studentsin terms of different ability level as a result of intelligence test scores. Then, they calculated coefficients between the students' attitude to school mathematics test scores and their summative mathematics test scores for each ability group. Minato and Yenese (1984) concluded that mathematics achievement and attitudes to school mathematics were more strongly correlated with for group of less able students than group of able students.

On the other hand, Ma and Kishor (1997) investigated the relationship between attitude toward mathematics and achievement in mathematics at the elementary and secondary school level by using meta-analysis. They found that overall mean effect size was 0.12, and concluded that relationship between attitude toward mathematics (ATM) and achievement in mathematics (AIM) was weak for educational practices in spite of positive and statistically significant.

Cai (1995) was also found a positive but weak correlation between student attitudes toward mathematics and their mathematics achievement. In this study, mathematics attitude scale was administrated to 125 6th grade students. The students' achievement in mathematics was defined as their national percentiles in the test administrated when they were 5th grade.

These inconsistent research results may stem from that nature of connection between those two variables. Attitudes do not directly liked to achievement in mathematics, and interaction between attitude and achievement is more complicated than being thought (Ma, 1997). Instead of unilateral interaction, the link between attitude and achievement is in reciprocal manner (Ma, 1997). In briefly, "attitude and achievement are interacted with each other in complex and unpredictable ways" (McLeod, 1992, p.582).

Some researchers also investigated attitudes' predictive role in student mathematics achievement. For example, Aiken and Drager (1961) examined that the role of attitudes in predicting mathematics performance in their study and studied with collage student. Math Attitude Scale, which prepared by the researchers, was used to predict collage students' final grade in the courses including general mathematics, intermediate algebra, or college algebra. Verbal reasoning, numerical ability was also included by researcher as the predictive variables to estimate performance in mathematics. As a result of multiple regression analysis, while all independent variables expect for attitude made a significant contribution the prediction males' final grade, math attitude scores and numerical ability make a significant contribution to the prediction of their final grades in a mathematics course for female. In other words, attitudinal variable was only significant for estimation of females' mathematics achievement.

Capraro (2000) studied specifically geometry achievement unlike previous researcher, and investigated relation between 6^{th} grade students' attitude toward mathematics and their achievement in geometry. The attitude toward mathematics test was composed of subscale of usefulness of mathematics, intrinsic value of mathematics, worry about math, confidence in learning math, perceptions about math, and attitude toward success. As a result of study, there was found a significant correlation between only two subscales and geometry content knowledge test scores, which was confidence in math and usefulness of math subscales.

Although numerous studies have been conducted regarding ATM and AIM, there have been very few studies related to attitude toward geometry (e.g. Bulut, *et al.* 2002) or including attitude toward geometry (e.g. Duatepe, 2004).

In conclusion, affective factors like attitudes seem to explain less variance in achievement that cognitive ones, however they are still significant and worth to be investigated. Although inconsistent research results exist related to correlation between ATM and AIM, most of them showed that correlation between those two variables was low in the positive way and statistically significant. Lastly, it has been realized that educational literature is very limited on the concept of attitude toward geometry unlike ATM.

2.4 Summary

Students differ in academic performance, and their characteristics play an important role on this difference. The main question is why some students just good at mathematics or geometry, why others not; and why some students are able to learn mathematics easily, why others face with difficulties. This issue has attracted many researchers' attention for many years and they conducted studies aiming to identify individual variables which can be significant in learning (Riding, 2005). As a result of their studies, several student characteristics which could be important in learning mathematics were identified. Among these factor, which can be related to performance in mathematics or geometry, spatial ability (e.g. Battista, *et. al*, 1982; Battista, 1990; Guay & McDaniel, 1977; Noraini, 1998; Sherman, 1979) field dependence/independence cognitive style (Bieri, Bradburn & Galinsky, 1958; Noraini, 1998; Robinson & Gray; Satterly, 1976; Vaidya & Chansky, 1980;), attitude (e.g. Ethington, 1991; Minato, 1983, Minato & Yanase, 1984) were stated.

Spatial ability refers to "the ability to generate, maintain and manipulate mental visual images (Carrol, 1993, p.315). According to McGee (1979), there were two different spatial abilities, which are spatial orientation and spatial visualization. A number of researchers found statistically significant association between achievement in mathematics and spatial abilities (Battista, 1990; Battista, Wheatley & Talsma, 1982; Fennema & Sherman 1977, 1978; Guay & McDaniel, 1977; Noraini, 1998; Sherman, 1979).

Style can be defined as "preferred way of doing something" in general (Grigorenko & Sternberg, 1995 in Colls, 2007). More specifically, it was defined the way of a person perceives, thinks, solves problems, learns or behaves to others (Witkin, Moore, Goodenough & Cox, 1977). According to Riding and Rayner (1998), cognitive style is a complementary part between personality and cognition.

Many cognitive style models were developed; however, the presents study was interested in cognitive style model developed by Witkin and collages. They developed this cognitive styles model based on the results of several laboratory studies aiming to investigate individual difference in spatial perception, and identified basic features of field dependents and independents. They described field-independent individual as showing better ability to overcome the effect of distracting context and tend to perceive context more analytically. On the other hand, more influenced by distracting context and tented to be more global in their perceptions was described as field-dependent individuals.

According to Witkin and colleagues (1977), cognitive style has a bi-polar dimension, which is a feature separate it from ability. While one extreme pole is field-dependence, the other pole is field-independence. Individuals stay in a point between two poles. More close to field-dependence point or more successful in task required disembed a simple figure from complex design is called relatively field dependent individual. Each style is just different and each style has equal value. However, individual with one style may be more successful in a specific area than individuals with the other style. Many researchers found performance in field independence task and achievement in mathematics or geometry were significantly correlated, and field independent tent to be more successful in mathematics achievement task (Bein, 1974, Bieri, Bradburd & Galinsky, 1958; Naroni, 1998; Renninger & Snyder, 1983; Roberge & Flexer, 1983). Therefore, all research mentioned above indicated cognitive style can be important predictor of achievement in geometry. According to Ma (1997), student characteristics are most significant predictor of mathematics achievement. Attitude is another student characteristics can be important in explaining achievement. The correlation between attitude and achievement have not been found low to moderate but statistically significant and positive way (Aiken & Drager, 1961; Aiken, 1970, 1976; Ethington & Wolfe, 1986; Minato, 1983; Minato & Yanase, 1984; Ethington, 1991; Ma, 1997; Ma & Kishor, 1997; McLeod, 1992; Schiefele & Csikszentmihalyi, 1995; Schoenfeld, 1989; Tuğ, 2000; White, 2001)

Consequently, the literature review indicated that spatial abilities, field dependence/ independence cognitive style and attitude were correlated with achievement and they could be significant factors in learning mathematics and geometry. Although the importance of all these factors was realized separately by the researcher; these factors have not been investigated in a study together. All studies mentioned in the literature were focused on one of these factors, and a few was taken into consideration several. In present study, the factors which were found separately important in learning geometry and mathematics were taken into account and the predictive values of all these variables were investigated.

CHAPTER 3

METHODOLOGY

The aim of this chapter presents methods used to investigate the research problems and procedures used for testing the research hypothesis.

The chapter composes of eight sections, and starts with overall design of study section, in which research steps and the purpose of the study is explained. Secondly, the research problem section contains main problem, sub-problems hypothesis of the present study. Then, in sample selection part, number of participant and sampling method used is mentioned. Instruments used to collect research data, their reliability and factor analysis result report in instrument part. After that, definition part explains terms related study and statistical technique explain procedures used to analyze research data and test hypothesis. Lastly, possible limitation of the study listed in assumption and limitation part.

3.1 Overall Design of the Study

In correlational research, it is studied on possible relationships among various variables, and the researcher does not try to influence the variables (Fraenkel&Wallen, 2000). The present study was a correlational research, and multiple regression technique was used to determine how well 9^{th} grade students' geometry achievements account for through four predictive variables, which were spatial visualization, spatial orientation, field-dependence/independence cognitive style, attitude toward geometry.

In the correlational researches, it is aimed to clarify understanding of important phenomena through the identification of the relationships among variables (Fraenkel & Wallen, 2000, p.360).

In order to supply an understanding related to 9th grade students' failure problem on geometry concept, it was investigated the correlations between geometry achievement, field dependent/independent cognitive styles, spatial visualization, spatial orientation and attitude toward geometry and it was also investigated significance of cognitive style, spatial orientation, spatial visualization and attitude toward geometry in predicting geometry achievement of students who graduated from elementary school .

3.2 Subjects of the study

The target population of the present study was defined as all 9th grade students in Eskişehir, which is a city in the middle region of the Turkey. The accessible was all high schools in the city center. In selection of sample observed, convenience sampling method was used.

In the Table 3.1, the number of student enrolled the research with respect to type of high school was given.

Table 3.1: 9th Grade Students' Distribution with respect to School Types

Type of Schools	Total Number of Students
General	160
Anatolian	86
Vocational	89
Anatolian Fine Art	43

As seen in Table 3.1 four different type of high schools were selected to conduct research. The type of school enrolled to research was General High School, Anatolian High School, Commercial Vocational High, and Anatolian Fine Art High School. Totally 378 9th grade student (183 male and 195 female) enrolled the research. The aim to select different type of high school was to supply that the research sample reflects the population. The number of student was approximately equal to each other in Anatolian High School and Vocational High School.

The different kinds of schools participating in the study have different conditions while accepting students. For instance, students should pass the OKS examination that is administered at the end of the 8th grade to go to the Anatolian High School.

3.3 Statistical Techniques:

Item and reliability analysis of GAT and GAS were conducted by using ITAMAN package program. Data collected from the subjects' were analyzed by using the SPSS package program. Descriptive statistics and stepwise multiple regression analysis were conducted in this program.

3.4 Instruments:

Four instruments were used in this study. Those are Geometry Achievement Test (GAT), Group Embedded Figure Test (GEFT), Spatial Ability Test (SAT), Geometry Attitude Scale (GAS).

The research instruments were administered in fall semester of 2007- 2008 academic year. Data collection continued about one month. Each week, one of the instruments was administered in each research school.

3.4.1 Geometry Achievement Test (GAT):

The Geometry Achievement Test (GAT) was developed by researcher to determine the students' geometry achievement and to measure the students' degree of acquisition of the objectives defined in elementary mathematics curriculum program (MEB, 2000). The test is given in Appendix A and the table specification is given in Appendix B.

Firstly, the objectives in National Elementary Mathematics Curriculum (MEB, 2000) published by Ministry of National Education was reviewed and the objectives related geometry concept in 6th, 7th and 8th grade level selected, the others were eliminated. To evaluate students' level of acquisition of those objectives, an item bank with 182 questions was prepared by researcher. Some questions were selected from the item bank by taking into consideration objective criticality measured by the item, content validity of the test. The opinion about the face and content validity of GAT was taken from an elementary school teacher and a researcher who is interested in mathematics education. As a result their suggestion, a GAT with twenty five questions (see Appendix A) was composed by the researcher.

In a pilot study of GAT, it was administrated to approximately 110 9^{th} grade students studying at an Anatolian School in the first semester of 2007-2008 academic years. The aim of pilot administration was to determine difficulty of questions, examine clarity and suitability of questions, and check test the adequacy of duration of test. The item analysis of GAT was made by using ITEMAN program, and the reliability of GAT was calculated by using SPSS package program.

The ITEMAN program supplies to calculate item discrimination power as a biserial coefficient and item difficulty power as the percentage of correct responses to each item. The criterion for the item difficulty power was that the coefficient should be between 0.2 and 0.8 (Ebel, 1965 as cited in Crocker & Algina, 1986). Additionally, the criterion was that the item discrimination power should be greater or equal to 0.2.

Some items were dropped since they did not have appropriate discrimination or difficulty power. Item 3, Item7, Item9 and Item 10 were eliminated because of discrimination power lower than .20. Although the item discrimination powers of Item 2 and Item 8 were less than 0.2; and, item difficulty powers for Item 2 was .88 we decided to hold these two items instead of removing them from the GAT in order to meet the content validity of the test. Both discrimination power and point biserial values of Item 1 was .18 and it was very close to critical value, we also decide to keep this item in GAT.

Consequently, four questions were eliminated after the pilot study. Alpha reliability coefficient of the GAT with 21 items was found as 0.72 in the ITEMAN program. KR21 reliability coefficient was also calculated, and it was found as .62. This reliability coefficient should be at least .70 (Fraenkel & Wallen, 2000). Even if, it was close to critical value, the KR21 reliability coefficient value of the GAT was found to be low. KR21 reliability coefficient was also calculated and it was found as .84 for actual study.

In evaluation of this test, each correct answer is one point and the total score of the GAT is 21.

3.4.2 Group Embedded Figure Test (GEFT)

The Group Embedded Figure Test (GEFT) (see Appendix C) was developed by Witkin, Oltman, Raskin, and Karp (1971) and Turkish version, which was developed by Cebeciler (1988), was used to determine whether students' cognitive style field- dependent or field- independent.

Each question in GEFT, there is a complex figure in which a simple figure are embedded. Participants are asked to find and trace the outline of wanted simple figure in complex figure in limited time. Subjects who tend to be field-independent figure out the simple shapes from complex ones and get higher score on GEFT than the subjects who tend to be field- dependent.

This is a sample question in GEFT:

Try to find simple form named “B” in the complex figure and trace it in pencil directly over the lines of the complex figure.

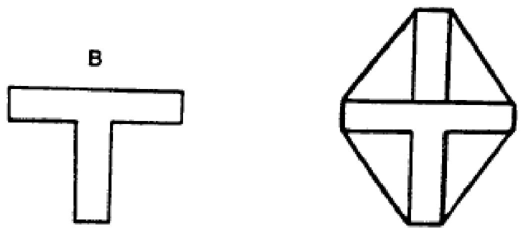

Figure 3.1: The sample question of GEFT (Witkin, et. al, 1971)

The test composes of three section and totally 25 questions. The first section, which contains 7 questions, does not take account when subjects' score calculate since this section aims to have made participants to practice on how questions are answered. The other two sections consist of 9 questions. Time limitation is 2 minutes for first section and 5 minutes for second and third section (Cebeciler, 1988). The scores of test range from 0 to 18.

Subjects whose scores on GEFT one-half standard deviation above the mean classified as field-dependent, subjects whose scores on GEFT one-half standard deviation under the mean classified as field-independent. Subject whose score around one standard deviation the mean classified as intermediate.

The reliability coefficient for GEFT was calculated as .86 for the present study. It was calculated by using KR21 formula. Reliability coefficient should be at least .70 (Fraenkel & Wallen, 2000), since reliability coefficent was found higher than .70, GEFT had enough reliability to be used.

3.4.3 Spatial Ability Test (SAT):

Spatial Ability Test administrated to measure students' spatial orientation ability and spatial visualization ability. The SAT (see Appendix C) was developed by Ekstrom (1976) and translated into Turkish by Delialioğlu (1996).

The SAT consists of four subtests, which are Paper Folding Test (PFT), Surface Development Test (SDT), Card Rotation Test (CRT), and Cube Comparison Test (CCT). First two tests aim to measure subjects' spatial visualization and last two ones aim to measure subjects' spatial orientation ability. Spatial visualization scores were the sum of the scores of the PFT and SDT; and spatial orientation scores were the sum of the scores of the CCT and CRT.

Paper Folding Test (PFT): Each question in this sub-test, a piece of paper fold and drill. The participant are asked to select the correct choose how paper will looks unfold. Each correct answer evaluated as one point, and totally there are 20 questions in this section. It was asked the students to complete PFT in six minutes.

The question below is a sample in PFT;

The square shaped paper on the left side of the vertical line is folded and then a hole is made. After unfolding the paper, which one of the shape in the right side of the vertical line will appear?

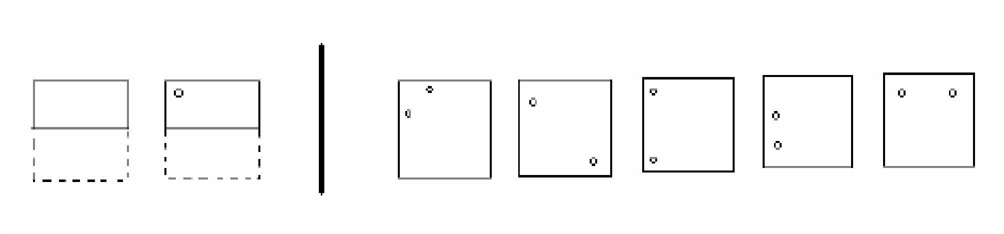

Figure 3.2: The sample question of PFT (Ekstrom, et. al, 1976)

Surface Development Test (SDT): The questions of this sub-test consist of folded and unfolded version of objects, and it is required that subjects match number and letter written on the side of figures. There are 12 question and each question consists five matching's. Every correct response is evaluated as one point. Therefore, the total score of SDT is 60. The students were asked to complete the SDT in twelve minutes.

The question below is a sample in SDT;

When the paper is folded from the dotted lines, the subject on the right will be formed. By imagining the folding of the paper, match the numbered edges to the letters. The surface marked by X on unfolded paper on the left and on the subject on the right shows the same surfaces.

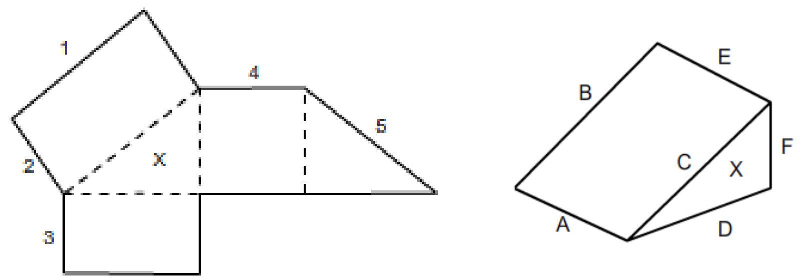

Figure 3.3: The sample question of SDT (Ekstrom, et. al, 1976)

Card Rotation Test (CRT): In this section, each question contains eight figures, and participants'' asked to compare first figure with other eight figures which are rotated and find whether these figure same with first one of not. There are 20 question and for sub-question 8 for each, so totally 160 question. Since each correct answer evaluated one point, total score of the CRT is 160. It was asked the students complete the CRT in six minutes.

The question below is a sample in CRT;

Find out whether the shapes on the right side can be determined by rotating the shape on the left side of the vertical line, in other words examine whether the shapes are the same or different. If the shapes are the same as the shape on the left side of the vertical line then mark S (Same), otherwise mark D (Different).

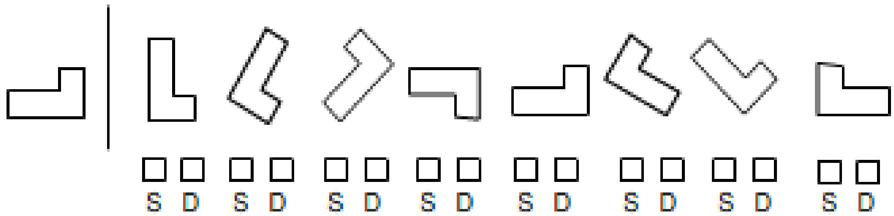

Figure 3.4: The sample question of CRT (Ekstrom, et. al, 1976)

Cube Comparison Test (CCT): Each question contains two cubes whose six surfaces figures or letters are written on. Only three surfaces of those cubes are showed, cube pair can be rotated form of the same cube. The participants are asked to decide whether pair of cube same or different by looking at figures or letter on their surface.

The question below is a sample in CCT;

In the following cubes all the numbers, figures and letters appears only once on each cube, but it can be in an unseen position. Then, find out whether the cubes on the left and the right are the same. If the cubes are the same then mark S (Same), otherwise mark D (Different).

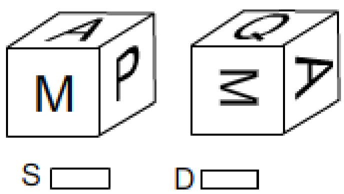

Figure 3.4: The sample question of CCT (Ekstrom, et. al, 1976)

Table 3.1 indicates reliability coefficients calculated by using KR21 formula for the present study, and the number of questions and total scores and limits of time given to subject to answer questions

Table 3.1 Reliability Coefficients, Number of Questions and Total Scores and Time Limits

Tests	Reliability	Number of questions and total scores	Duration
Spatial Orientation			
CRT	.72	160	6 minutes
CCT	.78	42	6 minutes
Spatial Visualization			
PFT	.75	20	6 minutes
SDT	.70	60	12 minutes

As seen in Table 3.1 the reliability coefficients were found .75 for PFT, .70 for SDT, .72 for CRT and .78 for CCT. Reliability coefficient should be at least .70 (Fraenkel & Wallen, 2000). SAT had enough reliability to be used since reliability coefficent was found higher than .70 for each sub-tests.

3.4.4 Geometry Attitude Scale (GAS):

Geometry Attitude Scale (GAS) was used to measure 9th grade students' attitude toward geometry. It was developed by Bulut, İşeri, Ekici and Helvacı (2002) (see Appendix E). According to Bulut, İşeri, Ekici and Helvacı (2002), GAS measures three different dimensions, like/dislike geometry, usefulness of geometry and anxiety about geometry.

The item format of the GAS was the five-point Likert scale. The possible responses "strongly agree", "agree", "undecided", "disagree", and "strongly disagree" and participants were asked to mark a five-point Likert scale by evaluating the statements. While the GAS was scoring, positively worded statement responses were coded starting from "Strongly Agree" as 5 to "Strongly Disagree" as 1 and for negative statements, the reversion was made. Higher scores in this scale indicate more positive attitude toward geometry.

The research data were analyzed by using SPSS, and the analysis indicated that eleven items (items 1, 2, 4, 5, 6, 8, 9, 11, 14, 16 and 17) constituted the first factor, three items (items 7, 14 and 15) constituted the second factor, and four items (items 3, 10,12, 13, 15) constituted the third factor. Zwick and Velicer's (1986) asserted that "at least three significant loading is required for factor identification" (p .432), so it can be conclude that the GAS measures three different dimension. The first factor was labeled as like/dislike geometry, the second one labeled as anxiety about geometry and the last factor labeled as usefulness of geometry for the present study.

The results of the factor analysis were the same as factors found by Bulut *et. al.* (2002) except for item 14. They were accepted this item as a measure of the dimension of "like/dislike geometry". The factor loading of this item indicated that it could be included both "like/dislike geometry" dimension and "anxiety" dimension. Since it has higher factor loadings in "anxiety" factor than "like/dislike" factor, it included the anxiety dimension of the GAS.

Table 3.2: Factor Analysis Result of GAS

	Factors		
Items	1	2	3
5-Geometri benim için zevkli bir konudur	**.818**	.296	.103
11-Geometri konularını severim	**.800**	.325	.177
4-Geometri ilgimi çeker	**.797**	.233	.125
6-Geometri konularını severek çalışırım	**.780**	.304	.135
17-Geometri konularını benim için eğlencelidir.	**.760**	.377	.081
1-Geomtri konularını tartışmaktan hoşlanırım	**.755**	.221	.107
8-Geometri ile ilgili ileri düzeyde bilgi edinmek isterim	**.672**	-.095	.225
9-Çalışma zamanımın çoğunu geometriye ayırmak isterim	**.669**	.109	.045
16-Geometri derinde zaman benim için çabuk geçer.	**.658**	.366	.075
2-Geometri konuları benim için sıkıcıdır	**.647**	.455	.082
7-Geometri konularından korkarım.	.123	**.808**	.022
15-Geometri öğrenilmesi benim için zor bir kondur.	.298	**.749**	.097
14-Geometri konusuna çalışmak içimden gelmez.	.521	**.618**	.098
3-Geometri gerçek yaşamda kullanılmayan bir konudur.	.000	-.008	**.859**
13-Geometri ile ilgili öğretilenleri günlük yaşama uygulayabilirim.	.482	.045	**.514**
12-Geometri konuları okulda öğretilmesede olur.	.103	.473	**.500**
10- Geometri konuları zihin gelişimine yardımcı olmaz.	.332	.266	**.341**

Cronbach alpha reliability coefficient of GAS scale was found .92 by using the SPSS package program.

3.5 Procedure

Procedure of the present study is explained below:

- A literature review was made to identify factors related with geometry achievement and to determine which factors worth to include research in order to explain students' geometry achievement.

- Target population was defined as all 9th grade students in Eskişehir.

- To measure defined factors to be correlated with students' geometry achievement, instruments which used for collect research data were obtained except GAT.

- GAT developed by researcher, and a pilot study was conducted with 110 9th grade students.

- All necessary permission was taken from Ethic Committee and Ministry of National Education.

- Respetively GEFT, GAS, SAT and GAT were administrated to the research school, and administration of the instruments was made at the same order in all school participating research.

3.6 Data Analysis:

The research data gathered through the research instruments was analyzed by using Statistical Package for Social Sciences (SPSS).

The stepwise multiple regression technique was employed to analyze the data in the present study. The regression analysis is used to analyze the associations between one dependent variable and several independent variables (Tabachanik & Fiddell, 2001). It is also used to predict scores on dependent variable of subjects by using their scores in several independent variables and to identify the best prediction equation (Tabachanik& Fiddell, 2001). The result of regression analysis does not indicated causality among variables, it just demonstrate the relationship between them, which may stem from many sources (Tabachanik & Fiddell, 2001).

The alpha level, a criterion of statistical significance, was accepted as 0.05 for statistical procedures.

3.7 Internal Validity:

Internal validity is refer to detected differences in dependent variable is related to independent variables, it is not other uncontrolled variables (Fraenkel & Wallen, 2000).

There are several threats to internal validity in the research. One of a possible treat for internal validity can be subject characteristics. In the present study, subject characteristics were not a problem, since all students were at same grade level, and their ages were close to each other. Another threat is mortality effect, which is loss of subjects as the study progress (Fraenkel & Wallen, 1996). In the present study, the number of the subject who was absent during the administration of one or more tests was low. According to Tabachnick and Fidell (2001), it is necessary 40 cases for each predictor. Since there were four predictive variables in the present study, at least 160 cases were necessary. There were 378 cases; so, data were collected from enough number of subjects. Furthermore, the location, where data are collected or instuents are carried out is called location threat (Fraenkel & Wallen, 2000). In this study, the classrooms at the research school had similar condition and outside events that could influence the subjects' responses were not observed during administration of the tests. The way of using the instruments may also lead a threat to internal validty (Fraenkel & Wallen, 2000). Instrument decay, data collector characteristics and collector bais could not be a threat for internal validity. The research data was collected in the same way from all the school. To eliminate instrument decay, all instruments examined carefully by the researchers, any scoring procedure change was not made.

3.8 External Validity

External validity refers to extending to which the results of a study can be generalized (Frankel & Wallen, 2000).

3.8.1 Population Validity

In the present study, convenience sampling was utilized instead of random sampling, so generalization of the findings of the study was limited. On the other hand, generalizability can be done for the subjects who have the same characteristics.

3.8.2 Ecological Validity

The ecological validity refers to the degree to which results of the study can be extended to other conditions or settings (Frankel & Wallen, 2000). The present study was conducted with 9th grade students studying regular settings, so the findings of the study can be generalized to similar settings.

3.9 Assumptions:

- The administration of the tests and questionnaire were completed under standard conditions.

- The participant responded to instruments' items accurately and honestly.

- The subjects were able to understand the test items correctly.

3.10 Limitations:

- The research was limited 9th grade students studying in high school in Eskişehir, a city in the middle of Turkey.

- The self-report technique used while gathering research data and it require that the participants respond tests and the questionnaire sincerely or honestly. Otherwise, the result of study may be misleading. Therefore, the study carries the limitation of self- report technique.

- Convenience sampling procedure was utilized, which may cause to a problem limited generalizability of findings of the present research.

CHAPTER 4

RESULTS

This chapter composes of three sections. In the first section, descriptive statistics results of the data collected by means of SAT, GEFT, GAT and GAS are presented. The second section is inferential statistics section where the results of the stepwise regression analyses which were employed to investigate the predictors of 9th grade students' geometry achievement are presented. In the last section, the conclusions obtained.

4.1 Descriptive Statistics

In this section, descriptive statistics results of the research data obtained from raw scores are given. The participants of the study were 378 9th grade students. 195 (51.6%) of subjects were girls and 183 (48.4%) of them were boys. Table 4.1 shows the means and standard deviations of the predictive variables and dependent variable.

Table 4.1: Means and Standard Deviations of Measures of the Study

Variables	Out of	M_{girls}	SD_{girls}	M_{boys}	SD_{boys}	M_{total}	SD_{total}
GEFT	18	7.985	4.849	6.175	4.649	7.108	4.883
CCT	42	21.753	5.984	20.69	5.256	21.24	5.662
CRT	160	75.16	30.054	68.867	36.166	72.123	33.249
SO	202	96.91	32.817	89.56	38.716	93.36	35.926
PFT	20	8.103	4.125	6.834	3.823	7.49	4.027
SDT	60	11.247	8.138	9.292	7.694	10.304	7.977
SV	80	19.35	10.168	16.13	9.878	17.79	10.145
SAT	282	116,263	39.223	105.685	44.963	111.157	42.368
GAS	5	3.358	.816	3.369	.783	3.363	.799
GAT	21	8.005	4.887	6.175	4.649	7.382	4.899

As seen Table 4.1, the mean of GEFT, which was used to measure participants' tendency to field-dependence or field-independency, was found 7.108 and standard deviation was calculated as 4.883 for entire sample. Another research instrument of the study, SAT was composed of sum of four subtests, which were CCT, CRT, PFT and SDT. The sum of scores in CCT and CRT was composed of SO scores, similarly sum of scores in PFT and SDT was composed of SV scores. The mean of participants' SAT scores was found 111.157 and standard deviation was found 42.368. This table also shows that mean and standard deviation of scores of tests for both boys and girls separately.The mean of SAT scores of the girls found higher that the mean of SAT scores of the boys. The mean of GAT was found 7.382 out of 21 and standard deviation was calculated as 4.899. While the mean of girls in GAT (M_{girls} =8.005) was found higher than the mean of boys was (M_{boys}=6.175).The standard deviation for boys was 4.649 and for girls was 4.887 in GAT. The mean of subjects' score on GEFT calculated as 7.12, and standard deviation was found as 4,84.

In the Table 4.2, the distribution of subjects with rescept to their cognitive styles, and GEFT scores used to classify participants are given.

Table 4.2: Distribution of Field Dependent/ Independent and Intermediate Students

	GEFT score (# correct)	Number of students
Field-dependent	0-4	108
Intermediate	5-9	137
Field-independent	10-18	133

As seen Table 4.2, participants whose GEFT scores were between 0 and 4 were classified as field-dependent and participant whose GEFT scores were between 10 and 18 were classified as field-independent. According to this classification, 108 students grouped as field-independent, 133 students as field- independent and 137 students as intermediate.

4.2 Inferential Statistics

In this section, the problems of the study will be examined by means of the null hypothesis at a significance level of 0.05

The main problem of the present study is "How well can 9th grade students' geometry achievement be explained in terms of their cognitive style, spatial ability and attitude toward geometry?"

4.2.1 Result of Testing for First Sub-problem of the Study

The first sub-problem of the main problem is "What is the extent to which 9th grade students' cognitive style, spatial orientation, spatial visualization and attitude toward geometry could account for their geometry achievement?"

For investigating this sub-problem a hypothesis was stated and given below:

H_o: The four variables together (cognitive style, spatial orientation, spatial visualization and attitude toward geometry) do not explain a significant amount of variance in 9th grade students' geometry achievement.

Before conducted regression analysis, the assumptions of the analysis were tested, which includes sample size, normality, linearity, homoscedasticity, multicollinearity, and singularity.

Firstly, whether the sample size of the study was enough to be conducted regression analysis was controlled. Tabachnick and Fidell (2001) suggested a practical formula for required sample size to utilize regression analysis. This formula is that 40 cases require for each independent variable to reach reliable conclusions for stepwise regression analysis. In the present study, there are four predictors; so, the number of cases should be 160 or more. The sample size is adequate to be conducted stepwise regression analysis since 375 subjects involved in the study.

Another assumption of the regression analysis is multicollinearity and singularity. Multicollinearity and singularity can be described as very high correlation among independent variables (Tabachnick & Fidell, 2001). To avoid inclusion of multicollinear independent variables Tolerance and VIF (Variance Inflation Factor) values should be controlled. Tolerance is an indicator of how much of the variability of specified independent variable is not explained by other independent variables in the model, and VIF is just the inverse of the Tolerance value (Pallant, 2005, p.150). Table 4.2 indicated tolerance and VIF values. Tolerance value is less than .10 or VIF value is higher than 10 indicate that multiple correlations with specified independent variable and other independent variable in the model are very high and muticollinearity exist (Pallant, 2005).

Tablo 4.2: Collinearity Statistics Results for all Subject of the Study

	Tolerance	VIF
GEFT	.632	1.583
SV	.615	1.626
SO	.632	1.582
GAS	.881	1.135

As seen Table 4.2, the fact that tolerance values were higher than .10 and VIF values less than 10 indicated that there were no multicollinear independent variables. However, even tolerance and VIF values show the nonexistence of multicollinearity or singularity, correlation among independent variables should also be controlled (Pallant, 2005). Table 4.3 displays correlation coefficients between independent variables.

Table 4.3: Pearson Correlation Values among Predictive Variables for all Subjects of the Study

	GEFT	GAS	SO
GAS	.331*	-	
SO	.501*	.227*	-
SV	.518*	.248*	.551*

Tabachnick and Fidell (2001) recommended that the correlation among independent variables should be less than .70. None of correlation among independent variables (cognitive style, spatial orientation, spatial visualization and attitude toward geometry) was more than .70. In conclusion, since tolerance, VIF and correlations among independent variables did not exceed critical values, it can be concluded that there was no multicollinearty and singularity problem for the present study.

Another assumption of regression analysis is normality. To check whether the normality assumption is verified, skewness and kurtosis values of the scores should be checked (Pallant, 2005). According to Kunnan (1998), the skewness and kurtosis values between –2 and +2 can be assumed as approximately normal (as cited in Yayan, 2003).

Table 4.4 indicated skewness and kurtosis values.

Tablo 4.4: Skewness and Kurtosis Values of Tests Scores for all Subjects of The Study

	GAT	GEFT	SAT	GAS
Skewness	.919	.528	.779	-.333
Kurtosis	-.219	-.640	.805	-.077

As seen in Table 4.4, all skewness and kurtosis values are between -2 and +2, so distribution of GAT, GEFT, SAT and GAS scores can be accepted normally distributed.

Additionally, “examination of residuals scatterplots provides a test of assumption of normality, linearity, and homoscedasticity between predictive variables scores and errors of prediction (Tabachnick and Fidell, 2001, p.136).” If all assumptions are met, the residuals will be nearly rectangularly distributed with a concentration of scores along the center (Tabachnick and Fidell, 2001, p.137).

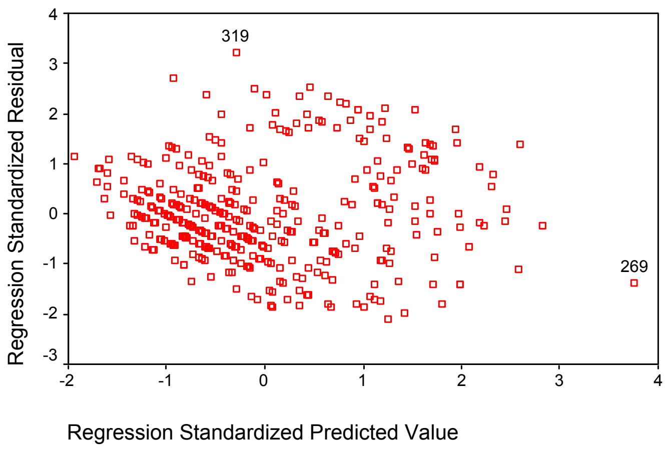

Figure 4.1: Scatterplot of Regression Standardized Residual for all Subject of the Study

Furthermore, extreme cases have too much impact on the regression solution and should be deleted, rescored or the variable transformed (p.133). The detection of extreme cases or outliers can be made the means of scatterplot of regression standardized residuals (Pallant, 2005). Outliers is defined as cases which have a standardised residual of more 3.3 or less than -3.3 (Tabachnick and Fidell, 2001) It may not be required to take any action when a few outliers exist (Pallant, 2005). When looking at scatterplot only two values seem to be exceeding 3.3. Therefore, it is unnecessary to take an action against outliers' threat.

Lastly, the bivariate correlation was also performed to determine which predictive variables to be used in the multiple linear regression analysis. The Table 4.5 indicated that the Pearson product moment correlation coefficients between independent variables and students GAT scores.

Tablo 4.5: Pearson Product Moment Correlations Coefficients between Predictive Values and Geometry Achievement Test Scores for all Subjects of The Study

	GEFT	GAS	SO	SV
GAT	.611*	.344*	.492*	.529*

*p<0.05

As shown in Table 4.5, all correlations were found statistically significant at the .05 level, so these predictive variables could be included regression analysis. Pearson correlation coefficient is also one of measures of effect sizes (Field, 2005). According to Cohen (1988), Pearson’s correlation coefficients which equal to 0.5 or higher are categorized as large effect size. Therefore the correlations between GAT scores and, SO, SV scores had large effect size; that is, the correlations had practical significance in addition to statistical significance. According to Cohen’s classification, the correlation between GAT and GAS scores had medium effect size; so, two variables shared a moderate amount of common variance. Coefficent determination, which is the square of correlation coefficients, indicates the measure of the proportion of the variance shared by two variables (Field, 2005). Since the correlation coefficient between GAT and GEFT scores was found as .611, coefficient determination was calculated as .37, which means that 37% of the total variance was shared by these two variables. Similarly, when coefficient determinations for GAS, SV and SO was calculated separately, it were found that 12% of the total variance was shared by GAT and GAS; 24% of the total variance was shared by GAT and SO; %28 of the variance was shared by GAT and SV variables.

Consequently, any assumption violation was not detected; so, the first hypothesis was examined by using linear stepwise regression at a significancye level of .05. The result of combined effect of predictors is given Table 4.6.

Table 4.6: Linear Stepwise Regression Analysis Results for Combined Effect of Four Significant Predictors on all Subjects' Geometry Achievement

	Sum of Squares	df	Mean Square	F	Sig.
Regression	4179.057	4	1044.764	80.602	.000
Residual	4795.945	370	12.962		
Total	8975.003	374			

As shown in Table 4.6, four predictive variables (GEFT, SO, SV and GAS) explained a significant amount of variance in 9th grade students' geometry achievement [$F(4,374) = 80.602$; $p=0.000$]. The results for individual effect of predictors is given in Table 4.7.

Table 4.7: Linear Stepwise Regression Analysis Results for Individual Effect of Four Significant Predictors on all Subjects' Geometry Achievement

	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
GEFT	.385	.048	.379	7.935	.000
SO	.021	.007	.153	3.204	.001
SV	.104	.023	.215	4.445	.000
GAS	.047	.015	.130	3.213	.001

As shown Table 4.7, all predictive variables had statistically significant contributions in explaining the variance in students' geometry achievement ($p<0.05$). Additionally, GEFT had the highest beta coefficient; so, it had the largest contribution to the explained variance in geometry achievement because Pallant (2005) stated that beta under standardized coefficient indicates the contribution of the predictive variable in explaining the variance in the predicted variable when the variance explained by all other variables in the model is controlled. Four predictive variables had a significant contribution to explain the variance in students' geometry achievement and enter the regression model.

Model summary for all subjects of the study was given in the Table 4.8. In this table individual effect of each predictor can be seen.

Table 4.8: Model Summary as a Result of Stepwise Regression Analysis

Predictors	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Sig. F Change
GEFT	.373	.371	3.8837	.373	.000
GEFT,SO	.419	.416	3.7439	.046	.000
GEFT,SO,SV	.451	.446	3.6452	.032	.000
GEFT,SO,SV,GAS	.466	.460	3.6003	.015	.001

As shown in Table 4.8, all predictive variables of the present study entered to the model ($p<0.05$). In the first step, GEFT contributed statistically significantly to the variance in students' geometry achievement. The amount of variance in this step was 37%. In the second step, both GEFT and SO entered to the model. While they explained 42 % variance in GAT scores, SO explained only 4.6% variance. In the third step, in additon to these variables SV also entered the model and three predictors together explained 45 % of the variance in achievement. Only SV explained only approximately 3% variance in GAT score. In the last step, all predictive variables entered the regression equation and explained 47% of the variance in geometry achievement. GAS, which entered last in regression model, explained 1.5% of the variance. Consequently, cognitive style, spatial visualization, spatial orientation, and attitude toward geometry explained a significant amount of variance in students' geometry achievement. All these variables of the study entered the regression equation and explained 47 % of the variances

Linear regression equation was written below by using beta values given in Table 4.7.

$$Y= 0.379.X_{GEFT} + 0.153.X_{SO} +0.215.X_{SV} + 0.130.X_{GAS}$$

In equation, X_{GEFT}, X_{SO}, X_{SV} and X_{GAS} respectively represent GEFT scores, spatial orientation tests scores, spatial visualization scores and attitude toward geometry.

4.2.2 Results Concerning Second Sub-problem of the Study

The second sub-problem of the study was "What is the extent to which cognitive style, spatial orientation, spatial visualization and attitude toward geometry could account for 9th grade girls' geometry achievement?"

For investigating this sub-problem a hypothesis was stated and given below:

H_o: The four variables together (cognitive style, spatial orientation, spatial visualization and attitude toward geometry) do not explain a significant amount of variance in 9th gare girls' geometry achievement.

Before conducted regression analysis, the assumptions of the analysis were tested, which includes sample size, normality, linearity, homoscedasticity, multicollinearity, and singularity.

Firstly, whether the sample size is enough to be conducted regression analysis was controlled. Since there were four predictive variables, sample size should be at least 160 (Tabachnick and Fidell, 2001). When girls' test scores separately included in the regression analysis, the number of subjects was still exceed 160. Therefore, the sample size would be still enough for conducting regression analysis to analyze the data obtained from girls.

Secondly, multicollinearity, and singularity was controlled by examining VIF and tolerance values. Table 4.9 indicates the VIF and tolerance values of predictive variables.

Table 4.9: Collinearity Statistics Results of Test Scores of Girls

	Tolerance	VIF
GEFT	.634	1.507
SV	.724	1.381
GAS	.841	1.189

As seen in Table 4.9, VIF values are less than 10 and tolerance values higher than .10; so, it was concluded that there was no multicolinearity among predictive variables. Additionally, the correlation coefficients among the predictors were controlled. The results were given in Table 4.10.

Table 4.10: Pearson Correlation Coefficients among Predictive Variables

Predictors	SO	SV	GAS
GEFT	.555*	.520*	.390*
SO		.537*	.348*
SV			.274*

*p< 0.05

As seen Table 4.10, correlation coefficients between predictive variables did not exceed .70, which indicated that there was no multicollinearity or singularity among these variables.

Another assumption for regression analysis is normality. Table 4.11 indicates the skewness and kurtosis values.

Table 4.11: Skewness and Kurtosis Values of Tests Scores of Girls

	GAT	GEFT	SO	SV	GAS
Skewness	.756	.415	.666	.936	-.319
Kurtosis	-.520	-.768	.473	1.454	-.278

Table 4.11 indicates that all skewness and kurtosis values between were -2 and +2, it was accepted that the normality assumption was verified. In

addition to, if the assumption of normality, linearity, and homoscedasticity were verified, the scatterplot should be nearly rectangular (Tabachnick & Fidell, 2001).

As seen Figure 4.2, there were not any cases which have a standardized residual of more 3.3 or less than -3. 3; so, there were not any outliers.

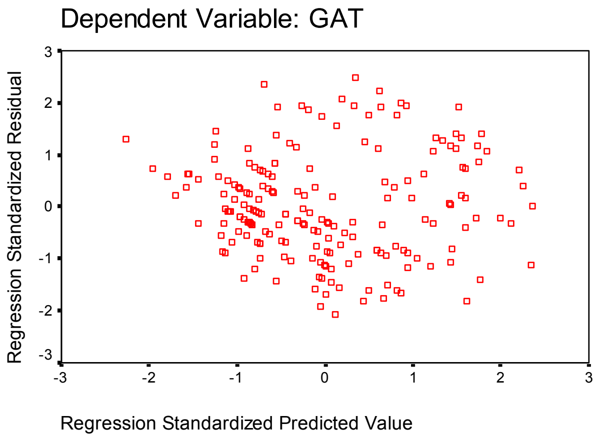

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Figure 4.2: Scatterplot of Regression Standardized Residual for Girls'

Consequently, any assumption violation was not detected; so, the second hypothesis was examined by using stepwise regression at a significance level of .05. The result for combined effect of predictive variables is given in Table 4.12.

Table 4.12 indicated that models obtained as a result of stepwise regression analysis.

Table 4.12 Linear Stepwise Regression Analysis Results for Combined Effect of Three Significant Predictor Variables on Girls' Geometry Achievement

	Sum of Squares	df	Mean Square	F	Sig.
Regression	2228.052	3	742.684	58.699	.000
Residual	2403.948	190	12.652		
Total	4632.000	193			

As shown in Table 4.12, three predictive variables (GEFT, SV, GAS) explained a significant amount of variance in girls' geometry achievement [F (3,193) = 58.699, and p=0.000].

The individual effect of each predictor can be seen in the Table 4.13.

Table 4.13: Linear Stepwise Regression Analysis Results for Individual Effect of Three Significant Predictors on Girls' Geometry Achievement

Predictors	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
GEFT	.315	.065	.309	4.814	.000
SV	.171	.030	.354	5.770	.000
GAS	.078	.020	.222	3.886	.000

As Table 4.13 indicates that, GEFT had highest beta value, it can be concluded that the highest contribution was made by this independent variable in predicting girls' performance in GAT. The independent values made statistically significant contribution in explaining girls' geometry achievement were GEFT, SV and GAS, since these predictor significance values less than .05.

Table 4.14: Model Summary a Result of Regression Analysis for Girls

Predictors	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Sig. F Change
GEFT	.580	.337	.333	3.99982	.337	.000
GEFT,SV	.663	.440	.434	3.68601	.103	.000
GEFT,SV, GAS	.694	.481	.473	3.55702	.041	.000

Table 4.14 revealed that girls' GEFT, SV and GAS were explained 48% variance in GAT scores. GEFT score explained 34% of the variance in their geometry achievement by itself. On the other hand, SV explained 10% and GAS explained only 4% of the variance in GAT scores.

Using Table 4.12, a linear regression equation can be written to predict girls' geometry achievement. Since GEFT, SV and GAS significant contribution in explaining their geometry achievement and enter the regression model, linear regression equation was:

$$Y= 0.309.X_{GEFT} + 0.354.X_{SV} + 0.\ 222.\ X_{GAS}$$

In equation, X_{GEFT}, X_{SV} and X_{GAS} respectively represent GEFT score, spatial visualization tests scores, and attitude toward geometry respectively.

4.2.3 Results Concerning Third Sub-problem of the Study

The third sub-problem of the study was “What is the extent to which cognitive style, spatial orientation, spatial visualization and attitude toward geometry could account for 9th grade boys’ geometry achievement?”

For investigating this sub-problem a hypothesis was stated and given below:

H_o: The four variables together (cognitive style, spatial orientation, spatial visualization and attitude toward geometry) do not explain a significant amount of variance in boys’ geometry achievement.”

Before conducted regression analysis, the assumptions of the analysis were tested, which includes sample size, normality, linearity, homoscedasticity, multicollinearity, and singularity.

Firstly, sample size should be at least 160, since it is necessary at least 40 subject for each predictor (Tabachnick and Fidell, 2001). When boys’ test scores separately included in the regression analysis, the number of subjects was still exceed 160. Therefore, sample size would be still enough for the regression analysis to analyze boys’ data separately.

Secondly, multicollinearity or singularity was controlled. Table 4.15 indicates the VIF and tolerance values of boys’ predictors.

Table 4.15: Collinearity Statistics Results of Test Scores of Boys

	Tolerance	VIF
GEFT	.807	1.239
SO	.807	1.239

Since VIF values are less than 10 and tolerance values higher than .10. Additionally, the correlation coefficient is given Table 4.15.

Table 4.16 indicates beta values for independent variables, which was entered the regression equitation.

Table 4.16: Pearson Correlation Coefficients among Predictive Variables of Boys

	SO	SV	GAS
GEFT	.439*	.486*	.279*
SO		.556*	.117
SV			.225*

* p<0.05

As seen in Table 4.16, correlation coefficents between predictors did not exceed .70, which indicated that there was no multicolinearity or singularity among independent variables.

Another assumption for regression analysis is normality. Table 4.17 indicates kurtosis and skewness values of the tests.

Table 4.17: Skewness and Kurtosis Values of Tests Scores of Boys

	GAT	GEFT	SO	SV	GAS
Skewness	1.150	.679	.651	2.540	-.351
Kurtosis	.338	-.406	.165	1.454	.198

As seen Table 4.17, all kurtosis and skewness values are between +2 and -2; so, it was concluded that normality assumption was also verified.

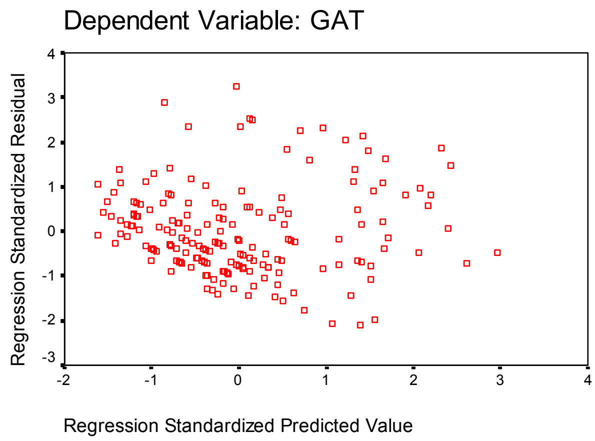

Figure 4.3: Scatterplot of Regression Standardized Residual for Boys'

As seen in Figure 4.3, there were few cases which have a standardized residual of more 3.3 or less than -3. 3; it was not necessary to take any action for outliers.

Consequently, any assumption violation was not detected; so, the stated hypothesis was examined by using stepwise regression at a significance level of 0.05.

Table 4.18: Linear Stepwise Regression Analysis Results for Combined Effect of Two Significant Predictive Variables on Boys' Geometry Achievement

	Sum of Squares	df	Mean Square	F	Sig.
Regression	2032.837	2	1016.418	82.423	.000
Residual	2195.053	178	12.332		
Total	4227.890	180			

As shown Table 4.18, two predictive variables (GEFT, SO) explained a significant amount of variance in boys' geometry achievement. [F (2,180) = 82.423, and p=0.000]

Table 4.19: Linear Stepwise Regression Analysis Results for Individual Effect of Significant Predictors Variables on Boys' Geometry Achievement

	Unstandardized Coefficients		Standardized Coefficients		
	B	Std. Error	Beta	t	Sig.
GEFT	.513	.063	.491	8.169	.000
SO	.040	.008	.319	5.307	.000

In Table 4.19, beta values were indicated that GEFT was made strongest contribution to explain boys' GAT scores. Additionally, only SO and GEFT had statistically significant contribution to explain boys' geometry achievement since significance values were less than 0.05 for these two variables, and SV and GAS did not have a significant contribution in explaining variance in boys' geometry achievement.

Table 4.20: Model Summary as a Result of Stepwise Regression Analysis for Boys

Predictors	R	R Square	Adjusted R Square	Std. Error of the Estimate	R Square Change	Sig. F Change
GEFT	.631	.399	.395	3.76869	.399	.000
GEFT,SO	.693	.481	.475	3.51166	.082	.000

R Square value in Table.4.20 indicated that boys' GEFT and SO were explained 48% variance in geometry achievement. Only GEFT score was explained 40% of the variance in their geometry achievement. On the other hand, SO was explained 8% of the variance in boys' geometry achievement.

Since GEFT, SO significant contribution in explaining their geometry achievement and enter the regression model, linear regression equation was written below by using beta values in Table 4.19.

$$Y= 0.491.X_{GEFT} + 0.319.X_{SO}$$

In equation, X_{GEFT} and X_{SO} respectively represent GEFT score, and spatial orientation tests scores.

4.2.4 Effect Size

Effect size refer to a measurement of the strength of the influence of the independent variables on the dependent variables (Kline, 2004), and it is used to describe practical significance of statistical results (Vaske, Gliner & Morgan, 2002 as cited in Carson, n. d.). Since statistically significant results necessarily mean that they are practically important or helpful for making decision, effect size was also calculated in the present study.

Cohen's effect size index (f^2) is a measure of effect size used for regression analysis; and, it is calculated by using the formula, which is $R^2/ (1-R^2)$. Table 4.18 indicates that f^2 values calculated by using this formula for each analysis.

Table 4.21: The Effect Sizes

	1st Hypothesis	2nd Hypothesis	3rd Hypothesis
Effect Size	.887	.932	.932

Cohen (1988) suggested a classification for effect size index. In this classification, an effect size of .20 is described as small, of .50 is described as medium, and .80 described as large. According to this classification, all analyses have large effect size.

4.3 Conclusions of the Study

In the light of findings obtained as a result of analysis of the research data, the fallowing conclusions can be deduced:

1. 9th grade students' filed dependency/independency cognitive style, spatial orientation ability, spatial visualization ability, and attitude toward

geometry variables explained statistically significant amount of variance in their geometry achievement.

2. Four predictive variables of the study is explained 47% variance in geometry achievement.

3. Field dependency/ independency cognitive style is found as the best single predictor of 9th grade students' geometry achievements, and it explains %37 of variance in geometry achievement. The second most important predictive variable is found as spatial orientation ability. Thirdly, spatial visualization ability and lastly attitude toward geometry is found significant in account for achievement in geometry.

4. Different regression equation models were found for boys' and girls'.

5. Field dependency/independency cognitive style, spatial visualization and attitude toward geometry entered the regression equation, and explained 48% variance in girls' geometry achievement. Spatial orientation ability did not explained significant amount of variance in girls' geometry achievement.

6. Field dependency/independency cognitive style, and spatial orientation entered the regression equation, and explained 48% variance in boys' geometry achievement. Attitude toward geometry and spatial visualization ability did not explain significant amount of variance in boys' geometry achievement.

7. Cognitive style was found as the most important predictive variable in explaining both girls' and boys' geometry achievement.

8. While spatial visualization ability significantly accounted for girls' achievement in geometry, spatial orientation ability accounted for boys' achievement in geometry.

9. Attitude toward geometry accounted for girls' geometry achievement significantly, but it did not account boys'.

10. The geometry achievement had a correlation coefficient of .611 with field dependence/ independence cognitive style, .529 with spatial visualization ability, .492 with spatial orientation ability, and with .344 attitude toward geometry at 0.05 significance level.

11. According to Cohen's classification, the effect sizes of the three analyses was found as large.

CHAPTER 5

DISCUSSION

In this chapter, the interpretation of findings of the present study, discussion and recommendations for further studies is presented. In the first section, the result of the study restated and the discussion on these results is given. In the second section, recommendations for further studies and implications are stated.

5.1 Discussion

The main focus purpose of the study was to investigate the role of students' spatial ability, field dependent/independent cognitive style and attitudes toward geometry in predicting their performance in geometry. Moreover, the relationship between geometry achievement and predictive variables and differences between boys and girls were also examined.

The linear stepwise regression analysis was conducted on research data to investigate how well independent variables would account for the variance in geometry achievement. The results revealed that spatial visualization, spatial orientation, field-dependency/ independency and attitude toward geometry were significant predictors of 9^{th} grade students' geometry achievement and they explained statistically significant amount of the variance in geometry achievement for all subjects. When research data analyzed separately for boys and girls, different regression equation were obtained. While cognitive style, spatial visualization and attitude toward geometry were accounted for significant amount of variance in girls' geometry achievement, cognitive style and spatial orientation were significant predictors of boys' geometry achievement. Field dependency/independency cognitive styles were only common significant predictor of geometry achievement for boys and girls. This cognitive style model was preferred, since there is substantial amount of information on theoretical base for field-dependence/independence cognitive style, and on its relationship with learning mathematics and geometry when it is compared with other cognitive style model or label.

All stepwise regression analysis results were found statistically significant. Additionally, whether the results were also practically important was examined by means of effect sizes. The effect sizes were revealed that the results also had practically importance.

Although all predictive variables made a statistically significant contribution in explaining 9th grade students' geometry achievements, beta values and R^2 obtained as a result of the analysis (see Table 4.6 and Table 4.8) indicated that the most important predictive variable was students' cognitive styles. Field dependency/ independency cognitive style alone accounted for the 37% of the variance in geometry achievement of all subjects. This finding is in line with previous studies (Roberge & Flexer, 1983; Chai, 1995; Naroni, 1998) which were concluded that students' cognitive style is important predictor of students' geometry and mathematics achievement. For instance, Noarini (1998) was found field-dependence/ independence cognitive style was best single predictor of students' performance in geometry tasks as result of regression analysis. Another researcher, Chai (1995) was also found cognitive style as influential factor in explaining students' mathematics achievement.

A reason can be that, cognitive styles are closely related how an individual perceives, processes information and learns. Students' cognitive styles may affect how they perceived illustration in geometry, how they interpret information given, and which strategies they used while answering geometry questions or solving geometric problems.

Another reason can be that success in geometry task is required to be able to perceive a figure in a different way beside as it is, and able to ignore some part of figure and work on relevant part. All of these are also requirement of getting higher score on GEFT. Consequently, since GEFT and geometry achievement test have similar requirements, cognitive style may found as best single predictor of achievement in geometry.

Additionally, some researchers asserted that the more able to disembed relevant information or shape from distracting information or complex design may create an advantage in geometry achievement tests; since both geometry achievement tests and GEFT are required to disembed a relevant geometric figure from context (e.g. Naroni,1998). It was also suggested that both success in GEFT and achievement in geometry test are required to analytical ability; it could be the reason why cognitive style and achievement was found highly correlated (Witkin et.al., 1977).

The relationship between scores students got in GEFT and GAT was also examined, and Pearson correlation coefficient was found .611 (see Table 4.5), which was statistically significant at the level of .05. This means that students who showed high ability to disembed simple figure from complex one, and so tented to be more field-independent cognitive style, were more probably got high scores in geometry achievement test. On the contrary, students indicating less ability to disembed simple figure from complex one was possible got low scores in GAT. This result was consistent with previous studies indicating significant association between field independency and mathematics achievement (Bieri, Bradburn & Galinsky, 1958; Bein, 1974; Buriel, 1978; Kagan & Zahn, 1975; Kagan, Zahn, & Gealy, 1977; Roberge & Flexer, 1983; Robinson & Gray; Satterly, 1976; Vaidya & Chansky, 1980). According to Bein (1974), analytical ability, which is related to perceptual disembedding and developing problem-solving strategies based on the way of reorganizing and restructuring information, is requirement of field dependence and mathematics achievement tests can be a reason for high correlation between them (as cited in Viadya, 1980).

Consequently, the fact that cognitive style was best predictor of geometry achievement and the fact that it was found high correlation between GEFT scores and GAT scores (r= .611) suggested that cognitive style can have important impact on learning geometry. In the present study, the reason of the results can be that both success in geometry and GEFT require analytical ability. Moreover, based on these findings, it can be concluded that students who have more ability to separate simple figure from complex one, perceive more analytically, and overcome districting stimulus may have advantage in learning geometry when compared with students who perceive an object or figure as it is, face with difficulties to overcome distracting stimulus, are less able to disembed simple figure from complex design, and whose perceptions are more global.

The regression analysis was also indicated that the variance in students' geometry achievement was predicted significantly by spatial visualization and spatial orientation for all subjects. However, when they compared with cognitive style predictive variable, they found less important. Students' spatial orientation abilities just accounted for 4.6 % of the variance in geometry achievement, their spatial visualization ability 3.6% of the variance in geometry achievement. This finding of the present study is consistent with the result of the research of Sherman (1979), Battista (1990), and Naroni (1998). These studies were also indicated that spatial visualization accounted for statistically significant amount of variance in achievement, however it was not found as most important predictor of achievement in geometry or mathematics.

Moreover, the correlation coefficient between SV and geometry achievement scores was calculated as .539; and, it was found between SO and geometry achievement scores as .492 (see Table 4.5). Both of them were statistically significant at the significance level of .05. Similar high correlations have also been found in the literature. For instance, Fennema and Sherman (1977) found correlation between SV and mathematics achievement as .48. Guay and McDaniel (1977) also was found correlation coefficient between mathematics test and surface development test, which is one of tests measuring SV ability, as .50 at 6^{th} grade level and .54 7^{th} grade level. Battista and collages (1982) was found relation scores in SV tests and grades in geometry lesson as about .40. Additionally, Naroni (1998) was found correlation between spatial ability and geometry achievement as .351. A reason can be that, spatial ability is seen as one of fundamental or primary abilities constitute of mathematical ability (Bishop, 1980). Additionally, Clements and Battista (1992) asserted that the reason of the existence of relationship between spatial ability and geometry can be that geometry contains lots of visual components.

In present study, spatial abilities were less important when they were compared with cognitive style, since the amount of variance explained by SV and SO for total sample was far less that the amount of variance accounted for GEFT scores. There were studies concluded similarly. For instance, Battista, Wheatley, & Talsma (1982) had found similar result when they compare relative importance of cognitive development and spatial ability. They found cognitive development was better predictor of geometry achievement measure by course grade even if spatial ability was explained significant amount of variance. A reason can be that, even if spatial ability is received as necessary to understand presented information or ideas; a number of other non-spatial factors can reduce the effect of this ability in learning geometry (Battista, et.al., 1982). Students' logical reasoning abilities or non-spatial strategies used by students to solve geometric problem or to answer geometry questions may reduce the significance of spatial abilities in explaining achievement.

In the literature, there were several researches in which regression analysis conducted in order to predict students' achievement (Battista, 1990; Battista, Wheatley, & Talsma, 1982; Sherman, 1980). In some of these studies, it was concluded different regression equations for girls and boys. While spatial visualization was a significant predictor for girls' achievement, and it was not entered into the regression equation for samples composing only boys. For instance, Battista (1990) found spatial visualization as single significant predictor of girls' geometry achievements, and he found that it accounted for 37% of the variance in their geometry achievement.

The result of the present study was in line with these previous studies. SV was found as significant variable in explaining girls' geometry achievement test scores, but not boys' achievement in geometry. This finding indicated that a critical difference in the role of spatial visualization ability in accounting for boys' and girls' geometry achievement can exist.

One explanation why spatial visualization was found statistically significant and second most important predictor girls' geometry achievement and it was not a significant predictor of boys' geometry achievement can be that the gender differences in spatial abilities. It was frequently found boys show better performance in spatial task than girls, spatial visualization is less problematic issue for boys than girls. Since boys already good at spatial tasks and they have high spatial visualization ability in general, this variable does not create discrimination among boys. Therefore, it could not be significant predictor for achievement in mathematics or geometry. On the other hand, girls have low spatial visualization ability in general; this variable cause of discrimination among girls, girls with high spatial visualization has advantage.

The results of present study were also revealed that there was a significant difference in the role of spatial orientation ability in accounting for boys' and girls' achievement in geometry. While spatial orientation was found significant predictor for boys' achievement in geometry; it was not a significant predictive variable for girls'.

Studies on spatial abilities in the literature have widely focused on spatial visualization ability, and a few focused on spatial orientation ability (e.g. Tarte, 1990). There was not any study investigating gender difference in spatial orientation ability and its predictive value in explaining students' achievement. Therefore, the finding related to spatial orientation could not be compared with other studies. Nevertheless, some studies indicated that the magnitude of gender difference in spatial abilities altered one type of spatial ability to another (Linn & Peterson, 1985). Therefore, the magnitude of difference in spatial orientation between boys and girls can be different the magnitude of gender difference in spatial visualization ability; and, this can led to be found different regression equation for boys and girls.

In sum, the fact that different spatial abilities entered the regression equation for boys and girls indicated that spatial orientation and spatial visualization may stem from the gender difference in these abilities. The difference in these abilities may affect learning geometry for girls and boys differently by influencing the strategies used to reach solution of geometry questions.

Additionally, even if spatial visualization and spatial orientation abilities were explained statistically significant variance in geometry achievement, they did not account for amount of variance in achievement as high as it was expected. When the amount of variance accounted by cognitive style was compared with the amount of variance explained by these abilities, it was far less.

Attitude has been thought as a possible factor which can influence performance in mathematics; however, the result of researches has not been concluded consistently. Attitude and performance in mathematics has been studies widely but the studies were interested in the relation between attitude and achievement in geometry has been very limited. While some indicated low correlation between achievement in mathematics and attitude, others were concluded that significant positive correlation exist between two (Chai, 1995). In present study, it was found that students' attitude toward geometry was weakly and positively correlated with their achievement in geometry; however correlation was found statistically significant. This result was consistent with the studies that indicated low significant positive correlation between geometry and attitude toward geometry (Aiken & Drager, 1961; Aiken, 1970, 1976; Ethington, 1991; Ethington & Wolfe, 1986; Ma, 1997; Ma & Kishor, 1997; Minato, 1983; Minato & Yanase, 1984; Schiefele & Csikszentmihalyi, 1995; Schoenfeld, 1989; Tağ, 2000; White, 2001). According to Neale (1969), there is a diynamic reciprocal interaction between achievement in mathematics and attitude toward mathematics. Attitude influences achievement and achievement also influences attitude.

The attitude toward geometry was found as a significant predictor of geometry achievement for total sample and for girls. However it was found that attitude was not a significant predictor of boys' geometry achievement and it did not enter the regression equation for boys. Therefore, it can be concluded that attitude is a better predictor of achievement of girls than of boys. This finding is also consistent with previous research result in the literature. For instance, Aiken and Drager (1961) found that scores on attitude toward mathematics scale was a significant predictor of final mathematics grade of collage girls but not of collage boys (as cited in Aiken, 1970). Aiken (1976) iterated that “girls mathematics marks are more predictable from their attitudes than boys’ marks” (p. 296) in his review.

5.2 Recommendations

In this section, recommendations are stated based on conclusions and interpretations reached as a result of analysis of the data of the study. The findings of the study revealed that the role of cognitive styles, spatial abilities, and attitude in predicting geometry achievement.

On the light of the finding of this study and literature review, the suggestions below can be offer;

5.2.1 Recommendations for Teachers

- In the present study, some cognitive and attitudinal characteristics of the students were investigated and the results indicated that student characteristics play an important role in achievement. Therefore, it is helpful for teachers to know students’ characteristics. They should be aware of significance of cognitive styles and spatial abilities, and should make students be aware of the importance.

- The results indicated that field dependency/independency cognitive style has a critical role in learning geometry. Therefore, teachers should inform about the importance of students’ cognitive styles in geometry teaching.

- The teachers should be informed about characteristics of field dependent/ independent students and suitable instructions for students with different cognitive styles. For instance, Kogan (1971) has proposed that a discovery method of instruction might prove beneficial to field independent children, whereas field-dependent children might learn more from a didactic mode of teaching (as cited in Threadgill, 1979, p.219). Additionally, level of guidance provided by teachers should differ with respect to students' cognitive style. Field-dependent students need more explanation or guidance provided by the teacher, whereas field-independent students are more comfortable when working independently and making discoveries without much assistance (McLead, et. al., 1978).

- Literature review and the result of this study indicated that the students with field dependent cognitive style have a disadvantage in learning geometry concepts. Therefore teachers should prepare and perform different instructional activities to remove field-dependent students' disadvantages in learning geometry. For instance, field-dependent students may more successful with socially oriented learning tasks (Saracho, 1998). Teachers can use cooperative teaching method for field-dependent students.

- According to Saracho (1998), some students might show better performance in mathematics and science assignments and might have field-independent cognitive style characteristics; whereas, some might be more competent in social learning task and might have field-dependent cognitive style characteristics. To encourage students just to specialize in the area they good at may restrict or limit them. To prevent the danger of stereotyped expectations of what students with specific cognitive style can achieve, he suggested that teacher should give opportunity for the students by assigning them to either matched or mismatched tasks with their cognitive styles. In briefly, teacher should help students to acquire skills mismatching their cognitive styles.

- The findings of this study indicated the significance of individual difference in learning geometry. Teacher should not expect students to learn in the same way, at the same rate. Some students may need more time, or may need to be taught different way.

- The preserves teachers should be qualified on how geometry be taught students with different cognitive style. Additionally, they should be qualified on how students' spatial abilities improve.

5.2.2 Recommendations for Curriculum Developers

- The findings of the present study indicated that importance of individual differences. Curriculum developers should prepare curriculum providing alternative ways for students with different cognitive or ability level. Saracho (1998) suggest to creating curriculum flexibility. Teachers and students enable to prefer tasks or concepts suitable for them.

- Curriculum developers should emphasize the development of spatial abilities since many investigations and this study indicated the significance of these abilities in learning mathematics and geometry.

- Curriculum developers should make authors include activities that help remove field dependent students' disadvantages in learning geometry.

5.2.3 Recommendations for Further Studies

- It is recommended the study should replicate with other samples selected randomly to examine generalizability of the results.

- Further studies can be conducted on different individual variables which can be related to achievement in geometry. It is recommended that other variables such as previous knowledge in geometry, cognitive development level be investigated.

- It is recommended that a comparison be made between schools in a distinct with different demographics to find out other possible effective variables.

- Further studies can be conducted on difference between students with field dependent cognitive style and students with field independent cognitive style in terms of way of learning geometry.

- Further studies can be conducted to examine feasibility of instructions or educational materials for students with different cognitive styles.

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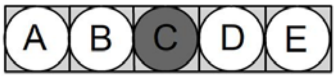
APPENDIX A

GEOMETRY ACHIEVEMENT TEST

Sevgili öğrenciler,

Test 25 çoktan seçmeli sorudan oluşmaktadır. Herbir sorunu beş seçeneği vardır. Beş seçenekten sadece bir tanesi doğru cevaptır. Doğru olduğunu düşündüğünüz seçeneği, cevap kâğıdında o soru için ayrılan bölüme işaretleyiniz.

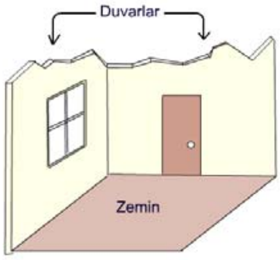
Örnek kodlama:



Sorular, İlköğretim 6, 7 ve 8. Sınıf Matematik dersi kapsamında işlenen geometri konularını içermektedir. Her doğru soru 1 puan değerindedir. Testin tümü için verilen cevaplandırma süresi 1 ders saati (45 dk) dır.

Sınav bitiminde soruları cevap kağıdınızila birlikte teslim ediniz.

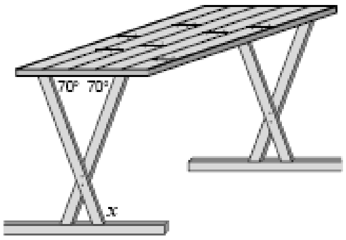
1.



Şekilde iki duvar ve zemin birer düzlem olarak düşünülürse, bu üç düzlemin kesişimi nedir?

A) Bir doğru
B) Bir nokta
C) Birbirini kesen üç doğru
D) Üç doğru parçası
E) Aynı noktadan çıkan üç ışın

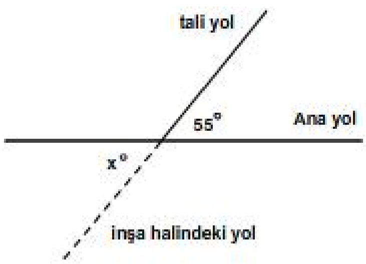
2.



Şekildeki masanın bir bacağı, masanın üst yüzeyiyle 70º lik açı yapıyor**.** Masanın yüzeyi yere paraleldir. **Buna göre, xº açısının ölçüsü kaç derecedir ?**

A) 40º B) 70º C) 90º D) 110º E) 130º

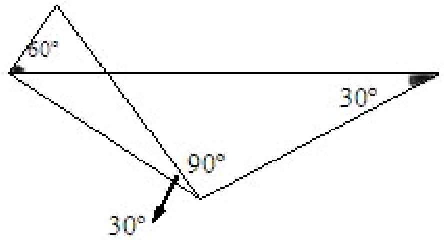
3.



Tali yolun ve yeni inşa edilen yolun düz bir doğru olabilmesi için xº açısının ölçüsü kaç derece olmalıdır?

A) 55 B) 60 C) 90 D)110 E) 125

4.



I- İkizkenar üçgen

II- Geniş açılı üçgen

III- Eşkenar üçgen

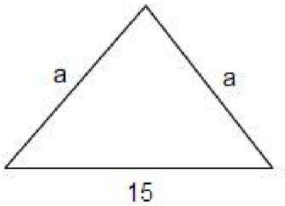
IV- Çeşit kenar üçgen

Yukarıdaki şekilde üçgen çeşitlerinden hangileri vardır ?

A) I ve II B) II ve III C) I, II ve IV

D) I, II ve III E) I, II, III ve IV

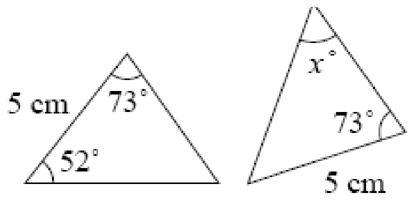
5.



a bir tamsayı olmak üzere, **a' nın alabileceği <u>en küçük</u> değer kaçtır?**

A) 4 B) 5 C) 8 D) 10 E)12

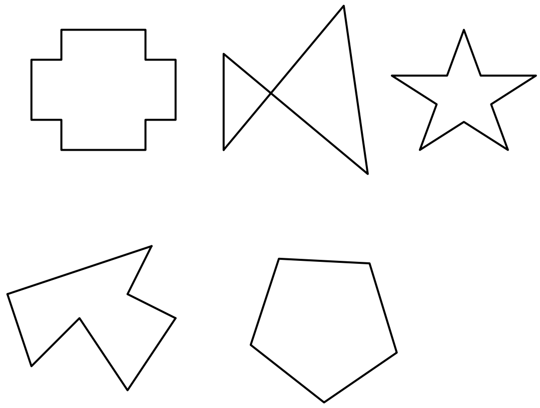
6.



Şekildeki iki <u>eş</u> üçgenin açıları ve kenar uzunlukları gösterilmiştir. **Buna göre, xº açısının ölçüsü kaç derecedir ?**

A) 52º B) 55º C) 65º D) 73º E) 75º

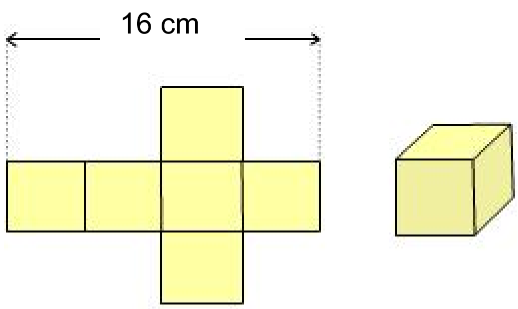
7. Aşağıdakilerden hangisi bir çokgen **değildir** ?



8. Bir çokgenin iç açılarının ölçüleri toplamı dış açılarının ölçüleri toplamına eşittir.
Bu çokgen aşağıdakilerden hangisidir ?

A) Üçgen B) Dörtgen C) Beşgen
D) Altıgen E) Sekizgen

9.



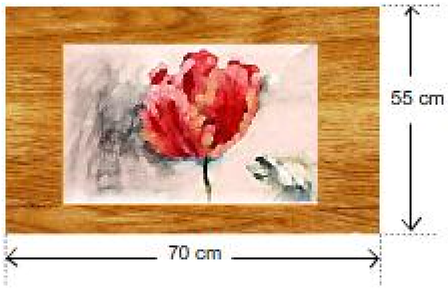
Yukarıdaki altı eş kareden oluşan şekil katlanıp küp haline getiriliyor.
Küpün hacmini kaç cm^3 olur?

A) 9 B) 16 C) 27 D) 64 E) 81

10. Bir eşkenar dörtgenin bir kenar uzunluğunun, çevresine oranı kaçtır ?

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

11.

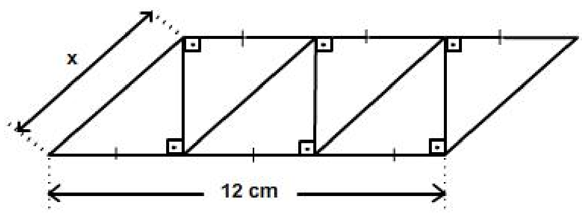


Şekildeki çerçevenin ölçüleri 70cm, 55cm'dir. Resmin ölçüleri ise 45cm ve 30 cm'dir.

Buna göre, çerçevenin alanını kaç cm^2 dir?

A) 1350 B) 1500 C) 2500 D)2750 E)3500

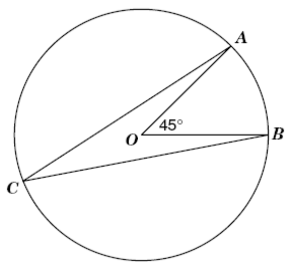
12.



Şekildeki paralel kenar **<u>altı</u> <u>eş dik üçgenden</u>** oluşmuştur. Paralel kenarın alanı 48 cm^2 dir. **Buna göre, x uzunluğu kaç cm'dir?**

A) $2\sqrt{3}$ B) 4 C) $4\sqrt{2}$ D) $4\sqrt{3}$ E) 6

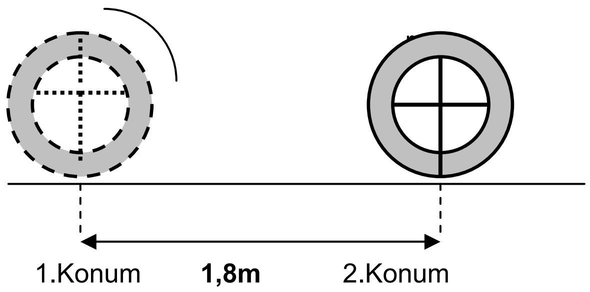
13.



O merkezli çemberde AOB açısı 45º dir. **ACB açısının ölçüsü kaç derecedir?**

A) 15 B) 22.5 C) 45 D) 67.5 E) 75

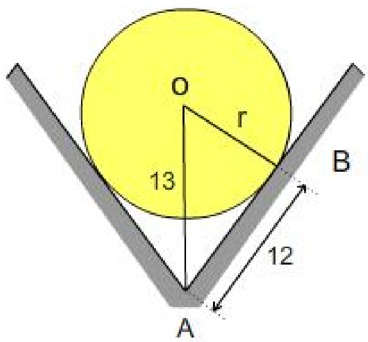
14.



Şekilde 1. konumdaki teker yerde bir tur yuvarlandıktan sonra 2. konuma geliyor. Bu sırada yerde 1,8 m yol alıyor. **Tekerin yarıçapını kaç cm'dir?** (π = 3 alınız)

A) 0,2 B) 0,3 C) 0,6 D) 0,8 E) 0,9

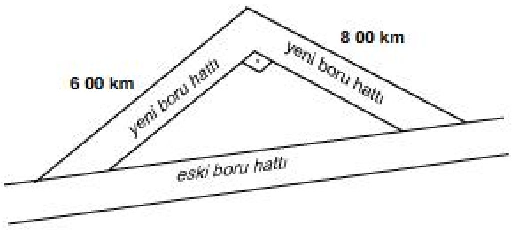
15.



O merkezli, r yarıçaplı bir top, iki duvar arasında durmaktadır.
│OA│= 13 cm, │AB│= 12 cm olduğuna göre, **topun yarıçapı r kaç cm dir?**

A) 5 B) 6 C) 8 D) 10 E)11

16.

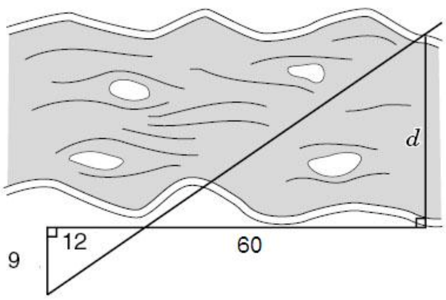


Orman arazisinin dışından geçecek yeni bir petrol boru hattı inşa edilecektir. Yukarıdaki şekil eski ve yeni petrol boru hatlarının güzergahlarını göstermektedir.

Yeni petrol boru hattı kurulduğunda, petrol yaklaşık fazladan kaç km daha akacak?

A) 150 km B) 200 km C) 250 km D) 300 km E) 400 km

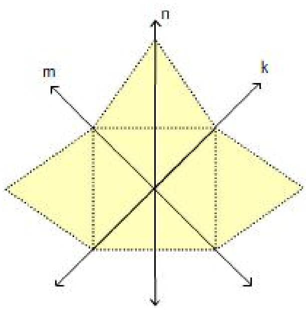
17.



Nehrin yaklaşık genişliği şekildeki ölçüm yapılarak bulunmak isteniyor. **Nehrin genişliği olan d uzunluğu kaç metredir ?**

A) 20 B)35 C) 40 D) 45 E) 50

18.

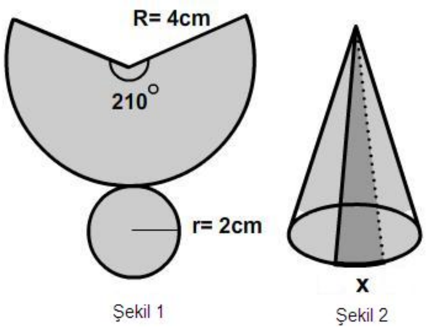


Şekil, bir kare ve birbirini aynı üç eşkenar üçgenden oluşmaktadır. **k,m,n doğrularından hangisi ya da hangileri şeklin simetri eksenidir?**

A) Yalnız n B) Yalnız m C) m ve n

D) n ve k E) m ve k

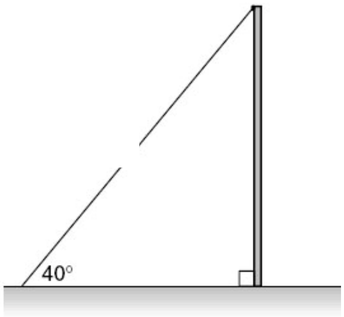
19.



Şekil-1' deki gibi kesilmiş bir karton parçasından koni yapılmak isteniyor.Karton katlandığında, kartonun bir kısmı üst üste biniyor**. Buna göre, Şekil-2 de gösterilen fazlalığa ait x yay uzunluğu kaç cm'dir ?** (π = 3 alınız)

A) 0,5 B) 1 C) 2 D) 2,5 E) 3

20.



50 m uzunluğundaki bir tel, şekildeki gibi direğin tepe noktasıyla yerdeki bir nokta arasında geriliyor. **Tel, yerle 40º lik bir açı yaptığına göre, direğin uzunluğu yaklaşık kaç metredir?** (sin 40º = 0.64, cos 40º = 0.77, tan 40º = 0.84)

A) 26.4 B) 32 C) 36.8 D) 38.5 E) 42

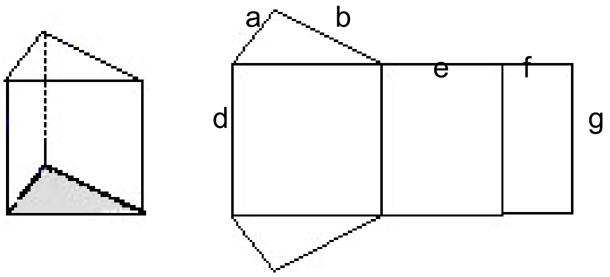
21.

Küre şeklinde bir dünya modelinin yarıçapı 6 cm dir. **Modelin hacmi kaç cm^3 tür?**

(π = 3 alınız)

A) 144 B) 216 C) 432 D) 576 E) 864

22.

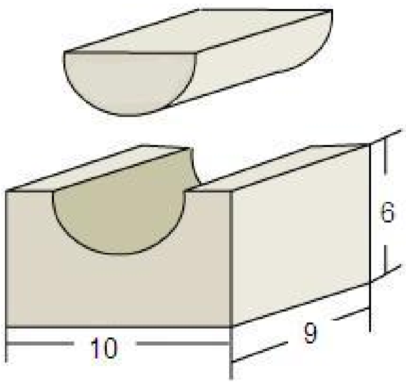


Şekil-1'de kartondan yapılmış üçgen dik pirizma açılarak Şekil-2' deki hale getiriliyor.

Pirizmanın açık şeklinde gösterilen a, b, c, d, e, f ve g uzunlukları için aşağıdakilerden hangisi <u>kesinlikle</u> doğrudur?

A) a = f B) c = e C) e > b D) d > g E) b = c

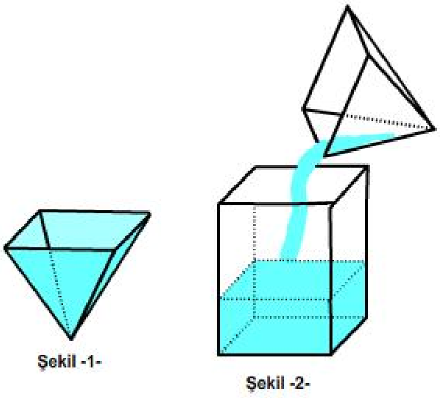
23.



Şekilde ayrıtlarının uzunlukları 6cm, 9cm ve 10cm olan dikdörtgenler pirizmasından yarım silindir şeklinde bir parça çıkartılıyor**.** Silindirin yarıçapı 2cm'dir. **Buna göre, kalan parçasının hacmini kaç cm^3 tür?** (π = 3 alınız)

A) 363 B) 382 C) 428 D) 432 E) 486

24.

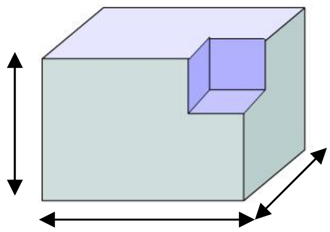


Taban alanı **S** yüksekliği **h** olan kare dik piramit şeklindeki bir kap tamamiyle su ile doludur. Su, taban alanı yine **S** olan kare dik prizma şeklindeki bir kaba boşlatılıyor.

Buna göre, kare dik prizmadaki suyun yüksekliği nedir?

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

25.



Ayrıtlarını uzunlukları a, b ve c olan dikdörtgenler pirizmasının köşesinden bir ayrıtının uzunluğu x olan küp şeklinde bir parça çıkarılıyor**. Parça çıkarıldıktan sonra, dikdörtgenler pirizmasının yüzey alanı nedir?**

A) $2(a.b + b.c + a.c) - 3x^2$

B) $2(a.b + b.c + a.c) + 3x^2$

C) $a.b.c - x^3$

D) $a.b.c$

E) $2(a.b + b.c + a.c)$

APPENDIX B

TABLE OF SPECIFICATION

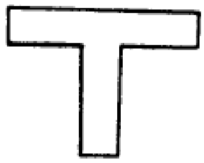
Content				
	Knowledge	Comprehension	Application	Analysis
Point, Line Plane		Item 1		
Angels			Item 3 Item 4	
Triangles			Item 5	Item 4
Area of Polygons			Item 11	Item12 Item 25
Volume of Objects	Item 21		Item 23	Item 9 Item 19
Symmetry			Item 18	
Circle			Item 13 Item 14	
Similarity	Item 6		Item 17	
Polygons	Item 7		Item 10	
Pythgoras Theorem			Item 15 Item 16	
Trigonometry			Item 20	
Prism				Item 22

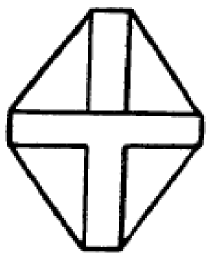
APPENDIX C

SAMPLE QUESTIONS OF GEFT

Try to find simple form named “B” in the complex figure and trace it in pencil directly over the lines of the complex figure.

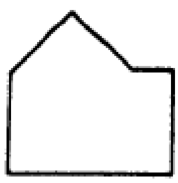
B

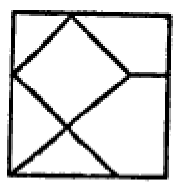




Try to find simple form named “D” in the complex figure and trace it in pencil directly over the lines of the complex figure.

D



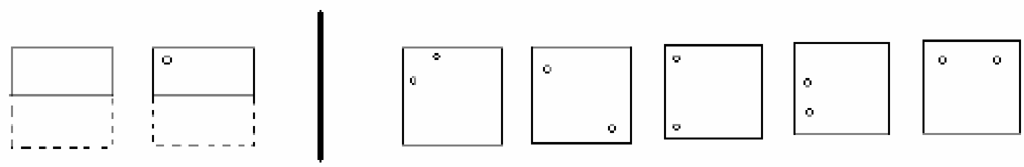


APPENDIX D

SAMPLE QUESTIONS OF SAT

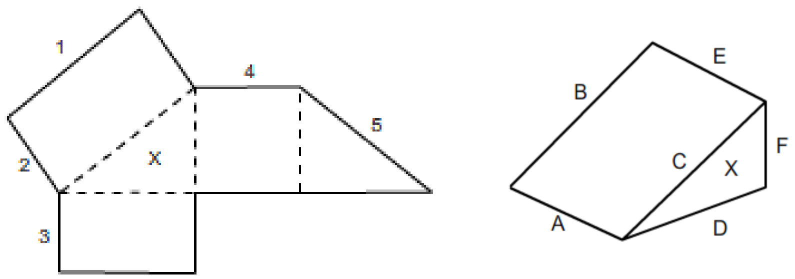
Paper Folding Test (PFT)

The square shaped paper on the left side of the vertical line is folded and then a hole is made. After unfolding the paper, which one of the shape in the right side of the vertical line will appear?



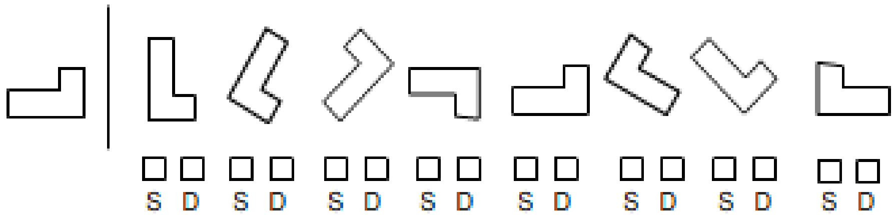
Surface Development Test (SDT)

When the paper is folded from the dotted lines, the subject on the right will be formed. By imagining the folding of the paper, match the numbered edges to the letters. The surface marked by X on unfolded paper on the left and on the subject on the right shows the same surfaces.



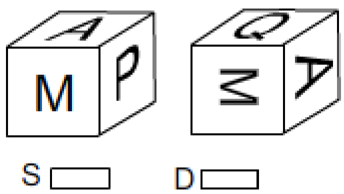
Card Rotation Test (CRT)

Find out whether the shapes on the right side can be determined by rotating the shape on the left side of the vertical line, in other words examine whether the shapes are the same or different. If the shapes are the same as the shape on the left side of the vertical line then mark S (Same), otherwise mark D (Different).



Cube Comparison Test (CCT):

In the following cubes all the numbers, figures and letters appears only once on each cube, but it can be in an unseen position. Then, find out whether the cubes on the left and the right are the same. If the cubes are the same then mark S (Same), otherwise mark D (Different).



APPENDIX E

GEOMETRY ATTITUDE SCALE

Genel Açıklama: Aşağıdaki geometriye ilişkin tutum cümleleri ile her cümlenin karşısında “Tamamen Katılıyorum”, “Katılıyorum”,”Karasızım”, “Katılmıyorum”, ve “Hiç Katılmıyorum” olmak üzere beş seçenek verilmiştir. Her bir cümleyi dikkatle okuyarak boş bırakmadan bu cümlelere ne ölçüde katıldığınızı seçenekleri işaretleyerek belirtiniz.

	Tamamen Katılıyorum	Katılıyorum	Karasızım	Katılmıyorum	Hiç Katılmıyorum
1. Geometri konulaarını tartışmaktan hoşlanırım.	O	O	O	O	O
2. Geometri benim için sıkıcıdır.	O	O	O	O	O
3. Geometri gerçek yaşamda kullanılmayan bir konudur.	O	O	O	O	O
4-Geometri ilgimi çeker	O	O	O	O	O
5-Geometri benim için zevkli bir konudur	O	O	O	O	O
6-Geometri konularını severek çalışırım	O	O	O	O	O
7-Geometri konularından korkarım.	O	O	O	O	O
8-Geometri ile ilgili ileri düzeyde bilgi edinmek isterim	O	O	O	O	O
9-Çalışma zamanımın çoğunu geometriye ayırmak isterim	O	O	O	O	O
10-Geometri konuları zihin geliştirimime yardımcı olmaz.	O	O	O	O	O
11-Geometri konularını severim	O	O	O	O	O
12- Geometri konuları okulda öğretilmese öğretilmese daha iyi olur	O	O	O	O	O
13-Geometri ile ilgili öğretilenleri günlük yaşama uygulayabilirim.	O	O	O	O	O
14-Geometri konusuna çalışmak içimden gelmez.	O	O	O	O	O
15-Geometri öğrenilmesi benim için zor bir konudur.	O	O	O	O	O
16-Geometri derinde zaman benim için çabuk geçer.	O	O	O	O	O
17-Geometri konuları benim için eğlencelidir.	O	O	O	O	O